THE

AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

FOURTH SERIES

VOL. XXIII—[WHOLE NUMBER, CLXXIII.]

WITH 1 PLATE.

NEW HAVEN, CONNECTICUT.

1907

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SCIENTIFIC INTELLIGENCE.

Number 138.

SCIENTIFIC INTELLIGENCE.

Established by BENJAMIN SILLIMAN in 1818.

THE AMERICAN JOURNAL OF SCIENCE.

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No. 133—JANUARY, 1907.

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THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

Published monthly. Six dollars per year, in advance. $6.40 to countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks (preferably on New York banks).

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Art. I.—*Colombian Meteorite Localities: Santa Rosa, Rasgata, Tocavita*; by Henry A. Ward.

The hopeless ambiguity in which these localities have heretofore rested makes the precision of the information secured by Professor Ward in his trip to South America in the early spring of 1906 a valuable contribution to scientific knowledge. The following article, clearing away this ambiguity, was begun by Professor Ward shortly before his death on July 4, 1906, and was left in such shape that it is practically his own. His assistant, Mr. Chester G. Gilbert, added the notes on the structure of the Santa Rosa iron from observations made during its cutting at Ward's Natural Science Establishment in Rochester, New York.

In 1824 two naturalists, Rivero and Boussingault, returning to Bogota from a trip through what was then the Republic of New Granada, published a memoir* concerning two native iron localities in the Eastern Cordiere of the Andes. The Tocavita Hill just back of Santa Rosa, a village about twenty miles northeast of Bogota, furnished the main locality, and from this hill, in 1810, by the united efforts of the community, a great block of pure native iron had been brought down to the village square. There it remained until 1818, when it was removed to the local smithy to do duty as an anvil,—a duty it was still performing when the travelers passed through the village. They recognized it at once as a massive siderite weighing approximately 750 kilograms; and, going to the hill whence it came, they found several fragments of the same pure malleable iron of granular texture. The other locality lay at Rasgata, near Saline de Zipaquira. Here the writers had seen one siderite weighing 41 kilograms and another of about half that size. The larger of these consisted of a hard malleable iron which was free from recesses and broke along

* Ann. de Chimie et de Phys., vol. xxv, pp. 438–443, Paris, 1824.

little facettes; the smaller, like the great Santa Rosa mass, was full of recesses.

The Rasgata meteorite was introduced into Europe in the form of a 13-pound piece which was sent by Rivero to a mineral collector named Heuland in London.* This piece was eventually divided, and, after the year 1837, specimens of meteoric iron bearing the name of Rasgata began to appear in the great European collections. The name Santa Rosa did not appear until 1863, when Rose used it† to designate an iron in the Berlin Collection very similar in structure to the Rasgata.

Little by little the representation of the two localities in European museums grew until in 1897 Wülfing, in preparing for his great work on meteorites,‡ found a total of 9·443 kilograms of Santa Rosa and Rasgata together, recorded in the great collections of the world. Some 1100 grams of this bore the former name, while the remainder was considered to have come from Rasgata. But no sharp line of distinction was ever drawn between the two. When they were spoken of together, it was with an expression of their similarity. Indeed in some few instances an indifferent interchanging of the two names seems to have taken place. The same evident confusion reigned in the minds of the authors of the rather copious literature on the two meteorites. So, despairing of the success of any attempt to differentiate between the irons, Wülfing grouped them under the one general head of Rasgata.

The authenticity of the Rasgata specimens in the various museums is, for the most part, sufficiently well-established by their history and identity of structure to leave no grounds for reasonable doubt: but such is by no means the case with the twelve or fourteen so-named Santa Rosa specimens. Of these latter only some two hundred grams, which Dr. Reiss and Dr. Stübel with their own hands removed from the great Santa Rosa mass as it stood once more in the market-place of the village, have a history well enough substantiated to carry weight.

The first noteworthy step toward clearing away the confusion which for many years hopelessly blended the different Colombia irons was taken by Cohen. In 1895§ he distinguished three localities as follows:

I. Santa Rosa, brecciated octahedrite. Zacatecas group (obz). Represented by the great mass in the village square, and by the fragments brought to Europe by Dr. Reiss and Dr. Stübel.

* Partsch. die Meteoriten im k.k. Hof-Mineralien-Kabinette zu Wien. Vienna, 1843.

† Beschreibung und Eintheilung der Meteoriten, Berlin, 1864.

‡ Die Meteoriten in Sammlungen und Ihre Literatur, Tübingen, 1897.

§ Annalen d. naturhist. Hofmuseums, Wien, vol. viii, pp. 131–138.

II. Tocavita, finest octahedrite (off). Represented by the fragments mentioned by Rivero and Boussingault as having been picked up on the Tocavita Hill, and by some few pieces in meteorite collections, notably that of Reichenbach, now in Tübingen.

III. Rasgata, ataxite. Nedagolla group (dn). Represented by the Rasgata masses spoken of by Rivero and Boussingault, and by most of the material variously known as Rasgata, Santa Rosa, and Tocavita in meteorite collections.

This differentiation, while the best that could be effected in the circumstances, is hypothetical, and contains an element of uncertainty introduced by the inexactness of the history of the material available for examination.

So matters stood when, in the late winter of the present year, I determined to undertake a journey into the heart of Colombia to secure, if possible, the great Santa Rosa meteorite for science; or, at least, to obtain facts which would serve either to confirm Cohen's distinction, or to establish a correct one should that prove erroneous.

A narrative of the difficulties incident upon the trip of five hundred miles up the Magdalena River from Barranquilla to Honda in a crawling river steamer; upon the arduous jaunt over seventy-five miles of mountain passes between the latter place and Bogota; and upon the expedition to Santa Rosa de Viterbo, fifty-three leagues to the northeast of the capital city, is reserved for a more popular form of article. The same occasion must await the story of the vengefulness of a South American community at the loss of a remarkable landmark, reverenced almost to the point of worship, and of the tribulations arising from the inconstancy of the Colombian mind.

Santa Rosa de Viterbo* lies, not twenty leagues as Rivero and Boussingault state, but fifty-three leagues from Bogota, in an almost due northeasterly direction, and the Tocavita Hill, whence the great mass and the fragments are supposed to have come originally, stands back of the village about a mile away. When I reached the village I found the object of my long journey crowning a fluted column in the market-place beside the fountain whence the entire community derived its water supply; and an inscription stated that it had been set up there in 1874. The tradition of its removal from Tocavita Hill still exists among the people, but neither there nor later in Bogota were any traces to be found of the Tocavita fragments reported by Rivero and Boussingault, and recorded by Cohen as constituting a distinct siderite fall. The early estimates as to the size of the great mass were exaggerated, as its weight is only 612·5 kilograms.

* Not Santa Rosa de Antioquia, lying northwest of Bogota.

In due time full possession of the historic siderite was secured, and it was started on its way to Bogota. There, however, the contract with the Santa Rosa municipality was nulli-

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fied, and the meteorite was seized for the National Museum. After protracted argument, a compromise was effected by virtue of which a piece weighing 150 kilograms was cut from the small end of the meteorite and delivered over to me. In addition to this, a piece of one of the Rasgata masses weighing

5½ kilograms was secured from the Bogota Museum, where the main part of this meteorite resides. The Rasgata locality lies near Cipaquira at a distance of ten leagues from Bogota, and a little to the west of a line between that city and Santa Rosa.

In view of the considerable distribution claimed for the Santa Rosa iron among the various museums, it is an interesting fact that the most careful scrutiny of its exterior before cutting failed to reveal a single place whence even the smallest piece had been removed. The accompanying cut describes better than words the general shape and appearance of the siderite. Its three dimensions are 77^{cm}, 49^{cm}, and 46^{cm}. The entire natural surface of the mass is covered with shallow saucer-like depressions which give it an undulating appearance. Other sharper-walled and deeper pits show by the troilite often to be found occupying their bases, that they have been formed by the weathering away of mineral accessories. A thin semi-lustrous coating, grading from brownish-black to rust-brown, encases the siderite and represents a somewhat altered natural crust. The small end of the block is interesting in a quite different way. Here, as may be seen in the cut, the crust has been removed, the projections smoothed down, and the pitting effaced by the battering of the smith's sledge, during long service as an anvil. The piece secured was taken from this end, and the slicing has been carefully made so as to preserve the anvil portion,—a historic as well as beautiful specimen,—for the Ward-Coonley Collection.

Immediately upon my return to this country, I sent a specimen of the Santa Rosa iron to my friend, the eminent authority, Dr. Brezina, and shortly afterward received the following in reply:

"This iron (Santa Rosa) corresponds exactly with the description given by Professor Cohen. It consists of differently oriented grains 2 to 3^{cm} in diameter, which are separated by very fine fissures filled with schreibersite or (rarely) with magnetite (Eisenglas). The grains are formed by octahedral lamellæ of kamacite nearly free from taenite and plessite, but rich in skeletons of schreibersite crystals. The lamellæ average a thickness of 2 to $2{\cdot}5^{mm}$. The kamacite is strongly hatched and grained, the diameter of the grains being $0{\cdot}05$–$0{\cdot}10^{mm}$, and presents a great number of dimples so as to show a vivid oriented glitter. Troilite is scarce, one bulky plate measuring 2×10^{mm}.

Along the natural surface an alteration-zone of $0{\cdot}5$–2^{mm} thickness is seen, which is dull; outward of it, on one corner, a scoriaceous bark of half-molten iron a millimeter in thickness is seen.

Cohen gives an analysis made by Sjöström, which shows—

Fe	92·30
Ni	6·52
Co	0·78
Cu	0·02
P	0·36
S	0·04
C	0·18
Cr.	tr.
	100·20

If C, P, and S are calculated as cohenite, schreibersite, and troilite, respectively, the above separate as follows :

	Cohenite.	Schreibersite.	Troilite.	Nickel-iron.
Fe	2·45	1·35	0·07	88·43
Ni	0·06	0·62	---	5·84
Co	0·01	0·01	---	0·76
Cu	---	---	---	0·02
P	---	0·36	---	---
S	---	---	0·04	---
C	0·18	---	---	--
Cr	---	---	---	tr.
	2·70	2·34	0·11	95·05

The nickel-iron has the composition of kamacite, which corresponds with the microscopic state, taenite and plessite wanting.

Cohenite is in most cases not to be distinguished from schreibersite otherwise than by chemical proofs ; and for this reason by many authors carbon is not counted as cohenite, but accredited to nickel-iron. It has been shown, however, by Moissan and Osmond that cohenite constitutes the outermost layer on the schreibersite corona which surrounds the nuggets of troilite and graphite. Where these two companions have been distinguished, they proved to be developed in nearly equal quantities. For this reason C is to be calculated as cohenite where cohenite and schreibersite have not been distinguished.

The iron of Santa Rosa is a member of the Zacatecas group of brecciated octahedrites. Three localities have furnished these—Zacatecas in Mexico, known since 1520, Santa Rosa in Colombia, found in 1810, and Barranca Blanca in Chile, found in 1855.

Dr. Aristides Brezina.

Vienna, June, 1906."

The description by Cohen, referred to by Brezina,* is the earliest in which Santa Rosa is distinguished as an octahedrite. According to this, the octahedral structure is not uniform throughout an etched face; but the lamellæ are differently oriented over each of the small areas up to $2{\cdot}5^{cm}$ across, into

* That referred to on page 2 of this article.

which the etched face is divided by fine fissures. Fissures are not everywhere present, and are so fine that they may often escape notice except where they are filled with schreibersite or magnetite. The lamellæ are short and fine, seldom exceeding 4^{mm} in length and $\frac{1}{4}^{mm}$ in width. The kamacite is granular, and contains etching pits which give it an oriented shimmer similarly oriented throughout individual lamellæ, and often throughout bundles of them. Plessite is not prominent partly because of its limited quantity, and partly because it is not to be distinguished from the kamacite in either color or structure.

Great difficulty was experienced in slicing the iron. A gang of eight saws, fed with emery, was kept running for 197 hours to obtain seven slices ranging from 450 to 600 square centimeters in size. When it was finally laid open, the first thing about the sections to attract attention was what appear in section to be almost, if not quite, perfectly spherical troilite nodules from 3 to 6^{mm} in diameter. It was not until after a closer scrutiny, and after a comparison of the concretions in the different slices, that they were found to be cigar-shaped, rather than spherical. The lay of these is, as nearly as may be determined, mutually parallel. Their direction is approximately perpendicular to the long axis of the meteorite, and happens also to be at right angles to the plane of the slicing.

In all, twenty-nine sections of different concretions are to be counted on the five main slices. Fifteen of these are of concretions extending through all five slices. In other words, of the twenty-nine different concretions met with in five successive slices of less than 600 square centimeters each, fifteen at least are parallel in position and more than 5^{cm} in length. The evenness of distribution, length, symmetry of form, and parallelism of direction, of this secreted troilite in the Santa Rosa siderite is a characteristic feature which, though approached in some few other meteoric irons, notably LaCaille, is equalled in none so far as I have observed.

The structure of the iron has been described so completely by Cohen and Brezina as to make further comment almost unnecessary. Polished faces are divided more or less completely by fine hair-like fissures into irregular areas 2 or 3^{cm} across. The fissuring is everywhere present, but is not always equally pronounced. A second form of fissuring is in the nature of magnetite-filled cracks, sometimes as much as a millimeter wide, extending inward sometimes 3^{cm} from the natural surface. One such magnetite-filled crack passes directly through a troilite concretion.

One of the slices, which has been etched, presents a mottled appearance of shimmery and dull areas, and as the angle of reflection is changed the bright spots vanish and new ones appear. This variable mottling is due in part to the fact that the sheen of the kamacite is differently oriented in different individual beams or groups of beams, and in part to the fact that a difference of orientation of the sheen as well as of the etching figures exists in the different areas marked off by the fissures. The iron is not a typical representative of the brecciated group, however, for the orientation is not invariably affected by the granulation. Sometimes a general orientation of the kamacite beams and of their sheen is to be found, with local disturbances, over areas 8 or 10^{cm} across. No traces of taenite are visible; and plessite, if present, is not distinguishable from the closely packed kamacite.

All of the troilite in the iron has been secreted to form the great cigar-shaped concretions. Schreibersite, although finely

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divided, is an important mineral accessory, filling most of the breccia-forming fissures, and thickly scattered in grains between lamellae.

Cohen's hypothetical division of the Colombian meteoric irons is thus seen to be correct in so far as it deals with the Santa Rosa locality, and the specimens of ataxitic iron recorded in certain of the meteorite collections under that name are wrongly designated. Apart from the conclusive proof afforded by the structure of the iron, this same conclusion is to be drawn from the fact already stated, that no appreciable amount had ever been removed from the meteorite up to last spring. Brevity forbids comment on the large specimen of Rasgata secured at Bogota for the Ward-Coonley Collection further than to state that its structure agrees with that of Cohen's Rasgata. But his justification of his third division, that of Tocavita, finest octrahedrite, is not so certain. There are no such fragments to be found either at Santa Rosa de Viterbo or in the National Museum at Bogota; nor is there any record or tradition anywhere except in the memoir by Rivero and Boussingault of the finding of such fragments.

Art. II.—*The Occurrence of Facetted Pebbles on the Central Plateau of Brazil;* by Miguel Arrojado R. Lisboa.

After the observations that were made upon facetted pebbles—the German Dreikanter—by Koken and Noetling in the Salt Range of India, and by E. Philippi in the south polar regions, the subject seems to be assuming the same importance as when Behrendt in 1876 first brought it to the notice of the Geological Society of Germany.

A plausible explanation,* based on local observations, gave rise to the theory of the glacial origin of the facetted pebbles of the Salt Range. This theory became more plausible after the discovery, by the Gauss expedition,† of facetted pebbles in the Antarctic polar regions.

The theory of glacial origin for all facetted pebbles is far from being accepted by geologists, and several objections have also been raised to the theory of their formation by the action of wind-blown sand in arid regions.

The occurrence of these pebbles in hitherto unknown localities will furnish a contribution to the subject worthy of attention. The author consequently takes the opportunity of announcing the discovery of characteristic facetted pebbles on the central plateau of Brazil.

Only two references to the existence of facetted pebbles in South America have been found. One of them, by Brackebusch,‡ refers to their occurrence in the Argentine valleys near the dunes derived from the sands of the Ataçama desert, 4000 meters above sea level. In the valleys of Tinogasta and Belen, effects analogous to those produced by glaciers were attributed to the action of sand blown by winds over the Bolivian desert. These facetted pebbles are, therefore, referred to as being of æolian origin. The other reference in the journal of the German Geological Society§ is a statement by Prof. Bruhns to the effect that in the Strasburg collection of South American rocks there are facetted pebbles of æolian origin, but the author does not know whether they come from the locality mentioned by Brackebusch.

When in 1884 Behrendt advanced the theory of the glacial origin of *Dreikanter*, the occurrence of these pebbles was

* E. Koken und F. Noetling, Geologische Mittheilung aus der Saltrange (pandschab) Centralblatt für Mineralogie, Geol. und Paleontology, 1903, n. 3, p. 72, n. 4, p. 97.

† E. Philippi, Ueber recente Facettengeschiebe von antarktische Eisbergen. Centralblatt f. Min., Geol. u. Pal., 1904, n. 24, 737.

‡ Petermann's Mittheilungen, 1893, xxxix, 153–158.

§ Zeitschrift der Deutschen Geologischen Gesellschaft, lvi, Protokollnotiz, p. 168, 1904.

considered to be a proof of local glacial action. Later, when Behrendt's theory was displaced by the theory of the action of sand blown by wind, the same pebbles were taken as a proof of existence of arid wastes or steppes in different geological periods.

Prof. Johnson* observes that in treating of existing deserts the glacial origin of facetted pebbles must be abandoned, so that, in view of the evidence of the Permian facetted pebbles and of the glacial pebbles of the south pole, we are confronted by two theories that demand essentially different geological conditions. It does not seem likely that two such different causes as glaciers and wind-blown sand would produce exactly the same type of facetted pebbles. To a certain extent, the existence of striæ would offer a point of reference for this determination, but the difficulty of proving their formation contemporary with the formation of the facets, and their complete absence in pebbles of undoubted glacial origin, show that other characteristics must be found to make it possible to discriminate between the two distinct types. This discrimination would be established if unquestionable facts confirmed the co-existence of the two causes in the formation of the pebbles.

From these considerations it is clear that only after the problem is completely solved will the occurrence of facetted pebbles form a secure criterion for the determination of glacial or æolian phenomena. A careful study of each occurrence seems now indispensable for the discovery of the causes of formation of these much discussed pebbles. From this point of view, the notes taken by the author are very defective. At the time of the discovery of these pebbles, his time would not permit a detailed study of them, and being unacquainted with the literature of the subject, it was not until some time later that he gave them the attention they deserved. The present notice, therefore, is only a description of the facetted pebbles accompanied by a general outline of the geology of the district in which they occur. The author does not intend to advance an opinion as to their origin before studying the local geological conditions.

The locality.—During the months of September and October, 1905, I visited the central plateau of Brazil, for the purpose of studying the diamond deposits on the left side of the upper basin of the S. Francisco River, a district about 700 miles from the Atlantic coast. There was but little time for geological observations outside the direct object of my trip, except a rapid survey of the roadsides or short excursions

* Zur Entstehung der Facettengesteine. Centralblatt. f. Min., Geol. u. Pal., 1903, n. 19, p. 593.

round the camp in the early morning, while preparations were being made for the day's journey. Our caravan happened to get lost for some time in the palm-groves between the river Borrachudo and Abaeté, and on this occasion my attention was attracted by the characteristic shape of the pebbles round my tent, then located in a dry creek bed. The pebbles were of a pyramidal shape, having the edges visibly rounded. From that time until reaching the banks of the Paracatú, my attention was especially drawn towards the shape of pebbles in the diamond alluvial deposits both on the plateau and in the beds of rivers, but the shape just described was not again found among them. In prospecting the Rio do Somno and Santo Antonio in the basin of Paracatú river, more than one thousand cubic meters of diamond gravel from different localities were washed without a single facetted pebble being found. There were many diamond washers about who came not only from the São Francisco valley, but also from the basin of the Jaquitinhonha, to get work in our party, so that I was able to verify the fact that they had never observed facetted pebbles in any part of the diamond district.

Circumstances obliged me to return by another route. About six kilometers east of the creek where the first occurrence of facetted pebbles was noticed, on the high plateau that separates the Borrachudo from the Abaeté, a second occurrence was met with, and here I gathered ten examples of facetted pebbles, which are described below. There being no detailed maps of the district, it is impossible to precisely define the two localities. The following notes may help to find them. Leaving Morada Nova by the road that crosses a small stream known as the Vereda do Pasto, one reaches the river Indayá, Corrego da Areia and Rio Borrachudo; from there after reaching the plateau, about 750 meters above sea level and following the watershed about twelve miles, the creek mentioned is reached. As the country is not peopled, it was impossible to obtain local names. The locality where facetted pebbles were again found is exactly on the watershed of the Borrachudo and Abaeté, along the highway that joins Morada Nova to Santo Antonio d'Agua Fria, 4400 meters north of the Borrachudo and 26,500 meters south of the Abaeté, these distances being measured by the pedometer along the highway.

As no samples were gathered at the first place, I here only describe those of the second one. In both cases, the pebbles were scattered about on the surface of the ground, several decimeters apart and not heaped up, as is usual with gold or diamond gravels.

The facetted pebbles.—As a rule the pebbles have one very rough and flat side, which, being the largest, serves as the base of the polyhedron, the other facets being polished and shiny with a general tendency towards convexity. The polished surfaces are sometimes quite smooth; at other times they are covered with small holes, reminding one of small pock-marks.

The pebbles may be grouped under two general divisions:

1. *The pyramidal type.*—To this type belong six of the samples. (*a*) Numbers 1, 2, and 3 are distinguished by their elongated shape. They are 8 or 10 centimeters long, 6 or 7

Facetted pebbles from the central plateau of Brazil.
About half the natural size.

broad and 3 or 4 high. Two of them have a rough base, full of holes. This, in the most perfect or regular sample, shows three sharp edges joining the three polished facets. In number 3, only the top edge is well defined, uniting two facets which are separated on the other side by a curved facet with undefined edges which seem to have been worn out. Two of these specimens have the base rough, full of holes and sufficiently flat to form a solid base. Number 3 is the only one of the collection which fails in this respect, showing an irregular and pointed base, seeming to have been partly polished. Number 1 has a polished facet that may be considered plane and which is opposite another facet also polished and perfectly convex which is like the surface of any round, polished pebble.

There are small pits in Nos. 1 and 2 although not very deep. All of these pebbles have conchoidal fractures at the base of the polished faces and on the edge of the base. Photograph No. 3 shows these fractures clearly. The concave part of these fractures is as perfectly polished as the surface of the two facets. The two specimens 1 and 3 show this fracture in the lower edge, resembling a broken lip. These breaks seem to be produced by another body rubbing against the pebble after it was already polished.

The polished surfaces of these three samples have blackened spots, formed by microscopic lichens, and the small pits are sometimes filled with them. This vegetation is limited by a line along the lower part of the pebble. Below this line and over the whole base there is no sign of vegetation and the stone is reddish, showing that it has been lying half buried in the clay of the plateau for a long time, whilst the upper part was exposed to the action of the atmosphere. In No. 3 it is clear that part of the polished surfaces were under clay. This specimen. is especially notable because its lower part is not smoothed but is full of rounded pits which seem to have been caused by rubbing against other hard rocks.

(*b*) The three other samples of this type resemble in shape a regular pyramid with a roundish base. They measure 6 or 7 centimeters in diameter at the base and about 4 in height. In other respects they are like those already described. Like them, they have a more or less plane base, the other faces tending towards convexity and showing more or less rounded edges.

Number 4 shows four perfect facets and corresponding edges. A sample which was not photographed has more convex facets and has a conical shape. The polished facets join upon a rough base.

Number 4 has near the base a slightly concave fracture with polished edges which seem to show that it was there before the polishing took place and, in spite of this, was not polished in its concave part.

2. *Facetted pebbles of different shapes.*—Of these four samples were gathered.

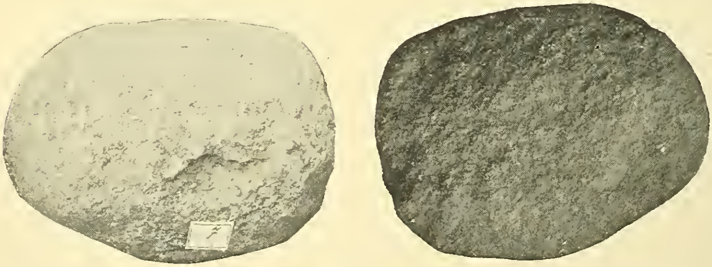
(*c*) Number 6 is flat in shape and has two equally developed opposite faces, forming between them a very sharp angle. The base is rough, full of small holes and sufficiently flat to be stable. The opposite face is polished and has deep pits blackened by vegetation. On one side these two faces are united by a thick rounded edge which is as well polished as the face

4 4a 5 5a

Facetted pebbles from the central plateau of Brazil.
About half the natural size.

opposite to the base, this polished surface continuing for some millimeters down the under part of the stone. These two flat faces of the pebble are joined on the other side by a rounded surface, such as may be observed on a common waterworn pebble.

7 7a



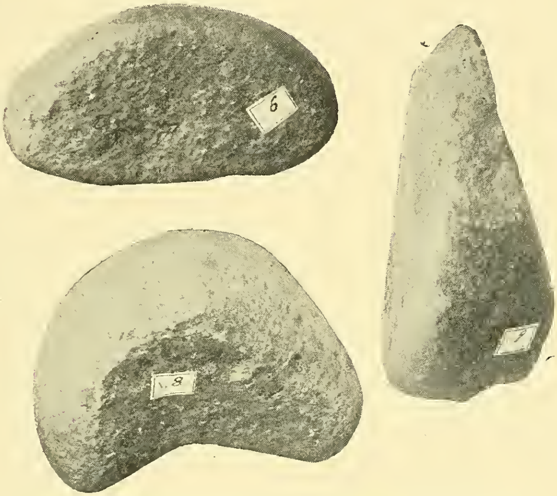
Facetted pebbles from the central plateau of Brazil.
About half the natural size.

(*d*) Number 7 is flat having the two opposite faces parallel. The largest face or the base is rough and plane. The upper side is only partly polished and is very much blackened by weather action, having its depressions full of microscopic vegetation.

(*e*) No. 8 seems to show by its shape that it was formed from a common rounded stone, and it still preserves much of its primitive form. The remarkable feature of this stone is a concave face which is quite as polished as the convex one and it is also full of pits and vegetation. The base is rough but sufficiently plane to stand firmly. The rounded out edge of the bottom clearly shows the line of division between the part that was sunk into the clay and the part exposed.

(*f*) The pebble shown in No. 9 is a facetted wedge-

6 9 8



Facetted pebbles from the central plateau of Brazil.
About half the natural size.

like stone that has been polished on all its faces except on the smallest one, which looks as if it had been chipped off. Only one of its facets is convex and probably represents the remaining part of what was formerly a common water-worn pebble. All around the pebble is a line which seems to show the stratification of the rock, which is perpendicular to the chipped side. The pits on this sample are not so developed as on the three above described. On the bottom edge there is an irregularity resembling a broken lip, half resting on the polished convex face and with equally polished edges. On one of the polished flat faces can be noticed slight cavities that indicate friction from another hard body. On this sample can also be observed the distinctive coloring of the zone that was under the clay and the one exposed to the weather.

Materials of the pebbles.—All the samples examined were of quartzite or metamorphosed sandstone, older than the dark shales and sandstones that constitute the rocks of the plateau where the specimens were found. These older rocks have been found on the highest parts of the plateau, forming the material of the superficial gravel, and often also in isolated blocks. They have been considered as formed from the disintegration of the conglomerates of horizontal shales and sandstones.* These pebbles are considered to be contemporaneous with the formation of the plateau sediments.

Geology of the region.—The following geological notes of the district may serve as preliminary information until more detailed observations are made with a view to determining the origin of the facetted pebbles.

As a rule, the rocks of the lower parts of the Borrachudo and Abaeté valley belong to two groups. The lower group consists of argillaceous shales and hard, bluish sandstone that are considered to be of Lower Paleozoic age. These rocks come to the surface in the deepest parts of the valleys. On them rests another group of rocks likewise composed of hard, bluish sandstone and argillaceous shale which is hardly distinguished from that of the preceding group except for its constant approximate horizontality. The line of contact between these two groups may be observed near the localities of the facetted pebbles not far from Rio Abaeté.

This last group forms the plateau of the region, rising 700 to 800 meters above sea level. As to the age of this group it is impossible to make a definite assertion. Fossil wood fragments, which have lately been identified as angiosperms† and which are referred to by Liais as belonging to the sandstone formation‡ of the sources of the Indayá, seem to indicate the existence in the district of rocks of the Upper Jurassic, or more probably, of Cretaceous age. The occurrence of these angiosperms has not yet been described in detail, nor are there any positive notes on their relation to the different rocks of the region. It is not safe, therefore, to consider the rocks of the Borrachudo and Abaeté plateaux as belonging to the Upper Mesozoic age, before further observations have been made.

Mention should here be made of the common occurrence in the district of superficial deposits of gravel, not only at the bottoms of valleys but also on high parts of the plateaux. The high gravels have been considered as the result of the disinte-

* O. A. Derby, Reconhecimento geologico dos valles do Rio das Velhas e Alto S. Francisco, p. 29.

† O. A. Derby, Nota sobre a geologia e Paleontologia de Matto-Grosso. *Archivos do Muzeu Nacional*, p. 68.

‡ Cited by O. A. Derby in Paleontologia de Matto Grosso; Liais, Géologie du Brésil, p. 210.

gration of a conglomerate. This gravel generally contains diamonds, especially in the valleys of the Abaeté, Santo Antonio and Somno, where they are more abundant. The material of these pebbles is variable according to localities, yet sandstones belonging to diverse geological horizons, including quartzites and other metamorphic rocks, predominate in them. The origin of the material of the pebbles may always be traced in any one of the localities, without excepting pebbles belonging to the oldest horizons. Quartzites and itabirites are found at Areado, about 60 miles to the east of the facetted pebble beds. According to Eschwege they will be found, also *in situ*, in the spur of the Serra da Matta da Corda, which passes by the Sta. Rita coming from the basin of the Sto. Antonio to the São Francisco, in the direction of Paraopeba.

Climate of the region.—An important circumstance in connection with the problem of facetted pebbles is the semi-arid nature of the region. Rain is very unevenly distributed, being abundant in summer and almost or quite lacking in winter. The nature of the rocks also contributes to the aridness of the soil. The region in summer is one of prairies which disappear in winter, leaving the soil quite denuded in some places. The topography of the country shows much more undulation than would be expected on a high plateau, and in spite of this, there are large areas where small rivulets are flowing in the rainy season. For this reason much of the district is uninhabited.

Under these conditions, it is not impossible that the high parts of the ground have been influenced by wind action under a semi-arid climate and that the region has experienced many of the phenomena peculiar to the steppes or avant-pays of the deserts. In any case it is certain that the attention of observers in this country has never been turned to this subject.

Résumé.—The above notes are intended to open the way to future studies, and only after such have been made will it be possible to establish, or to discuss with certainty, the origin of the facetted pebbles of central Brazil. Whatever theory the facts may justify, this problem is one of great geologic interest.

Hypothesis of their glacial origin.—The idea of the ice age in the tropical zone of Brazil, in the Pleistocene epoch, was advanced by Agassiz and has been much discussed. It was attacked by Barão de Capanena in a public conference and was afterward abandoned even by its author.* Thus the drift of Agassiz as well as his glacial bowlders and his *roches mountonnées* of the vicinity of Rio are due to phenomena of decomposition common in tropical climates. As an explanation of

* J. C. Branner, Jour. Geol., i, 753–772.

facetted pebbles, the hypothesis of the Pleistocene glaciation is, therefore, out of the question.

There remains the hypothesis of a Permo-Carboniferous glacial epoch. Permian rocks exist in southern Brazil, but in the central region they have not hitherto been reported in the extensive basin of the upper São Francisco. As far as the geology of the region is known, there is no positive evidence in contradiction to this hypothesis, and any facts supporting it would be of great geological importance.

Another problem of no less importance is that of glaciation at the close of the Paleozoic era. When Waagen wrote on the subject of glaciation in the southern hemisphere, in the Permo-Carboniferous epoch, he referred to this part of America. His observations drew forth a letter from Prof. Derby in which certain pebbles and bowlders of Itú, S. Paulo, were referred to glacial action of that period, and it was said that the lack of positive evidence of glacial phenomena was due to a lack of knowledge of the country.* The subject has since been left on the same footing. The absence of striæ is a negative fact of great importance, but until the present time no one has ascertained whether local conditions are not unfavorable to their preservation.

Hypothesis of their æolian origin.—The climatic conditions of the district are such that the hypothesis of wind action is naturally suggested, but here also the author finds not a few difficulties.

Rains on the extensive central Brazilian plateau vary greatly, not only from year to year but also locally. On the whole the region may be considered semi-arid and even arid in some parts.

The climate of central Brazil has been but little studied. In one of his recent writings, Professor Derby† calls attention to this fact and observes that the meteorological data gathered on the coast are often erroneously applied to the arid regions of northern Brazil. He compares some zones of the central plateau of Brazil‡ to the great American desert.

Certain conditions in the occurrence of the facetted pebbles seem to exclude the presumption of their being of recent date. This point may be easily ascertained with further observations. We are considering a large surface of country approximately with the same conditions of climate, topography and geography

* Waagen and Derby, Mittheilung eines Briefes von Herrn A. Derby über Spuren einer carbonen Eiszeit in Sudamerika. Neues Jahrbuch für Mineral. 1888, II Band, Briefliche Mittheil., p. 172.

† O. A. Derby, O reigmen das chuvas nas regiões das seccas. Jornal do Commercio, Rio de Janeiro, 24 de Março, 1906.

‡ With a medium rainfall below one meter and evaporation more than twice as great as precipitation.

throughout, and consequently the effects of wind-blown sand would be general. At present it may be presumed that facetted pebbles are of exceptional occurrence in the country under consideration. In the hypothesis even of action restricted to a certain locality, the æolian effect would not be limited to a few pebbles but would extend to them all, leaving at the same time an unquestionable proof on the surface of the surrounding rocks, and it is very singular that, if these effects exist, they should not have been noticed.

The recently published observations of Prof. J. C. Branner* on the formation of the reefs of the coast show that the existence of an arid climate in this part of the continent should date from Cretaceous times and that this aridness must continue to occur as long as the present geographic conditions remain. This allows the possibility of referring the formation of facetted pebbles to a period anterior to ours, perhaps as far back as the Cretaceous, and possibly under a still more arid climate.

EXPLANATION OF FIGURES.

FIGURES 1 and 1*a*, 2 and 2*a*, 3 and 3*a*, 4 and 4*a*, 5 and 5*a*.—Facetted pebbles of pyramidal type, elongated shape. Seen from the faces opposite to the base and from the side.

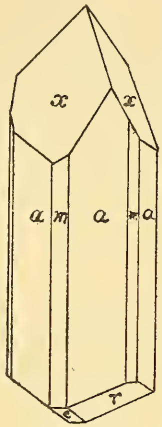
FIGURES 7 and 7*a*.—Flattened form, 7*a* shows the base of pebble No. 7. This face is identical in all the samples except number 3.

FIGURES 6, 8, 9.—Facetted pebbles of diverse shapes.

* The stone reefs of Brazil, Bulletin of the Museum of Comparative Zoology, Harvard College, xliv, Geological Series, vol. vii, May 1904; also, Bull. Geol. Soc. Amer., xvi, 5 and 12, Feb. 1905.

ART. III.—*Mineralogical Notes;* by F. A. CANFIELD.

IT was the desire of the writer to have the late Professor Penfield publish the following notes, as they are, in a way, supplemental to the three papers published by him on the respective subjects. As this is now impossible he feels obliged to do it himself.



I. *Willemite.*—In his paper on willemite.* Professor Penfield illustrates in fig. 7 a crystal with a tetartohedral termination. The other end of the crystal was buried in the matrix and could not be examined. By carefully removing the rock, this termination was found to be of the common form, made up of *r* and *e* planes in about the relative proportions shown in fig. 1.

As far as known to the writer, this is a unique occurrence of a hemimorphic crystal of willemite. This specimen was found in the deep mines at Stirling Hill, N. J., and not at Franklin Furnace, as stated in the paper cited.

II. *Argyrodite.*—In his paper on argyrodite,† Professor Penfield expressed regret at the lack of knowledge as to the occurrence of argyrodite in Bolivia. The writer first saw this mineral in Potosi, in the winter of 1885–1886, but he was unable to learn much about it except that it was very rich in silver. It was impossible to obtain any specimens owing to the pride of the owners in the possession of such rich ore. It was only when financial distress, due to investments in unprofitable mines, was felt, that the rare specimens could be obtained. Argyrodite is always associated with the richest silver ores, such as pyrargyrite, stephanite and native silver and perhaps argentite, although this last mineral is quite as rare as the argyrodite. The gangue is blende with perhaps a little pyrite and siderite. This class of ore is found in quantity only at Porco and Colquechaca. These towns are about one hundred and twenty miles apart. The largest masses of argyrodite were found at Porco. One piece weighs more than five kilograms. The largest crystals were also found there; one rhombic dodecahedron measures two and a half inches on its axis. An octahedron modified by the rhombic dodecahedron was shown to the writer in Porco. It measured about an inch along its axis. Unfortunately this specimen was lost, its

* This Journal, xlvii, 305. † Ibid., xlvi, 107.

owner having no recollection of its existence. The best formed crystals were found at Colquechaca. The piece that Professor Penfield analyzed came from Porco, but the crystals that he examined, and from which he determined the true crystalline form of the mineral, were found at Colquechaca.

III. *Canfieldite.*—In the description of this species by Professor Penfield the locality is given as La Paz, Bolivia.* The writer having a personal interest in canfieldite, has endeavored to find its true locality, feeling certain that it was not La Paz.

Mr. William E. Hidden, who furnished the specimen that Professor Penfield examined, told the writer that it was sent to him by a collector in La Paz, but that he had no reason for thinking it was found in or near that city. By correspondence with friends in La Paz, and by personal interviews with residents of that city, the writer has found no evidence that there is any active silver mine nearer La Paz than Oruro, which is 150 miles distant.

Bolivia is a peculiar country; nearly the entire white population is concentrated in a few large cities, which are widely scattered. The weekly parcels post and the freighters make it easy to transmit samples and cargoes of ores to the important business centers. The writer saw collections of ores, from the various mining districts, in every large town that he visited. He got his best specimen of pyrargyrite in La Paz, but it came from Colquechaca. The type crystals of argyrodite were secured in Potosi, while the largest mass of this mineral was obtained in Sucre from the owner of a mine in Porco. Many similar cases could be given, but this is a sufficient explanation how any particular specimen could be found in La Paz. This is negative evidence. When in Colquechaca in 1887, the writer was presented with a specimen of canfieldite by the manager and part owner of a mine, in his office, at the entrance of the main adit of the mine, so there can be no question as to its locality. The principal crystal is much smaller than the one in the Brush Collection, but otherwise its appearance is identical with the type crystal, even to the line of twinning that is seen on the faces of the rhombic dodecahedron. As there is no direct evidence that this mineral has been found at any place besides Colquechaca, it is but reasonable to conclude that the type crystal came from the mines in that place.

The specimen obtained by the writer at the mine in Colquechaca is a group of crystals of pyrargyrite with wire silver. Many crystals of canfieldite are scattered over the pyrargyrite. Most of them show on the dodecahedral faces the depression

* This Journal, xlvii, 451.

mentioned by Professor Penfield. This depression has the effect of a double face, each half of which is striated by lines lying nearly parallel with one side of the rhombic face and meeting the lines of the adjacent face at an angle of about 90 degrees, at the bottom or center line of the depression. These lines may have been caused by interruptions during the growth of the crystal. Some of the crystals are twinned spinel fashion, and on some of these the dodecahedral faces are depressed and striated. A very few of the crystals are simple octahedrons, and a few show faces of the cube in combination with the other forms. The type crystals of argyrodite do not show the depressions and striations.

When in Colquechaca, the writer purchased several specimens which are similar to those described by Messrs. G. T. Prior and L. J. Spencer, in their paper on "Stanniferous Argyrodite from Bolivia," etc.* The crystals do not show the striated depressions. Many are spinel twins. These crystals have not been analyzed. One specimen is made up of brilliant black rhombic dodecahedrons with but few traces of the octahedron. The angles are sharp with no signs of twinning. It is probably argyrodite.

In 1889, the writer identified his crystals by a specimen in the British Museum Collection, which was labeled† "brongniardite" from Aullagas, Bolivia. Damour described this mineral as coming from Potosi. It is safe to say that none of these minerals was found in the mines near the city of Potosi. The Department of Potosi covered more than 10,000 square miles and included Porco and Colquechaca, and in this sense the locality as given was correct. It is more probable that the specimens of the so-called brongniardite of A. Damour and Louis Saemann were carried to the city of Potosi from Porco or Colquechaca.

Dover, New Jersey.

* Min. Mag., xii, 5, 1900.

† Messrs. Prior and Spencer (l. c.) have proved this specimen to be stanniferous argyrodite.

ART. IV.—*On the Chemical Composition of Amphibole;* by S. L. PENFIELD and F. C. STANLEY.*

OWING to the common occurrence of amphibole and the important rôle it plays as a rock-making mineral, its chemical composition has naturally been the subject of repeated investigation, with the result that there has accumulated a large amount of analytical data, yet there is still wanting a satisfactory explanation of the variations in chemical composition exhibited by the mineral. The present investigation was undertaken, therefore, with the hope that by having a few analyses made with the utmost possible care on material of unquestionable purity a clue might be gained which would help to elucidate some of the difficulties presented by the problem. And here at the outset it may be stated that the present communication is only a preliminary one: It is intended to make more analyses than are given in this paper, but since it happens that the work must be interrupted for a time, it is believed that data of sufficient interest have already been accumulated to warrant publication. It is also intended to make a careful study of the optical properties of the various amphiboles which have been analyzed, but the carrying out of that part of the investigation must be left for the future.

Turning to text-books and treatises on Mineralogy for an explanation of the chemical composition of amphibole, it is found that the formulas suggested by Tschermak† are the ones which are almost always given. Briefly stated, Tschermak's

* NOTE:—Prof. Penfield had had the problem of the chemical composition of amphibole in mind for a number of years, but the opportunity for carrying out an investigation to solve it did not present itself until about two years ago, when Mr. F. C. Stanley, a graduate student, commenced, under his direction. the series of amphibole analyses which are quoted in the present paper. These analyses formed the basis of a thesis which Mr. Stanley presented in 1905 for the degree of Doctor of Philosophy. The results of the analyses were not published at that time, for it was hoped, as Prof. Penfield states, that the investigation could be continued and made more complete, but circumstances prevented Dr. Stanley from continuing the work, and hence during May and June, 1906, Prof. Penfield wrote up the investigation as far as it had proceeded. After his death in August last, the manuscript of the article presented here was found in his desk. Fortunately it was in such an advanced stage that it has been possible to print it almost exactly as Prof. Penfield left it, the only changes being occasional verbal ones and the only addition being the concluding paragraph, headed Summary and Conclusion.

Prof. Penfield, had he lived, would undoubtedly have extended the article somewhat by the discussion of still other analyses taken from the literature, and would, as was his invariable custom, have subjected the whole manuscript to rigorous revision. But as it stands it forms a clear, well developed and illuminating contribution, not only to the problem of the chemical composition of amphibole itself, but also to the wider problem of the composition of pneumatolitic minerals in general.—W. E. FORD.

† Mineralogische Mittheilungen, 1871, page 41.

theory is as follow: To tremolite, the simplest form of amphibole, the formula $CaMg_3Si_4O_{12}$ is assigned; ordinary green amphibole, actinolite, corresponds to $Ca(Mg,Fe)_3Si_4O_{12}$; while in varieties containing considerable amounts of sesquioxides, there is assumed the existence of an alumo-silicate molecule $(Ca,Mg)_2Al_4Si_2O_{12}$ and a corresponding one containing ferric iron, $(Ca,Mg)_2Fe_4Si_2O_{12}$. The last two molecules have only a theoretical existence; they are supposed to be isomorphous with $Ca(Mg,Fe)_3Si_4O_{12}$, but no pure chemical combinations corresponding to them have ever been observed. The presence of alkalies is ascribed to the existence of the metasilicate molecules $Na_2Al_2Si_4O_{12}$ and $K_2Al_2Si_4O_{12}$, the former being analogous to jadeite, $NaAlSi_2O_6$. Water is supposed to be due to alteration and there is no provision in the formulas for fluorine, which is an almost unfailing constituent of amphibole. In Tschermak's latest publication* the formulas suggested for amphibole are $CaMg_3Si_4O_{12}$, $CaFe_3Si_4O_{12}$, and two alumo-silicates, $CaMg_2Al_2Si_3O_{12}$ and $Na_2Al_2Si_4O_{12}$.

It is true that by a combination of the several molecules suggested by Tschermak theoretical compositions may be calculated which correspond rather closely to some of the analyses, but the formulas are in general found to be wanting in many respects when subjected to careful comparison with existing analyses, and Tschermak freely admits that the problem is one presenting numerous difficulties.

Rammelsberg† has pointed out that amphibole analyses conform to the formula $R''SiO_3, R = Ca,Mg,Fe,Mn,Na_2$ and K_2, plus varying proportions of Al_2O_3 (and Fe_2O_3), which formulas, however, do not apply to arfvedsonite and related minerals of the amphibole group, rich in soda and sesquioxides. In their essential features the formulas of Tschermak and Rammelsberg are alike, $Ca(Mg,Fe)_3Si_4O_{12}$ of Tschermak being equivalent to $4RSiO_3$, and the alumo-silicate molecules $(Ca,Mg)_2Al_4Si_2O_{12}$ to $2RSiO_3+2Al_2O_3$. They differ in that Tschermak regards the alkalies as belonging to molecules like $Na_2Al_2Si_4O_{12}$, respectively $Na_2Fe_2Si_4O_{12}$, while Rammelsberg recognized Na_2SiO_3 as isomorphous with $CaSiO_3$ and $MgSiO_3$. Neither of them take into account water and fluorine, which, as will be shown, are essential and often prominent constituents of amphibole and should not be disregarded.

Numerous other formulas have been suggested by various investigators, but these in general refer only to analyses of single specimens of amphibole, and it does not seem necessary to discuss them at the present time.

* Lehrbuch der Mineralogie, 1894, p. 458.
† Mineralchemie, 1875, page 394.

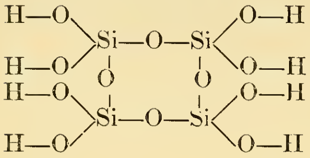
Before presenting the new analyses and entering upon their discussion, it seems best to set forth certain premises which may well be taken into consideration.

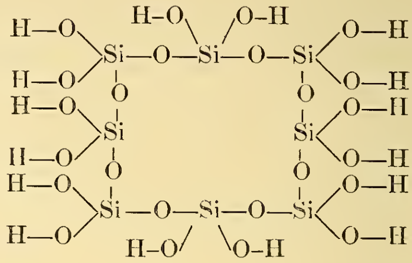
In the first place, it may be noted that amphibole contains an unusually large number of constituents, SiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, H_2O and F, among which are metallic elements having valences of three, two and one, and if any reasonable formula is to be proposed there must be some satisfactory disposition made of hydrogen and fluorine. For a mineral having so many and such variable constituents, and likewise having them in very variable proportions, it seems reasonable to assume a *complex chemical structure.* Compare amphibole for example with chrysolite, and a marked difference is noted; the formula of the latter is $(Mg,Fe)_2$-SiO_4, and, disregarding impurities, if constituents other than SiO_2, MgO and FeO are noted in the analyses, they are either NiO or MnO, which are readily explained as isomorphous with MgO. In what are generally regarded as simple chemical compounds only such constituents are to be found which are alike in valence and in grouping according to the periodic system, and thus conform to the ordinary law of isomorphism; for example, FeO and MnO ismorphous with MgO. It may be noted also that in general Na_2O is not isomorphous with either K_2O or CaO, nor CaO with MgO, such constituents when occurring together generally forming double salts. In amphibole, however, owing as it is believed to its complex chemical structure, or to what one of the present writers has called *mass effect*,* such unlike constituents as H_2O, Na_2O, CaO, MgO and Al_2O_3 are in some way brought into a molecule as isomorphous constituents or radicals, a result which we do not meet with nor expect to meet with in the case of simple chemical compounds.

Again, when we consider the great diversity in chemical composition of the various minerals of the amphibole group, including glaucophane, riebeckite and arfvedsonite, all of them being essentially alike in crystallization, in cleavage and in prismatic angle, it must be assumed that there is some controlling factor responsible for this similarity in crystallization, and it is believed that this controlling factor is *the acid.* From the composition of the simplest minerals of the group, tremolite and actinolite, it seems definitely proved that the amphiboles are salts of metasilicic acid, not necessarily H_2SiO_3, but some multiple of this. Tschermak has suggested $H_8Si_4O_{12}$ as the stoichiometrical formula of the amphibole acid, and there are reasons for believing that this, or some multiple of it, is correct. It is to be regretted that at the present time there is

* This Journal, xiv, 211, 1902.

no means of determining the size of the molecule of a crystallized solid. Metasilicates are naturally and readily written structurally as ring formulas, and although such formulas are wholly hypothetical they are at least suggestive and hence useful. If $H_8Si_4O_{12}$ is the formula of the amphibole acid, or perhaps $H_{16}Si_8O_{24}$, natural ways of expressing these graphically would be as follows:





Although wholly incapable of proof, it is altogether within the bounds of reason to believe that the amphibole acid has a ring structure, and that as in organic chemistry we have a benzol ring which plays so important a rôle in a vast number of compounds, so in mineral chemistry we may speak of a probable *amphibole ring*, carrying with it a certain controlling force which conditions a kind of crystallization recognized as characteristic for the amphibole group of minerals. As will be pointed out later, calcium atoms replace one quarter of the hydrogen of the amphibole acid, and it may be that the position of the particular hydrogen atoms replaced by calcium is a matter of importance, just as in organic chemistry the ortho-, meta- or para-positions in the benzol ring are determining factors.

As has already been stated, it is believed that amphibole has a complex molecular structure; it is not readily made artificially and if fused and allowed to cool there result simple substances, especially pyroxene. If the ring theory is correct, it may be assumed that by fusion the amphibole ring is broken down and is incapable of reformation under ordinary conditions of heat and pressure.

To our knowledge amphibole has only once been made artificially, and this result was achieved by von Chrustchoff.* The accomplishment of this brilliant and too little known experiment is so important and throws so much light upon the

*Neues Jahrbuch 1891, 2, page 86. [In a recent article entitled, "Minerals of the Composition $MgSiO_3$; Case of Tetramorphism" (this Journal, Nov. 1906), Messrs. E. T. Allen, F. E. Wright and J. K. Clement have described the synthesis of orthorhombic and monoclinic forms of pyroxene and amphibole. The monoclinic amphibole was obtained with considerable difficulty and only in small amounts and in microscopic crystals. W. E. FORD.]

mode of formation of amphibole in nature that a brief outline of von Chrustchoff's method may be given here to advantage. In his experiment aqueous solutions of silica, alumina and ferric hydroxide were taken, carefully prepared by dialysis, freshly precipitated ferrous hydroxide, lime water, magnesium hydroxide suspended in water and sodium and potassium hydroxides; these constituents when brought together made a rather stiff gelatinous mass, which was placed in several glass bombs *(Birne)*: the bombs were then exhausted, hermetically sealed, and continuously heated for a period of three months at a temperature of 550° C. Several of the bombs exploded, but three of them withstood the severe strain, and on opening these there was found a brownish deposit containing well formed crystals 1^{mm} long and $\frac{1}{4}^{mm}$ thick, of brilliant luster, dark color and showing forms commonly observed on amphibole; *b* (010), *m* (110) and *r* (011). The prismatic angle could only be measured approximately, but $r \wedge r'$, $011 \wedge 0\bar{1}1$, gave with exactness 31° 32′, which is like one of the fundamental amphibole angles of Koksharov. An analysis of the crystals is here given and for comparison the results obtained by Stanley from the black amphibole (hornblende) from Edenville, N. Y.

	Artificial Crystals		Edenville	
Sp. gr.	3·245		3·284	
SiO_2	42·35		41·99	
TiO_2	----		1·46	
Al_2O_3	8·11	16·02	11·62	14·29
Fe_2O_3	7·91		2·67	
FeO	10·11	24·44	14·32	25·74
MnO	....		0·25	
MgO	14·33		11·17	
CaO	13·21		11·52	
Na_2O	2·18		2·49	
K_2O	1·87		0·98	
H_2O (loss on ignition)	0·91		0·53	
(H_2O at 110°)	----		0·08	
F	----		0·80	
	100·98		99·83	

The two analyses are very much alike, especially when it is taken into consideration that the higher Al_2O_3 and FeO of the Edenville material are offset respectively by lower Fe_2O_3 and MgO.

The failure to make amphibole by ordinary methods of synthesis, and the success of von Chrustchoff's experiment indicate clearly that the conditions necessary for the formation of the mineral are those which are obtained with difficulty in a laboratory, namely the combined action of heat and pressure, maintained for a considerable period of time; conditions, however, of common occurrence in nature. Amphibole is undoubtedly a mineral which commonly owes its origin to what is known as pneumatolitic action, that is to aqueous vapors and other gases working under the combined action of heat and pressure. In minerals formed under such conditions are found water with hydrogen playing the rôle of a metal, hydroxyl, fluorine and, as in the case of tourmaline, boron. Many of the minerals have complicated chemical formulas, for which possibly the mode of formation is responsible, pressure and other agencies giving rise to molecular structures more intricate than are generally met with. In several of these pneumatolitic minerals, amphibole, tourmaline and the micas for example, there may be noted the occurrence of a large number of elements, of varying valences and evidently occurring in some way as isomorphous constituents.

In spite of the fact that pneumatolitic minerals have been produced with difficulty, if at all, by synthetic methods, it is reasonable to suppose from their common occurrence in nature that they might be produced with comparative ease if the right conditions could be obtained. It is probable that with a suitable container provided with electric heating appliances, within which a high pressure could be maintained, the conditions favorable for the synthetic production of numerous pneumatolitic minerals might be attained and satisfactory results expected.

To recapitulate, our premises are as follows:—Amphibole is presumably a mineral of complex molecular structure, a salt of some multiple of H_2SiO_3, very probably of an acid characterized by a ring structure, but the number of silicon atoms contained in the ring it is impossible to state. This much also seems probable, that the number of silicon atoms in the amphibole molecule, and their arrangement, whatever that may be, exert such a controlling influence that by virtue of *mass effect* the hydrogen atoms of the acid may be replaced by elements of different valences and by radicals without exerting any appreciable effect upon the crystalline form.

Selection and preparation of materials for the new analyses.—The endeavor has been made to select materials representing a wide range in chemical composition and also with the view of having the samples prepared for analyses as pure as possible. Most of the specimens have been selected from the Brush Collection. As a rule they were well crystallized and the materials were at first carefully selected by hand picking; subsequently they were pulverized and sifted to an uniform grain, suspended in heavy solutions and from each a portion was selected which floated and sank within narrow limits. The heavy solutions used were potassium-mercuric iodide for the lighter and barium-mercuric iodide for the heavier varieties of amphibole. In every case the powders were washed with great care to remove every trace of the heavy solutions; they were also examined under the microscope to note the presence of any possible impurities. It may be stated with confidence that all of the materials which have been analyzed were of the utmost possible purity.

Method of Analysis.—The methods employed in making the analyses were like those for a long time in use in the Sheffield Laboratory, and essentially the suggestions as outlined by Clarke and Hillebrand* and by Washington† were followed. The analyses were made by Stanley, and before starting on them considerable time was spent in gaining familiarity with the methods of separation, for which purpose numerous artificial mixtures were made and analyzed. In cases where much iron and alumina were present the separation from magnesia was made by means of a double basic acetate precipitation. Fluorine was determined by the Berzelius method as outlined by Penfield and Minor,‡ and from experiments made with artificial mixtures containing the same constituents in about the same proportions as in amphibole it is probable that the results obtained for fluorine are all too low by about 0·10 to 0·15 per cent. Water was in all cases determined by the closed-tube method described by one of the present writers.§ In several cases, especially in the early part of the investigation, analyses of the same material were repeated four or six times in order to gain the greatest possible accuracy in the determinations. With few exceptions the determinations were always made in duplicate.

New Analyses and discussion of results:—Amphibole occurs in several distinct varieties, some of which are conveniently designated by names, and it seems best to take up the analyses in groups, commencing with the simplest types. The discussion of the analyses is based upon the ratios derived by dividing the percentages of the several constituents by their molecular weights. In the case of fluorine the percentages are divided by twice the atomic weight, in order to make the quotients comparable to those obtained from the percentages of H_2O; two fluorine atoms being equivalent to two hydroxyl radicals, represented in the analyses by the hydrogen atoms of H_2O. Hydrogen unquestionably plays a double rôle in amphibole and numerous other minerals having a complex

* Analyses of Rocks and Analytical Methods, U. S. G. S. Bull. 148.
† The Chemical Analysis of Rocks.
‡ This Journal, xlvii, 387, 1894.
§ This Journal, xlviii, 31, 1894.

chemical structure. In part it goes with oxygen to form hydroxyl (OH), which radical has the character of an unmetallic, acid-forming element, as shown by its isomorphism with fluorine; in part also hydrogen is basic like a metal, H_2 being isomorphous with Na_2, Ca or Mg, or, in accordance with our conventional method of expressing analyses, H_2O is isomorphous with Na_2O, CaO, MgO, etc. From the results of the determination of water in analyses, there seems at the present time no way of determining how much hydrogen is to be ascribed to hydroxyl and how much is basic. In both cases the resulting water is driven off only on intense ignition. In the present analyses so much confidence is felt in the purity of the materials analyzed that the question of hydroscopic water or water resulting from alteration does not enter into the calculations, nor is water of crystallization present.

From the supposed mode of formation of amphibole by pneumatolitic action, both hydroxyl and fluorine enter into the composition of the mineral and must be reckoned with the same as other constituents: Water as a base, isomorphous with Na_2O, CaO, MgO, etc., must also be taken into consideration, and this is such an important matter that it seems best to refer to a simple yet striking example encountered by one of the writers* in the investigation of a very pure variety of anthophyllite. In the analysis water was first estimated as loss at a low red heat and found to be only 0·19 per cent. On completing the analysis the summation was unsatisfactory, as was also the ratio of SiO_2 to the bases, FeO, MgO with traces of MnO and CaO. In endeavoring to find an explanation for the defects of the analysis and its failure to give a good ratio, some of the powdered mineral was heated with a blast-lamp in a closed tube, when at a very high temperature abundant water was given off. This water, amounting to 1·67 per cent, brought the summation of the analysis to 99·99 and the ratio of SiO_2 to $FeO+MnO+MgO+CaO+H_2O$ became 1·00 : 0·997. Therefore in this comparatively simple combination of silica with protoxide bases there can be no question but that H_2O is isomorphous with MgO and FeO.

In addition to the ratio of silica to the protoxide bases, it will be interesting to note the relative proportion of the several bases present: This is conveniently expressed in per cents and is given with each analysis.

The analyses are as follows:

Tremolite.

Of this material, representing the simplest type of amphibole, two analyses have been made. The specimens selected

* This Journal (3), xl, p. 394, 1890.

for study were purposely chosen from quite widely separated regions, and because of their being very unlike in appearance and mode of occurrence.

I. *Tremolite from Richville, near Gouverneur, New York.*—This locality is the one famous for its brown tourmalines, known to collectors the world over. The specimen consisted of a mass of large white crystals, some showing distinct outline and the ordinary forms, *m* (110), *b* (010) and *r* (011). When broken up the fine splinters were perfectly transparent. The material used for analysis floated on the heavy solution at 3·002 and sank at 2·992; the average specific gravity, therefore, may be taken as 2·997.

The results of the analyses are as follows—

	I	II	Average	Ratio	Per cents of protoxide bases	
SiO_2	57·47	57·43	57·45	·957		
TiO_2	----	----	----			
Al_2O_3	1·28	1·32	1·30	·014		
Fe_2O_3	·18	·18	·18			
FeO	·22	·22	·22	·958	0·3	65·2
MnO	·07	---	·07		0·1	
MgO	24·87	24·83	24·85		64·8	
CaO	12·84	12·94	12·89		24·0	25·8
K_2O	·49	·58	·54		0·7	
Na_2O	·68	·66	·67		1·1	
H_2O	1 30	1·20	1·16		6·9	
F_3	·77		·77		2·1	
					100·00	
Loss at 110°			·09			
			100·19			
$O = F_2$			·32			
			99·87			

The ratios of this and the following analyses will be discussed later.

II. *Tremolite from Lee, Massachusetts.*—This material consisted of bladed crystals, showing only prisms, somewhat striated, embedded in a grayish-white, fine-grained, crystalline, dolomite-marble. As far as was observed, the crystals never show distinct terminal faces. The tremolite crystals have a grayish white color, but small fragments are colorless and transparent. The crystals were first carefully selected by hand and after pulverizing and sifting to a uniform grain, the powder was treated for a while with warm, dilute hydrochloric acid to insure removal of possible traces of attached dolomite.

The material used for analysis floated on the heavy solution at 2·984 and sank at 2·975, the average being 2·980. The results of the analysis are as follows :—

	I	II	Average	Ratio		Per cents of protoxide bases	
SiO_2	57·61	57·78	57·69	·961	·963		
TiO_2	·14	·14	·14	·002			
Al_2O_3	1·85	1·75	1·80	·018	·018		
Fe_2O_3	·00	·00	·00	·000			
FeO	·55	·55	·55	·007		0·7	
MnO	trace	trace	trace	·000		0·0	64·2
MgO	24·12	24·12	24·12	·606		63·5	
CaO	13·07	13·30	13·19	·236	·954	24·7	
K_2O	·22	----	·22	·002		0·2	25·7
Na_2O	·48	----	·48	·008		0·8	
H_2O	1·76	1·61	1·56	·087		9·0	
F_2	·37	----	·37	·011		1·1	
Loss at 110°			·10			100·0	
			100·22				
		$O=F_2$	·15				
			100·07				

ACTINOLITE.

Of the green variety of amphibole, characterized by a low percentage of sesquioxides and commonly known as *actinolite*, four varieties have been analyzed. As regards localities, association and mode of occurrence they are as widely separated as possible.

III. *Actinolite from Greiner in Tyrol. Specimen No. 349, Brush Collection.*—This is one of the well known localities, where crystals of a fine, dark-green color, showing the combination of the prism *m* (110) and pinacoid *b* (010), occur imbedded in talc. To obtain material for analysis the crystals were first carefully selected by hand, and as they were found to be coated with a fine talcose powder, they were treated for a while with a mixture of warm dilute hydrofluoric and hydrochloric acids, which left them clean and brilliant. When broken up and sifted to an uniform grain the fragments were found to be wonderfully pure when studied with the microscope. A very small proportion of the particles were found to contain minute black grains, presumably of magnetite, but these being heavier were removed by treatment with the heavy solution. The material for analysis floated at 3·058 and sank at 3·036, the average specific gravity being 3·047.

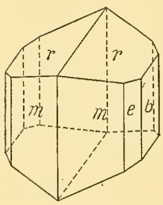
The results of the analysis are as follows :—

	I	II	Average	Ratios		Per cents of protoxide bases	
SiO_2	56·13	56·36	56·25	·938	·938		
TiO_2	·00	----	·00	---			
Al_2O_3	1·24	----	1·24	·012	·017		
Fe_2O_3	·74	·82	·78	·005			
FeO	5·50	----	5·50	·076	·935	8·1	65·5
MnO	·48	----	·48	·007		0·9	
MgO	21·18	21·20	21·19	·529		56·5	
CaO	12·15	12·00	12·08	·216		23·1	23·7
K_2O	·29	·28	·28	·003		0·3	
Na_2O	·19	·18	·19	·003		0·3	
H_2O	1·89	1·73	1·81	·100		10·7	
F_2	·04	----	·04	·001		0·1	
			99·84			100·0	

The amount of fluorine in this analysis is so small that a distinct qualitative test could not be obtained.

IV. *Actinolite from Russell, St. Lawrence Co., New York. Specimen No. 424, Brush Collection.*—The specimen chosen for analysis is typical for amphibole found throughout quite an extensive area in St. Lawrence Co. The piece analyzed consists of crystals varying from 2 to 4^{cm} in diameter, having the forms shown in figure 1, *m* (110), *e* (130), *b* (010), *r* (011), and occasionally *i* (031). The color of the crystals is dark green, but small splinters have a rather light color and are transparent. The powdered material floated at 3·102 and sank at 3·081, the average being 3·092. The results of the analysis are as follows:—

1



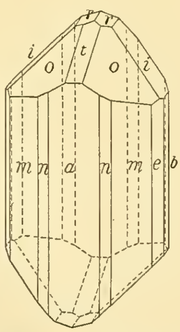
	I	II	Average	Ratios		Per cents of protoxide bases	
SiO_2	54·85	54·75	54·80	·913	·914		
TiO_2	·10	----	·10	·001			
Al_2O_3	2·56	2·59	2·58	·025	·041		
Fe_2O_3	2·40	2·60	2·50	·016			
FeO	4·68	4·82	4·75	·066	·913	7·30	63·2
MnO	trace	----	trace	----		----	
MgO	20·24	20·36	20·30	·507		55·9	
CaO	12·19	11·97	12·08	·216		23·8	25·5
K_2O	·24	----	·24	·003		0·3	
Na_2O	·82	----	·82	·013		1·4	
H_2O	1·56	1·64	1·60	·088		9·1	
F_2	·77	----	·77	·020		2·2	
Loss at 110°			·11				
						100·0	
			100·65				
		$O = F_2$	·32				
			100·33				

V. *Actinolite from the Mines of Kragerö, Norway.*—The material for analysis was taken from a large, striated, prismatic crystal, without terminal faces, which was presented to the Brush Collection by Prof. W. C. Brögger of Christiania. The color of the large crystal was dark olive-green, but fragments were light colored. The material floated at 3·180, sank at 3·094, the average being 3·137. The results of the analysis follow:—

	I	II	Average	Ratios		Per cents of protoxide bases	
SiO_2	57·07	51·64	51·85	·864	·880		
TiO_2	1·26	....	1·26	·016			
Al_2O_3	4·36	4·37	4·36	·043	·059		
Fe_2O_3	2·58	----	2·58	·016			
FeO	5·46	----	5·46	·075		8·6	64·8
MnO	·33	·37	·35	·005		0·5	
MgO	19·35	19·61	19·48	·487		55·7	
CaO	10·40	10·81	10·60	·189		21·6	26·1
K_2O	·35	----	·35	·004		0·5	
Na_2O	2·15	---	2·15	·035		4·0	
H_2O	1·35	1·33	1·21	·067		7·7	
F_2	·46	----	·46	·012		1·4	
Loss at 110°			·13			100·0	
			100·24				
		$O = F_2$	·22				
			100·02				

VI. *Actinolite from Pierrepont, St Lawrence Co., New York.*—The specimen from which material for analysis was

2



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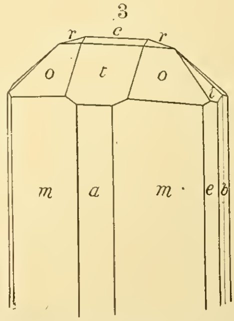


taken was collected by one of the writers while engaged in mineralogical work for the U. S. Geological Survey, and thanks are due to the Director of the Survey for permission to use the material in any way for scientific purposes. The habit of the crystals is unusual and is shown by figure 2, but, the crystals being attached, doubly terminated ones have not been observed. Figure 3 represents one end of a twin crystal. The forms which are quite numerous for amphibole are: *a* (100), *b* (010), *c* (001), *n* (310), *m* (110), *e* (130) *r* (011), *i* (031), *t* (101) and *o* (121). It was throught that perhaps the unusual development of these crystals might be due to some peculiarity in chemical composition, but the results of the analysis have not borne out this supposition. The color of the crystals is a dark greenish-black. The powder used for analysis floated at 3·115 and sank at 3·107, the mean specific gravity being 3·111.

	I	II	Average	Ratios		Per cents of protoxide bases	
SiO_2	52·58	52·05	52·31	·872	·876		
TiO_2	·25	----	·28	·004			
Al_2O_3	2·72	2·66	2·69	·026	·045		
Fe_2O_3	3·32	2·85	3·09	·019			
FeO	6·83	6·53	6·68	·093	·917	10·1	63·8
MnO	·70	----	·70	·010		1·1	
MgO	19·12	19·42	19·27	·482		52·6	
CaO	11·88	11·88	11·88	·212		23·1	25·0
K_2O	·50	----	·50	·005		·6	
Na_2O	·78	----	·78	·012		1·3	
H_2O	1·55	1·45	1·42	·079		8·6	
F_2	·93	----	·93	·024		2·6	
Loss at 110°			·08			100·0	
			100·59				
		$O = F_2$	·39				
			100·20				

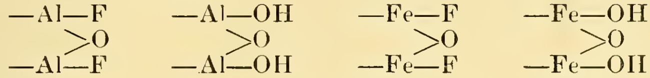
Discussion of the Tremolite and Actinolite Analyses:— Since tremolite and actinolite constitute a group by themselves, differing somewhat in molecular ratios from other varieties containing high percentages of sesquioxides (Al_2O_3 and Fe_2O_3) which will be considered later, it seems best at this point to discuss the analyses already described. Attention may first be called to the ratio of SiO_2 to the protoxide bases $R''O$, the latter including K_2O, Na_2O, H_2O and F_2. The ratios are as follows:—

			SiO_2	:	R'''_2O_3	:	$R''O+F_2$	SiO_2	:	$R''O+F_2$
Tremolite	I.	Richville	·957	:	·014	:	·958	1	:	1·001
	II.	Lee	·963	:	·018	:	·954	1	:	·991
Actinolite	III.	Greiner	·938	:	·017	:	·935	1	:	·997
	IV.	Russell	·914	:	·041	:	·908	1	:	·993
	V.	Kragerö	·880	:	·059	:	·874	1	:	·993
	VI.	Pierrepont	·876	:	·045	:	·923	1	:	1·05

In the first five analyses the ratios of $SiO_2 : R''O+F_2$ are almost exactly as 1 : 1, and attention may be called to the fact that such close approximations to an exact ratio are seldom met with in mineral analyses. It may be concluded therefore from the ratios that the materials were very pure, the analyses exceptionally good, and that both water and fluorine, which have been generally disregarded in previous calculations, must be taken into consideration. Five such results preclude the possibility that the close agreement of the ratios to 1 : 1 is a matter of accident. Analysis VI is irregular in that it shows an excess of $(R''O+F_2)$ over SiO_2. This may be due to defects in the analysis, to possible impurities in the material, or this special variety may be a transition between actinolite and hornblende, the latter, as will be shown later, being characterized by having an excess of $(R''O+F_2)$ over SiO_2. Analyses IV, V VI, the ratios derived from them, and the percentages of the several constituents are so nearly alike, that it seems best to class the mineral from Pierrepont as actinolite. The analysis needs revision.

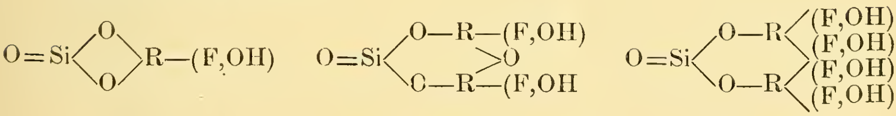
Except as regards fluorine, the ratios derived from the six analyses confirm the theory of Rammelsberg, namely, that the composition is $RSiO_3 + R_2O_3$, the $RSiO_3$ including $MgSiO_3$, $FeSiO_3$, $CaSiO_3$ and Na_2SiO_3, while considerable H_2SiO_3, which Rammelsberg left out of consideration, must also be included. The ratios also confirm in a general way the theory of Tschermak except that considerable hydrogen would have to be brought into the formulas and some provision made for fluorine. Moreover the ratios indicate clearly that the idea advanced by Tschermak, that sodium is present as a molecule, $Na_2Al_2Si_4O_{12}$, is quite untenable, since for every Na_2O there would have to be deducted $1Al_2O_3$ and $4SiO_2$, which would deplete the total silica and destroy the 1 : 1 ratio.

In a large number of minerals it has been shown that fluorine and the isomorphous hydroxyl unite with metallic elements to form radicals, thus $(MgF)'$, or $(MgOH)'$, univalent, and $(AlF)''$ or $(AlOH)''$ bivalent, and it seems probable that fluorine, and to some extent hydroxyl, enter in some way into the amphibole molecule in combination with trivalent aluminium and iron. It is possible in one way to account for the presence of both R_2O_3 and fluorine without destroying the 1 : 1 ratio shown by the analyses. Thus, for example, the constituents Al_2O_3 and Fe_2O_3 may be regarded as combined with F and OH to form the following radicals:



The foregoing radicals are bivalent and, as may be seen, the addition of F_2 to the protoxide ratios means the introduction of Al_2 (or Fe_2) into the molecule, and when F_2 fails or is not sufficient to satisfy all of the sesquioxides, $(OH)_2$, derived from H_2O, accomplishes the same result. If, therefore, the ideas as set forth on page 28 are correct, namely that amphibole is a salt of a complex metasilicic acid, the assumption is now made that some of the hydrogen atoms of the acid are replaced by bivalent radicals, containing aluminium and ferric iron in combination with fluorine and hydroxyl as given above. These bivalent radicals therefore are regarded as isomorphous with Fe and Mg. It may be asked why the radicals $[R_2'''OF_2]''$ and $[R_2'''O(OH)_2]''$ have been selected instead of others? for example, $[R'''F]''$ or $[R'''F_2]'$, and their respective hydroxyl equivalents, and the answer is simply because only the former satisfy the 1 : 1 ratio of silica to protoxide bases shown by the analyses.

Since, however, the amounts of Al_2O_3 and Fe_2O_3 in tremolite and some varieties of actinolite are small, the assumption of either of the radicals $[R'''(F, OH)]''$ or $[R'''(F, OH)_2]'$ would not materially affect the ratios in some cases. For the sake of comparison the possible fluor-hydroxyl radicals of trivalent elements in combination with metasilicic acid may be expressed graphically as follows:



According to the first assumption, bringing R''' into the molecule as a bivalent radical $[R-(F, OH)]''$, the protoxides as given on page 36 would be increased; according to the last $[R_2(F, OH)_4]''$ the protoxides would be diminished, the resulting ratios being as follows:

	SiO_2	:	$R''O+[R'''(F, OH)]''O$	SiO_2	:	$R''O+[R'''(F,OH)_2]'_2O$
I	1	:	1·02	1	:	0·98
II	1	:	1·01	1	:	0·97
III	1	:	1·02	1	:	0·98
IV	1	:	1·04	1	:	0·95
V	1	:	1·06	1	:	0·93

The ratios are not bad in the first three analyses, but in the last two they are unsatisfactory and, moreover, in analysis V there is not sufficient fluorine and hydroxyl to satisfy the last assumption. The burden of proof rests with the more exact ratios as given on page 36, and the assumption that the sesquioxides enter the metasilicate molecule as bivalent radicals corresponding to $[R_2'''O(FOH)_2]''$.

It is interesting to note to what extent the hydrogen atoms of the amphibole acid are replaced. According to the long-accepted formula for tremolite, $Mg_3CaSi_4O_{12}$, three-quarters, or 75 per cent, are replaced by Mg and the remaining quarter by Ca, while in actinolite the isomorphous Fe, Mn and Mg together have been regarded as replacing three-quarters of the hydrogens. The replacement, expressed in per cents, as they appear in the analyses, are as follows:

	I	II	III	IV	V
$[Fe+Mn+Mg]''$	65·2	64·2	65·5	63·2	64·8
$[Ca+K_2+Na_2]''$	25·8	25·7	23·7	25·5	26·1
$[R_2'''O(F,OH)_2]''$	1·5*	1·9	1·8	4·5	6·7
H_2 in excess of (OH)	6·9	8·2	9·0	6·8	2·4
Ca alone	24·0	24·7	23·1	23·8	21·6

* A slight excess of fluorine (0·23%) in the analysis. See page 50.

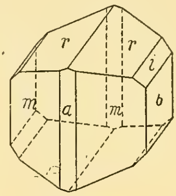
It may be seen from the foregoing table that (Fe+Mn+Mg) never make up 75 per cent of the total hydrogen replacement, and that the figures are remarkably constant at about 65 per cent. Ca alone never replaces 25 per cent of the total hydrogens, but if there are added to the Ca the small amounts of alkali metals present, K_2 and Na_2, the near approach to 25 per cent is remarkable; in analysis II, where Ca alone is low, the deficiency is made up by a rather high percentage of Na_2O (2·15%), while in the remaining analyses it ranged frem 0·19 to 0·82, averaging 0·54%. In all cases K_2O was low, ranging from 0·22 to 0·54 and averaging 0·33%. The trivalent elements, Al and Fe, presumably entering into the amphibole molecule as bivalent fluor-hydroxyl radicals, are quite variable, and so also are the amounts of hydrogen in excess of that required in each analysis for combination as hydroxyl with Al and Fe.

Edenite—Pargasite—Hornblende.

The name *edenite* has been employed to designate light-colored varieties of amphibole containing considerable alumina. Chemically there are analogous dark-colored varieties sometimes called *pargasite*, containing high percentages of iron, and both kinds doubtless grade imperceptibly into one another and also into actinolite. The names are not very characteristic nor significant, and perhaps the designation of these various varieties as *hornblende* is more satisfactory than the attempt to make use of several names. As will be shown, the hornblendes are characterized by having a somewhat different ratio of SiO_2 to the protoxide bases than that determined for tremolite and actinolite.

VII. *Hornblende from Renfrew, Ontario, Canada.*—The crystal analyzed was of an unusually black color and brilliant luster, showing the forms *a* (100), *b* (010), *m* (110), *r* (011) and *i* (031), figure 4. The specimen is No. 487 of the Brush Collection. Fragments used for analysis floated at 3·330 and sank at 2·249, the mean specific gravity being 3·290. The results of the analysis follow:—

4



	I	II	Average	Ratios		Per cents of protoxide bases	
SiO_2	43·92	43·60	43·76	·728	·738		
TiO_2	·78	----	·78	·010			
Al_2O_3	8·35	8·31	8·33	·081	·124		
Fe_2O_3	6·99	6·80	6·90	·043			
FeO	10·40	10·54	10·47	·146	·797	18·3	58·7
MnO	·50	----	·50	·007		0·9	
MgO	12·67	12·60	12·63	·315		39·5	
CaO	9·86	9·82	9·84	·176		22·1	30·8
K_2O	1·28	----	1·28	·014		1·8	
Na_2O	3·43	----	3·43	·055		6·9	
H_2O	·75	·55	·65	·036		4·5	
F_2	1·82	----	1·82	·048		6·0	
Loss at 110°			·10			100·0	
			100·49				
		$O=F_2$	·76				
			99·73				

VIII. *Hornblende from Edenville, Orange Co., New York.*—Crystals from this locality occur large and of a black color, very closely resembling those from Renfrew; the forms also, *b*, *m*, *r* and *i* are frequently developed as in figure 4. The material used for analysis floated at 3·291 and sank at 3·278, the average being 3·285. The results of the analysis follow:

	I	II	Average	Ratios		Per cents of protoxide bases	
SiO_2	41·92	42·06	41·99	·699	·717		
TiO_2	1·46	----	1·46	·018			
Al_2O_3	11·73	11·51	11·62	·112	·129		
Fe_2O_3	2·54	2·80	2·67	·017			
FeO	14·28	14·36	14·32	·199		25·0	
MnO	·25	----	·25	·003		·4	60·4
MgO	11·21	11·13	11·17	·279		35·0	
CaO	11·50	11·54	11·52	·206		26·0	
K_2O	·92	1·04	·98	·010	·798	1·2	32·2
Na_2O	2·66	2·32	2·49	·040		5·0	
H_2O	·66	·56	·61	·038		4·8	
F_2	·80	----	·80	·021		2·6	
Loss at 110°			·08			100·0	
			99·96				
		$O = F_2$	·33				
			99·63				

IX. *Hornblende from Cornwall, Orange Co., New York.*—This is a very black hornblende occurring in masses larger than a walnut and without crystalline outline, imbedded in a rather coarse aggregate of quartz and feldspar. It was originally described by Beck* in 1842 as a new species to which the name *Hudsonite* was given. It was classed by J. D. Dana† under pyroxene and was analyzed by Brewer‡ and by Smith and Brush.§

It has recently been reinvestigated by Weidman,‖ the material used being a specimen from the Brush Collection No. 139, sent to Professor Brush in 1853 by S. R. Horton, who first found the mineral and supplied Beck with specimens for his original description. The prismatic angle $m \wedge m$ was measured by Penfield and found to be 55° 31′. The optical properties are described in detail by Weidman and he also gives a new analysis by J. L. Nelson of the chemical department of the University of Wisconsin. On testing the mineral in a closed tube it was found that the water given off at a high temperature was decidedly acid and accompanied by a deposition of silica, indicating the presence of fluorine, hence it has been possible to make Nelson's analysis more complete by making a determination of fluorine in the material, 0·27 per cent being found. It may also be added that the presence of fluorine in the mineral was suspected because the analysis did not conform to the new ideas concerning the ratios it should

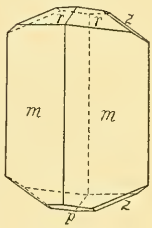
* Min. N. Y. 405, 1842.
† System of Mineralogy, 2d ed., 1844.
‡ Dana's Mineralogy, 3d ed., 269.
§ This Journal, xvi, 1853.
‖ Ibid., xv, 227, 1903.

give. The analysis of Nelson, modified by the introduction of 0·27 per cent of fluorine, follow :—

		Ratios		Per cents of protoxide bases	
SiO_2	36·86	·614	·627		
TiO_2	1·04	·013			
Al_2O_3	12·10	·119	·165		
Fe_2O_3	7·41	·046			
FeO	23·35	·324	·709	45·9	53·2
MnO	0·77	·005		·7	
MgO	1·90	·047		6·6	
CaO	10·59	·189		26·6	35·7
K_2O	3·20	·013		1·8	
Na_2O	1·20	·052		7·3	
H_2O	1·30	·072		10·1	
F	·27	·007		1·0	
	99·99			100·0	
$O-F_2$	·11				
	99·88				

X. *Hornblende from Monte Somma, Italy.*—The material analyzed was taken from a specimen showing an aggregate of small greenish black crystals, many of them terminated by faces having a brilliant luster, developed as shown in figure 5, the forms being, *m* (110), considerably striated, *r* (011), *p* ($\bar{1}01$) and sometimes *z* ($\bar{1}21$). The material used for analysis floated at 3·310 and sank at 3·255, the average specific gravity being 3·283. The results of the analysis follow :—

5



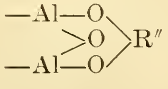
	I	II	Average	Ratios		Per cents of protoxide cases	
SiO_2	39·41	39·55	39·48	·658	·662		
TiO_2	·30	....	·30	·004			
Al_2O_3	12·71	13·27	12·99	·127	·172		
Fe_2O_3	7·30	7·21	7·25	·045			
FeO	10·73	....	10·73	·149	·759	19·6	59·3
MnO	1·14	·85	1·00	·014		1·9	
MgO	11·76	11·17	11·47	·287		37·8	
CaO	12·10	11·95	12·01	·214		28·2	35·1
K_2O	2·39	...	2·39	·025		3·3	
Na_2O	1·72	1·68	1·70	·027		3·6	
H_2O	·82	·95	·76	·042		5·5	
F_2	·05	....	·05	·001		·1	
Loss at 110°			·12				
			100·25			100·0	
		$O=F_2$	·02				
			100·23				

The hornblendes represented by analyses VI to X constitute a group by themselves, which may next be considered. They differ from the tremolite-actinolite group in that the ratio of SiO_2 : RO, instead of being as 1 : 1, indicates an excess of RO over SiO_2 and with the increase of RO there is a corresponding increase in the amounts of Al_2O_3 and Fe_2O_3. The relations are best shown in the accompanying tables, where the R_2O_3 quotients, (the sum of the results obtained by dividing the percentages of Al_2O_3 and Fe_2O_3 by the corresponding molecular weights) are given together with the SiO_2 : RO ratios, RO including Na_2O, K_2O, H_2O and F_2.

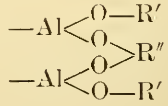
		R_2O_3 quotients	SiO_2		RO
VI.	Pierrepont	·045	1	:	1·05
VII.	Renfrew	·124	1	:	1·08
VIII.	Edenville	·129	1	:	1·10
IX.	Cornwall	·165	1	:	1·11
X.	Mte. Somma	·172	1	:	1·14

The first analysis of this group forms a connecting link between the actinolite and hornblende groups. If it is compared with analysis V no essential differences will be found; it is only when the ratios are examined that a slight excess of RO is noted in the mineral from Pierrepont, and this occurs with a smaller R_2O_3 quotient than that found in the actinolite from Kragerö; as previously stated, the two groups grade imperceptibly into one another. The other analyses are, however, considerably different from any thus far considered; they are all of dark green to black varieties, the color due to the presence of iron; the percentages of sesquioxides are high, about 20 per cent in IX and X, and the excess of RO as shown by the ratios is very noticeable. Another marked difference is seen on comparing the silica percentages; starting with about 57·5 per cent in tremolite, it falls below 37 per cent in analysis IX.

It is evident that if the minerals of the amphibole group are all to be regarded as salts of one acid, we must in some way be able to account for the introduction into the amphibole molecule of both sesquioxides and increasing amounts of protoxides. This may be done by assuming in addition to the fluor-hydroxyl radical $[R'''_2O(F,OH)_2]''$ thus far considered, some other radicals containing both R_2O_3 and RO. Thus there might be considered the following alumina and the corresponding ferric iron radicals.



or



The attempt will now be made to show that by assuming the existence of certain bivalent basic radicals of the type just indicated, and regarding them as replacing the hydrogen atoms of the amphibole acid, a similarity may be found between these basic hornblendes and the members of the tremolite-actinolite group. There will first be deducted from the ratios the alumo, fluor-hydroxyl radical $\begin{matrix} -Al-(F,OH) \\ >O \\ -Al-(F,OH) \end{matrix}$, the same as in the tremolite group. Next there will be deducted a radical of the type $\begin{matrix} -Al<^{O-Na}_{O} \\ \quad >(Fe,Mg) \\ -Al<^{O}_{O-Na} \end{matrix}$ and in most cases these two radicals may be so chosen as to satisfy or include all of the sesquioxides, and leave the protoxide base in sufficient amount to form $RSiO_3$. In one analysis (X) a third radical seems necessary $\begin{matrix} -Al-O \\ >O \quad >R \\ -Al-O \end{matrix}$. To indicate the method of calculation; there will be deducted from the total ratio first the alumo, fluor-hydroxyl radical, with its equivalent of silica, thus SiO_2, Al_2O_3 and (F,OH) in the proportion 1 : 1 : 1, and next the basic radical with Al_2O_3, (Fe,Mg)O and Na_2O with its equivalent of silica in the proportion 1 : 1 : 1 : 1. It is then possible to calculate the proportion of the total hydrogen atoms replaced by the several bivalent radicals and the different bases, and attention may be called to the fact that calcium, helped out at times by traces of sodium and potassium, satisfies 25 per cent, or one quarter of the total hydrogen atoms of the amphibole acid, the same as in the tremolite group;—that this is a mere coincidence seems hardly possible, and it may be taken, it is believed, in support of the theory advanced. The results of calculation are as follows:—

Analysis VII, Renfrew, Canada.

	Ratios	$\left[\begin{matrix} Al-(F,OH) \\ >O \\ Al-(F,OH) \end{matrix}\right]''$	Residue	$\left[\begin{matrix} Al<^{O-Na}_{O} \\ \quad >R \\ Al<^{O}_{O-Na} \end{matrix}\right]''$	Residue	
$[Si,Ti]O_2$	·738	—·065	·673	—·059	·614	
$[Al,Fe]_2O_3$	·124	—·065	·059	—·059	- - - -	
[Fe,Mn,Mg]O	·468		·468	—·059	·409	
CaO	·176		·176		·176 }	·186
$[K,Na]_2O$	·069		·069	—·059	·010 }	
H_2O	·036 }	—·065	·019		·019	
F_2	·048 }				——	
				Total RO=	·614	

The proportion of the various radicals and of the remaining bases in the foregoing analysis are as follows: —

	Ratios	Per cents
$[Al_2O(F,OH_2]''O$	·065	8·8
$[Al_2O_4RNa_2]''O$	·059	8·0
$[Fe,Mn,Mg]O$	·409	55·4
$[Ca,Na_2]O$	·186	25·2
H_2O	·019	2·6
	·738	100·0

From the foregoing interpretation it may be seen that all of the fluorine and about half of the hydrogen are needed to form the alumo, fluor-hydroxyl radical; that sodium is present in just about sufficient amount to form the second basic radical, and that calcium plus the trifling excess of sodium satisfies 25 per cent of the hydrogen atoms of the amphibole acid.

Analysis VIII, Edenville, N. Y.

	Ratios	[Al—(F,OH) >O Al—(F,OH)]″	Residue	[Al<O—Na, O >R, O, Al<O—Na]″	Residue
$[Si,Ti]O_2$	·717	—·051	·666	—·078	·588
$[Al,Fe]_2O_3$	·129	—·051	·078	—·078	----
$[Fe,Mn,Mg]O$	·481	----	·481	—·078	·403
CaO	·209	----	·209 }	—·078	·181
$[K,Na]_2O$	·050	----	·050 }		
H_2O	·030 }	—·051		Total RO =	·584
F_2	·021 }				

Proportion of radicals and remaining bases:—

	Ratios	Per cents
$[Al_2O(F,OH)_2]''O$	·051	7·1
$[Al_2O_4RNa_3]''O$	·078	11·0
$[Fe,Mn,Mg]O$	·403	56·5
CaO	·181	25·4
		100·0

According to the interpretation, in this analysis all of the fluorine and water are needed for the alumo-hydroxyl radical; sodium is not quite sufficient for the second basic radical, so a very little of its nearest related constituent, calcium, is taken; in the final residue SiO_2 and RO are present in the proportion ·588 : 584 or 1 : ·992; while again it is found that the residual calcium satisfies 25 per cent of the hydrogen atoms of the amphibole acid.

Analysis IX, Cornwall, N. Y.—Hudsonite.

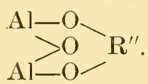
	Ratios	[Al—(F,OH) >O Al—(F,OH)]''	Residue	[Al<(O—Na)(O) >R Al<(O)(O—Na)]''	Residue
$[Si,Ti]O_2$	·627	—·076	·551	—·089	·462
$[Al,Fe]_2O_3$	·165	—·076	·089	—·089	----
$[Fe,Mn,Mg]O$	·376	----	·376	—·089	·287
CaO	·189	----	·189 }	—·089	·165
$[K,Na]_2O$	·065	----	·065 }		
H_2O	·072 }	—·076	·003		·003
F_2	·007 }				
				Total RO=	·455

Proportion of radicals and remaining bases:

	Ratios	Per cents
$[Al_2O(F,OH)_2]''O$	·076	12·2
$[Al_2O_4RNa_2]''O$	·089	14·3
$[Fe,Mn,Mg]O$	·287	46·3
CaO	·165	26·6
H_2O	·003	·5
	·620	100·0

The interpretation of this analysis is essentially like that of the previous one.

Analysis X, Mte. Somma.—In this analysis the amount of water is small and only a trace of fluorine is present, consequently in order to establish a 1 : 1 ratio between SiO_2 and RO it seems necessary to assume, in addition to the radicals previously suggested, a third one of the following type:



The interpretation is then as follows:—

	Ratios	[Al—OH >O Al—OH]″	Residue	[Al—O >O>R Al—O]″	Residue	[Al<O—Na O>R O Al<O—Na]	Residue
$[Si,Ti]O_2$	·662	—·043	·619	—·032	·587	—·097	·490
$[Al,Fe]_2O_3$	·172	—·043	·129	—·032	·097	—·097	- - - -
[Fe,Mn,Mg]O	·450		·450	—·032	·418	—·097	·321
CaO	·214		·214		·214 }	—·097	·169
$[K,Na]_2O$	·052		·052		·052 }		
H_2O	·042 }	—·043	——				——
F_2	·001 }					Total RO	·490

Proportion of the radicals and remaining bases :—

	Ratios	Per cents
$[Al_2O(OH)_2]''O$	·043	6·5
$[Al_2O_3R]''O$	·032	4·8
$[Al_2O_4RNa_2]''O$	·097	14·7
[Fe,Mn,Mg]O	·321	48·5
CaO	·169	25·5
	·662	100·0

Except for the added radical the interpretation of this analysis is like that of the previous ones, and again the residual calcium replaces 25 per cent of the hydrogen of the amphibole acid.

Attention will next be called to some varieties of hornblende which do not conform to the two groups previously considered.

XI. *Basaltic Hornblende from Bilin, Bohemia.*—To collectors, this is probably the best known of all basaltic hornblendes. It occurs in good sized and well formed crystals, generally showing the forms *m* (110), *b* (010), *r* (011) and *p* ($\bar{1}01$), often developed so as to appear like a hexagonal prism with rhombohedral terminations. The material used for analysis was obtained from carefully selected crystals, sent to this laboratory by Mr. Warren M. Foote of Philadelphia. The material used for analysis floated on the heavy solution at the specific gravity 3·242 and sank at 3·210, the average being 3·226. The results of the analysis are as follows —

	I	II	Average	Ratios		Per cents of protoxide bases	
SiO_2	39·88	40·02	39·95	·666	·687		
TiO_2	1·70	1·66	1·68	·021			
Al_2O_3	17·49	17·68	17·58	·173	·218		
Fe_2O_3	7·25	7·25	7·25	·045			
FeO	2·18	----	2·18	·031	·694	4·5	55·5
MnO	trace	----	trace	----		----	
MgO	14·14	14·16	14·15	·354		51·0	
CaO	12·07	11·86	11·96	·213		30·7	41·1
K_2O	1·98	----	1·98	·021		3·0	
Na_2O	3·16	----	3·16	·051		7·4	
H_2O	·55	·53	·41	·023		3·3	
F_2	·03	----	·03	·001		·1	
Loss at 110°			·13				
						100·0	
			100·46				
		$O=F_2$	·01				
			100·45				

In this analysis it will be noted that with a large R_2O_3 quotient the ratio of $SiO_2 : RO = \cdot687 : 694 = 1\cdot00 : 1\cdot01$, or almost exactly 1 : 1, thus differing from analysis VII to X (summarized on page 42), all of which showed an excess of RO. It is also interesting to note that the ratio of this hornblende is like that of garnet; $SiO_2 : R_2O_3 : RO$ being 3·00 : 0·95 : 3·03, a very close approximation to 3 : 1 : 3.

In the interpretation of the analysis there may be assumed, in addition to the alumo-hydroxyl radical, one similar to that used in analysis X, $[Al_2O_3R]$, except that in this case it is proposed to double the radical and make one R equal (Fe,Mg) the other Na_2 plus a little Ca; or, since there is practically no fluorine in the mineral, the water may be regarded as basic and only one radical need be used. The results in detail, regarding (OH) as combined with alumina, are as follows:

	Ratios	$\begin{bmatrix} Al{-}OH \\ \quad >O \\ Al{-}OH \end{bmatrix}''$	Residue	$[Al_2O_3(Fe,Mg)]''$ $[Al_2O_3(Na_2,Ca)]''$	Residue
$[Si,Ti]O_2$	·687	—·024	·663	—·194	·469
$[Al,Fe]_2O_3$	·218	—·024	·194	—·194	----
$[Fe,Mg]O$	·385	----	·385	—·097	·288
CaO	·213 }	----	·213 }	—·097	·188
$[K,Na]_2O$	·072 }	----	·072 }		
H_2O	·023 }	—·024	----	----	----
F_2	·001 }				
				Total RO=	·476

Or disregarding the small amount of fluorine present and considering all the water as basic, only the second radical need be used, as follows:

	Ratios	$[Al_2O_3(Fe,Mg)]''$ $[Al_2O_3(Na_2,Ca)]''$	Residue
$[Si,Ti]O_2$	·687	—·218	·469
$[Al,Fe]_2O_3$	·218	—·218	----
$[Fe,Mg]O$	·385	—·109	·276
CaO	·213 }	—·109	·176
$[K,Na]_2O$	·072 }		----
H_2O	·023		·023
		Total RO=	·475

Proportion of radicals and remaining bases, I regarding (OH) as combined with Al, II regarding water as basic:

	Ratios I	Per cents I	Ratios II	Per cents II
$[Al_2O(OH)_2]''O$	·024	3·4	----	----
$[Al_2O_3R]''O$	·194	28·0	·218	31·5
$[Fe,Mg]O$	·288	41·5	·276	39·8
CaO	·188	27·1	·176	25·4
H_2O	----	----	·023	3·3
	·694	100·0	·692	100·0

Of the two interpretations the latter is probably the simpler and brings the residual calcium nearer to 25 per cent as in the previous analysis. It should be pointed out also that if the basic alumo-radical used in this analysis is taken by itself and combined with its equivalent of silica, the result becomes $(Na_2,Ca)(Fe,Mg)Al_4Si_2O_{12}$, analogous in type to the basic alumo-silicate molecule of Tschermak, page 24. The essential difference in this particular case between Tschermak's theory and the present one is that, according to the former a definite basic alumo-silicate molecule is regarded as isomorphous with $Ca(Fe,Mg)_3Si_4O_{12}$.

XII. *Hornblende from Grenville township, Quebec, Canada.*—This hornblende is very unusual on account of the large amounts of alumina and fluorine it contains and the low percentages of iron, a combination not often met with. It has been analyzed by Prof. B. J. Harrington,* who has kindly sent on material for study, and by R. A. A. Johnston.† The color of the mineral is a light brown, with somewhat of a reddish tone : it is unusually transparent and shows a perfect prismatic cleavage. The specific gravity as given by Harrington is 3·110. The new analysis by Stanley, from which the ratio is calculated, confirms the results of the earlier analyses.

	Harrington	Johnston	Stanley	Ratios		Per cents of protoxide bases	
SiO_2	45·50	46·09	45·79	·763	·778	56·5	57·5
TiO_2	·68	undet.	1·20	·015	·778		
Al_2O_3	12·25	12·93	11·37	·112			
Fe_2O_3	·28	·79	·42	·003	·115		
FeO	·75	none	·42	·006			
MnO	·11	·36	·39	·006	·934	·6	57·7
MgO	20·63	20·82	21·11	·528		·6	
CaO	13·31	12·91	12·71	·227		56·5	
K_2O	1·76	1·84	1·69	·018		24·3	30·5
Na_2O	2·76	2·36	2·51	·040		2·0	
H_2O	·40	·66	·67	·037		4·2	
F_2	2·80	2·84	2·76	·072		3·9	
						7·9	
	101·23	101·60	101·06				
$O=F_2$	1·17	1·19	1·16			100·0	
	100·06	100·41	99·90				

It may be noted first that with a sesquioxide quotient of ·115 the ratio of $SiO_2 : RO+F_2$ is as 1 : 1·20, which is not exactly in accord with the results obtained from analyses VII

* This Journal, xv, 392, 1903. † Geol. Sur. of Can., vol. xiii.

to X as summarized on page 42. The relations, moreover, are not materially altered if the titanium is regarded as Ti_2O_3, when the excess of oxygen recorded in the analysis as TiO_2 would be just about sufficient to convert the FeO and MnO of the analysis to sesquioxides: according to the latter interpretation the sesquioxide quotient becomes ·128, and the ratio of $SiO_2 : RO = 1 : 1·21$. With the high percentage of fluorine in the mineral it seems necessary to assume that some of it is united with a bivalent element, magnesium for example, to form a radical [MgF]; and according to this assumption a balance may be struck so as to leave a final residue in which $SiO_2 : RO = 1 : 1$. The interpretation is as follows:—

	Ratios	[MgF / MgF]''	Residue	[Al—F / >O / Al—F]	Residue	[Al<O—Na, O / O>R / Al<O, O—Na]''	Residue
[Si,Ti]O_2	·778	—·038	·740	—·034	·706	—·081	·625
[Al,Fe]$_2O_3$	·115	----	·115	—·034	·081	—·081	----
[Fe,Mn,Mg]O	·540	—·076	·464	----	·464	—·081	·383
CaO	·227	----	·227	----	·227 }	—·081	·204
[K,Na]$_2$O	·058	----	·058	----	·058 }		
H_2O	·037	----	·037	----	·037	----	·037
F_2	·072	—·038	·034	—·034	----	----	
						Total RO	·624

Proportion of radicals and remaining bases:—

	Ratios	Per cents
[MgF']$_2$O	·038	4·9
[Al_2OF_2]''O	·034	4·4
[$Al_2O_4RNa_2$]''O	·081	10·4
[Fe,Mn,Mg]O	·383	49·3
CaO	·204	26·2
H_2O	·037	4·8
	·777	100·0

The final result here again shows 25 per cent (a little over) of the hydrogen atoms replaced by calcium.

In analysis I there was noted a slight excess of fluorine over that required by the alumina to form the radical [Al_2OF_2]'', and it may be assumed that a very small amount of the radical [MgF] is present in that variety of tremolite.

Summary and Conclusion.—The chemical composition of amphibole can be explained by assuming that it is based upon a metasilicate molecule, which is, however, undoubtedly of a multiple and complex nature. The uniformity in crystallization of the different varieties in spite of the fact that they show a wide range in their chemical composition, is a strong argument for the uniformity in structure of the acid part of the molecule, enabling it to exert a controlling influence throughout the series and so to determine the crystal form. That fluorine and hydroxyl present are integral parts of the amphibole molecule and that they are to be regarded as isomorphous with the protoxides is considered as definitely proven by the results of the analyses. The presence in many amphiboles of considerable amounts of sesquioxides is explained by their introduction into the metasilicate molecule in the form of various basic, bivalent radicals. It is suggested that the character of these radicals and the degree to which they enter the amphibole molecule may be due to the influence of *mass effect* determined by the conditions under which the mineral was formed. This method of interpretation of the analyses of amphibole is upheld by the following facts: first, in the analyses of the simpler varieties, tremolite and actinolite, the 1 : 1 ratio between RO and SiO_2 is very sharp and indicates clearly that the structure of the molecule is that of a metasilicate and the small amounts of RO present cannot be introduced into the formula without destroying this ratio except in the form of the

```
                  —R—(F,OH)
                    \
bivalent radical     O       ; secondly, the identity of the
                    /
                  —R  (F,OH)
```

crystalline structure of the whole amphibole series points strongly to the assumption that the acid radical is the same throughout; thirdly, in the analyses of the hornblendes, by the assumption that two or more radicals, containing the trivalent elements with smaller amounts of the protoxide bases, enter the molecule isomorphous with RO, the residue left after the subtraction of these molecules gives the metasilicate ratio of $RO : SiO_2 = 1 : 1$; fourthly, in all cases the calcium oxide of the analyses together with the small amounts of oxides of the alkalies available forms very closely 25 per cent of the various radicals and bases, or in other words replaces one-fourth of the hydrogen atoms of the amphibole acid. This last fact is too constant throughout the analyses to be looked upon as a coincidence, but would seem rather to be a fundamental fact concerning the amphibole molecule, and furnishes one of the strongest pieces of evidence as to the correctness of the present method of interpreting the chemical constitution of the mineral.

Mineralogical Laboratory of the
Sheffield Scientific School of Yale University,
New Haven, Conn., October, 1906.

ART. V.—*Notes on the Relation of the two genera of tubicolous Annelids, Vermilia* Lamarck, 1818, *and Pomatoceros* Philippi, 1844; by K. J. BUSH, Ph.D.

[Brief Contributions to Zoology from the Museum of Yale Univ., No. LXVII.]

IN 1844 Philippi described a species from the Mediterranean, figuring its operculum (*P*) under the name of *Pomatoceros tricuspis*, creating for it the then new genus *Pomatoceros*, at the same time calling attention to its possible identity with *Serpula triquetroides* Delle Chiaje '28, which identity was established by Claparède '69 (p. 182). Philippi also pointed out its resemblance to *Vermilia triquetra* Lamarck '18, but on a later page applied this latter name to a form having a different operculum cap, which he also figured (*F*).

Among a number (12) of beautifully preserved specimens recently received from the Naples aquarium, under the name *Pomatoceros triquetroides (Vermilia triquetra)*,* two have the operculum capped by a low asymmetrical calcareous cone surmounted by a group of three conspicuous tapered spines, well figured (*P*) in front view by Philippi, as *P. tricuspis*. Two have a similar but much elongated cone gradually tapered to the narrow truncated tip without spines, well figured (*F*) in back view by Philippi,† as *Vermilia triquetra* Lamarck; one is splitting at the summit, revealing a shorter interior cone. All of the others have the short cone without spines, comparatively broadly truncated on the end, the tip sometimes elongated and indistinctly notched. Similar great variation in form of the operculum cap is found among specimens in the Yale Museum, of *Pomatoceros triqueter* Linné from Denmark. The same forms were also figured by Sowerby '20 (pl. 1, figs. 2 *a*, *b*, *c*,), as *Serpula triquetra* Linné‡ (*Vermilia* Lamarck, explanation of plate). The various species and even the genera with which these forms, being separated, have been identified by several more recent authors, apparently without establishing other more essential differences, has brought about the present great misconception or misinterpretation of the original application of names. In the two species under observation no generic differences, as the development of the tho-

* This combination is given by Lo Bianco '93 (p. 86).

† The operculum is often found with concave base, the wall drawn upward, giving in back view the effect of the median angle shown in Philippi's figure.

‡ As the fragment of mollusk to which the tubes of *Vermilia* represented in Sowerby's figure 2 are attached is presumably that of *Pecten maximus* found on the coast of England, his species could not have been the true *Serpula triquetra*. Its identity as suggested by Johnston '65, with *Vermilia conica* Fleming '25 and *Serpula armata* Johnston (not Edwards + Lütken + Grube), seems not to have been definitely established.

racic membrane, form of collar, setæ and uncini, are found, but only those of specific importance, as comparative size, number of branchiæ, comparative length and breadth of setæ and number of teeth on uncini, as well as the form of the operculum cap. The form of the tubes from Naples is also accurately shown in Sowerby's figure 2.

Lamarck '18, under this name (*Vermilia triquetra*), gives three widely separated localities (European Ocean, Mediterranean Sea, and Australian Sea), showing that there must have been three similar but distinct species under consideration, presumably *Serpula triqueter* Linné from North Atlantic, *Serpula triquetroides* Delle Chiaje (Philippi's figure *F*) from the Mediterranean, and variety *b* from Australia, which does not appear to have been identified with any of the more recently established species from that region.

As *V. rostrata*, the first species given by Lamarck under his genus *Vermilia*, has been found to be a typical *Spirobranchus* (Blainville '17), the second species would naturally stand for the type and the first named locality as the type locality, thus making *Serpula triqueter* Linné* (Lamarck in part) the type of the genus *Vermilia*, and as the *triqueter* Linné *non* Lamarck has been correctly referred by more recent authors to the genus *Pomatoceros* (Philippi '44), this name becomes synonymous with *Vermilia*, but for convenience might possibly be used as a varietal name to distinguish the form having the cluster of spines on the operculum cap, which occurs in the various species. Quatrefages '65 united *Pomatoceros* and *Vermilia*, but extended the limits of this genus to include many distinct genera.

Among the nine (9) species placed in the genus by Philippi '44, the first (*Vermilia triquetra*) only occurs among the eight (8) originally described by Lamarck, so that Philippi's interpretation is correct only as far as his species agree with this type. His species differ, however, not only in having the operculum capped by a calcareous or chitinous end, but also in the form of the peduncle, some being simple, stemlike, sometimes annulated, others somewhat compressed with conspicuous side appendages, as *V. triquetra* (fig. *F*), *V. elongata* (fig. *L*), *V. polytrema* (fig. *N*), a character apparently not hitherto considered of special interest; the manner of its attachment to the operculum or the relation of one to the other, which considerably modifies the form of both, is also important. These facts have been either ignored or, as stated by Claparède '70 (p. 523), thought of small importance, until the genus

* This was erroneously given by the writer '05 (p. 222) as the type of the genus *Pomatoceros*. *P. tricuspis* Philippi '44 (not Leuckart '49) was the only species given by Philippi.

Vermilia has become a kind of dumping ground for ill-defined, little understood, often unfigured forms, even sometimes for the empty tubes themselves. As more material has been studied, the species thus becoming better understood, the animals in many instances have been found to agree only in having a more or less bulbous operculum on a simple stemlike peduncle, capped by a horn-colored chitinous end (see Langerhans, Marenzeller, Ehlers, Moore). Comparative studies of other characters have revealed tangible differences, showing that even this interpretation, often designated as the *Vermilia* of Philippi, has been too laxly applied, necessitating the establishing of new genera, as follows:—

Vermiliopsis Saint-Joseph '94, restricted,—type *V. infundibulum* Philippi '44, as *Vermilia*, figure, not of authors. See p. 56. Mediterranean Sea.

The uncini have about 13 angular closely appressed teeth (in profile), the last one large and truncated. The abdominal setæ are strongly bent at the base of the rather broad angular tapered blades.

Metavermilia Bush '05,—type *M. multicristata* (Philippi '44, as *Vermilia*, figure+Marenzeller '93, as *Vermilia*, figures) Bush. Mediterranean Sea.

The uncini approach the form of those characteristic of the genus *Protula* and have about 18 sharp closely appressed teeth, the last one long, slender and curved. The abdominal setæ are but moderately bent, with broad abruptly tapered blades.

Paravermilia Bush '05,—type *P. bermudensis* Bush '05. Bermuda.

The uncini with about 15 sharp appressed teeth, the last one large and truncated and more prominent. The abdominal setæ are but little curved, with long angular regularly tapered blades. Thoracic membrane forming a 3-lobed collar and lateral border to about the fifth segment; no posterior border.

Pseudovermilia gen. nov.,—*P. occidentalis* (McIntosh '85, as *Spirobranchus*, figures) Bush. Bermuda.

The uncini with about 13 closely appressed teeth, the last one prominent, large and bifid on end. The abdominal setæ bent, with long, angular abruptly tapered blades. Thoracic membrane forming a 3-lobed collar only, without lateral and posterior border.—

Specimens of *Vermilia triquetra* Linné (*Pomatoceros triqueter* Mörch) in the Yale Museum from Denmark are of good size, twice as large as *V. triquetroides* (Delle Chiaje), with 7 thoracic and about 70 abdominal segments, the branchiæ and peduncle beautifully banded with blue. There are 16 rather short, stout branchiæ in each lobe, connected by a basal membranous web. The peduncle arising from the outer base of one of the lobes is compressed, with a thin gradually widening membrane on each side terminating in a long tapered free end at the base of the operculum, which, developing abruptly at the back, is in profile somewhat triangular in form, deep in front, oblique beneath, and truncated on top, capped by a calcareous more or less flattened disk having an abruptly developed asymmetrical cone-shaped mass or node of calcareous deposit on top, often bearing a group of three conspicuous spines, in other instances very irregular in outline; none seen forming a regular elongated cone as in Sowerby's figure 2*c*. The thoracic membrane is conspicuously developed, forming a deep rolling 3-lobed collar, the median lobe large, deepest in the middle, with conspicuously fimbriated edge, the lateral lobes less fimbriated, extending backward as a wide free lateral border joining a deep angular posterior flap. Inside the collar at the base of each lateral incision or cleft is an elongated irregular-shaped organ. Collar fascicle small, the setæ somewhat geniculate, with rapidly tapered blades; other six fascicles in very oblique series at the end of long tori situated in the posterior border of separate membranous areas, the setæ simple tapered; the uncini trapezoidal with 8 rather coarse strongly curved pointed teeth, the terminal one square cut and twisted. Abdominal setæ a little flaring with serrate edge and long slender tapered end. *Vermilia triquetroides* (Delle Chiaje) is readily distinguished by the very different form of the operculum and operculum cap, it being rather shallow, concave beneath, but giving evidence of becoming inflated and bulbous in form under favorable conditions; the cap is invariably an asymmetrical calcareous cone roughened by concentric lines of growth (see p. 52).

There are 14 or 15 branchiæ in each lobe united for a considerable distance by a delicate membranous web. The thoracic membrane is much developed, forming a very deep rolling 3-lobed collar, with conspicuously fimbriated edge merging into a wide lateral border and deep tapered posterior lobe. A peculiar irregularly shaped elongated organ is attached inside the collar at the base of each lateral cleft or incision. Philippi '44 and Lo Bianco '93 give the number of branchiæ as 18 in each lobe, so that the specimens under consideration cannot be fully developed.

Animals taken from the tubes are beautifully banded with blue.

A very young specimen between 2 and 3^{mm} long, taken from its tube, has the side appendages on the peduncle with the very slender free ends at the base of the small angular operculum, which is capped by a simple unequally thickened calcareous disk (there are 5 branchiæ in each lobe). Another considerably larger specimen has a scarcely raised asymmetrical cone, which in profile has the appearance of an unevenly thickened disk very much like figure *N* given by Philippi as *Vermilia polytrema* (p. 194) and described as a very short oblique cone, so that there can be little question that his species represents the young of the Mediterranean *V. triquetroides*. The figure given by Langerhans '83, under the name *V. polytrema* variety *digitata*, from Madeira is also probably the young of some species; the drawing (fig. 48) is, however, very misleading, as the digitate or fimbriate edge of the collar appears as a part of the operculum. The *Vermilia dinema* Mörch '63 (p. 388) also becomes synonymous.

Historical Notes on the name Vermilia infundibulum.

Serpula infundibulum Martini, 1776 (figure); Gmelin, ed. 1806 (p. 607); Lamarck 1818 (p. 364). Seas of India, on stones, tube only.

Lamarck describes tubes in his cabinet from the same locality with variety *b* from Isle of King, Australia. The name does not occur under his genus *Vermilia*. West Indies is given by Mörch '63 (p. 389) as the locality for Martini's species, which does not appear to be again mentioned under any of the species belonging to that fauna; Lamarck is quoted (p. 382) in the synonymy of *Serpula vermicularis;* his locality, however, is omitted. Both Quatrefages '65 (p. 524) and Claparède '70 (p. 523) state that it is impossible to correctly determine Gmelin's species.

Serpula infundibulum Delle Chiaje '28 (p. 226, figures) + Lo Bianco '93 (p. 83) *non* Martini.

Serpula crater Claparède '70 (p. 525, figures). Mediterranean, Bay of Naples.

This species is referred to the genus *Hydroides* by Mörch '63 (p. 380).

Vermilia infundibulum Philippi '44 (p. 193, figure) not of authors.

Vermilia multivaricosa Mörch '63 (p. 389) + Marenzeller '93 (p. 39, figures) *non* Lo Bianco.

Vermiliopsis multivaricosa Saint-Joseph '94 + Bush '05 (type, p. 223).

Vermiliopsis infundibulum (Philippi) Bush *non* Saint-Joseph. Mediterranean.

As none of the foregoing species prove to be the same as Philippi's, the name *multivaricosa* becomes superfluous, unfortunately causing great confusion in names, especially as *multivaricosa* was given for the type of the genus *Vermiliopsis* in

1905 and Saint-Joseph's interpretation in 1906 does not appear to be in accord with Philippi's species. A comparison of the figures of the operculum given by the two authors, as well as of those of the setæ and uncini given by Langerhans '84, as *V. infundibulum* and *V. spirorbis*, and Marenzeller '93, as *V. multivaricosa*, reveals well-marked differences. The species described by Lo Bianco '93 appears very like the one given by Marion and Bobretzky '75, as *V. infundibulum.*

Vermilia infundibulum Claparède '70 (p. 523, figures) + Langerhans '80 (p. 119, figures) *non* Philippi.

Genus ? Claparèdei nom. nov.

Bay of Naples and Atlantic at Madeira.

Although well-figured and described, the true generic relation of this species, for which a new name is required, cannot be determined, as the thoracic membrane is not sufficiently well defined. It is described as large, forming a 3-lobed collar, and is represented in the figure as not forming a posterior border. The species is cited by Saint-Joseph as a typical *Vermilia.* Figures given by Langerhans '84 as *V. spirorbis* show marked affinity with those of Claparède.

Vermilia infundibulum Marion and Bobretzky '75 (p. 98, figures) *non* Philippi and Claparède.

? Vermilia multivaricosa Lo Bianco '93 (p. 93) *non* Marenzeller.

Genus ? Marseillesensis nom. nov.

Mediterranean at Marseilles and Bay of Naples ; off Cannes ?

Generic relation doubtful, shows affinity with the species dredged off Cannes, figured (116) by Saint-Joseph '06, as *Vermiliopsis infundibulum* in part. The *Vermilia galeata* Grube '60 (p. 113, figure) from Porto Re, Adriatic, is a related species.

Vermilia infundibulum Langerhans '84 (p. 278) *non* '80 and preceding authors. (Teste Saint-Joseph.)

Vermiliopsis infundibulum Saint-Joseph '06 (p. 249, figure) in part.

Paravermilia (?) mediterranea nom. nov.

Atlantic at Madeira and Mediterranean off St. Raphaël.

This species as described by Saint-Joseph has some affinity with the type of the genus *Paravermilia*, but a comparison of the setæ and uncini is necessary before this generic relationship can be definitely established. The second briefly mentioned example seems a distinct species.

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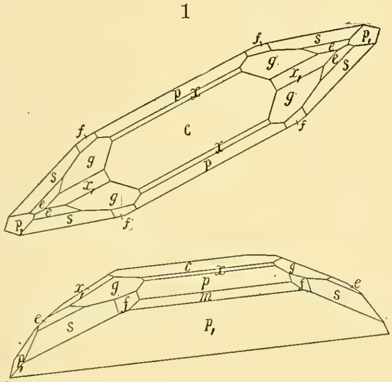
Zoological Laboratory,
December 14th, 1906.

ART. VI.—*Chalcopyrite Crystals from Arakawa, Japan;* by W. E. FORD.

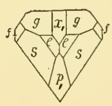
A SMALL suite of unusually interesting chalcopyrite crystals from Arakawa, Japan were recently presented to the Brush Collection by Professor T. Wada of Tokyo. The crystals present no forms new to the mineral but show such unusual habits of crystallization for chalcopyrite as to warrant a brief description. The following forms were identified upon the crystals; c (001), m (110), g (203), e (101), x (113), p (111), x_1 $(1\bar{1}3)$, p_1 $(1\bar{1}1)$, f (312), s (513); the only quite rare form among them being the tetragonal scalenohedron (312), which has been designated by the letter f. This form has been previously observed by Sonheur on crystals from the Victoria Mine near Burgholdingshausen, Siegen*.

All of the different forms present on the crystals are represented in an ideal combination in figure 1, which will also

1



2

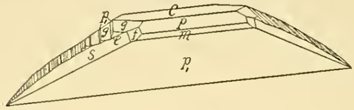


serve to illustrate one of the types of development. The peculiar development of the crystals is brought about by the entire suppression or the great subordination of half of the faces of the forms c, x, p, m, and p_1. This causes the crystals to be greatly lengthened in the direction of one of the horizontal diagonal axes and gives a prominent development to the faces in the zone m, p, c, while the occurrence of only one base causes the faces of the negative sphenoid p_1 to meet in a sharp keel-like angle below. Figure 2, which is an orthographic projection upon aplane parallel to m''' $(1\bar{1}0)$, of the ideal crystal represented in figure 1, has been introduced to better illustrate this last peculiarity. Only the upper faces of the various scalenohedral forms are to be found and they serve to terminate the crystals at either end.

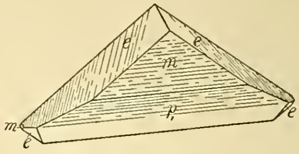
* Zs. Kryst., xxiii, 545, 1894.

Figure 3 is an attempt to represent one of the crystals of this type in its true proportions. The faces g, p_1, and e, as is shown, often are repeated many times at the ends of the crystals; g and p_1 by their oscillation with each other form at

3



5



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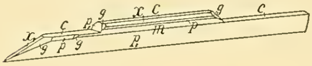
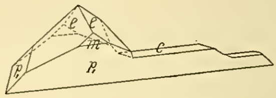


6



first a series of steps, but this soon results in simply fine striation lines which give a rounded appearance to the ends of the crystals. The crystal represented by figure 3 is 17^{mm} in its greatest length and 5^{mm} in height. Figure 4 is of a crystal of the same general type but having the tendency to elongate parallel to the diagonal axis greatly accentuated. The vertical extension of a portion of the crystal as shown in the figure is quite characteristic. This crystal is much smaller than the one previously illustrated, its length being 16^{mm} and its height $1{\cdot}5^{mm}$. The length of the complete crystal however may have been much greater, as the specimen is only terminated at one end, the other being broken.

Figure 5 represents a crystal which, while showing the same forms as those already described and having some of the same peculiarities of development, presents however quite a different appearance. This is due chiefly to the absence of the upper basal plane which was prominent on the first type; in this case the crystal being terminated above by the faces of the pyramid of the second order e (101). All of the faces on this crystal are striated on account of the oscillation of faces in the same zone with each other, and in the case of m and p_1 no sharp dividing line between them can be observed, one face yielding gradually to the other. This crystal is the largest of the suite, its greatest dimensions being 23^{mm} in length and 12^{mm} in height.

Figure 6 is interesting as showing a crystal which combines the two types described above. The larger crystals, like those shown by figures 3 and 5, are bright in luster, being only slightly tarnished, while the slender and smaller crystals, like figures 4 and 6, are dull in color, being covered with a greenish black deposit.

Mineralogical Laboratory of the Sheffield Scientific School
of Yale University, New Haven, Conn.,
November, 1906.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Vaporization of Solid Substances at Ordinary Temperature.*—It has been shown by C. Zenghelis that many solid bodies, even at ordinary temperature, possess a certain vapor pressure. This is exceedingly minute in the case of substances which have a very high melting point, such as metals, their oxides, and other metallic compounds, so that it has escaped the attention of chemists. The author's method of detecting such vapors consists in absorbing them by means of thin silver leaf which is placed for a long time above the substance to be tested, in a closed space. In many cases the presence of the volatilized substance was detected analytically in the silver leaf, although its presence was usually readily recognized by the change in color of the silver. Other means were also used to detect volatilization, for instance potassium ferrocyanide solution for metallic copper and iron. Moisture appeared to facilitate the volatilization, while silver appeared to be the only metal capable of detecting the vapors with delicacy. The less readily oxidizable metals showed no volatility in these experiments, but copper, lead, iron, zinc, tin, antimony and arsenic, when used in a finely divided form, showed volatilization. Many oxides, for instance, CuO, PbO, ZnO, Fe_2O_3 and Fe_3O_4 gave a reaction, as did also several hydroxides, $Ba(OH)_2$, $Cr(OH)_3$, etc., and a very large number of salts.—*Zeitschr. physikal. Chem.*, lvii, 90. H. L. W.

2. *Investigations upon the Rare Earths.*—Auer von Welsbach, whose investigations of more than twenty years ago led to the well-known important results in practical illumination, and who separated the old supposed element didymium into neodymium and praseodymium, has announced that he is again working in the field of the rare elements. Long ago he became convinced from his observations that certain of these substances which have been considered as elements are actually compound bodies, and that it is within the range of possibility to separate them into their true elements. In a preliminary article he describes work of fractionation carried out upon half a ton of the yttrium earths obtained from monazite, and states that he has obtained certain indications of the decomposition of ytterbium.—*Monatshefte*, xxvii, 935. H. L. W.

3. *Re-determination of the Atomic Weight of Potassium.*—Theodore W. Richards and Arthur Staehler have determined the ratios $KCl : AgCl$ and $KCl : Ag$, and assuming the atomic weights $Ag = 107{\cdot}93$ and $Cl = 35{\cdot}473$, they have obtained in each case the result $K = 39{\cdot}114$. This determination is lower by ·007 than the recent result of Archibald, and consequently it varies still more from the previously accepted atomic weight based upon the work of Stas. The details of the work are

highly interesting as an example of the refinement of the work of Richards in atomic weight determinations.—*Berichte*, xxxix, 3612. H. L. W.

4. *Qualitative Analysis*, by WILLIAM CONGER MORGAN, 8vo, pp. 351. New York, 1906 (The Macmillan Company. Price $1.90 net).—This text-book has been prepared for use in teaching qualitative analysis during freshman year in college. The course presupposes good chemical training in secondary schools. The first, or general part, of about 60 pages, is devoted to such theoretical matters as have a bearing upon qualitative analysis, including ionization. The second part, of about 175 pages, gives an extensive description of qualitative reactions. The elements in this part are arranged strictly according to the order of Mendeleéff's periodic system, which makes it very in convenient for reference in connection with the analytical groups. There are some useful tables here showing the formula, color, character, and solubility of each of the commoner salts of sodium, potassium, silver, and barium. The third part, systematic analysis, occupies about 90 pages, and is mostly tabular in its arrangement, with notes or discussions on the pages facing the tables. The methods appear to be generally well chosen for the purpose in view. The use of the terms "basic analysis" and "acid analysis" in this part is hardly in keeping with the modern aspect of the terms usually employed. The book as a whole may be praised as showing many good features, but the reviewer cannot read with patience such spellings as "oxid," "iodin" and "sulfid," for they lead to the mispronunciation of these English words. H. L. W.

5. *A History of Chemistry*, by F. P. ARMITAGE, 12mo, pp. 259. London, 1906 (Longmans, Green & Co.).—This is an ably written book dealing largely with the development of chemical theories. It is adapted for the use of the student of chemistry rather than for that of the general reader. In all cases, where possible, authorities have been made to tell their own story. The nomenclature and notation used are those of the times described. The work is to be highly recommended to serious students of chemistry who wish to grasp the problems that have been presented and solved in the past. H. L. W.

6. *A History of Chemistry*, by ERNST VON MEYER. Translated by GEORGE MCGOWAN, 8vo, pp. 691. London and New York (Macmillan Company. Price $4.25 net).—This is the third English, translated from the third German edition, of a well known and valuable work which is well worthy of the attention, not only of chemists, but of all who are interested in the development of science. The English text has had the advantage of the author's revision, and contains various additions not found in the corresponding German edition. H. L. W.

7. *Absorption of Light.*—Two investigators, working with similar apparatus, publish papers on this subject. The paper by ERNST MÜLLER is entitled Absorption of Light in Solutions, and

that of ROBERT ALEXANDER HOUSTOUN is entitled Investigation upon the Influence of Temperature on the Absorption of Light in Isotropic Bodies. Müller gives tables of the extinction-coefficient ϵ in various substances; ϵ is defined by the formula:

$$\epsilon = \frac{\log \tan \alpha_1 - \log \tan \alpha_2}{d}$$

in which α_1 and α_2 are angles through which the polarizing apparatus must be turned to bring two beams of light passing through two solutions to equal brightness: d is thickness of solution. The method is an interesting one, and the conclusions are important to the student of molecular physics. The chief interest of Mr. Houstoun's paper lies in its bearing on the electron theory. He remarks that it is apparent that the number of electrons with fundamental vibrations per unit of mass changes with temperature in the visible spectrum, and that the simple dispersion theory is extended by a consideration of the *wechselseitige* forces of the electron.—*Ann. der Physik*, No. 13, 1906, pp. 515–573.

J. T.

8. *The Doppler Effect in Canal Streams.*—If the cathode in an exhausted tube is perforated with holes 0·5 to 1^{mm} in diameter, the so-called canal streams are observed behind this cathode, apparently streaming diametrically opposed to the direction of the cathode rays toward the anode. J. STARK publishes three papers on these canal rays, entitled, respectively, Light Emission of the Canal Rays in Hydrogen, Canal Rays in Potassium and Sodium Vapor, The Doppler Effect in the Spectrum of Mercury Vapor. He finds a displacement of certain spectrum lines which he attributes to a change of velocity in the line of sight, and thus substantiates his previous observations on canal rays. Not only is there a displacement, but also a broadening, which is proof to his mind of this Doppler effect—analogous to the change in position of a spectrum line of a star which is either approaching or receding. This Doppler effect has been sought by various observers, but has not been hitherto observed. Stark discusses at considerable length the conditions of temperature and pressure for the proper observation of this effect, and the broadening of series lines due to this effect. The papers seem very important: but are difficult to review on account of a certain diffusiveness of style and lack of a summary of conclusions.—*Ann. der Physik*, No. 13, 1906, pp. 401–470. J. T.

9. *Oscillatory Discharge of a Polarized Cell.*—F. KRÜGER, by means of a Helmholtz pendulum, detects oscillatory discharges as well as non-oscillatory discharges of polarized cells. The oscillatory discharges are often concealed, but can arise since the cells have electrostatic capacity and self induction is provided by the leading wires. He quotes Nernst's observations on the analogy between the oscillations of the polarized cells and the movements of a stimulated nerve. The observations are supported by a long mathematical discussion on the diffusion capac-

ity and the concentration of ions. Interesting curves of the oscillations and aperiodic effects in various forms of cells accompany the paper.—*Ann. der Physik*, No. 14, 1906, pp. 701–755.

J. T.

10. *Electric Waves.*—A paper on this subject forms the last contribution of P. Drude to the Annalen, and, therefore, has a peculiar interest. The conclusions of the paper are as follows: The best systems of wireless telegraphy, in his opinion, must have:

(1) Magnetic coupling.
(2) Perfect identity between sender and receiver.
(3) As a receiver, the iron bundle of wires (magnetic detector) must be surrounded by the wire which is connected to the capacity.—*Ann. der Physik*, No. 14, 1906, pp. 832–847. J. T.

11. *Fluorescence and Magnetic Rotation Spectra of Sodium Vapor and their Analysis.*—Professor R. W. Wood has discovered a remarkable effect of the magnetic field on the radiations emitted by sodium vapor when it is stimulated by light of various wave-lengths and light from different sources. He shows that the complex fluorescent spectrum is made up of six or more series of lines, with regular spacings.—*Phil. Mag.*, Nov., 1906, pp. 499–524. J. T.

12. *Radioactive Transformations;* by E. Rutherford. Pp. 287. New York, 1906 (Charles Scribner's Sons).—This volume presents in published form the series of eleven lectures delivered in March 1904 in the Silliman Memorial Lecture course at Yale University.

The subject is treated systematically and critically from the standpoint of the disintegration theory, and as the work of the pen of so eminent an authority in these matters is a valuable contribution to the literature. In a short historical introduction, the theories concerning the electrical nature of matter, the ionization of gases, the more important properties of radio-active bodies and the various methods of measurement of radio-active quantities are briefly but clearly given. The succession of radioactive changes taking place in thorium are then treated in detail as a typical example of the processes occurring in radio-active substances and the theories advanced for their explanation. The more complex problem of the changes in radium is next considered and the successive transformations taking place in this series are explained and analyzed. This is followed by a chapter on uranium and actinium and the connection between the different radio-elements. The production of helium, the radioactivity of the earth, the properties of the α rays and the radio-active processes in general are then discussed in separate chapters. It is significant of the rapid increase in our knowledge on the subject of radio-activity that the author has thought it desirable to incorporate the results of many important investigations which have been made since the lectures were delivered.

The book is most readable and suggestive throughout and would seem to supply the demand which has existed up to the present for a work on the subject of radio-activity which is not too technical and which is at the same time trustworthy and entertaining for the average scientific reader. B. B. B.

13. *Das elektrische Bogenlicht. Seine Entwicklung und seine physikalischen Grundlagen ;* von WALTHER BIEGON VON CZUDNOCHOWSKI. Lief IV–VII, pp. 291–698. Leipzig, 1906 (S. Hirzel).—The earlier parts of this admirably exhaustive work on the electric arc light have already been noticed in this Journal. The four parts now issued carry the work through to its conclusion. Of these Parts 4, 5, and 6 continue the historical account of the development of the arc light including the period from 1879 to 1900, in which the greatest activity and variety of invention were exhibited, and then from 1900 to the present. The second portion of the work included in Part 7 discusses the theory and practice of the present time, dealing first with the electrodes, then with the lamps and current generators, and finally with the various forms of accessory apparatus which are essential. The work as a whole covers about 700 large octavo pages, is well illustrated, and brings together a vast amount of information which is both scientifically and practically interesting and important.

II. GEOLOGY AND MINERALOGY.

1. *United States Geological Survey ;* CHARLES D. WALCOTT, Director.—The recent publication of the U. S. Geological Survey are noted in the following list :

FOLIO, No. 140.—Geologic Atlas of the United States. Milwaukee Special Folio, Wisconsin. Description of the Milwaukee Quadrangle ; prepared under the supervision of T. C. CHAMBERLIN, geologist in charge ; by WILLIAM C. ALDEN. Pp. 12, with 2 colored maps and 15 figures.

No. 141. Bald Mountain–Dayton Folio, Wyoming. Description of the Bald Mountain and Dayton Quadrangles ; by N. H. DARTON. Glacial Geology, by R. D. SALISBURY. Pp. 15, with 7 colored maps and 12 figures.

PROFESSIONAL PAPERS, No. 46.—Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas; A. C. VEATCH. Pp. 422, with 51 plates and 33 figures.

No. 51.—Geology of the Bighorn Mountains ; by N. H. DARTON. Pp. 129, with 47 plates and 14 figures.

No. 54.—Geology and Gold Deposits of the Cripple Creek District, Colorado ; by WALDEMAR LINDGREN and F. L. RANSOME. Pp. xix, 516, with 29 plates (3 in pocket) and 64 figures.

No. 55.—Ore Deposits of the Silver Peak Quadrangle, Nevada; by JOSIAH EDWARD SPURR. Pp. 174, with 24 plates and 40 figures.

BULLETINS. No. 283.—Geology and Mineral Resources of Mississippi; by A. F. CRIDER. Pp. 99, with 4 plates and 3 figures.

No. 289.—A Reconnaissance of the Matanuska Coal Fields, Alaska, in 1905; by G. C. MARTIN. Pp. 36, with 5 plates and 4 figures.

No. 292.—The Bryozoan Fauna of the Rochester Shale; by RAY S. BASSLER. Pp. 137, with 31 plates.

No. 293.—Reconnaissance of some Gold and Tin Deposits of the Southern Appalachians; by L. C. GRATON with Notes on the Dahlonega Mines by WALDEMAR LINDGREN. Pp. 134 with 9 plates and 16 figures.

No. 295.—The Yukon-Tanana Region, Alaska. Description of Circle Quadrangle; by L. M. PRINDLE. Pp. 27, with map in pocket and 3 figures.

No. 298.—Record of Deep-Well Drilling for 1905; by MYRON L. FULLER and SAMUEL SANFORD. Pp. 299.

No. 299.—Geographic Dictionary of Alaska; by MARCUS BAKER. Second edition. Pp. 690. Prepared by JAMES McCORMICK.

No. 301.—Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the year 1901–1905, inclusive; by FRED BOUGHTON WEEKS. Pp. 770.

WATER SUPPLY AND IRRIGATION PAPERS.—No. 159. Summary of the Underground Water Resources of Mississippi; by A. F. CRIDER and L. C. JOHNSON. Pp. vi, 86, with 6 plates and 11 figures.

No. 161.—Quality of Water in the Upper Ohio River Basin and at Erie, Pa.; by SAMUEL JAMES LEWIS. Pp. 114, with 6 plates and 3 figures.

No. 164.—Underground Waters of Tennessee and Kentucky West of Tennessee River, and of an Adjacent Area in Illinois; by L. C. GLENN. Pp. 173, with 7 plates and 13 figures.

Nos. 175, 177.—Report of Progress of Stream Measurements for the Calendar Year 1905: prepared under the direction of F. H. NEWELL.—Part XI.—Colorado River Drainage above Yuma; by M. C. HINDERLIDER and G. L. SWENDSEN. Pp. v, 194, with 1 plate and 2 figures. Part XIII.—Great Basin and Pacific Ocean Drainages in California, and Colorado River Drainage below Gila River; by W. B. CLAPP and J. C. HOYT. Pp. 273, with 1 plate and 2 figures.

No. 179.—Prevention of Stream Pollution by Distillery Refuse, based on Investigations at Lynchburg, Ohio; by HERMAN STABLER. Pp. 34, with 1 plate and 5 figures.

No. 180.—Turbine Water Wheel Tests and Power Tables; by ROBERT E. HORTON. Pp. 134, with 2 plates and 33 figures.

No. 181.—Geology and Water Resources of Owens Valley, California; by WILLIS T. LEE. Pp. 28, with 6 plates.

No. 184.—The Underflow of the South Platte Valley; by C. S. SLICHTER and H. C. WOLFF. Pp. 43, with 13 figures.

No. 185.—Investigations on the Purification of Boston Sewage with a History of the Sewage-disposal Problem; by C.-E. A. WINSLOW and E. B. PHELPS. Pp. 163, with 22 figures.

No. 186.—Stream Pollution by Acid-Iron Wastes. A Report based on Investigations made at Shelby, Ohio; by HERMAN STABLER. Pp. 36, with 1 plate.

2. *The Origin and Structure of the Roxbury Conglomerate*; by GEORGE ROGERS MANSFIELD. Pp. 180, 7 pls. Cambridge, Mass., Nov. 1906. Bull. of the Museum of Comparative Zoology at Harvard College, vol. xlix. Geol. Series, vol. viii, No. 4.—The term Roxbury Conglomerate is applied to a series of ancient sediments which occupy a large part of the so-called Boston Basin. The series consists of arkoses and coarse and fine conglomerates, interbedded with sandstones and shales, and is considered to be the equivalent of the massive Carboniferous conglomerates of the Narragansett Basin.

The author has made a thorough study of the formation as a whole, but to geologists in general the most valuable portion of the report consists in the discussion, covering forty-five pages, on the origin of conglomerates. A careful search of the literature has been made and the observations and opinions of various writers assembled and well discussed. The careful reader will notice, however, that there is a great scarcity of real observation and too much hypothesis in many of the statements quoted, causing generalizations to be founded upon few examples and sometimes upon mere opinions.

In the general summary eleven conclusions are stated of which perhaps the two most significant are: (8) The evidence, largely negative and unsatisfactory, favors non-marine origin for this Carboniferous formation; (9) Glaciers were not directly concerned with the deposition of the conglomerates, but they probably furnished material to torrents by which it was deposited either upon the land or in lakes. J. B.

3. *Geology of the Bighorn Mountains*; by N. H. DARTON. U. S. Geological Survey. Professional Paper No. 51. Pp. 129, pls. 47, figs. 14, 1906. Washington.—This paper, accompanied by a geological map, is a readable and valuable report of a region interesting alike to the tourist and to the scientist. The geological structure is well exposed, the marks of previous glacial action are strongly developed and the scenery is of a high order. The illustrations, reproduced from photographs, taken by several geologists, are of high artistic merit and add greatly to the attractiveness and value of the report. The treatment of the sedimentary formations is especially complete. J. B.

4. *The Glacial History of Nantucket and Cape Cod*, with an argument for a fourth center of glacial dispersion in North America; by J. HOWARD WILSON. Pp. 90, pls. and folding maps xxxviii, 1906. New York (The Columbia University Press. The Macmillan Co. agents).—Mr. Wilson has made a very complete study of the glacial phenomena of Cape Cod and the islands to the south, representing the most southeasterly exposure upon the continent of the terminal moraine. Evidence is found for the unsuspected conclusion that Newfoundland and Nova Scotia formed a separate center of glacial dispersion of

which Martha's Vineyard and later Cape Cod formed the most southwesterly limits. This hypothesis, well supported by the facts, assists in the solution of a problem, pointed out by Shaler, that the drift of Cape Cod and Nantucket contains igneous and sedimentary materials not known to occur in place in southern New England. Some knowledge is thus obtained of geological formations now submerged on the eastern portion of the continental shelf. Cambrian fossils have in the past fifteen years been determined from some of these erratics. Evidence of a glacial lake has been determined, formerly existing over Cape Cod and Cape Cod Bay and confined between two lobes of the glacier. This body of glacial water has been named Lake Shaler. J. B.

5. *Les Variations Periodiques des Glaciers.* Onzième rapport, 1905 rédigé par Dr. Harry Fielding Reid et E. Muret, Président et Secrétaire de la Commission Internationale des glaciers. Extrait des Annales de Glaciologie, t. I, Sept. 1906, pp. 161–181. Berlin (Frères Borntraeger, Editeurs).—Reports are published concerning glaciers of all the continents, showing the amount of advance or retreat or the stationary attitude. The report contains a valuable series of data which in the course of time must throw a great deal of light upon the question of the smaller and larger variations of climate. J. B.

6. *The Roman Comagmatic Region*, by H. S. Washington. Carnegie Institution, Publication No. 57, 8vo, 199 pp. Washington, D. C., 1906.—This volume contains the results of a great amount of careful, accurate and laborious work, in the field and in the laboratory, upon the volcanic rocks of central Italy. The work is essentially petrographic and not geologic in character, though enough descriptive matter of a geologic nature has been added by the author to enable the reader with the aid of the map to understand the relation of the places and mode of occurrence of the different rocks investigated. These comprise the various types which occur in the main line of volcanoes extending from Lake Bolsena southeast to Vesuvius and the Phlegrean Fields. They have been thoroughly studied and compared and of forty-four of them complete and elaborate chemical analyses have been made, thus adding very greatly to our knowledge of the chemical nature of the magmas composing this interesting and important series of eruptive centers.

As one result of this exhaustive study of a large number of leucitic rocks the author is able to present certain interesting generalizations regarding the origin and conditions of formation of leucite.

In the final portion of the work the author treats the district as a whole and presents its general aspects as a "petrographic province" or as he suggests in the place of this term a comagmatic region. In other comagmatic regions which have thus far been studied, the only one which, in the high potash content of its rocks approaches it, is that of Central Montana.

The new quantitative classification has been employed throughout and in each case a typal qualifier derived from a geographic root has been applied to the magmatic name of the new system, to indicate the modal appearance presented by the minerals, texture, etc. The author has also cast the petrographic description into a certain definite form which is proposed for future usage. The work may thus be taken as a practical example of the new system; the many new names and terms and the definiteness and conciseness of the descriptions will make it appear very strange to those accustomed only to the more or less general names and indefinite methods of description prevailing under the old terminology and classifications. For the benefit of such the older names, as well as the newer ones, are used to designate the rocks.

It is especially on the chemical side that this work exhibits its highest value; a great number of analyses of the rocks of central Italy have been previously made, but they are either old, so that the analytical methods were inadequate to yield complete and accurate results, or they have been made by persons whose training and experience were not extensive enough to enable them to obtain results sufficiently complete and exact to meet the demands made by modern petrographical science. The rocks of central Italy have been so long well known and many of them have been so often studied in other ways that they have become classic in the literature of petrography: the lack of thoroughly complete and trustworthy analyses has been felt to be a serious gap in our knowledge concerning them, and this contribution by Washington is therefore particularly valuable and timely in supplying this omission. The institution under whose patronage this work has been carried on and finally brought out is to be congratulated, no less than the author, on the excellence of the results which have been obtained. L. V. P.

7. *Geology and Petrography of Mt. Yamaska, Province of Quebec;* by G. A. Young. Ann. Rep. Geol. Surv. Canada, vol. xvi, Pt. H, 43 pp. + map.—Through the investigations of Prof. F. D. Adams and his associates the line of igneous intrusive masses extending eastward from Montreal, and to which he has given the name of the Monteregian Hills, have proved petrographically of great interest. In this complete and careful study of one of them by Dr. Young another chapter has been added to our knowledge concerning them.

The mountain consists of a volcanic neck of igneous rock projecting upward through the Cambrian-Silurian sediments, which have been considerably metamorphosed by it. Several varieties of igneous rocks compose the mass, ranging from feldspathic to ferromagnesian types, and their arrangement and gradations into one another are such as to lead to the belief that they have been produced by differentiation in place, with some subsequent movement. The types described consist of syenite (var. åkerite), essexite and a very basic variety termed yamaskite. These are associated with, or cut by, dikes of syenite-aplite, nephelite-syenite, bostonite and camptonite. The general arrangement of the mass is such that the most feldspathic variety, åkerite, is on the periphery while the most basic, the yamaskite, is at the center.

The *yamaskite*, which is a new rock type, has the same general chemical composition as the jacupirangite of Derby and Washington but differs quite decidedly in its mineralogical composition. It consists of pyroxene, pink and pleochroic in section, basaltic brown hornblende, anorthite and ilmenite as the chief minerals. It is far more basic than essexite, as may be seen from the two analyses quoted :

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O
I	39·97	8·68	8·63	7·99	10·32	15·18	1·19	0·74
II	36·24	9·05	10·64	9·58	7·75	14·97	1·05	0·43

	CO_2	TiO_2	P_2O_5	FeS_2	MnO	H_2O	Total
I	1·15	4·05	0·10	1·01	0·19	0·57	= 99·77
II	....	7·12	0·01	0·97	0·29	0·65	= 99·75

It is noteworthy that No. II, which is an extremely basic rock, has more anorthite than No. I, containing about 15 per cent. The rock has a coarse, even granular texture. Its coördinates in the new quantitative classification are IV ; 2, Sec. 1 ; I, Sec. 2 ; 2, which is termed yamaskose, as it is a hitherto undescribed sub-rang.

The work represents a thesis prepared as a part of the requirements for the attainment of the degree of doctor of philosophy in Yale University. L. V. P.

8. *Geology of the Volcanic Area of the East Moreton and Wide Bay Districts, Queensland, Australia* ; by H. I JENSEN, Proc. Linn. Soc. New South Wales, 1906, Pt. I, pp. 73–173.—This account of the geology of two districts in Queensland is of more than local value on account of the interesting types of rare volcanic rocks which are described. These are alkalic trachytes and allied rocks, comendites and pantellarites. They contain blue amphiboles (riebeckite and arfvedsonite) and cossyrite (aenigmatite). They are somewhat briefly described and a number of excellent analyses of them are given. The work shows clearly the existence of a province of alkalic rocks in the region described, whose complete petrographic investigation would undoubtedly yield results of great interest and value. L. V. P.

9. *The Building and Ornamental Stones of North Carolina;* by THOMAS L. WATSON and FRANCIS B. LANEY, with the collaboration of GEORGE P. MERRILL. Pp. xiii, 283, with 32 plates and 11 figures. Raleigh, 1906 (E. M. Uzzell). Bulletin No. 2 of the North Carolina Geological Survey : JOSEPH HYDE PRATT, State Geologist.—The State of North Carolina is well supplied with a great variety of building stones, particularly those of the granitic type ; with the possible exception of Georgia, it ranks higher in this field than any of the other Appalachian States south of New England. This fact, taken in connection with the mildness of the climate and the cheapness of labor, should result in the

development of a very extensive industry, an end which will be materially stimulated by the present volume.

The various types of rocks, from the granites to the sandstones and quartzites, are described in detail and an account is also given of the quarries in actual operation. Under the marbles some new localities are mentioned, and one marble of special interest is described from Mitchell County; this is pure white in color and suitable for those purposes for which the finest grades of marble are required. Some stones of peculiar interest in the State are the quartz porphyry or leopardite, found in Mecklenburg County, and the orbicular-gabbro diorite, found in Davis County. Both of these are attractive stones for monumental purposes. Another unusual rock is the variety of granite known as unakite, composed of yellow-green epidote, dull pink or red feldspar and quartz.

The concluding chapters describe the methods of quarrying, the weathering of building stones and the rocks suitable for road building.

10. *Clays: Their Occurrence, Properties and Uses with especial reference to those of the United States*; by Heinrich Ries. Pp. xiv, 490, with 44 plates and 65 figures. New York, 1906 (John Wiley & Sons).—The author of this volume has already made extensive studies of the clays and clay industries in the United States, in connection with the U. S. Geological Survey and also the Surveys of Maryland and New Jersey. He has now rendered a great service not only to geologists and chemists, but also to those commercially interested, by bringing together within the limits of a single volume all that is most important in relation to this subject. The book opens with a brief statement in regard to the origin of clay beds, and then goes on to discuss in detail the chemical and physical properties and the different types of clays useful for different purposes. The last half of the book is given to an account of the distribution of clay at the many localities at which it occurs in the different states, the facts being arranged conveniently according to the geological formations. This latter portion of the work is liberally illustrated with many reproductions from photographs, which add much to the value of the descriptions.

11. *Palæozoic Fossils*, Vol. III, Part IV: by J. F. Whiteaves. Geol. Surv. Canada, 1906, pp. 243–352, pls. xxiii–xlii.—This part concludes the third volume of Paleozoic Fossils begun by Billings in 1861, and consists of four papers, as follows:—

5. The Fossils of the Silurian (Upper Silurian) rocks of Keewatin, Manitoba, the northeastern shore of Lake Winnepegosis, and the lower Saskatchewan River.

6. The Canadian species of Plectoceras and Barrandeoceras.

7. Illustrations of seven species of fossils from the Cambrian, Cambro-Silurian, and Devonian rocks of Canada.

8. Revised list of the fossils of the Guelph formation of Ontario. With appendix, consisting of a list of errata, and an index to the volume. C. S.

12. *The Bryozoan Fauna of the Rochester shale;* by RAY S. BASSLER. Bull. No. 292, U. S. Geol. Survey, 1906, 137 pp., 31 pls.—This Silurian formation of western New York has 48 genera and 80 species of Bryozoa, of which 30 forms are here described for the first time. The writer shows that the Rochester formation is chiefly, if not exactly, equivalent of the Osgood beds along the western side of the Cincinnati axis, for more than 40 per cent of the Bryozoa of the former region are also found in the West, while less than 20 per cent are common to the Rochester and the Waldron shale which lies above the Osgood. Paleozoic Bryozoa are usually regarded as limited in geographical range, but in this case at least five species are common to America and the Wenlock (Buildwas) of England and of Scotland. Four of these forms, however, belong to the simpler Ctenostomata and Cyclostomata. C. S.

13. *The Fossil Fauna and Flora of the Florissant (Colorado) shales;* by T. D. A. COCKERELL. Univ. Colorado Studies, iii, 1906, pp. 157–176, one plate.—This paper gives a summary of the fossils thus far recovered from about Florissant. There are 11 vertebrates (2 birds, 9 fishes), 1 mollusc (*Planorbis*), 1032 insects of which 608 are described, 213 Coleoptera (187 undescribed), 2 Hymenoptera (228), 9 lepidoptera (7), 54 Diptera, 24 Orthoptera, 80 Homoptera, 140 Heteroptera, 6 Ephemeroptera, 12 Neuroptera, 9 Odonata, 6 Platyptera, 22 Trochoptera, 1 Thysanura, 1 Ballostoma, 30 spiders, and 145 plants.

The author states "that we must cease to refer to the Florissant shales as belonging to the Green River Group," and with Lesquereux regards the fossils as of Miocene age. The climate of Florissant was then "moister and warmer than that of the present day. . . . a warm temperate region . and . . . semi-alpine or boreal in character." C. S.

14. *Geological Survey of Ohio*, EDWARD ORTON, JR., State Geologist, Bulletin Six: A Bibliography of Ohio Geology. Part I, pp. 1–233, a subject Index of the Publications of the Geological Survey of Ohio, from its inception to and including Bulletin Eight of the Fourth Series; by ALICE GREENWOOD DERBY. Part II, pp. 235–332. A Bibliography of the Publications relating to the Geology of Ohio, other than those of the State Geological Survey; by MARY WILSON PROSSER. Columbus: August, 1906.—The completeness of the bibliographies in the two parts of this Bulletin make it a highly important contribution to all those concerned with the geology of Ohio.

15. *Handbuch der Mineralogie;* von DR. CARL HINTZE. Zehnte Lieferung. Pp. 1441–1600, with 35 text-figures. Leipzig, 1906 (Veit & Comp.).—Mineralogists will be interested in the appearance of the tenth part of Volume I of Hintze's Mineralogy. It completes the description of quartz, includes also the other forms of silica, and the three forms of TiO_2, brookite, anatase (octahedrite) and rutile. This is the twenty-second part of the entire work, which was begun in 1889, and brings the completion of the whole within sight, an end which both the author and the mineralogical public have long desired.

III. Miscellaneous Scientific Intelligence.

1. *The Integrative Action of the Nervous System;* by Chas. S. Sherrington, Professor of Physiology in the University of Liverpool. Being the Silliman Memorial Lectures for 1904 at Yale University. Octavo, 393 pages with numerous graphic records and index of bibliography. New York (Charles Scribner's Sons).—The problem dealt with in these lectures is postulated thus: "In the multicellular animal, especially for those higher reactions which constitute its behaviour as a social unit in the natural economy, it is nervous reaction which par excellence integrates it, welds it together from its components, and constitutes it from a mere collection of organs an animal individual." The elementary form of nervous system, the simple nerve-net exemplified in Medusa, affords merely diffuse conduction. It obeys the "all or none" law, and affords the animal only a single invariable response to all adequate stimuli whatever their character or point of application. Contrasted with this simplicity and uniformity, the wide variety of response by which the higher animals adjust themselves to, and indeed dominate their environment, is not merely due to the greater complexity of their "effector" mechanisms, but is peculiarly the endowment afforded by the "synaptic" nervous system. The unit reaction in nervous integration, the simple reflex, is probably a purely abstract conception, but a fiction which is essential to the analysis of complex coördinated reactions. Its machinery consists of (1) a "receptor" organ which is usually endowed with a specialized irritability so that because of its low threshold value for one form of stimulus and relative insensibility to all other changes of the environment it affords a selective character to the reaction which it evokes. (2) A "private path" or afferent neurone connecting the "receptor" with the central grey matter of the nervous system. (3) The efferent neurone which the author denominates the "final common path" because upon it debouch all the "private paths" and through it are effected all reactions. (4) The "effector" organ, muscle fiber or gland cell. And (5) between the afferent and efferent neurones a "synapse" or surface of separation between their interlaced but non-continuous dendrites. Nerve fibers are mere conductors. Bethe's experiment on Carcinus shows that the perikarya (nerve-cell bodies) are not responsible for the features characteristic of reflex arc conduction. In the "synapse" therefore must be found those properties upon which depend such phenomena as latency, after-discharge, summation, "Bahnung" fatigue, inhibition, tonus, refractory phase, and the manifold relations between intensity of stimulus and intensity of reflex reaction. These phenomena are in turn discussed on the basis of the author's illuminating investigations on the "spinal" dog. Especial attention is devoted to the phenomena of "interference" at the "synapse" by which when any private path because of excita-

tion connects with the "final common path" to induce its characteristic reaction all antagonistic afferent arcs are thereby simultaneously excluded. This is the basis of all coördination of reactions and also of the great psychical process of "attention." From it result the singleness of action every instant and the prevention of confusion which are the keystones of the unity of the individual.

The term "proprio-ceptors" is applied to those afferent end-organs which lying beneath the animal's surface are influenced only by interior conditions. Their important shares in coördination are discussed, and the conclusion reached that "cerebellum is the head ganglion of the proprio-ceptive system."

The "distance-receptors" for sight, hearing, and smell initiate and guide long series of reactions of the animal as a whole. Their influences are dominant, for through long chains of reactions conductive to a final reaction relatively remote they direct the animal to obtain its food, and escape its enemies. The conscious concomitants of these processes constitutes mentality. "The cerebrum is the ganglion of the distance-receptors."

Space forbids a further discussion of these intensely interesting lectures. The striking individuality of treatment involving the development of a terminology in great part new, the importance of the experimental data afforded by Professor Sherrington's researches in the difficult field between the physiologic and the psychic realms, the breadth of grasp and depth of insight in the treatment of the subject matter, are such as cannot fail to influence profoundly the attitude toward the problems of the nervous system of every physiologist who carefully reads this book. For the psychologist it possesses an even greater interest, for it represents a long step forward toward the comprehension of the physiologic basis of psychic phenomena. Y. H.

2. *Annual Report of the Board of Regents of the Smithsonian Institute. Report of the U. S. National Museum for the year ending June 30, 1905.* Pp. 131. *Report of the U. S. National Museum for the year ending June 30, 1906;* by RICHARD RATHBUN. Pp. 120. Washington, 1906.—These reports prepared by Dr. Rathbun give a very interesting account of the growth of the National Museum down to the middle of 1906. The construction of the new building, commenced in 1904, although carried forward less rapidly than was expected, is now well under way and the completion is anticipated in two years more. The facilities which this building will provide are urgently needed, since the collections are increasing at a very rapid rate, during the last year, for example, to the extent of upwards of 250,000 specimens. These additions cover all the different departments of science, from geology and natural history to ethnology, archeology and technology.

3. *Report of the Superintendent of the Coast and Geodetic Survey, showing the Progress of the Work from July 1, 1905, to June 30, 1906.* Pp. 230, with 9 pocket maps. Washington, 1906.—This annual report of Dr. O. H. TITTMANN gives a sum-

mary of the work of the Survey during the year. It includes the determination of longitude in Alaska, both on the coast and in the interior, by the telegraphic method; the examination of the boundary lines between Alaska and Canada, and also between Canada and the New England States, were both carried forward. The magnetic survey includes observations at 382 stations and also contains records of the observations at the permanent observatories at Cheltenham, Md., Baldwin, Kans., Sitka, Honolulu, and Vieques, P. R.; special observations were also made during the solar eclipse of August 30th. These observations are given in Appendices 3 and 4.

4. *Annals of the Astronomical Observatory of Harvard College;* EDWARD C. PICKERING, Director. — Recent publications include the following:

Vol. XXXIX, Part II. Peruvian Meteorology 1892–1895, compiled and prepared for publication by SOLON I. BAILEY, under the direction of EDWARD C. PICKERING. Pp. 157–292, with five plates and six figures. The nine stations occupied, and for which (except Arequipa) the tabular observations are given, vary in altitude from Mollendo near the sea-level (80 ft.) to Chachani 16,650 ft. and the summit of Misti at 19,200 ft. An appendix contains an account of the remarkable sand dunes near La Joya in the desert of Islay.

Vol. LVIII, Part II. Observations and Investigations made at the Blue Hill Meteorological Observatory, Massachusetts, in the years 1903 and 1904, under the direction of A. LAWRENCE ROTCH. With an Appendix on the Errors of Absorption Hygrometers. Pp. 67–141, with one plate.

Vol. LX, No. I. Geometrical Methods in the Theory of Combining Observations; by ARTHUR SEARLE. Pp. 1–32.

No. II, Early Observations of the Sixth Satellite of Jupiter. Pp. 33–42.

CIRCULARS 113–118.

5. *Carnegie Institution of Washington.*—The following publications have been recently issued:

No. 32. Chimaeroid Fishes and Their Development; by BASHFORD DEAN. Pp. 194, with 11 plates and 53 figures.

No. 33. Researches in Stellar Photometry during the years 1894 to 1906: made chiefly at the Yerkes Observatory; by JOHN A. PARKHURST. Pp. 192, with 119 tables and 39 figures.

No. 36, Part II. Studies in Spermatogenesis, Part II. A Comparative Study of the Heterochromosomes in certain species of Coleoptera, Hemiptera and Lepidoptera, with especial reference to Sex Determination; by N. M. STEVENS. Pp. 33–74, with plates viii–xv.

No. 57. The Roman Comagmatic Region; by HENRY S. WASHINGTON. Pp. vi, 199, with 3 figures.

Contributions from the Solar Observatory, Mt. Wilson, California. No. 9. Latitude and Longitude of the Solar Observatory; by GEORGE E. HALE. Pp. 4.

No. 10. The Spectroscopic Laboratory of the Solar Observatory; by GEORGE E. HALE. Pp. 7.

No. 11. Preliminary Paper on the Cause of the Characteristic Phenomena of Sun-spot Spectra; by G. E. HALE, W. S. ADAMS and H. G. GALE. Pp. 29.

No. 12. Sun-spot Lines in the Spectrum of Arcturus; by W. S. ADAMS. Pp. 9.

6. *American Association.*—The fifty-seventh meeting of the American Association for the Advancement of Science will be held at Columbia University in New York City, during the week from December 27, 1906, to January 2, 1907. Dr. W. H. Welch, of Baltimore, is the president. Eleven societies meet in New York in affiliation with the Association at this the fifth of its convocation week meetings.

7. *Amerikanisches Hochschulwesen: Eindrücke und Betrachtungen* von DR. W. BÖTTGER, Pp. 70. Leipzig, 1906 (Wilhelm Engelmann).—The author of this pamphlet spent a year as research associate in the laboratory of physiological chemistry in the Boston Institute of Technology. The results of his observations and studies in regard to the general system of American universities were presented by him in a lecture delivered before the Chemical Society of Leipzig. This lecture is the basis of the present paper, which has been expanded and completed. Those interested in university work, and particularly in the essential differences between the institutions in this country and Germany, will find here much of interest.

8. *Notes on Adirondack Mammals, with Special Reference to the Furbearers;* by MADISON GRANT. Reprinted from the eighth and ninth Reports of the Forest, Fish and Game Commission, State of New York. Pp. 319–334.—A brief account of the larger mammals of the North Woods, including some which have long since disappeared from the region. The paper is accompanied by 24 plates of very satisfactory photographs of these animals.

9. *Annual Report of the Director of the Weather Bureau of the Philippine Islands for the year 1904.* Parts I and II. Pp. 208. Manila, 1906 (Bureau of Printing).—This report of the Rev. Jose Algué, Director of the Weather Bureau at Manila, contains the hourly meteorological and magnetic observations made at the Manila Central Observatory in 1904. The Director has also issued from the advance sheets of the September bulletin an account of the destructive Hongkong typhoon of September 18, 1906.

10. *Science Bulletin of the Museum of the Brooklyn Institute of Arts and Sciences.* Vol. I, No. 9.—This recently issued bulletin contains the following papers: On new and known genera and species of the Family Chrysomelidae; by CHARLES SCHAEFFER. Pp. 221–253. Hemiptera from Southwestern Texas; by H. G. BARBER. Pp. 255–289.

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Established by BENJAMIN SILLIMAN in 1818.

THE AMERICAN JOURNAL OF SCIENCE.

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FOURTH SERIES

VOL. XXIII—[WHOLE NUMBER, CLXXIII.]

No. 134—FEBRUARY, 1907.

WITH PLATE I.

NEW HAVEN, CONNECTICUT.

1907

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

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RECONSTRUCTED RUBIES.

At the recent meeting of the American Society for the Advancement of Science, these rubies were exhibited as made in a crucible and also in the different raw shapes and cut gems, and attracted more attention from the scientists present than anything else exhibited at this meeting. A number of orders from Washington officials and other scientists have been received since, and almost all have duplicated their orders.

These rubies are as good as the natural ones, if not better; are made from the same chemical substance, and have the same hardness and lustrous color, as a genuine ruby. They have also the true pigeon-blood color. The only difference between a natural one and a reconstructed ruby is, that the natural one comes out of the pocket of a rock, and the reconstructed one comes out of a crucible. Litigation is now going on in the Custom House, to put a larger duty on reconstructed rubies. It is a great damage to the large gem dealers, who have large quantities of genuine rubies, so they are fighting to put a large duty on the reconstructed rubies also. So if you want to secure one, you can now secure them at a very reasonable price; but, as soon as the Custom House raises the tariff, naturally enough, we have to increase the price. We have about 400 on hand, from ½ to 3k. and cost from $3 to $5 per carat.

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RARE MINERALS.

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LATEST ARRIVALS.

A few of the choice minerals mentioned last month still remain. In addition to these, another very fine consignment has arrived, a partial list of which we give below:

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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

Art. VII.—*On the Ultimate Disintegration Products of the Radio-active Elements. Part II. The Disintegration Products of Uranium*; by Bertram B. Boltwood.

[Contributions from the Sloane Physical Laboratory of Yale University.]

The general question of the nature of the ultimate disintegration products of the radio-active elements, as indicated by the occurrence of certain chemical elements in the radio-active minerals, has been discussed in an earlier paper,* and it was there pointed out that lead, bismuth and barium might perhaps be included among the possible disintegration products. As more recent experiments† have indicated, however, that actinium is probably an intermediate product between uranium and radium, the number of possible ultimate products has been correspondingly reduced. In addition to this careful examinations have been made of specially selected samples of typical primary uraninites from Branchville, Conn., and Flat Rock, N. C., and of thorianite from Ceylon, which have led to the conclusion that neither bismuth nor barium can be considered as disintegration products in the main line of descent from either uranium or thorium, at least on the basis of the present disintegration theory.

The conditions essential for the identification of the final disintegration products of uranium from a study of the composition of the natural minerals which contain this element would appear to be the following: In unaltered primary minerals of the same species, and of different species from the same locality, that is, in minerals formed at the same time and therefore of equal ages, a constant proportion must exist between the amount of each disintegration product and the

* This Journal, xx, 253, 1905. † Ibid., xxii, 537, 1906.

amount of the parent substance with which it is associated. And, in unaltered, primary minerals from different localities, the proportion of each disintegration product with respect to the parent substance must be greater in those minerals which are the older and should correspond with the order of the respective geological ages of the localities in which the minerals have been found. It also follows that in secondary minerals, namely, in minerals which have been formed by the subsequent alteration of the original, primary minerals, the relative amounts of the disintegration products must be less than in the primary minerals from the same locality, provided, however, that the disintegration products can not be considered as original chemical constituents of the secondary mineral.

It is the purpose of the present paper to show that the above requirements are practically fulfilled by lead and by helium also, in so far as the gaseous nature of the latter element will permit of its retention in the minerals. The suggestion that lead was one of the final (inactive) disintegration products of uranium was first made by the writer in a paper presented before the New York Section of the American Chemical Society on February 10, 1905, and published later in the Philosophical Magazine.*

The amounts of uranium and lead present in a considerable number of primary uranium minerals have been calculated from the published analyses of these minerals. The number of such analyses to be found in the literature is not large, and, what is still more unfortunate, with the exception of those made by Hillebrand and a few others, cannot be considered as particularly accurate. Many of the analyses were made with special objects in view, such as the identification of a given specimen with a species already known or its recognition as a new variety or species. There is also what is perhaps an unfortunate tendency on the part of many mineralogists to carry out an analysis merely for the purpose of assigning to the mineral some definite chemical formula, which often leads to the overlooking or ignoring of a number of the minor constituents. And in addition to this there are also the actual analytical difficulties to be taken into account, which may be very considerable in the case of such minerals as samarskite, fergusonite, euxenite and other minerals containing notable proportions of niobium, tantalum and titanium. Notwithstanding these objections, however, it is necessary to rely very largely on these published analyses, for the simple reason that the greater number of the uranium minerals are extremely rare and the obtaining of suitable samples of the various species and varieties is either extremely difficult or altogether impossible.

* April, 1905.

In the table which follows (Table I) are given the results obtained from the calculation of the ratio of the percentage of lead to that of uranium contained in the different minerals as indicated by the analyses.

No.	Mineral Locality	Per cent U	Per cent Pb	Ratio $\frac{Pb}{U}$	Analysis by
1.	Uraninite, Glastonbury, Conn.,	70	2·9	0·041	Hillebrand, this Journal, xl, 384, 1890.
2.	Uraninite, Glastonbury, Conn.,	70	3·0	0·043	Hillebrand, *l. c.*
3.	Uraninite, Glastonbury, Conn.,	70	2·8	0·040	Hillebrand, *l. c.*
4.	Uraninite, Glastonbury, Conn.,	72	3·0	0·042	Hillebrand, *l. c.*
5.	Uraninite, Glastonbury, Conn.,	72	2·9	0·040	Hillebrand, *l. c.*
6.	Uraninite, Branchville, Conn.,	74	4·0	0·054	Hillebrand, *l. c.*
7.	Uraninite, Branchville, Conn.,	75	4·0	0·053	Hillebrand, *l. c.*
8.	Uraninite, Branchville, Conn.,	74	4·0	0·054	Hillebrand, *l. c.*
9.	Uraninite, Branchville, Conn.,	66	3·5	0·053	From an analysis by the writer.
10.	Uraninite, Spruce Pine, N. C.,	77	3·9	0·051	Hillebrand, *l. c.*
11.	Uraninite, Spruce Pine, N. C.,	77	4·2	0·055	Hillebrand, *l. c.*
12.	Uraninite, Spruce Pine, N. C.,	67	3·3	0·049	From an analysis by the writer.
13.	Uraninite, Marietta, S. C.,	71	3·3	0·046	Hillebrand, this Journal, xlii, 390, 1891.
14.	Uraninite, Llano Co., Tex.,	55	9·4	0·17	Hillebrand, *l. c.*
15.	Uraninite, Llano Co., Tex.,	56	9·5	0·17	Hidden and Mackintosh, this Journal, xxxviii, 481, 1889.
16.	Mackintoshite, Llano Co., Tex.,	19	3·4	0·18	Hillebrand, this Journal, xlvi, 98, 1893.
17.	Yttrocrasite, Burnet Co., Tex.,	2·3	0·44	0·19	Hidden and Warren, this Jour., xxii, 515, 1906.
18.	Samarskite (?) Douglas Co., Colo.,	3·5	0·67	0·19	Hillebrand, Proc. Col. Sc. Soc., iii, 38, 1888.
19.	Samarskite (?) Douglas Co., Colo.,	3·7	0·74	0·20	Hillebrand, *l. c.*
20.	Samarskite (?) Douglas Co., Colo.,	5·1	0·99	0·19	Hillebrand, *l. c.*
21.	Uraninite, Anneröd, Norway,	66	8·4	0·13	Hillebrand, this Journal, xl, 384, 1890.

No.	Mineral Locality	Per cent U	Per cent Pb	Ratio Pb/U	Analysis by
22.	Uraninite, Anneröd, Nor.,	68	7·8	0·12	Blomstrand, Jour. prakt. Chem., xxix, 191, 1884.
23.	Annerödite, Anneröd, Nor.,	15	2·2	0·14	Blomstrand, Dana's System of Min., p. 741.
24.	Uraninite, Elvestad, Nor.,	66	9·3	0·14	Hillebrand, this Journal, xl, 384, 1890.
25.	Uraninite, Elvestad, Nor.,	57	8·0	0·14	Hillebrand, *l. c.*
26.	Uraninite, Skaartorp, Nor.,	65	8·8	0·13	Hillebrand, *l. c.*
27.	Uraninite, Huggenäskilen, Nor.,	68	8·8	0·13	Hillebrand, *l. c.*
28.	Uraninite, Huggenäskilen, Nor.,	76	9·0	0·12	Lorenzen, Nyt. Mag., xxviii, 249, 1884.
29.	Thorite, Hitterö, Nor.,	8·2	1·2	0·14	Lindström, G. För. Förh., v, 500, 1881.
30.	Uraninite, Arendal, Nor.,	56	9·8	0·17	Hillebrand, *l. c.*
31.	Uraninite, Arendal, Nor.,	61	10·2	0·17	Hillebrand, *l. c.*
32.	Uraninite, Arendal, Nor.,	56	9·4	0·17	Lindström, Zeit. f. Kryst., iii, 201, 1878.
33.	Thorite, Arendal, Nor.,	9·0	1·5	0·17	Nordenskiöld, G. För. Förh., iii, 228, 1876.
34.	Orangite, Landbö, Nor.,	7·5	1·2	0·16	Hidden, this Journal, xli, 440, 1891.
35.	Xenotime, Naresto, Nor.,	2·9	0·62	0·21	Blomstrand, G. För. Förh., ix, 185, 1887.
36.	Hielmite, Falun, Sweden,	1·9	0·20	0·10	Weibull, *ibid*, ix, 371, 1887.
37.	Polycrase, Slättakra, Sweden,	7·4	0·85	0·12	Blomstrand, Dana's Min., p. 745.
38.	Thorianite, Sabaragamuwa Province, Ceylon,	9·8	2·1	0·21	Dunstan and Blake, Proc. Roy. Soc. Lond., lxxvi (A), 253, 1905.
39.	Thorianite, Sab. Prov., Cey.,	10·8	2·7	0·25	Dunstan and Blake, *l. c.*
40.	Thorianite, Sab. Prov., Cey.,	12·8	2·4	0·19	Dunstan and Blake, *l. c.*
41.	Thorianite, Sab. Prov., Cey.,	11·2	2·7	0·24	Analysis by writer.
42.	Thorianite, Cey.,	11·1	2·3	0·21	Büchner, Nature, lxxv, 169, 1906.
43.	Thorianite, Galle District, Cey.,	25	2·1	0·086	Dunstan and Jones, Proc. Roy. Soc., Lond., lxxvii (A), 546, 1906.

In the above table the minerals can be divided into seven general groups according to the localities from which they were obtained, namely; Group I from Connecticut (Nos. 1 to 9); Group II from North and South Carolina (Nos. 11 to 13); Group III from Texas (Nos. 14 to 17); Group IV from Colorado (Nos. 18 to 20); Group V from Norway (Nos. 21 to 35); Group VI from Sweden (Nos. 36 and 37); Group VII from Ceylon (Nos. 38 to 43). These groups can be further subdivided into Group I_1 from Glastonbury* and Group I_2 from Branchville, Group V_1 from localities in the neighborhood of Moss (21 to 29) and Group V_2 from Arendal, and Group VII_1 from the Sabaragamuwa Province and Group VII_2 from the district of Galle.

If the ratio of the lead to the uranium in these groups is now considered, it is evident that in Group I_1 the average value is 0·041 and the maximum divergence is less than five per cent. In Group I_2 the average is 0·0535, which is in close agreement with the four separate values given. In Group II the agreement of the different values is not so good, but is still very striking when the fact is taken into account that the two specimens from North Carolina examined by Hillebrand showed unmistakable evidence of slight secondary alteration as did also the specimen from South Carolina, which moreover is from a different locality and is placed with this group only because there are no others with which to compare it. The material used by the writer was to all appearances free from alteration.

In Group III an opportunity is afforded for the comparison of different species from the same locality, for the yttrocrasite described by Hidden and Warren was found only just across the Colorado River from the famous Barringer Hill locality which supplied the other Texas specimens. Here the agreement of the ratios is again very satisfactory, especially in the case of the yttrocrasite, which is one of the minerals the care-

*I have been informed by Mr. E. B. Hurlburt of Glastonbury, Conn., who has made a careful study of the mineral occurrences in his locality, that he considers it to be highly improbable that the specimens examined by Hillebrand and described as from Glastonbury were actually found in that place or even in the neighboring quarries of South Glastonbury. Columbite, monazite, a mineral resembling polycrase and autunite are found at South Glastonbury, but Mr. Hurlburt, who has looked into the matter quite thoroughly, is of the opinion that the specimens of uraninite credited to Glastonbury must have been found in the feldspar quarries of Portland, a town on the east bank of the Connecticut River between South Glastonbury and Middletown. A number of years ago uraninite in some quantity was found at Portland, and as some of the workmen in the Portland quarries had their homes in South Glastonbury, its occurrence in the latter locality may readily have been assumed by the collectors who afterwards obtained the specimens. It is also equally possible that the specimens in many collections labelled as from Middletown are also really from Portland.

ful analysis of which presents so many difficult problems. The writer had the good fortune to meet Professor Warren at the time that this analysis was in progress and the latter kindly consented to take special precautions in the determination of the lead and uranium.

In Group IV the analyses of three samples of a mineral closely resembling samarskite give values for the ratio showing a good agreement, although the different specimens were, according to Hillebrand, quite different in general appearance.

In Group V_1 the agreement is again very good, while in Group V_2, including Nos. 34 and 35, the agreement is excellent, for the difference in the case of the xenotime from Narestö, near Arendal, is no more than is to be expected when the relatively small amounts of both uranium and lead are taken into consideration.

In Group VI the ratios given by the two species from different Swedish localities are of little value for the present purposes of comparison, and are significant only as indicating a ratio of the same general order as that found in Group V_1.

It is unfortunate for the purpose of the present calculation that the analyses of thorianite from Ceylon by Dunstan and Blake and by Dunstan and Jones have been published in so incomplete a form. This interesting mineral, containing a relatively high proportion of both thorium and helium, affords an exceptional material for the study of radio-active changes, and an accurate knowledge of its general composition would be of much assistance in settling some of the doubtful questions. The published analyses are defective however in the following particulars:—In analyses Nos. I and II* (Nos. 38 and 39 in Table I) the results as given indicate that all of the uranium is present in the form of uranous oxide (UO_2), while in analysis No. III (*l. c.*) (No. 40 in Table I) a greater proportion of uranic oxide (UO_3) than of uranous oxide is shown. Such an extreme variation in composition is not only highly improbable, but (in the light of a more recent analysis of thorianite of a similar variety† in which the uranium is given as $UO_2 + UO_3 = 13{\cdot}4$ per cent) is probably quite misleading as to the actual composition. Out of the seven analyses given in the paper by Dunstan and Jones, in only one (No. 43 in Table I) are the separate amounts of uranous and uranic oxides shown, while in the other six a number representing the sum of the percentages of the two oxides is inserted, which affords no reliable clue as to the amount of either oxide or the amount of uranium itself contained in the mineral.

The following table containing the values given in the paper by Dunstan and Jones would not appear to be contradictory to

* Proc. Roy. Soc. Lond., lxxvi (A), 253, 1905. † Dunstan and Jones, *l. c.*

the assumption that the lead and uranium are in a constant ratio to one another in the thorianite from the Galle district.

Table II.

Sample No.	$UO_2 + UO_3$	PbO
I	32·7	2·56
II	10·3 18·9	2·29
III	28·2	2·29
IV	28·7	2·50
V	27·0	2·99
VI	28·0	2·90

In the paper by Dunstan and Jones an analysis of a specimen of thorianite from the Balangoda district, showing $UO_2 + UO_3 = 13·4$ per cent and $PbO = 2·54$, suggests a close agreement of the ratio of lead to uranium in this mineral with the same ratio in the material from the Sabaragamuwa Province.

The minerals given in the preceding table are all primary minerals, in the general sense in which this term is used. In the following table (Table III), the ratio of lead to uranium has been calculated for some secondary minerals from the same localities.

Table III.

No.	Mineral Locality	Per cent U	Per cent Pb	Ratio $\frac{Pb}{U}$	Analysis by
1.	Uranophane, Mitchell Co., N. C.,	55	0·56	0·01	Genth, Am. Ch. J., i, 88, 1879.
2.	Uranophane, Arendal, Nor.,	40	1·6	0·04	Nordenskiöld, G. För. Förh., vii, 121, 1884.
3.	Thorogummite, Llano Co., Tex.,	19	2·0	0·10	Hidden and Mackintosh, this Journal, xxxviii, 480, 1889.

These analyses all agree in giving a lower ratio for the secondary minerals than for the primary minerals from the same localities. The most common alteration product of uraninite known as gummite can be left out of present consideration since lead is apparently one of its natural, chemical constituents.

The actual value of the ratio varies considerably for the primary minerals from different localities, the maximum value being about six times the minimum. It is beyond the writer's province to discuss the data bearing on the geological ages of the different deposits, but he is indebted to Professor Joseph Barrell of Yale University for the statement that, so far as the knowledge of the latter extends, the relative values of the ratios are not contradictory to the order of the ages attributed by geologists to the formations in which the different minerals occur.

From the data which have been presented in the preceding tables it is apparent that the requirements for a disintegration product of uranium are fulfilled by lead within the limits of probable experimental error. On the basis of this evidence the assumption would appear to be justified that lead is the final product of uranium.

Helium.

Few experimental determinations of the relative quantities of helium in minerals of known composition are to be found in the literature. A careful search has brought to light only the following: Twelve determinations by Hillebrand* of the "nitrogen" present in an equal number of samples of uraninites of known composition; the determination by Ramsay and Travers† of the per cent of helium in a sample of fergusonite, the analysis but not the locality of which is given; the determinations by Strutt‡ of the amounts of helium in a number of minerals which had been analyzed for uranium only; a determination by Dunstan and Blake§ of the helium in an analyzed sample of thorianite from the Sabaragamuwa province, Ceylon; and the determination of helium in another specimen of the same mineral by Büchner.‖

Considering the great exactness of all the analytical work carried out by Hillebrand, and the general method which he followed in his determinations of "nitrogen," it is highly probable that by dividing the values which he gives in his paper by seven ($N_2 : He = 28 : 4$) a very reliable number for the percentage of helium is obtained.

It has been shown conclusively by a number of different experimenters that the disintegration of radium is accompanied by the production of helium, and it is further stated by Debierne¶ that the disintegration of actinium furnishes helium also. If the assumption is made on the basis of analogy that the entire change from uranium to lead is accompanied by the production of helium, then the quantities of matter involved in this change can be represented by the equation

$$\text{Uranium } (238{\cdot}5) = \text{lead } (206{\cdot}9) + \text{helium } (31{\cdot}6),$$

in other words, that for every 207 parts of lead there will be formed 32 parts of helium.

From a knowledge of the amount of lead present in the minerals it is, therefore, possible to calculate the amount of helium

* This Journal, xl, 384, 1890; ibid., xlii, 390, 1891.
† Proc. Roy. Soc. Lond., lii, 316, 1898. ‡ Ibid., Lond., lxxvi (A), 88, 1905.
§ *l. c.* ‖ Nature, lxxv, 165, 1906. ¶ C. R., cxli, 383, 1905.

which would be formed according to this hypothesis, and to compare this amount with the amount actually present in the minerals.

Calculations and comparisons of this sort have been made for a number of minerals and the results are given in the following table (Table IV).

TABLE IV.

No.	Mineral	Per cent Lead	Per cent Helium present	Per cent Helium calculated	R
1.	Uraninite, Glastonbury, Conn.,	2·9	0·34	0·43	79
2.	Uraninite, Branchville, Conn.,	4·0	0·39	0·60	65
3.	Uraninite, Elvestad, Nor.,	9·3	0·18	1·40	13
4.	Uraninite, North Carolina,	3·9	0·05	0·58	9
5.	Uraninite, Skaartorp, Nor.,	8·8	0·15	1·32	11
6.	Uraninite, Huggenäskilen, Nor.,	8·8	0·15	1·32	11
7.	Uraninite, Anneröd, Nor.,	8·4	0·17	1·26	13
8.	Uraninite, Elvestad, Nor.,	8·0	0·15	1·21	12
9.	Uraninite, Llano Co., Tex.,	9·4	0·08	1·40	6
10.	Uraninite, Colorado,	0·6	0·02	0·10	20
11.	Uraninite, Arendal, Nor.,	10·2	0·16	1·53	10
12.	Thorianite, Ceylon,	(2·6)	0·16	0·40	40
13.	Aeschynite, Hitteroe, Nor.,	(1·2)	0·02	0·18	11
14.	Samarskite, North Carolina,	(0·42)	0·03	0·06	50
15.	Gadolinite (?), Ytterby, Sweden,	(0·25)	0·04	0·04	100
16.	Cyrtolite, Texas,	(0·53)	0·02	0·08	25
17.	Euxenite, Arendal, Nor.	(0·41)	0·013	0·06	20
18.	Uraninite, Canada,	10·5	0·12	1·6	8
19.	Thorianite, Ceylon,	2·40	0·19*	0·36	53
20.	Thorianite, Ceylon,	2·25	0·15	0·34	44

Nos. 1 to 11 and No. 18 are from analyses by Hillebrand, Nos. 12 to 17 from determinations by Strutt (the per cent of lead being calculated from the ratios in Table I), No. 19 from the analysis of Dunstan and Blake, and No. 20 from that of Büchner. In the last column under the heading *R* is given the ratio of the amount of helium actually present to the amount formed according to the hypothesis multiplied by 100, or in other words, the percentage of the total helium formed which has been retained by the mineral.

It will be noted that the values obtained in this manner for *R* are very reasonable numbers and are not unlike what might be expected from general considerations. This relation is the more evident when the density of the minerals is also exam-

* In the analysis of Dunstan and Blake an error is made in calculating the per cent of helium in this mineral, which is given as 0·39 per cent of helium. It is stated that the mineral contained 10·5^{cc} of helium per gram which is equal to 0·19 per cent of helium.

ined. The densities of only the first ten minerals are known, and these densities with the corresponding values for *R* are given in the table which follows.

TABLE V.

No.	Sp. gr.	R	No.	Sp. gr.	R
1.	9·62	79	6.	8·93	11
2.	9·35	65	7.	8·89	13
3.	9·14	13	8.	8·32	12
4.	9·08	9	9.	8·29	6
5.	8·96	11	10.	8·07	20*

None of the minerals listed in Table IV contains *more* helium than is to be expected from the assumption that helium is produced by the disintegration of uranium only, and in general with greater density of the mineral a greater proportion of the total helium formed has been retained within it.

Age of Minerals.

If the quantity of the final product occurring with a known amount of its radio-active parent and the rate of disintegration of the parent substance are known, it becomes possible to calculate the length of time which would be required for the production of the former. Thus, knowing the rate of disintegration of uranium, it would be possible to calculate the time required for the production of the proportions of lead found in the different uranium minerals, or in other words the ages of the minerals.

The rate of disintegration of uranium has not as yet been determined by direct experiment, but the rate of disintegration of radium, its radio-active successor, has been calculated by Rutherford† from various data. Rutherford's calculations give 2600 years as the time required for half of a given quantity of radium to be transformed into final products. The fraction of radium undergoing transformation per year is accordingly $2{\cdot}7 \times 10^{-4}$, and preliminary experiments by the writer on the rate of production of radium by actinium‡ have given a value which is in good agreement with this number. The quantity of radium associated with one gram of uranium in a radio-active mineral has also been determined§ and was found to be $3{\cdot}8 \times 10^{-7}$ gram. On the basis of the disintegration theory, when radium and uranium are in radio-active equilibrium, an equal number of molecules of each disin-

* It should be explained that No. 10 is really a secondary uraninite and is, therefore, not directly comparable with the others.

† Phil. Mag. (6), xii, 367, 1906.

‡ This Journal, xxii, 537, 1906.

§ Rutherford and Boltwood, this Journal, xxii, 1, 1906.

tegrate per second, and, for our present purposes, we can neglect the difference in atomic weight and simply assume that in any time the weights of radium and uranium which undergo transformation are the same. In one gram of uranium the weight of uranium which would be transformed in one year would therefore be $2{\cdot}7{\cdot}10^{-4} \times 3{\cdot}8{\cdot}10^{-7} = 10^{-10}$ gram, and the fraction of uranium transformed per year would be 10^{-10}.

In the table which follows (Table VI) the ages of the minerals included under Table I have been roughly calculated in accordance with the method outlined above. The ages of the minerals in years are obtained by multiplying the average value of the ratio 10^{10}. The general plan of calculating the ages of the minerals in this manner was first suggested to the writer by Prof. Rutherford.

Table VI.

Locality.	Age of minerals in million years.
Glastonbury (Portland), Conn.	410
Branchville, Conn.	535
Spruce Pine, N. C.	510
Marietta, S. C.	460
Llano and Burnet Co., Texas	1800
Douglas Co., Colorado	1900
Moss District, Norway	1300
Annerod, Norway	1700
Sabaragamuwa Prov., Ceylon	2200
Galle District, Ceylon	860

The actual values obtained for these ages are, of course, dependent on the value taken for the rate of disintegration of radium. When the latter has been determined with certainty, the ages as calculated in this manner will receive a greater significance, and may perhaps be of considerable value for determining the actual ages of certain geological formations.

Disintegration Products of Thorium.

The available data on the composition of the radio-active minerals serve to throw some light on the nature of the disintegration products of thorium as well as uranium. The relative proportions of uranium and thorium may show large variations in minerals from the same locality without exercising a noticeable effect on the value of the lead-uranium ratio for that locality. It can therefore be concluded with certainty that lead is not a disintegration product of thorium. This fact is particularly emphasized by the composition of the thorite found with the thorianite in the Sabaragamuwa province of Ceylon and in all probability of contemporaneous formation. The constituents of this mineral* are in part as follows: ThO_2, 66·26 per cent; CeO_2, 7·18 per cent; ZrO_2, 2·23 per cent; UO_2, 0·46 per cent. No lead at all is indicated as present, and the amount to be expected from the uranium is only 0·08 per cent, which was probably overlooked in making the analysis. A similar result was obtained in an examination by the writer of a specimen of thorite from Norway, which contained only 0·40 per cent of uranium, 52·0 per cent of ThO_2 and less than 0·10 per cent of lead. No mention is made of the presence of helium in the former of these thorites and in the specimen examined by the writer no indications of the presence of helium in measurable quantities were obtained. Although it has been stated by Ramsay† that the relatively large amount of helium contained in the thorianite from the Sabaragamuwa province is conclusive evidence of the production of helium by thorium, it seems quite probable that the evidence furnished by this mineral is quite the contrary, since it appears to contain only half of the amount of helium which would be produced by the disintegration of the uranium alone.

Summary.

Evidence has been presented to show that in unaltered, primary minerals from the same locality the amount of lead is proportional to the amount of uranium in the mineral, and in unaltered primary minerals from different localities the amount of lead relative to uranium is greatest in minerals from the locality which, on the basis of geological data, is the oldest. This is considered as proof that lead is the final disintegration product of uranium.

It has also been shown that, on the basis of the experimental data at present available, the amounts of helium found in radio-active minerals are of about the order, and are not in excess of the quantities, to be expected from the assumption that helium is produced by the disintegration of uranium and its products only.

The improbability that either lead or helium are disintegration products of thorium has been pointed out.

December 27, 1906.

* Dunstan and Blake, *l. c.*

† Jour. Chem. Phys., iii, 617, 1905.

ART. VIII.—*On a Dike of Diabase in the Potsdam Sandstone in the Valley of Virginia;* by THOMAS LEONARD WATSON.

THE occurrence of igneous rocks in the Paleozoic sediments of the Appalachian region is unusual. In 1883 Professor Fontaine* made record of basic igneous material intersecting the Virginia Appalachian Paleozoic sediments. This record was of a dike of igneous rock penetrating the Valley (Shenandoah) limestone of Cambro-Ordovician age, and located two and a half miles northwest of Waynesboro, in Augusta county, Virginia. He says: "A heavy dike of trap penetrates the limestone on Mr. Steele's place, running in a N.W. and S.E. direction, and passing a considerable distance in the Valley."

In 1890, Mr. Darton† described the occurrence of a small group of basalt dikes in the Upper Silurian and Lower Devonian beds in Highland county, lying west of Staunton, Virginia. Mr. Darton's paper was accompanied by descriptive notes on the petrography of the basalt dikes by Mr. Diller.

In 1896, Mr. Darton‡ extended his observations farther west, which resulted in the discovery of additional basalt dikes, and a very interesting series of acid dikes, classified by Mr. Keith as "felsophyre." The acid and basic igneous material collected by Mr. Darton was studied microscopically by Mr. Keith and his results were incorporated in the former's paper. Two of the dikes described were found in the adjoining portion of Pendleton county, West Virginia.

Keith recognized three distinct types of texture in the basic rocks, which were the basaltic, the diabasic, and the porphyritic. Considerable variations of texture characterized the acid rocks. According to Mr. Darton, the dikes penetrate limestones, shales, sandstones, and quartzites, which range in age from Cambro-Ordovician to Lower Devonian, inclusive.

While studying the manganese deposits along the western base of the Blue Ridge during the summer of 1906, I was attracted by the occurrence of a small isolated exposure of basic igneous rock in the Valley Paleozoic sediments. A careful examination showed the exposure of igneous rock to be in the so-called Potsdam sandstone (Cambrian) and very near its contact on the west with the Valley (Shenandoah) limestone. This exposure is in Augusta county and about one mile north of Basic, and about fifty paces from and on the east side of the Shenandoah Valley division of the Norfolk and Western Railway, near the crossing of the railroad by the wagon road.

* The Virginias, iv, 45, 1883.

† This Journal, vol. xxxix, 269–271, 1890. ‡ Ibid., vol. vi, 305–315, 1898.

The igneous rock was readily traceable for a distance of 100 feet or more in a nearly north-south direction, by large and small bowlders on both sides of the wagon road, and by partially decayed rock *in place* in the wagon road. A search in the immediate vicinity of the exposure failed to reveal more of the material.

The rock is very dark, nearly black in color and is of dense medium texture. A microscopic examination of a thin section of it shows a typical olivine diabase in mineral composition and texture. The principal constituents are augite, plagioclase, feldspar, olivine, and magnetite. The lath-shaped feldspars are enclosed by the crystalline augite in typical diabasic structure. Measurements of the extinction angle on 010 of the feldspar show it to be a basic plagioclase, a part of which corresponds to labradorite and a part to bytownite, largely to the more basic bytownite series.

As to the age of the diabase, it can only be suggested that it is Mesozoic, since it is in every respect entirely similar to the diabase dikes found penetrating the Newark series of rocks in Piedmont, Virginia, east of the Blue Ridge. It is entirely massive and unaltered, save from atmospheric agents, which have resulted in the formation of a crust of clayey limonitic material on most of the bowlders.

Geological Department, Virginia Polytechnic Institute,
Blacksburg, Virginia, December, 1906.

Art. IX.—*A Spectrum of the Röntgen Rays from a Focus Tube, and the Relatively Selective Absorption of Röntgen Rays in Certain Metals. A preliminary note;* by John Mead Adams. (With Plate I.)

In the course of a research upon the transmission of Röntgen rays through metallic sheets, it became necessary to test by direct experiment Röntgen's theory that an ordinary beam of Röntgen rays is heterogeneous and that substances show selective absorption toward the different kinds of rays; and furthermore to ascertain whether the selective absorption, if it exists, follows the same law for all substances; in other words, whether the absorption of different substances is relatively selective.

To obtain a direct answer to these questions a spectrum of Röntgen rays was sought by the following method: A Röntgen-ray tube (see figure 1, Plate I) was prepared, like an ordinary focus tube in all essential respects except for the target. The target consisted of a strip of platinum $6{\cdot}3^{cms}$ long by $1{\cdot}3^{cms}$ wide, bent into a circular arc of 5^{cms} radius and placed in the tube in the position indicated by T in the figure. A thick lead screen was set up in front of the tube (that is, facing the concave side of the target) in a plane parallel to the axis of the tube, and about 18^{cms} distant from it. At a point opposite to the target this screen was pierced by a small hole about $0{\cdot}15^{cm}$ in diameter with bevelled edge. A photographic plate or a fluorescent screen could be placed parallel to the lead screen and about as far in front of it as the axis of the tube was behind it. When the tube was in operation under these circumstances, an observer at the fluorescent screen perceived a bright spot upon it—the image of the spot on the target where the cathode discharge from the electrode C focused, formed according to the principle of the pin-hole camera. A magnetic field was then applied to the tube in the neighborhood of the electrode C, in direction perpendicular to the plane of the paper, and of such magnitude that the cathode discharge was spread into a spectrum* along the concave surface of the target. The bright spot upon the fluorescent screen was now drawn out into a band, and it was to be expected that the Röntgen rays at different points along this band would show different properties, since they were produced by cathode particles which differed from one another, presumably in velocity.

That a more or less complete separation of the Röntgen rays into a spectrum was actually effected was made plain by divid-

* Birkeland, Comptes Rendus, cxxiii, p. 492, 1896.

ing the band into halves lengthwise, and photographing it while one-half was covered by a sheet of copper 0·0044^{cm} thick, the other half being uncovered. Figure 2 shows a photograph thus obtained. The width of the band was limited by brass strips with bevelled edges about 0·3^{cm} apart. The Röntgen rays produced by the least deviated cathode particles are at A, those produced by the most deviated cathode particles at B. The difference in absorbing power of the copper at the two ends of the band is plain. The variations in intensity along the uncovered half of the spectrum give a rough idea of the distribution of the different kinds of rays.

The existence of relatively selective absorption in the case of one pair of metals, aluminium and silver, was shown by photographing one-half of the spectrum through a sheet of one metal, the other half through a sheet of the other. The aluminium was 0·16^{cm} thick, the silver 0·002^{cm}. Figure 3 shows a set of these photographs. In that figure CD is a comparison spectrum, photographed without the interposition of any metal. In the photograph EF, the silver was on the left and the aluminium on the right. The thicknesses of the two sheets were so chosen that the rays at E, corresponding to the least deviated cathode particles, were equally absorbed in them. Under these circumstances, the rays at F were transmitted by the silver in much greater quantity than by the aluminium. To show that this effect was not to be explained by a difference in thickness of either sheet at different points along the spectrum, the sheets were turned in their own plane through two right angles, and the photograph GH was then made, showing the effect unchanged. Secondary radiation from the sheets was not present in appreciable quantity at the photographic plate; for if it had been, it would have resulted in a blurring of the boundaries of the shadows on the plate, the distance between the latter and the sheets being about 2^{cms}.

Another pair of metals, aluminium and tin, has been found to show relatively selective absorption to some extent, but the effect has not yet been obtained sufficiently well marked for reproduction.

The conclusions to be drawn from these experiments are the following:

(1) The beam of Röntgen rays from a focus tube which yields a magnetic cathode spectrum is heterogeneous.

(2) A metallic sheet shows selective absorption of the different rays.

(3) This selective absorption does not follow the same law in all metals: in certain pairs of metals the absorption is relatively selective.

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ART. X.—*The Limeless Ocean of Pre-Cambrian Time;* by
REGINALD A. DALY, Ottawa, Canada.

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Introduction.

Unfossiliferous pre-Cambrian and Cambrian formations.—In comparatively recent years a new stratigraphic province has been discovered in the mountain-tracts of British Columbia, Alberta, Montana and Idaho. A dozen workers in Canada and the United States have now established that the region is underlain by an exceptionally thick series of sedimentary rocks, sandstones, argillites, conglomerates, limestones and dolomites. These rocks are proved to be of Cambrian and pre-Cambrian age. Along the international boundary the series is conformable throughout. In the southern Selkirk range its base is exposed and nearly 27,000 feet of these sedimentaries, besides 6,500 feet of contemporaneous basic lavas, are seen resting, in strong unconformity, upon an older, Archean, series of schists, quartzites and impure dolomites. In the Purcell range some 20,000 feet of the rocks are exposed, and, in the Rocky Mountains proper, about 14,000 feet are exposed, but in neither case is the base there seen.

This stratigraphic province is notable for furnishing the characteristic "Algonkian" fossil, *Beltina danai*, one of the most ancient organisms yet found. At the international boundary the sedimentary series is no less remarkable for its almost absolute failure to carry other fossil shells or skeletons. During the summer of 1906 the writer secured evidence that the Siyeh formation in Montana is stratigraphically equivalent to the main division of the Castle Mountain limestone in Alberta, and is therefore of Cambrian age; but this evidence, while very strong, is based entirely on the lithological similarity of the two formations and of the respective underlying formations. Willis, Weller and Walcott have all carefully searched for fossils in the Siyeh dolomite, limestone and argillite as well as in the associated rocks, but have met with almost no success, except in the *Beltina* horizon (Altyn limestone), as already noted. Considering their age and relations, these rocks are all singularly free from signs of important dynamic metamorphism. As the writer has worked, season after season, on the magnificent sections exposed along the forty-ninth parallel, the failure to find fossils anywhere through thousands of feet of the most likely looking shales and limestones, has itself become a geological problem.

Explanations of the Unfossiliferous Character of pre-Cambrian Sediments.

1. *Hypothesis of the metamorphic destruction of fossil remains.*—The view that shells or skeletons were actually once present in anything like the proportions characteristic of Silurian or later marine sediments, and have since been destroyed through either static or dynamic metamorphism, has proved as unsatisfactory for these pre-Silurian American terranes as it has for pre-Silurian terranes throughout the world. The opposed hypothesis that the hard parts of marine animals were seldom entombed in pre-Cambrian strata is worthy of careful examination. This latter hypothesis is multiple, since it may postulate different causes for the lack of entombment. All postulates must, however, recognize the fact that the mechanical conditions of burial and preservation were all present. So far as chemical composition, detrital composition, rapidity of deposition, etc., are concerned, the sediments of the Cordilleran province, as of other pre-Cambrian formations, are ideal for perfect fossilization.

2. *The Brooks hypothesis.*—The admirable essay of W. K. Brooks in the Journal of Geology (vol. ii, 1894, p. 455) states one conceivable hypothesis. He suggests that the photobathic zone of the sea, including the bottom, first became inhabited just before Cambrian time. He considers it probable that all the fundamental types of animals from protozoon to mollusc and arthropod, but all as yet soft-bodied, had been evolved in the surface waters of the open sea, far from land. At the

close of pre-Paleozoic time the pelagic fauna first discovered the advantages of life alongshore and the special advantages of life on the bottom of the shallow coast-waters. Owing to the intense struggle for existence within the shore-zone, there was, in early Cambrian time, a rapid acceleration of development which tended towards the relatively sudden evolution of hard calcareous and chitinous structures, which functioned as means of protection, of offence or of otherwise perfecting the animals for successful combat. The fossilization of marine animal types, therefore, first became possible in Cambrian time simply because hard parts had then first become evolved.

A principal and perhaps fatal objection to Brooks's idea is that there is no apparent reason for the long postponement of the "discovery of the sea-bottom." We can hardly doubt that, throughout the history of marine life, the shore-zone was as accessible to pelagic larvae, etc., as it is now and that the shore-zone afforded an advantageous habitat to marine organisms in pre-Cambrian time as at the present. Professor Brooks agrees with most other authorities that the time occupied in the evolution of the soft-bodied but highly diversified pelagic species must have been enormous. It is scarcely conceivable that, in the time taken to evolve such high types as cephalopods and trilobites, the shore-zone should not have been long successfully colonized. Skeletal and shell structures should, therefore, have been developed several geological ages before the epoch of high specific differentiation illustrated in the Cambrian. The conclusion seems unavoidable that the sudden appearance of abundant fossils in certain Cambrian beds is not due to a relatively late colonization of the shore-zone. Everyone must recognize the value of the shore-zone as stimulating the evolutionary process, but the Brooks hypothesis breaks down because it grants an inexplicable postponement of the shore-line's influence.

3. *A suggested hypothesis.*—A third hypothesis may be based on most of the fundamental postulates of biology involved in Brooks's conception. Among these may be specially recalled: (*a*) the very slow evolution of higher animal types from primordial, soft-bodied, simple types; (*b*) the supposition that the bulk of marine animals and plants were, in pre-Cambrian time as now, pelagic and free-swimming; (*c*) the further reasonable supposition that the pre-Cambrian sea was thoroughly tenanted with animals. The point of departure of this third hypothesis lies in the premise that, accepting these three postulates, it was impossible during much of life's evolutionary period, for animals to secrete limey structures at all; for *practical physiological purposes* lime salts were non-existent in the sea-water for most of the pre-Cambrian life-period.

So far as known to the writer, this hypothesis as a whole has not been stated in geological or biological literature. Macallum has suggested that calcium salts were but sparingly present in the "earlier Archæan seas," and notes the possibility that pre-Cambrian organisms could therefore not have acquired the "lime habit"; but he gives no explanation of the supposed small content of lime in the sea-water.* Such explanation is the kernel of the hypothesis. The present paper is intended to be a statement of the chemical grounds on which may be based a reasonable belief in a nearly limeless sea during most of Eozoic time.† Incidentally, there is offered a suggestion as to the origin of dolomite and of magnesian sediments so abundantly represented in pre-Cambrian formations. The origin of certain iron ores, cherts, jaspers and certain emanations of petroleum and natural gas will also be briefly considered.

The writer's sincere thanks are due to Mr. R. A. A. Johnston of the Canadian Geological Survey for much help in discussing the basal chemical reactions.

Precipitation of Lime Salts Through the Decomposition of Dead Organisms.

It follows from the main biological postulates of the hypothesis that, in the earliest sea, the higher animal types, including the active hunters and scavengers, were not yet evolved. An important corollary is that the carcasses of countless animals living at the surface would, after death, fall to the sea-floor, there accumulate and decompose. The rate of decay is in some direct proportion to the temperature. It is in the highest degree probable that the pre-Cambrian polar waters were much warmer than the polar waters are now. Since the bottom temperatures of the whole ocean-basin are influenced by polar temperatures, it is fair to conclude that the bottom temperatures of the pre-Cambrian sea were relatively high. Animal carcasses fallen to the sea-floor would therefore not be in cold storage but would undergo putrefaction. Murray holds that putrefaction takes place even at the present low temperatures of the sea-bottom.‡

During putrefaction ammonium carbonate is given off in large volumes. This powerful alkali has the property of rapidly converting the chloride and sulphate of calcium into

* Transactions, Canadian Institute, vol. vii, 1903, p. 536.

† Throughout this paper the term "Eozoic" will be used to designate the entire pre-Paleozoic æon of life-history on the earth. Still earlier time will be referred to as belonging to the "Azoic" æon.

‡ Report on the Deep Sea Deposits, Challenger Expedition, 1891, p. 256.

precipitated carbonate of calcium. The usual equations for the reactions may be noted:

$$CaSO_4 + (NH_4)_2CO_3 = CaCO_3 + (NH_4)_2SO_4$$
$$CaCl_2 + (NH_4)_2CO_3 = CaCO_3 + 2NH_4Cl$$

Both of these reactions are reversible,* so that new calcium carbonate introduced by rivers into sea-water after the original sulphate and chloride had been converted, would be first changed to the sulphate or chloride and then finally precipitated.

The precipitation occurs, of course, only in the bottom stratum of the sea-water. Diffusion and the vertical interchange of water must tend, in a long period, to remove all the calcium salts from the ocean. At length there would remain in solution only a minute quantity of calcium salts brought into the ocean by the short pre-Cambrian rivers and not yet diffused to the bottom stratum.

Experiment shows that the pure magnesium salts of sea-water from which calcium salts have been eliminated are unavailable for the elaboration of carbonate shells and skeletons by organisms, although the organisms live and thrive in such water. Granting that the essential protoplasmic requirements were, in pre-Cambrian time, the same as now, experiments thus show the complete possibility of abundant pre-Cambrian marine life in the form of soft-bodied, highly diversfied animal types.

The Eozoic æon was, then, divided into two parts, a long period during which the calcium salts inherited from the Azoic sea were being precipitated, and a much longer period during which the steady evolution of animal types took place in an essentially limeless sea.

Duration of the limeless sea.—The conditions suitable for the development of lime-secreting organisms might have been established in three different ways.

Putrefaction on the sea-floor has, among its other effects, the generation of much sulphuretted hydrogen by the decomposition of sulphates. The bottom of the Eozoic ocean may have thus been poisoned by the gas in a manner similar to that observed in the world's largest perfect desert, the basin of the Black Sea. The evolution of bottom scavengers or at least the colonization of the general sea-bottom, may have been long delayed. Nevertheless, it is possible that the emanation of sulphuretted hydrogen from sea-water in which calcium sulphate was almost entirely removed (leaving magnesium sul-

* Like hydrochloric acid, most chlorides are practically completely dissociated in dilute aqueous solutions. Analytical Chemistry, by F. P. Treadwell, trans. by W. T. Hall, New York, p. 249, 1905.

phate and other sulphates acted on by decaying animal matter as one source of the gas) grew less as time went on, and that the sea-bottom water thereby became gradually sweetened and fit for colonization. The scavenging system once established, it would now be possible for river-borne calcium salts to accumulate in the sea.

Secondly, it is conceivable that the ancient animal types could elaborate limey structures from even the minute quantity of calcium carbonate which sea-water can hold in solution, and that these animals did not then need the sulphate or chloride of calcium for the secretion of calcareous structures. Calcium carbonate could not reenter the essential composition of the ocean until the acid radicals freed from the sulphate and chloride (inherited from the Azoic sea) were either destroyed as such or were satisfied by yet stronger bases than lime. The sulphuric acid of the existing seas is being constantly converted into insoluble iron sulphide and free sulphur. This reaction takes place best where ferruginous muds are suspended in the water. It would have but limited effects on the floor of the deep sea far from the pre-Cambrian land. Nevertheless, the whole water-body would, through diffusion and marine currents, be in time affected by the reaction and the sulphuric acid radical of the Eozoic sea would be slowly destroyed. How extensively the radical was replaced by the volcanic emanation of sulphurous gases from the earth's interior cannot be demonstrated.

Yet more obscure are the reactions which might have led to the more permanent binding of the sulphuric acid and chlorine radicals to magnesium introduced to the sea in the form of the carbonate by the rivers. The chlorine radical freed from calcium chloride might have become in part gradually bound to sodium.

The utmost efforts of chemists may be unable to determine fully the exact reactions that take place in so complex a solution as sea-water, but it seems fair to grant the possibility of some such rearrangements among the ions of the Eozoic sea-water. Sodium and magnesium salts are the dominant salts in the sea to-day and it is simplest to suppose that they have become so because of a slow evolution of an ocean tending towards a maximum ionic stability. The sulphates are to-day relatively subordinate because of the very extensive precipitation of insoluble sulphides and carbonates, directly or indirectly through the chemical influences of living or putrefying animals.

If, finally, the acid radicals became either destroyed as such or permanently bound to bases more powerful than lime, the concentration in the sea-water of calcium carbonate introduced by rivers first became possible. Then and then only might have been initiated the epoch in which an indefinitely continuous series of lime-secreting animals could be evolved. The beginning of this epoch might have been near the opening of the Cambrian period.

Or, thirdly, we may suppose that a relatively sudden influx of river-borne calcium salts might produce an excess of them in the sea-water solution over that amount which hitherto was kept continuously precipitated by organic decay on the sea-bottom. In this case it is simplest to postulate that acid radicals were still free in some measure to convert the river-borne carbonates into sulphates or chlorides. By such reactions the calcium would appear in those salts which are now normally used by lime-secreting animals; the animals would then have a much more abundant source of calcium for the elaboration of hard parts than if the much less soluble carbonate only were present.*

Toward the close of Eozoic time there occurred one of the world's greatest mountain-building revolutions. Very extensive mountain-ranges were then erected and the continents grew to large size. In a monograph summarizing some of Walcott's researches on the Cambrian formations of North America, the author writes:

"The continent was well outlined at the beginning of Cambrian time; and I strongly suspect, from the distribution of the Cambrian faunas upon the Atlantic coast, that ridges and barriers of the Algonkian continent rose above the sea, within the boundary of the continental plateau, that are now buried beneath the waters of the Atlantic. On the east and west of the continental area the pre-Cambrian land formed the mountain region; and over the interior a plateau existed that at the beginning of, or a little before, Upper Cambrian time was much as it is to-day. Subsequent mountain building has added to the bordering mountain ranges, but I doubt if the present ranges are as great as those of pre-Cambrian time that are now known only by more or less of their truncated bases. The Interior Continental area was outlined then and it has not changed materially since. Its foundations were built in Algonkian time on the Archean basement, and an immense period of continent growth and erosion elapsed before the first sand of Cambrian time was settled in its bed above them."†

Following the last world-wide, orogenic paroxysm of pre-Paleozoic time, there was a long interval of more or less perfect baseleveling. In the process thousands of cubic miles of rock were weathered and a large proportion of their mass went,

* Cf. Murray and Irvine, Proc. Royal Society of Edinburgh, vol. xvii, p. 90, 1889.

† 12th Annual Report, United States Geological Survey, p. 562, 1891.

in solution, to the sea. At least three conditions were present to favor at this time a special enrichment of the sea-water in soluble salts of calcium. Great volumes of basic volcanic rocks were now for the first time exposed to weathering, with the necessary evolution of lime salts; the limestones chemically precipitated in Azoic and earlier Eozoic periods were now, for the first time, exposed to solution in rain-water; and the areas of the lands and of drainage-basins, with all their assemblage of weathering heterogeneous rocks, were probably greatly increased over their magnitudes in former times.

In view of the slowness of diffusion in a body so great as the ocean, it is not difficult to believe that this special influx of river-borne calcium salts might keep the surface layers of the sea-water sufficiently supplied with calcium sulphate and carbonate for organic needs while the bottom stratum was as continuously being depleted of all lime salts. Since lower Cambrian time the continents have in part undergone submergence and emergence, but they have doubtless never resumed their small total area characteristic of the early Eozoic period. We are therefore justified in believing that the river-borne calcium salts have nearly as well supplied lime-secreting marine organisms throughout post-Cambrian time.

It is obviously impossible to decide as to which of these three suppositions is the true one or as to whether all three may contain some of the whole truth. As a working hypothesis the third alternative seems the most promising. There is something to be said for the view that the colonization of the general sea-floor by active scavengers did not occur until after Cambrian time; without here entering on the discussion of the question, this conclusion is assumed to be a fact. It seems almost certain, however, that the "lime habit" of marine organisms first became fully established at a time subsequent to the great pre-Cambrian orogenic revolution. We assume, for further argument, that the new "lime-habit" was, in the main, dependent on the preliminary secular weathering of the continents which were enlarged by that revolution, and enriched in the highly soluble limestones then upfolded.

The oldest calcareous fossils in the stratified rocks.—The invention of chitinous exoskeletons (which, themselves, in Cambrian types, contain some lime carbonate or phosphate and were preserved for that reason), furnishes the link between the soft-bodied Eozoic animals and the post-Cambrian dominant species armored with calcium carbonate. The Cambrian brachiopod shells are often similarly chitinous and offer other illustrations of the link between these two principal organic epochs.* The unique and permanent change in the oceanic

* J. D. Dana, Manual of Geology, p. 486, 1895.

composition made possible the dominance of post-Cambrian molluscs, brachiopods, etc., and made also possible the preservation of countless post-Cambrian fossils.

Following our main hypothesis, the chief animal fossils expected in Eozoic rock are impressions of soft-bodied species, the tests of siliceous organisms, and chitinous tests. The last will be expected only in the higher beds of the series and should owe their preservation to limey ingredients secreted by the animals inhabiting the late Eozoic sea. Along with the chitinous fossils may be a few calcareous shells or skeletons also evolved because of the late Eozoic enrichment of the sea in river-borne lime salts. These are, in fact, the kinds of fossils discovered in the pre-Cambrian rocks by Walcott, Barrois, Cayeux and others. For obvious reasons fossils of all four classes must be few or else difficult to discover in the rocks. The very presence of the impressions of medusæ in rocks as old as the lower Cambrian strengthens the suspicion that the metamorphic hypothesis cannot explain the absence of calcareous shells or of their impressions in many thousands of feet of equally little metamorphosed Eozoic sediments. The impression of a shell is assuredly more likely to be preserved in mud or sand than is the impression of a medusoid animal. It seems, on the other hand, certain that the pre-Cambrian rocks of the North American Cordillera never at any time contained any considerable number of calcareous shells or skeletons. The same conclusion applies in some measure to the Cambrian rocks of the British Columbia-Montana section.

Tests of the Suggested Hypothesis.

The rearrangement in the chemical constituents of pre-Cambrian ocean-water through the decay of animal matter is the fundamental premise of the hypothesis and it deserves special examination and illustration. The tests of the premise are at least threefold:—laboratory experiment, observations on existing seas, and the witness of pre-Cambrian deposits, particularly of the carbonates.

1. *Corroborative experiments.*—Murray, Woodhead and Irvine have made a number of valuable observations on the chemical modification of sea-water exposed to the emanations of putrefying animal matter and to the effete substances derived from living animals.*

In one experiment four small crabs weighing 90·72 grams were placed in sea-water absolutely free from carbonate of lime. After twelve months they produced an alkalinity in the water equal to the production of 45·36 grams of calcium

* Proceedings, Royal Society of Edinburgh, vol. xvii, p. 79, 1889.

carbonate. This effect was due to the decomposition of calcium sulphate by the uric acid, urea and other effete matter.

In a second experiment it was found that in seventeen days and at temperatures ranging from sixty to eighty degrees Fahrenheit, the decomposition of urine mixed with sea-water had precipitated practically all the sulphate of lime present. A similarly complete precipitation of all the sulphate in a solution of pure water and calcium sulphate present in the proportion of average sea-water, was effected in eleven days by the decomposition of urine added to the solution.

In a fourth experiment, nine small crabs were placed in two liters of water, where they died. Complete putrefaction set in and continued at temperatures varying from seventy to eighty degrees Fahr. Analysis showed that all the lime salts were precipitated in the form of the carbonate.

Irvine and Woodhead have shown conclusively that marine animals, even those normally secreting limey structures, will live and comparatively thrive in sea-water from which every trace of lime salts has been eliminated.* In one experiment they mixed sodium chloride, magnesium chloride, magnesium sulphate and potassium sulphate with pure water in about the proportions of average sea-water. In this artificial sea-water (No. 1) they placed a number of crabs. In their proper seasons the exoskeletons were shed but, naturally, were never rebuilt by the animals. Yet the crabs continued to feed and live long after the exfoliation had taken place.

In a second experiment ·0903 per cent by weight of calcium chloride was added to No. 1 water, giving No. 2 water. In this the crabs lived and rebuilt their exoskeletons. This new structure was composed of the carbonate and phosphate of lime and chitinous matter in the proportions present in normal shells. Other crabs similarly throve in a third water in which the calcium sulphate in average sea-water proportion was substituted for the calcium chloride of No. 2 water. The proof is clear that the secretion of calcareous structures is by no means dependent upon the presence of calcium carbonate in sea-water.

The result of the first experiment was strikingly corroborated by a fourth experiment in which sodium chloride and magnesium chloride were dissolved in pure water in the proportions of average sea-water. Crabs and fish were found to thrive in this water, "feeding greedily, but of course ecdysis (elaboration of cast exoskeletons) in such water was impossible." Ecdysis was, however, carried out when calcium chloride was added to the solution.

* Proc. Royal Society of Edinburgh, vol. xvi, p. 324, 1889.

The whole series of experiments cited indicate the possibility, first, that the pre-Cambrian ocean could hold but a minute quantity of lime salts in solution unless those salts were being continually and largely fed into the sea and preferably fed at the surface, farthest from the bottom stratum of water charged with the products of decaying animal matter; and, secondly, that abundant life existed in water so nearly limeless.

2. *Observations on the Black Sea.*—The well known, remarkable studies of Andrussow and others on the hydrography and deposits of the Black Sea show that we have in a large, existing basin a strong analogy to the imagined Eozoic ocean.* As a result of a special series of geological events, this sea-basin is devoid of bottom scavengers over the greater part of its area. On the other hand, the surface fauna has always been abundant. The bottom has therefore received the fallen carcasses of the surface animals which, unceasingly, have putrefied in the relatively high temperature of that sea-floor. Two soluble products, ammonium carbonate and sulphuretted hydrogen, have been generated in enormous quantities at the bottom. The gas has poisoned the water from the greatest depth (1227 fathoms) to the level of about 100 fathoms) from the surface. Below the 100-fathom level no life is possible except that of a few anaerobic bacteria, one of which has been studied and named as the primary cause of putrefaction.

Corresponding to our hypothesis, it has been found that the bottom muds of the Black Sea basin are rich in a powdery deposit of carbonate of calcium. Far from shore, and thus in areas not so abundantly supplied with silts, the carbonate occurs in thin white layers. In shallower water, from "300 to 717 fathoms," the mud is black and the presence of the carbonate is masked by the relative increase of mechanical deposit.

The black muds, and less conspicuously the deposits of the greater depths, are strongly charged with disseminated iron sulphide. The mode of formation of this sulphide is summarized by Murray and Irvine in the following equations:

$$RSO_4 + 2C = 2CO_2 + RS$$
$$RS + 2CO_2 + H_2O = H_2S + RCO_3CO_2$$
$$RS + RCO_3CO_2 + H_2O = 2RCO_3 + H_2S$$
$$Fe_2O_3 + 3H_2S = 2FeS + S + 3H_2O$$

These reactions presuppose the absence of free oxygen. Andrussow points out, not only the incompatibility of oxygen and

* Guide des Excursions, vii^me Congrés Géologique Internationale, No. 29, 1897.

free sulphuretted hydrogen, but also states another cause of the poverty of the bottom waters in free oxygen. It is in part due to the lack of normal vertical currents in the Black Sea; these are impossible because of the peculiar density stratification of this basin.

The equations show that, in the presence of ferruginous muds, free sulphur is precipitated along with the sulphide of iron. It is thus easy to understand the formation of the numerous nodules of iron pyrites found in the black muds. In the main ocean near muddy shores the foregoing reactions also apply to a part of the changes produced by putrefaction. The analogous case of the Black Sea, therefore, proves the truth of the prevailing views as to the formation of iron pyrites in marine sediments, and also the corollary of our hypothesis as to the gradual destruction of the sulphuric acid radical in Eozoic seawater. That all the lime salts have not been precipitated from the Black Sea water is, of course, due to the large amount of Mediterranean water constantly renewing the lime salts by way of the bottom current at the Bosphorus.

It seems clear that the Black Sea is carrying on a gigantic natural experiment which strengthens belief in the main deductions so far made as to the physical and biological conditions of the Eozoic sea. In one important respect the analogy breaks down; we shall see that, after all the lime salts are removed from sea-water, the ammonium carbonate has special power to attack the magnesium salts. This fact cannot, for the reason just stated, be illustrated in the case of the Black Sea.

3. *Pre-Cambrian Sedimentary Deposits.*

A third test of the hypothesis consists in an examination of actual rock-deposits in the pre-Cambrian.

Origin of dolomite and other magnesian sediments.—It is an established fact that dolomites and magnesian limestones, sandstones and argillites are very common in pre-Cambrian rock-series. Granting that Eozoic organisms could not secrete magnesium carbonate shells or skeletons, it follows that the magnesian content of these rocks must have had a chemical origin.

The magnesium carbonate was not thrown down simply because this little soluble salt, as it was introduced by the pre-Cambrian rivers, saturated the sea-water. Then as now calcium carbonate was doubtless much in excess of magnesium carbonate in river-waters. We have seen that the acid radicals set free in the persistent precipitation of calcium carbonate, would, during Eozoic time, prevent the permanent solution of magnesium carbonate in any appreciable quantity. On the other hand, we must conclude that the long-continued precipitation of magnesium carbonate was effected by the action of a strongly alkaline carbonate. We are thus naturally led to the discussion of the possible precipitation of magnesium carbonate also by the ammonium carbonate emanating from decaying animals.

The experiments on this subject are, at first sight, contradictory. Linck has recently shown that when ammonium carbonate is added to sea-water, aragonite is precipitated but no magnesium carbonate was found by him in the precipitate.* On the other hand, Pfaff, using an artificial sea-water similar in composition to average sea-water, found that, after a certain interval of time a part of the magnesium in the salts was thrown down as the basic carbonate while there was an abundant precipitation of calcium carbonate.† Pfaff's result accords with the general experience of analytical chemists; hydrous magnesium carbonate will be precipitated by the alkaline carbonate *if time enough* be allowed.

The reactions for magnesium sulphate and chloride commonly assume the following forms:

$$4MgSO_4 + 4(NH_4)_2CO_3 + H_2O = Mg_4(CO_3)_3(OH)_2 + CO_2 + 4(NH_4)_2SO_4$$

and

$$4MgCl_2 + 4(NH_4)_2CO_3 + H_2O = Mg_4(CO_3)_3(OH)_2 + CO_2 + 8NH_4Cl$$

The presence of ammonium chloride tends to prevent the precipitation of the carbonate from a solution of magnesium chloride; it is important, therefore, to note the fact that ammonium chloride formed in this way at the sea-bottom diffuses away to upper strata of the ocean-waters and would not interfere with the final completion of the reaction.

Besides the element of time and the undoubted presence of an appreciable amount of magnesium salts in the pre-Cambrian sea, another principal factor must be considered. Hunt has shown that the precipitation of magnesium carbonate from sea-water by alkaline carbonates is facilitated if the calcium salts be removed. Our hypothesis states that the latter were absent from the bottom stratum through most of Eozoic time.

Again we may turn to the noteworthy experiments of Murray and Irvine for a suggestion of the truth of the foregoing statements. Their table No. VII is here reproduced. It shows the composition of the precipitate thrown out of a mixture of sea-water and urine after standing seven days, the

* Neues Jahrbuch für Mineralogie, etc., Beilage Band xvi, p. 502, 1903.

† F. W. Pfaff, Neues Jahrbuch für Mineralogie, etc., Beil. Bd., vol. ix, p. 504, 1894.

urine meanwhile decomposing and furnishing the alkaline carbonate.

Table VII.

Water and organic matter containing ammonia (7·38 p. c.)	31·81
Carbonate of lime	4·85
Phosphate of magnesia and ammonia	51·10
Phosphate of lime	12·24
	100·00

Table VIII shows the composition of the precipitate thrown out of the mixture (after filtration from the precipitate which was thrown out in seven days), standing other ten days.

Table VIII.

Water and organic matter	20·25
Carbonate of lime	75·35
Carbonate of magnesia	1·02
Phosphate of magnesia	3·38
	100·00

These tables* prove that the magnesium carbonate came down only after much, perhaps nearly all, of the calcium was precipitated as carbonate. It should also be observed that a considerable amount of the precipitating alkali, ammonia, was removed from the mixture in the first precipitate.

Murray and Irvine have also investigated the composition of the water filtered out of the mud dredged from the bottom in Granton Harbor and also near the Forth Bridge.† The following table gives the resulting total analysis of the salts of the average mud-water and also bears a column indicating the analysis of average sea-water :—

	Average Sea-water	Mud-water
Sodium chloride	77·758	79·019
Magnesium chloride	10·878	11·222
Magnesium bromide	0·217	0·220
Magnesium sulphate	4·737	3·232
Potassium sulphate	2·365	2·506
Ammonium sulphate	-----	0·206
Magnesium carbonate	-----	0·909
Calcium carbonate	0·345	2·686
Calcium sulphate	3·600	-----
	100·000	100·000

* Murray and Irvine, op. cit., p. 104.
† Transactions, Royal Society of Edinburgh, vol. xxxvii, p. 490, 1895.

In the mud-water calcium sulphate is absent, magnesium sulphate is deficient when compared with average sea-water; calcium carbonate is increased, and magnesium carbonate and ammonium sulphate are both present. The high chlorides show that the carbonates are not in excess because of fresh-water inflow. The ratio of magnesium carbonate to calcium carbonate is 1 : 3. When the clear water filtered from the mud was boiled for a short time, a crystalline precipitate was thrown down, consisting of 73·3 per cent calcium carbonate and 26·7 per cent magnesium carbonate. The formation of both carbonates is ascribed by Murray and Irvine to the reaction of ammonium carbonate chiefly on the sulphates, a conclusion which cannot be doubted, especially in view of the presence of ammonium sulphate in the mud-water. The alkaline carbonate was, of course, derived from decaying animal matter contained in the muds.

These different experiments teach that hydrous carbonate of magnesium can be precipitated by ammonium carbonate emitted from decaying animal remains; that the precipitation is much slower than in the case of calcium carbonate and is retarded by the presence of calcium salts in the solution. We thus see how, in the nearly limeless sea-water of pre-Cambrian time, the proportion of precipitated magnesium carbonate would be high, even, possibly, approaching the ratio in true dolomite. Indeed, it is quite possible that precipitates of pure basic carbonate of magnesium later changed to magnesite, were formed in those places in the sea-basin where the calcium salts were completely absent from the oceanic composition.

Clearly our ideas must not be too rigid regarding the detailed history of these early magnesium deposits. We cannot say how far the sea-waters in which animal life first began were charged with magnesium salts. We cannot say how far these and the other salts brought in by the early rivers contributed to the formation of the extensive dolomites and magnesium limestones known to occur in pre-Cambrian terranes. Our hypothesis holds that the calcium carbonate of the dolomites and of the pure calcium-limestones was, for most of the Eozoic æon, introduced to the sea by the rivers. Notwithstanding the slowness of the precipitation of magnesium carbonate at ordinary temperatures, some excess of magnesium salts in solution in that sea might easily permit the basic magnesium carbonate to be thrown down in very high proportion when compared with the precipitate of the other carbonate. What determined the actual composition of any one bed cannot be declared. Opposite the mouth of a large river we might expect beds of practically pure calcium carbonate. Far from shores the chemical deposit would be more magnesian. Gradual changes in the rivers, in the marine currents, or in the configuration of the coast-line would cause alternations in the composition of the precipitate, the magnesium component rising or falling according to the highly variable circumstances. The beds would further be indefinitely varied according to the proportion and kinds of mechanical detritus intermixed with carbonates. Eozoic sediment may be fetid to-day because of the residual animal matter imprisoned in such detritus and chemical precipitate.

When calcium salts, at or about the beginning of Cambrian time, came into permanent excess in sea-water (i. e., excess over the needs of lime-secreting organisms), the precipitation of magnesium carbonate became more difficult, but this change would be extremely slow. Even at the present day the proportion of lime salts in sea-water is low. The existing rivers are nearly the greatest rivers the world has known, so far at least as drainage basins are concerned. Those rivers flow through immense tracts of limestone and dolomitic formations which evidently did not furnish carbonate to rivers of Paleozoic or Mesozoic age. It is clear that Paleozoic and Mesozoic rivers may have sent even less sulphate and carbonate of calcium into the sea than is now being poured into it. We should, therefore, expect that, during the Paleozoic and Mesozoic æons, there was a less abundant precipitation of magnesium carbonate than during the Eozoic, but a more abundant precipitation than at the present time.

Another factor has tended to operate in the same sense. Not only have the growing rivers tended to increase the proportion of calcium salts in the sea-water ; the establishment of a scavenging system on the general sea-floor has rendered it possible for the dissolved calcium sulphate to increase and so lessen the precipitation of magnesium carbonate.

According to Murray, the calcium sulphate now dissolved in the ocean could be introduced by existing rivers in about 600,000 years. Since the sulphate is being constantly decomposed by lime-secreting organisms and converted into deposited carbonate, it is probable that much more than 600,000 years have elapsed since the abyssal fishes and other scavengers colonized the general sea-floor. That the present content of calcium sulphate in sea-water would be largely and rapidly diminished if the scavenging system were not now at work in the ocean, is to be inferred from the test case of the Black Sea. The scavenging system was first developed probably several millions of years ago, perhaps in Cretaceous time. Since then the chemical precipitation of magnesium carbonate has been possible only under special conditions ; the recent period is a time of the minimum formation of magnesian deposits.

The observations of Murray and Irvine on mud-waters suggest that, at the present day, there may be a slow addition of magnesium carbonate to the deposits of pure calcium carbonate shells or skeletons. A fairly pure calcareous ooze or shell-bank or a porous coral reef may be charged with decaying animal matter. Within the myriad interstices of the deposit there is sea-water into which ammonium carbonate is being passed. This alkali precipitates all the calcium salts in the quasi-imprisoned water. Thereafter will follow a slow but steady precipitation of magnesium carbonate within the ooze or sand; if the amount of alkaline carbonate suffices, the magnesium salt may be added to the deposit in large amounts.

Again, the law of mass-action may also have sway. After the calcium salts have been precipitated from sea-water, the relatively abundant magnesium sulphate may possibly react on the already precipitated calcium carbonate so as to replace a considerable portion of it by magnesium carbonate.* The writer is not familiar with experiments bearing on this point but it is noted as a possible mode of the formation of dolomite, which is a real though indirect result of the decay of animal matter on the sea-bottom. So far as this method operated, it too was most potent in Eozoic times.

There are yet other ways in which magnesium carbonate may be elaborated from sea-water—through certain algae and a few animals known to secrete magnesium carbonate along with the dominant calcium carbonate of their hard structures, or, finally, through the local evaporation of sea-water. However, the quantitative value of all these sources just mentioned may well be suspected to be but subsidiary to a more general cause of dolomite formation. Most of the world's magnesian limestones and dolomites seem to owe their origin neither to the secretions of special organisms nor to evaporation. The special organisms are too rare in one case; evaporation must be too local for the other case.

The scope of the present paper does not permit of a critical discussion of the many published theories concerning the dolomites. It may only be stated that, if we accept the leaching hypothesis or the hypothesis that dolomite is the result of metamorphic processes by which magnesium comes to replace calcium in ordinary limestone, we meet with very grave difficulties, long ago stated and never overcome. The rapid alternation of clean-cut beds of pure or nearly pure calcium carbonate with other clean-cut beds of magnesian limestone or

* An experiment by Liebe showed that this mass effect does not take place where chalk was immersed a year and a half in variously concentrated solutions of magnesium chloride. Zeitschrift der Deutschen Geologischen Gesellschaft, vol. vii, p. 431, 1855.

dolomite is a fact hardly to be reconciled with these metamorphic theories. The metamorphism is, by these theories, accomplished through the activities of circulating underground waters; yet it seems impossible that such wholesale metamorphism could leave the original bedding so well marked. The alternation of clean-cut beds as described is a prominent fact illustrated, for example, in the pre-Cambrian formations of Montana and British Columbia. The facts of the field speak rather for an original deposition of the two carbonates arranged in very nearly their present relations.

It is scarcely necessary to dwell on the effect of burial on the chemical precipitate of basic magnesium carbonate. Pressure and a heightened temperature have gradually driven out the water of crystallization. The simultaneous formation of the double carbonate, dolomite, might be expected where both carbonates are present in large amount. The shrinkage consequent on the loss of water of crystallization amply accounts for the cavernous structure often seen in dolomites.

In conclusion, it appears that the hypothesis here proposed bears its third principal test so far as the carbonates of calcium and magnesium are concerned. It involves the precipitation of both carbonates from sea-water through the decay of animal matter. The magnesium carbonate should have been most abundantly thrown down in pre-Cambrian time; its precipitation must have been lessened through Paleozoic and Mesozoic time, and has reached its minimum since the abysses of the ocean became abundantly tenanted with scavengers. The study of 700 limestone analyses, selected by the writer to represent the different periods, seems to show, in fact, that the ratio, MgO : CaO, in the carbonate rocks is very high in pre-Cambrian terranes, lower in Paleozoic and earlier Mesozoic series, and much lower still in later deposits.*

Origin of the Lake Superior iron ores.—The many thorough studies that have been made of the several iron-producing districts about Lake Superior have demonstrated two original sources for the ore. One of these is the iron-silicate "greenalite," which has many points of resemblance to the modern glauconite and may be of chemical origin. The other source of the valuable oxides is iron carbonate, which still occurs in the form of distinct beds or in the form of an essential constituent of chert-bands or of frankly detrital deposits. It is worthy of consideration whether the siderite may be, in part at least, due to precipitation by ammonium carbonate of animal origin. If, for example, we imagine either chalybeate springs or a river furnishing special amounts of ferrous sul-

*Cf. C. R. Van Hise, Treatise on Metamorphism, p. 801, 1904; Chamberlin and Salisbury, Geology 1904, vol. i, pp. 360, 404.

phate to the pre-Cambrian sea, we have conditions favorable to the slow development of thick beds of iron carbonate or of sideritic shales, etc.

Origin of certain pre-Cambrian cherts and jaspers.—Liebig states that the same alkaline carbonate lessens the solubility of colloidal silica in water.* It is also a familiar fact that this carbonate precipitates most of the silica from solutions of water-glasses, silicate of sodium, silicate of potassium, etc., substances which are present in river-waters. The suggestion lies near that we may have here a partial explanation of the puzzling cherts and jaspers so specially associated with the Lake Superior ores. In this view they are due to the throwing down of silica from river-waters relatively rich in dissolved silica or silicates. As with the iron carbonate deposits these precipitates would be but locally developed within the ancient ocean-basin; such, according to the accepted authorities, seems to be the fact for both kinds of precipitate in the Lake Superior district.

The writer has but little first-hand knowledge of the district. The discussion of the intricate facts of field observation as detailed in the many able monographs on the iron-bearing rocks is as difficult as the discussion of the obscure chemistry of river-waters. The subject is here touched upon simply to indicate a possible test of the main hypothesis of the present paper; all that appears clear from the foregoing brief considerations is that, when we have final demonstration of the origin of the "greenalite," siderite, and ferruginous chert of the Lake Superior region, that demonstration may be found to favor the thesis here suggested regarding the chemistry of the pre-Cambrian sea.

Origin of the petroleum and natural gas emanating from pre-Cambrian sediments.—Finally, the hypothesis of an essentially limeless sea during Eozoic times correlates well with the undoubted fact that natural gas and petroleum are to-day issuing from pre-Cambrian strata. An excellent example of this is seen in the field now being prospected in the Flathead Valley of British Columbia, at points situated so far inside the eastern limit of the Rocky Mountains as scarcely to allow one to entertain the idea that these hydrocarbons really come from Cretaceous or other fossiliferous formation which here underlie the great Rocky Mountain overthrust. The entombment of the carcasses of soft-bodied animals is, it is true, partly prevented by their bacterial decomposition, but doubtless not more so than by the steady removal of carcasses from the sea-bottom by scavengers. Murray has shown that there is, in the

*Quoted from A. M. Comey's Dictionary of Chemical Solubilities, Inorganic; London, and New York, p. 360, 1896.

deep-sea deposits of the present time, a considerable percentage of organic (soft-bodied) matter. This fact is all the more striking since there is evidence that the bottom muds are being worked over and over by scavengers through whose bodies pass inorganic and organic matter together. Before the general scavenging system for the sea-floor was introduced, we should expect a still higher proportion of such organic matter to enter into the composition of marine sediments. It is therefore not a matter of surprise that sufficient organic (soft-bodied) matter was entrapped within Eozoic sediment to furnish, after subsequent distillation, the oil and gas actually seen issuing from these old rocks. The greatest amount of entombment would be expected after the marine animals had begun to cover themselves with shells and skeletons (these structures retarding complete bacterial decay), and before the scavenging system was well established; it may be partly for this reason that the older Paleozoic formations are relatively so rich in petroleum and natural gas. Nevertheless, these fluids may emanate from rocks in which there is not a trace of shell or skeleton—rocks as unfossiliferous as so many pre-Cambrian formations.

Summary.

Premises.—The conclusions emphasized in this paper are based on the following premises:

1. The truth of the evolutionary hypothesis, especially as regards the geologically late development of active hunters and scavengers on the general sea-floor;

2. The biologically deduced fact that the evolution of the main animal types, including those secreting hard parts, was accomplished in the ocean;

3. The fact that animal types were already highly diversified in Cambrian time;

4. The experimentally proved fact that representatives of all the main animal types can live and thrive in sea-water quite deprived of calcium salts;

5. The postulate that bacterial decomposition of animal remains occurred in Eozoic time and has occurred in all subsequent time;

6. The experimentally proved fact that bacterial decomposition of animal remains causes the emanation of ammonium carbonate among other products;

7. The experimentally proved fact that such ammonium carbonate can precipitate from sea-water all of its calcium salts in the form of the carbonate and some of the magnesium salts as basic magnesium carbonate. (This precipitation is proved to be actually progressing on the floor of the Black Sea);

8. The experimentally proved fact that the precipitation of magnesium carbonate is facilitated by the absence or low content of calcium salts dissolved in sea-water;

9. The probable fact that, in Eozoic time, the land-areas and therefore the river systems were greatly increased in size as a result of an orogenic revolution throughout the earth; much limestone then first exposed to weathering;

10. The fact that a prolonged period of partial or complete baseleveling followed the mountain-building period, implying a specially great addition of dissolved, river-borne calcium and magnesium salts to the ocean-water. This addition of calcium salts is assumed to have made a fundamental change in the conditions of marine life; the excess of calcium salts being so great as to permit of the secretions of calcareous shells and skeletons for the first time;

11. The fact that the land areas have ever since retained sufficient size and abundance of limestone to furnish the sea with lime salts in excess of the amount of those salts being precipitated by ammonium carbonate and being deposited in the form of organic shells and skeletons on the sea-floor.

Conclusions.—1. The lime salts of the ocean, inherited from Azoic times, were precipitated as calcium carbonate comparatively soon after the introduction of animal life into the sea.

2. During most of Eozoic time, i. e., pre-Cambrian time in which animal life existed, the ocean was practically limeless; calcareous secretions by animals were impossible.

3. Tests and skeletons of pure chitin were possible in Eozoic time, but were not abundantly preserved until some carbonate or phosphate of lime was built into those structures. The calcareo-chitinous tests of Cambrian and Ordovician trilobites and shells of brachiopods represent a transition stage between the Eozoic æon of dominantly soft-bodied animals and the post-Cambrian æon of dominantly lime-secreting animals. The notable fossilization of brachiopods, trilobites, molluscs, etc., was impossible until near the beginning of Cambrian time. Indeed, the conditions for truly abundant fossilization of calcareous forms were not established until after the Cambrian period. The striking variety or entire lack of organic remains in the thick Cambrian sediments of British Columbia, Alberta, Idaho and Montana, and in many other parts of the world, may be thus explained.

4. Eozoic limestones, dolomites, magnesian limestones and calcareous and magnesian deposits generally were chemically deposited through the medium of organic ammonium carbonate. This alkali acted on the primeval calcium and magnesium salts of the ocean and on the calcium and magnesium salts introduced to the ocean by pre-Cambrian rivers. A similar origin is suggested for the iron carbonate occurring in Eozoic

sedimentary beds. It is also suggested that possibly the silica of the cherts and jaspers characteristically associated with these carbonates, were likewise thrown out of solution by ammonium carbonate of organic origin. The petroleum and natural gas emanations from Eozoic sedimentary rocks receive explanation if the fundamental postulate of abundant Eozoic marine life be accepted.

5. The hypothesis seems to explain the greater development of magnesian rocks in the earlier geological formations, especially those belonging to the Eozoic system. The hypothesis throws light on the formation of dolomitic rocks of all ages.

6. The hypothesis suggests that, in general, secular variations in the oceanic composition may be found to explain some features of biological history, including certain accelerations and retardations in life development, especially as regards the elaboration of the hard parts of animals and the rise and fall of lime-secreting organisms.

According to the hypothesis the outlines of developments may be tabulated as follows:

Life.	Oceanic Composition.	River Influence on Oceanic Composition.	Carbonate Deposits.
		Azoic Period.	
----------------	?	?	?
		Early Eozoic Period.	
Pelagic, soft-bodied, low types of animals, and plants. Gradual evolution of higher types of animals, all soft-bodied. *Chief Fossils.*—Siliceous; impressions of soft-bodied animals; possibly tests of pure chitin; plants?	Beginning of precipitation of lime-salts. Followed by a long limeless stage.	Minimum: land-areas small; minimum area of limestone exposed to weathering.	Calcium carbonate followed by mixed deposits of calcium carbonate and magnesium carbonate; iron carbonate.
		Late Eozoic Period.	
Relatively high types of animals, soft-bodied. *Chief Fossils.*—As in former period; also some calcareo-chitinous.	Great and relatively rapid increase of river-borne carbonates of calcium and magnesium.	Orogenic revolution; land-areas enlarged; special increase of areas of weathering limestones; base-leveling.	Renewed abundance of calcium carbonate; continued deposit of magnesium and iron carbonate.

TIME PLACE OF THE GREAT UNCONFORMITY.*

Cambrian Period.			
Diversified animal types; beginning of lime secretion. *Chief Fossils.*—Calcareo-chitinous and calcareous.	Lime salts sufficient for lime secretion by animals.	Land-areas probably diminished but still large in absolute measure.	Both chemical and directly organic calcium carbonate; chemical magnesium carbonate in diminished proportion
From Cambrian to Epoch of Colonization of General Sea-floor.			
Limey structures of animals fully developed. *Chief Fossils.*—Calcareous.	Same as last period.	Land-areas, and areas of weathering limestone, slowly though not steadily increasing.	Same as last period.
Period Following Colonization of General Sea-floor.			
Same as last period.	Gradual increase of calcium sulphate in solution.	Land-areas approaching maximum extent; Rivers drain maximum area of limestone.	Directly organic calcium carbonate dominant; magnesium carbonate at its minimum.

*It may be noted that in British Columbia there is local conformity between the *Beltina* beds and the beds corresponding to the *Olenellus* zone. This is, of course, an exceptional relation between Cambrian and pre-Cambrian rocks as exposed on the continental plateaus.

Art. XI.—*On the Occurrence, in the Rocky Mountains, of an Upper Devonian Fauna with Clymenia;* by Percy E. Raymond.

It is the purpose of the present paper to announce the discovery in the Three Forks shales, near Three Forks, Madison County, Montana, of an Upper Devonian fauna containing *Clymenia*, *Entomis*, and goniatites.

The Devonian of the Three Forks region has been described by Peale* as consisting of 640 feet of massive limestone, capped by the Three Forks shales 135 feet in thickness. The limestones (Jefferson limestone) are dolomitic in character and nearly barren of fossils. Peale lists the following from a stratum about 30 feet below the top. They were identified by Dr. C. D. Walcott:—

Spirifer disjunctus,	*Smithia* sp. ind.,
Chonetes macrostriatus,	*Orthis* sp. ind.

In the vicinity of the Yellowstone National Park, from what appears to be the same formation, a few fossils were obtained by the United States Geological Survey parties. These were listed by Girty† as follows:—

Actinostroma sp.,	*Atrypa reticularis*,
Cyathophyllum cæspitosum?	*Athyris vittata*, var. *triplicata*,
Pachyphyllum sp.,	*Pleurotomaria*? sp.,
Cladopora sp.,	*P. isaacsi*?
Favosites sp.,	*Platyostoma minutum*,
Spirifer engelmanni,	*Loxonema delicatum*.
Atrypa missouriensis,	

This fauna was considered by Girty to be Lower or Middle Devonian, while the presence of *Spirifer disjunctus* in the list identified by Dr. Walcott argues a somewhat later age for the fossiliferous stratum at Logan.

The Three Forks shales were divided by Dr. Peale into three portions:—

3. Upper shales, with many fossils............. 65 feet.
2. Grayish-brown limestone, without fossils..... 15–20 feet.
1. Lower shales, without fossils. .... 50 feet.

*The Paleozoic Section in the Vicinity of Three Forks, Montana, Bull. U. S. Geol. Surv., No. 110; also Three Forks Folio, Geological Atlas of the United States.

† Geology of the Yellowstone National Park, Mon. xxxii, U. S. Geol. Surv., p. 483.

Division 3 is subdivided as follows:—

D.	Yellow sandstone, the lower part calcareous,	25 feet.
C.	Coal-black shale,	5 feet.
B.	Gray limestone,	10 feet.
A.	Green shales with bands of limestone,	30 feet.

Zones A, B, and D were described as fossiliferous, and Dr. Walcott identified 39 species from the collections made by Peale.

In 1895, while Mr. Douglass, now of the Section of Paleontology, Carnegie Museum, was collecting in the Tertiary deposits near Three Forks, he was shown specimens of *Spirifer disjunctus.* The gentleman who had these fossils later conducted Mr. Douglass to the locality from which they were obtained, and on this and succeeding visits Mr. Douglass collected the following fossils, which have been identified by Dr. George H. Girty*:—

Spirifer disjunctus,
Cleiothyris sp. nov.,
Camarotœchia tethys,
Pugnax pugnus,
Goniatites (2 sp.).

In September, 1905, Mr. Douglass and the writer visited this locality and obtained a large collection of fossils from the upper shales. The writer also made a collection from the Devonian ravine opposite Logan. These have been identified only provisionally, as a large number appear to be new and require more study than it has yet been possible to devote to them. It is thought, however, that the novelty of this fauna and its important bearing upon the problems of the distribution of Paleozoic lands and seas will justify this preliminary note.

In the 65 feet of strata constituting the upper shales at Three Forks, there are five zones in which the lithology and faunules differ somewhat. 1, 2, and 3 make up A above; 4 is the same as B; and 5 equals D. From C no fossils were obtained. These zones, beginning with the lowest, are as follows:—

1. *Red shale zone.*—The shales of this zone are hard, reddish, and fissile, the layers weathering into small sharp-pointed fragments. The fossils are preserved in pyrite, which is often partially altered to limonite, and they weather out on the surface in numerous bare spots along the strike of the beds. A set of fossils from this zone was sent to Dr. E. Holzapfel, whose determination of the species is quoted below:—

Orthoceras, 3 species,
Orthoceras, similar to *O. gregarium* Münst.,
Bactrites sp.

*Notes on the Geology of Southwestern Montana, by Earl Douglass. Annals Carnegie Museum, vol. iii, p. 416.

Goniatite, like *G.* (*Prolobites*) *delphinus*,
Cheiloceras, 2 species,
Clymenia,* somewhat like *C. annulata* Münst.,
Clymenia sp.,
Loxopteria, near *L. lævis* Frech,
Loxopteria, near *L. dispar* Sandb.,
Mecynodus, or *Goniophora* sp.,
Leiorhynchus sp.,
Camarotœchia sp.,
Spirifer Verneuili Murch. = *S. disjunctus* Sowerby,
Athyris sp.

In addition to these, the collection contains fragments of another species of *Clymenia*, a small gastropod, a *Nucula* and *Spirifer pinonensis* Meek.

In commenting on this faunule, Prof. Holzapfel states that the mode of preservation is exactly like that of some fossils

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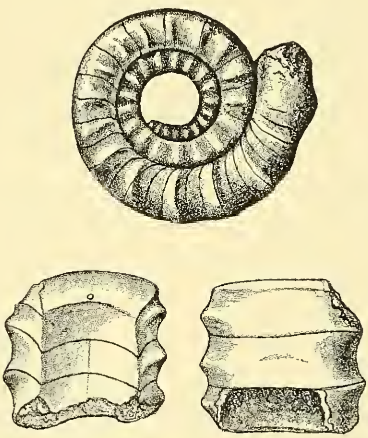

FIGURE 1.—An exfoliated specimen, natural size, of *Clymenia* (*Platyclymenia*) *americana*, in which the inner whorls are not preserved. Two views of a fragment of another specimen, twice natural size, to show position of the siphon and form of the suture line.
Cotypes in the Carnegie Museum.

in the Nehden shales, and that, except for the presence of *Clymenia*, which gives the fauna more the aspect of that of the Clymenia limestone, the composition of the fauna is analogous to that of the Nehden shales.

*This species of *Clymenia* is abundant in zones 1, 2, and 4, and may be readily recognized by its broad-backed, compressed and ribbed whorls. The suture is simple, as is shown by the accompanying figures. The name *Clymenia* (*Platyclymenia*) *americana* is here proposed for this species.

2. *Green shale zone.*—These are the green shales described by Peale (part of A, above). Fossils abound and further collecting should reveal a much larger fauna. *Clymenia* and *Entomis* are abundant, associated with a great number of brachiopods and lamellibranchs. For the complete faunal list, see the table below.

3. *White blocky shale.*—The exact horizon of this zone is not known, as the fossils were obtained at a locality where the layers seemed to be somewhat disturbed. In the field it appeared to be above the green shale, but it could not be located in any place where the beds were undisturbed. The faunal list is short, but the fossils are abundant:—

Fish spines,
Goniatite, either *Cheiloceras* or *Tornoceras*,
Orthoceras sp.,
Bellerophon sp.,
Posidonomya sp., very abundant,
Lingula sp.

4. *Gray limestone zone.*—This limestone weathers readily and produces great quantities of fine fossils, mostly brachiopods. Two species of *Clymenia* occur in this zone, but the goniatites are very rare. This same limestone is well exposed in the Devonian ravine at Logan, but no specimens of *Clymenia* were found at that locality; it has, however, furnished two fragments of cups of crinoids, one of which has been identified as a species of *Mariacrinus*, by Mr. Frank Springer. This is of interest, as it is the first crinoid reported from the Devonian of the Rocky Mountains. The fossils found in the limestone at these two localities are indicated in the table below. This seems to be the upper limit of the range of *Clymenia*.

5. *Yellow sandstone zone.*—This sandstone or sandy limestone forms the capping bed of the Devonian both at Three Forks and at Logan. A few beds are very fossiliferous and the fauna indicates a transition into the Mississippian (Madison limestone).

At Three Forks were found:—

Prorhynchus sp.,
Springothyris carteri,
Spirifer disjunctus,
Pugnax pugnus,
Camarotœchia contracta,
Leiorhynchus mesicostale?
Ambocœlia gregaria,
Cleiothyris sp.,
Schuchertella inflata,
Productus sp.,
Edriotrypa sp.

The fossils of the various zones are tabulated below to show the range of the species:

Species	Three Forks					Logan	
	1	2	3	4	5	4	5
Fish spines			c				
Proëtus sp.						r	
Ostracoda sp. ind.		c					
Entomis sp.		c					
Platyclymenia americana sp. nov.	c	c		c			
Clymenia sp., smooth form	r	r		r			
Clymenia sp.	r						
Prolobites ? sp.	c						
Cheiloceras sp.	c	c	c	r			
Cheiloceras sp.	r						
Bactrites sp.	c						
Orthoceras cf. *O. gregarium* Münst.	r						
Orthoceras, various species	c	c	c	c		r	
Platyostoma sp.				r		r	
Bellerophon sp.		r	r				
Pleurotomaria sp.		r					
Platyceras sp.						r	
Tentaculites sp.		c					
Aviculopecten, various species		c		r		r	
Lyriopecten sp.		r					
Crenipecten cf. *C. obsoletus* Hall		c					
Pteriniopecten sp.		r		r		r	
Actinopteria sp.		r					
Leptodesma sp.						r	
Loxopteria cf. *L. dispar* Sandb.	r			r			
Loxopteria cf. *L. lævis* Frech	c						
Mytilarca chemungensis Conrad		r					
Goniophora sp.	c	c		c			
Goniophora chemungensis Vanuxem				c		r	
Cypricardella sp.		r					
Modiomorpha sp.		c					
Prorhynchus sp.		r			r		
Cypricardinia arcuata ? Hall		c		r			
Grammysia minor Walcott						r	
Grammysia sp.		r		c		r	
Paracyclas peroccidens Hall and Whitf.				r			
Paracyclas sp.		r					
Nucula, large form		r					
Nucula, small form	r	r					
Palæoneilo sp.		r					
Leda sp.		r					
Spathella typica Hall				c		c	
Sphenotus sp.		r					
Posidonomya sp.			c				
Syringothyris carteri (Hall)					c	c	
Spirifer disjunctus Sowerby	r	c		c	c	c	

Species	Three Forks					Logan	
	1	2	3	4	5	4	5
S. disjunctus animasensis Girty				c		c	
S. pinonensis Meek	r	r		c		c	
Spirifer, new type				r			
Athyris sp.		r		r		r	
Cleiothyris sp.	c	c		c	c	c	
Ambocœlia gregaria Hall	r	c		c	c	c	
Pugnax pugnus (Martin)		r		c	c	r	
Camarotœchia contracta ? Hall	r	c		r		r	
Camarotœchia sp.		c		c	c	c	
Leiorhynchus, large form				r			
Leiorhynchus mesicostale ? Hall	c	c		c	c	c	
Leiorhynchus sp.				c		c	
Productus sp.				r	r	r	
Productella subaculeata Walcott		c		c		c	
(Not *P. spinulicosta* Hall)							
Productella sp.		c		c		c	
Strophalosia cf. *S. truncata* (Hall)				r		r	
Chonetes filistriatus ? Walcott						r	
Chonetes, large striæ						r	
Chonetes sp.		r					
Schuchertella chemungensis (Conrad)				c		r	
S. inflata White and Whitf.					r		
Schizophoria cf. *S. striatula* Schlotheim		c		c		c	
Schizophoria sp.		r		c		c	
Pholidops sp.		r					
Orbiculoidea sp.		r		r		r	
Lingula sp.		r	r	r			
Edriotrypa, large form		c		c		c	
Edriotrypa, small form		c					
Fenestella ? sp.		r				r	
Mariacrinus sp.						r	
Crinoid stems		c		c		r	
Streptelasma sp.						r	

Correlation.

Clymenia has been previously represented in America only by *Clymenia* (*Acanthoclymenia*) *neapolitana* (Clarke) from the Cashaqua shales of western New York. With that species occur the numerous goniatites and other fossils of the *Manticoceras intumescens* fauna, so well described by Dr. Clarke. The fauna of the Three Forks shales agrees with that of New York in the presence of *Clymenia*, *Cheiloceras*, *Bactrites*, *Entomis*, and *Loxopteria*, but the species are in all cases distinct; the associated fauna is very different and the guide fossil, *Manticoceras intumescens*, appears to be absent from the Three Forks shales.

The fauna here listed seems to be much more like that of the Upper Devonian of South Devon, the Rheinland, and other localities in Europe and Asia, where the top of the Devonian is indicated by one containing numerous species of *Clymenia* and goniatites. It is to be noticed, however, that the clymenias and goniatites of this American fauna are accompanied by indigenous forms suggestive of the typical Chemung of the eastern sections.

The Three Forks shale fauna cannot be directly correlated with any of those now known in the Rocky Mountains. It has a few species in common with the Devonian of the Eureka District, but these seem to be forms which have a long range in the Nevada section and are of little diagnostic value. With the fauna of the Devonian along the Mackenzie River this has little in common, as the fauna described by Whiteaves contains an abundance of corals, while these organisms are almost entirely lacking in the Three Forks shales.

The Ouray limestone of Colorado, described by Girty, contains one or two species found in the present fauna. *Spirifer disjunctus animasensis* is rather common in both.

In the uppermost zone of the Three Forks section the presence of *Syringothyris* and *Spirifer disjunctus* may prove to be of considerable interest in the correlation of these beds with Eastern sections. Williams* has noted the presence of *Syringothyris* and *Spirifer disjunctus* in beds overlying the typical Chemung and underlying the Waverly in southwestern New York. On account of the presence of *Syringothyris* these beds have been referred to the Mississippian. Dr. Girty, who has devoted a considerable time to the study of these strata and their enclosed fossils, has shown† that the fauna indicates a separate time interval, which he calls the Bradfordian. In this he includes the Cattaraugus, Oswego, and Knapp formations of the New York section, and considers these beds to represent the latest Devonian deposition in their province.

The fauna of the upper zone of the Three Forks section may, therefore, indicate the occurrence of the Bradfordian in the Rocky Mountains, and serves to confirm the reference of the *Clymenia americana* fauna to a very high Devonian horizon.

It is the intention of the writer to continue the study of this fauna, both in the field and in the laboratory, and further work may make possible more definite correlations.

Acknowledgment is here made to Dr. Holzapfel, of Aachen, in appreciation of his kindness in identifying a suite of fossils from the red shale zone, and to Mr. Douglass, the discoverer of the goniatites, for bringing the locality to the attention of the writer.

Carnegie Museum, Pittsburg, Pa., September 4, 1906.

* Bull. Geol. Soc. America, vol. xiv, p. 184, 1903.

† Science, vol. xix, No. 470, Jan. 1, 1904, pp. 24–25.

ART. XII.—*Wasatch and Wind River Rodents;* by F. B. LOOMIS.

MOST of the rodents from the Wasatch and Wind River beds have been loosely associated with the species of the Bridger formation, largely, it would seem, in accordance to size. A considerable number of specimens occurring in the Amherst collection of 1904 from the Wasatch and Wind River beds show at once that there was probably the same wealth of species in these beds as in the Bridger beds, and further very casual comparison developed that the species are characteristic in each horizon. While the Amherst collection seems to contain far more specimens from the lower beds than other collections, for purposes of comparison the Bridger material of Yale Museum was studied through and all the Tertiary rodent material of the American Museum of Natural History was generously loaned for generic and comparative study. It has become clear that a revision of the Bridger species is desirable, but in this paper that material is used only for generic characters.

Two genera are involved, Paramys of Leidy and Sciuravus of Marsh. The former has been well-defined and illustrated, but of the latter, though the material is abundant, there is not even a figure. Paramys was founded by Leidy in 1871.* The genus has many sciurine features, being probably ancestral to this family. The skull is long and narrow, especially so between the orbits, the width there being about $\frac{1}{8}$ the length. The brain case is moderately swollen and has a trace of a longitudinal crest along the dorsal median line. The external infraorbital foramen is not compressed as in squirrels, but broadly oval and opens almost directly above premolar 3. On the lower jaw the broad area for the attachment of the masseter muscle ends in front under the interval between molar 2 and molar 3. Otherwise the lower jaw is Sciurus-like. The dental formula is $\frac{1}{1}\ \frac{0}{0}\ \frac{2}{1}\ \frac{3}{3}$. The molars are characterized by a strong protocone on the inner side, and the hypocone either lacking or merely indicated.† On the outer side the paracone and metacone are strong cusps, with a small parastyle and tiny mesostyle also developed. Intermediates (paraconule and metaconule) are also present and usually more or less completely yoked to the paracone and metacone. An extra marginal ridge is developed front and rear. The lower molars are low crowned, the four

* Proc. Acad. Nat. Sci. Phila., p. 231.

† For convenience Osborn's tritubercular terms are used without commitment to the theory.

plump cusps being marginal and leaving a large interior basin. Between the two outer cusps a small mesostylid is developed. The anterior inner cusp (paraconid) is considerably higher than the others. The limbs are shorter and much heavier than those of a squirrel of the same length of body, this being especially the case with the hind limb; so that Paramys would have approximated the appearance of a woodchuck or marmot. As the limb bones are much heavier and the tuberosities well developed, and as the distal end of the humerus is expanded, it seems probable that these forms were terrestrial, not to say burrowing forms. The astragulus of Paramys is especially broad and the articulating surface flattened, with the head directed obliquely backward; while the same bone of squirrels is narrow with a deeply grooved articulating surface and the head directed straight back.

Sciuravus was founded in 1871 by Marsh* for a group of tiny rodents closely related to the foregoing but clearly separated by dental characteristics. Like that of Paramys, the skull is long and narrow especially between the orbits, being there about $\frac{1}{8}$ the length. There is no longitudinal crest. While the general characteristics of the skull are similar to Paramys, the upper molars are distinguished by having fonr subequal cusps, the hypocone being fully developed. There is no parastyle but the mesostyle is weakly developed. The intermediate cusps are weak or wanting. The lower molars are very low crowned, and the cusps all unusually low and small, making the upper surface less irregular than in Paramys. Following (p. 125) is a table to compare the three genera Sciurus, Paramys and Sciuravus.

The species of Paramys begin in the Wasatch and increase in abundance to their height in the Bridger, the last of them occurring in the Uinta. To facilitate the use of terms an upper and a lower molar is labeled in figure 1.

Paramys primaevus sp. nov.

Type No. 243, consisting of two upper jaws and parts of both lower jaws together with fragments of the incisors, found in the Wasatch beds of Buffalo Basin near Meeteetse, Wyo.

Of the upper teeth premolar 4 is without an anterior marginal ridge, but the ridge from the paracone extends to the protocone, the anterior intermediate being indistinguishable. The molars have the anterior marginal ridge, while that from the paracone includes the anterior intermediate, but does not reach to the protocone. The hypocone is merely indicated. The posterior intermediate cusp is distinct though

* This Journal (3), ii, p. 122.

	Sciurus carolinensis	Paramys copei	Sciuravus nitidus.
Length of skull	65^{mm}	80^{mm}	48^{mm}
Width between orbits	20^{mm}	10^{mm}	6^{mm}
Ratio	13:4	8:1	8:1
Crest	none	weak	none
Interval between lower incisor and premolar	14^{mm}	15^{mm}	9^{mm}
Masseter muscle ends under	interval between premolar 4 and molar 1	interval between molar 2 and molar 3	interval between molar 2 and molar 3
Infraorbital foramen	narrow and high considerably in front of premolar 3	oval and wide nearly over premolar 3	oval and wide nearly over premolar 3
Upper molars	3 cusps parastyle	3 cusps with trace of hypocone, parastyle	4 cusps, no parastyle
Humerus	60^{mm} long × 8 wide distally	58^{mm} long × 15 wide distally	
Ulna	61^{mm} long slender	38^{mm} long heavy	
Metacarpalic	38^{mm} long	28^{mm} long	
Pelvis	51^{mm} long	71^{mm} long	
Femur	60^{mm} long × 13 wide at head	——— × 12 wide at head	
Calcaneum	23^{mm} long × 9 wide	19^{mm} long × 10^{m} wide	
Astragulus	11^{mm} long × 5 wide, head straight	12^{mm} long × 8 wide, head oblique	

partly merged into the ridge from the metacone. The tiny mesostyle is simple. The lower molars are characterized by the cusps being rather low and entirely marginal, leaving a large interior basin. There is the beginning of a ridge inward from the protocone. The incisors are much compressed, measuring on the broken section $5\frac{1}{2}^{mm}$ deep by $2\frac{3}{4}^{mm}$ wide. The series of four lower molariform teeth occupy 15^{mm}.

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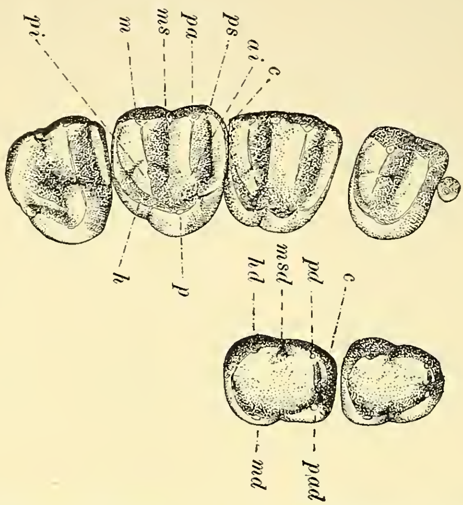

FIG. 1. *Paramys primaevus*, ×4; A, upper series of the right side; B, lower premolar 4 and molar 1 of the left side; *ai*, anterior intermediate or paraconule; *c*, anterior marginal ridge; *h*, hypocone; *hd*, hypoconid; *m*, metacone; *md*, metaconid; *ms*, mesostyle; *msd*, mesostylid; *p*, protocone; *pa*, paracone; *pad*, paraconid; *pd*, protoconid; *ps*, parastyle; *pi*, posterior intermediate or metaconule.

Paramys quadratus sp. nov.

Type No. 226a, a lower jaw of the right side, with three teeth (molar 1 lacking), found in Buffalo Basin near Meeteetse, Wyo.

The jaw is the largest of those known from the Wasatch,

2

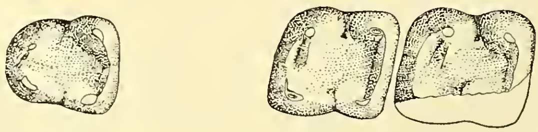

FIG. 2. *Paramys quadratus*, ×4; lower jaw of the right side.

the lower teeth being distinguished by being nearly as wide as they are long, the cusps being plump and marginal, the interior basin being very large and fairly deep. Premolar 4 has the two anterior cusps very close, the internal one being much higher than the external cusp. The wide molars have the two posterior cusps united by the posterior marginal ridge. The two anterior cusps on the other hand are not yoked, though an anterior marginal ridge starts from either one but dies down about midway. The mesostylid is very small. An incisor is of medium thickness, measuring on a broken surface $5\frac{1}{2}^{mm}$ deep by $2\frac{1}{2}^{mm}$ wide. The length of the four lower molariform teeth is 18^{mm}.

Paramys atwateri sp. nov.

Type No. 180, a lower jaw of the left side containing molars 1 and 2 and the roots of the other teeth, and found at the foot

3

FIG. 3. *Paramys atwateri*, × 4 ; lower jaw of the left side.

of Tatman Mt. near Otto, Wyo. The species is named after Mr. W. C. Atwater, a patron of the expedition.

This is the smallest of the Wasatch species, and characterized by the very plump cusps which are placed further in

4

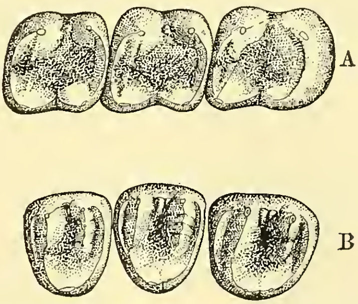

FIG. 4. *Paramys bicuspis*, ×4 ; A, molars of the right lower jaw ; B, premolar 4 and molars 1 and 2 of the left upper jaw.

from the margin than in other species, in consequence of which the interior basin is much reduced in extent. The two anterior cusps are united by a marginal ridge, as are also the two posterior cusps. The mesostylid is relatively large. The face of a broken incisor measures $3\frac{1}{2}^{mm}$ deep by 2^{mm} wide. The length of the series of lower molariform teeth is $12\frac{1}{2}^{mm}$.

Paramys bicuspis sp. nov.

Type No. 451, an upper jaw of the left side and a lower jaw from the right side, each with three teeth, and found in the Wind River beds on Bridger Creek near Lost Cabin, Wyo.

In size the species is about the same as *P. copei*, but is clearly distinguished by the mesostyle being double. On the fourth premolar and the first two molars of the upper jaw there is a strong anterior and a posterior marginal ridge. The protocone is well developed, the hypocone merely indicated. From the paracone a ridge (low in the middle) runs to the protocone, yoking them. From the metacone also a ridge runs inward to the metaconule. On premolar 4 and molar 1 the ridge appears a series of tiny cusps, but on molar 2 the ridge is less complete and the metaconule is distinct. The lower molars have low marginal cusps, the paraconid being very prominent. While shallow the interior basin is large. There is a posterior marginal ridge, and in front an anterior marginal ridge, incomplete in the middle. Then on the slopes of the protoconid and paraconid, facing each other, there is a trace of a fold. The posterior ridge of the last molar is a broad inrolled buttress very characteristic of the species. A broken face of the incisor is $4\frac{1}{2}^{mm}$ deep by $2\frac{1}{4}^{mm}$ wide. The four molariform lower teeth measure 14^{mm}.

Paramys copei sp. nov.

Type No. 4755 of the Cope collection in the Amer. Museum of Natural History, already figured and described by Cope as *Plesiarctomys delicatissimus* Leidy.* The custom of assigning Wind River specimens to Bridger species was here followed by Cope.

This species is a trifle larger than *P. delicatissimus.* Lower premolar 4 of *P. copei* has a larger and smaller cusp anteriorly; while *P. delicatissimus* has but a single cusp in the same position. The cusps of *P. copei* are less plump and the interior basin is larger. The upper molars can not be compared, as *P. delicatissimus* is founded on a lower jaw and is a rare species. The upper teeth of *P. copei* are marked by the ridges from the paracone and metacone being simple and including the paraconule and metaconule respectively. The mesostyle is simple. The known specimens are found in the Wind River beds along the Wind River in Wyoming.

Paramys major sp. nov.

Type No. 327a, a lower jaw found in the Wind River beds on Bridger Creek near Lost Cabin, Wyo.; and the same form

* Rep. U. S. Geol. Surv. Terri., vol. iii, p. 182; and pl. 24a, fig. 1-10.

as was described and attributed to *Plesiarctomys delicatior* Leidy by Cope.*

The species is characterized by its considerable size, the plump marginal cusps, and large interior basin. The two anterior cusps are united by a paralophid ridge, in front of which is the beginning of a cingulum or anterior marginal ridge. The two rear cusps are connected by a posterior marginal ridge. The mesostyle is very small. On molar 3 the posterior margin is considerably widened. From *P. delicatior* this species is distinguished by the general slenderer build,

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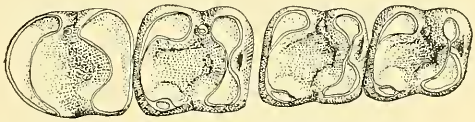

FIG. 5. *Paramys major*, ×4; lower jaw of the left side.

especially in the cusps being less plump, the interior basin larger, and the mesostylid less developed. The lower molar series measures $16\frac{1}{2}^{mm}$.

Paramys excavatus sp. nov.

Type No. 327, a lower jaw of the right side from the Wind River beds on Bridger Creek near Lost Cabin, Wyo.

This delicate species is distinguished by its slender jaw and low crowned teeth with tiny marginal cusps. The interior basin is large and fairly deep. The anterior cusps are not united by a marginal ridge, though from the protoconid two tiny ridges rise and start inward, soon however fading out.

6

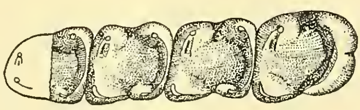

FIG. 6. *Paramys excavatus*, ×4; lower jaw of the right side.

The two posterior cusps are connected by a marginal ridge which on the last molar is a wide inrolling buttress. This last molar is distinguished from other species by the rear being notched medianly. The mesostylid is tiny. The incisors are rather wide, a broken face measuring $3\frac{1}{2}^{mm}$ deep by 2^{mm} wide. The length of the lower molariform series is 12^{mm}.

* Ibid., vol. iii, 1884, pl. 24a, fig. 11-13.

Sciuravus depressus sp. nov.

Type No. 432, three upper molars of the right side from the Wind River beds on Bridger Creek near Lost Cabin, Wyo. Cotype No. 458, molar 1 of the left lower jaw, from the same locality.

This rodent is characterized by its tiny size. The upper molars are rectangular, slightly longer than wide, having the hypocone equally developed with the other cusps. There is a front and rear marginal ridge. From each of the cusps a ridge runs inward, but these do not unite to make yokes. Neither protoconule or metaconule is visible in this species. There is a tiny mesostyle. The lower teeth have very low crowns with low isolated cusps. There is no anterior marginal ridge, but two low folds run a short distance from the protoconid, soon dying out. The inconspicuous mesostyle is more isolated than usual. The lower series of molariform teeth measure 8^{mm}.

7

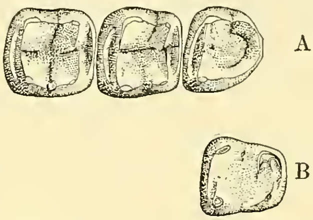

Fig. 7. *Sciuravus depressus*, × 6; A, type, molars of the right upper jaw; B, cotype, molar 1 of the left lower jaw.

Plesiarctomys ? buccatus Cope.

U. S. Geog. Surv. West of the 100th Meridian, 1877, p. 171.

This species, from the New Mexico Wasatch, I have not seen; but it is described and figured as having four cusps developed on the upper molars, which together with its small size leads me to consider it a Sciuravus.

Amherst College, Amherst, Mass.

Art. XIII.—*Descriptions of the two genera of tubicolous Annelids, Paravermilia and Pseudovermilia, with species from Bermuda referable to them ;* by K. J. Bush, Ph.D.

[Brief Contributions to Zoology from Museum of Yale Univ., No. LXVIII.]

These two genera, *Paravermilia* and *Pseudovermilia*, are most readily recognized by the greater or less development of the thoracic membrane and by the form of the terminal tooth on the uncini. Both have bulbous opercula with horn-colored chitinous caps; both have simple, regularly tapered setæ on the thorax, becoming more or less angular and bent on the abdomen ; both have somewhat similar shaped uncini.

Paravermilia Bush 1905.

Harriman Alaska Expedition, XII, pp. 221 and 223, 1905 ; this Journal, p. 54, 1907.

Species of good size are found at Bermuda, usually in dead coral, which agree in having a good sized bulbous four-sided operculum protected by a horn-colored chitinous end varying in form and composed of a number of pieces fitting closely one above the other ; the peduncle attached to one side of the base on a line with the front wall is rounded, much annulated, and often curved in contraction.

Branchial lobes in the form of rather stout, more or less elongated, rounded stems, bear rather stout, about equal branchiæ arranged in a semi-circle; crowded pinnæ abruptly decrease in length near the end of the rachis leaving a conspicuous oblanceolate or somewhat club-shaped terminal portion varying in length in preservation, probably extensile in life, the cells on the inner surface of the shorter ones being much crowded.

Thoracic membrane conspicuously developed, forming a deep, much ruffled, 3-lobed collar, deepest in the middle, with very large angular side lobes often overlapping medially, extending backward along the sides as a conspicuous border diminishing more or less abruptly between the 5th and 6th fascicles of setæ, not produced posteriorly. Seven fascicles of setæ at the end of six tori on the thorax. Setæ long tapered blades with slender lash-like ends, in the posterior bundles a few with broader more curved blades with broader serrate ends, on the collar a few inferior capillary ones resembling the slender ends of the superior ones. The uncini form a single series along the posterior border of separate rectangular membranous areas successively increasing in size. They are narrow or thin in front view with one series of striated teeth which in profile are sharp, appressed, above one large truncated, more prominent, terminal one; abdominal uncini much smaller. Abdominal setæ more or less curved or bent, with elongated, regularly tapered, somewhat angular blades; hair-like along caudal region.

The rounded, more or less thickened tubes taken from dead coral seldom show any distinguishing characters. Roughened by irregular lines of growth and occasional resting stages, a few show a varying number of longitudinal lines or carinæ.

Each species, however, can be readily identified by the form of the horn-colored cap on its operculum, the other characters appearing to differ only relatively.

The generic name *Paravermilia* was proposed for this group of species, with *P. bermudensis* as type.

PARAVERMILIA BERMUDENSIS Bush 1905.

Nine tubes of moderate size were found in 1898 and 1901, dredged in 30-40 feet in Great Harbor and other localities at Bermuda. They were taken usually from dead coral but occasionally were attached to mollusks, forming an irregularly twisted mass. The surface is sometimes ornamented with five conspicuous, longitudinal carinæ, the two outer ones usually the largest.

The species can be readily recognized by the good-sized bulbous operculum on its long, rounded, much annulated peduncle, capped by an elongated horn-colored chitinous cone which is asymmetrical and usually much curved, a few only having the cone erect. This cone, resembling a tiny spiral shell, is made up of numerous saucer-shaped pieces diminishing in size to the minute rounded tip, and are defined by darker rings sometimes numbering twelve; some are occasionally wanting on the end. The erect cone is shorter, made up of longer fewer pieces shown by a less number of rings; these may be designated as variety *minor*.

The branchiæ, about 12 in each lobe, are usually too much curled to determine their length; those of one animal are extended and appear equal to about the length of the thorax and are folded closely around the peduncle with the entire operculum exposed.

Thoracic membrane very delicate, excessively developed, the angular side lobes folding over each other enwrapping the body. Teeth on uncini sometimes numbering 18; caudal, hair-like setæ exceedingly long.

PARAVERMILIA INTERMEDIA sp. nov.

Three animals, smaller than *P. bermudensis*, often light olive-green in color, have from 10–12 branchiæ in each lobe and about 16 teeth on the largest thoracic uncini.

The operculum has the asymmetrical horn-colored cap, shorter and broadly rounded at tip, made up of but three unequal saucer-shaped pieces below the good-sized bulbous end-piece.

The small tube has five, unequal, rather fine, rounded longitudinal threads.

PARAVERMILIA AMBLIA sp. nov.

Five specimens about the size of *P. bermudensis* have 14-16 branchiæ in each lobe and the thoracic membrane very excessively developed. The large, sometimes cylindrical, operculum has a comparatively short, broadly rounded, symmetrical, light horn-colored cap of one or two convex or dome-shaped pieces covered by a very large, elongated, broadly-rounded end-piece. Occasionally one occurs in which the pieces decrease in diameter ; the cap tapered.

PARAVERMILIA ANNULATA (Schmarda).

Vermilia annulata Schmarda, Neue Wirbellose Thiere, II. p. 28, text figure and pl. XXI, fig. 176, 1861 ; *non* Ehlers, Blake annelids, p. 308, pl. 58, figs. 12–16 ; pl. 59, figs. 1–3, 1887 ; ? *non* Augener, Westindische Polychæten, p. 184, 1906.

Placostegus annulatus Mörch, Revisio Serpulidarum, p. 422, 1863.

? *Vermilia annulituba* Augener, op. cit., p. 185, pl. 8, figs. 153–161.

Seven specimens taken from dead coral from Castle Harbor, Bermuda, are larger than any of the preceding forms, the largest one with much curled branchiæ measuring about 22^{mm}. There are from 12–14 branchiæ in each lobe and 16 teeth on the largest uncinus.

The horn-colored chitinous cap of the operculum is concave on the end, being composed of two or three saucer-shaped pieces, destitute of an additional convex end-piece found in the other species. It is very like Schmarda's figure and description and also the figure given by Augener as *Vermilia annulituba* found north of Martinique in 210 fathoms.

The thoracic membrane in this very much larger species is not clearly defined, especially in the figure, and the terminal tooth on the uncinus is represented as bluntly rounded. Schmarda's figure also is not sufficiently clear for definite comparison.

The two animals found off Cuba in 292 and 310 fathoms, described and figured by Ehlers under Schmarda's name, on comparison were found to differ not only from this species but also from each other. Through the courtesy of Dr. Woodworth of the Museum of Comparative Zoology, these specimens have recently been examined and found to be two distinct species referable to two different genera.

One (No. 809), from 292 fathoms, described and represented in figure 13, plate 58, has an asymmetrical tapered segmented cone on the operculum, the end broken off, very closely related to, if not identical with, *P. intermedia* from Bermuda. The branchiæ are described as numbering 20 or 21 in each lobe but are represented as about half that number. The operculum of the other (No. 1,223) from 310 fathoms is not quite accurately shown in figure 14, an important line through the middle being omitted. The chitinous end is composed of two parts; a lower saucer-shaped piece with raised center on which rests a second cup-shaped piece with slightly convex top and upright flaring rim. This bears some resemblance to the chitinous opercular end found in species of *Pomatostegus*, but the peduncle shows no trace of side appendages characteristic of that genus. Unfortunately the specimen has become much dried so that important characters cannot at present be determined with sufficient accuracy to reveal its generic position.

PSEUDOVERMILIA Bush 1907.

This Journal, p. 54.

Three species, two from Bermuda (*Spirobranchus occidentalis* McIntosh, 1885, and an undescribed one) and one from the southern coast of Patagonia (*Vermilia nigropileata* Ehlers, 1900–'01), have a small, more or less elongated bulbous operculum gradually expanding from a long, slender, rounded peduncle becoming flattened and broadened distally, protected by a dark horn-colored (appearing as black) chitinous end differing in form; no thoracic membrane, i. e., no free border along the sides and posteriorly, but a well-developed 3-lobed collar; 7 fascicles of setæ and 6 short tori in straight series on the thorax; simple regularly tapered setæ, those on the abdomen bent and broadly angular at base, hair-like along caudal region; uncini with numerous appressed teeth, the terminal one large with notched or bifid end. No genus being known which includes all of these characters, the name *Pseudovermilia* was proposed with *occidentalis* McIntosh as type.

Branchial lobes more or less elongated, free, slightly spiral in retraction, rachis-like with few branchiæ on one side, not extending the entire length, leaving a small tapered end. Collar of about uniform depth, full, sometimes rolling, rounds abruptly on a line with the first torus, meeting along the median line of the thorax, with an incision or cleft on each side dividing it into three about equal parts or lobes with rounded ends. Setæ nearly colorless, rather stiff, with comparatively short abruptly tapered blades, those in the collar fascicle the shortest with a few capillary inferior ones. Uncini irregularly trapisiform with a number of sharp appressed teeth, the last one long, blunt and notched (bifid) on the end, those on the abdomen smaller and thicker, the notch on the end tooth not always discernible.

Tube conspicuously ornamented or sculptured when mature and perfectly developed, often marred by erosion, more or less spreading along the sides and attached the entire length (rarely lifted), the high median keel often prolonged as a spine-like projection at the aperture.

PSEUDOVERMILIA OCCIDENTALIS (McIntosh) Bush.

Spirobranchus occidentalis McIntosh, Challenger Report, XII, p. 429, pl. lv, fig. 10, pl. xxix *a*, figs. 31–2, 1885.
Pseudovermilia occidentalis Bush, this Journal, p. 54, 1907.

This species, recorded by McIntosh from off Bermuda in 435 fathoms attached to an echinoderm, is also found along the shores of Bermuda on the underside of the hat-coral (*Agaricea fragilis*) and other hosts.

It forms highly ornamented tapered tubes, usually isolated, variously curved and twisted, usually attached their entire length, thickened when mature and spreading along the sides with a high, conspicuous, dorsal keel often forming a spine-like projection at the aperture; conspicuously elevated transverse lines radiate from this ridge, arranged at first in herring-bone fashion beyond which they become irregularly curved; a small rounded thread rendered nodulose by the tranverse ornamentations, separates the two series and a similar but less developed one sometimes appears just below the dorsal keel. This characteristic sculpture is often obliterated by erosion and the young seldom show any trace of the transverse lines, so that as a determining specific factor the tubes are of little use.

Animal is slender, rounded, the forty (40) or more segments defined only by series of uncini on the abdomen widely separated along the median portion, becoming crowded posteriorly.

Branchiæ long with very long slender crowded pinnæ abruptly decreasing in length, forming a broad truncated tip, 6 in each lobe. Operculum with a somewhat thickened slightly concave disc-like dark brownish horn-colored (appearing as black) chitinous end, having a long, sharp, thorn-like spine near one side, often irregularly bent. One operculum shows the end in the act of slipping off, revealing another disk beneath. Uncini with about 13 teeth, the last large and notched on the end; well figured by McIntosh.

The genus *Spirobranchus* to which McIntosh referred his species differs not only in having a calcareous end on the operculum ornamented with antler-like spines, but has very strongly marked collar setæ.

The species described by Marion and Bobretzky from Marseilles and by Saint-Joseph from Cannes (see this Journal, p. 57) have a similar thorn-like projection on the operculum cap but the cap itself is elongated and composed of several pieces.

PSEUDOVERMILIA PILEUM sp. nov.

This species is very common along the shores of Bermuda. The tubes, similar to *P. occidentalis*, are found also on the hat-coral and on various shells (*Arca Adamsii*, *Turbo (Livona) picta*, *Astralium longispinum*, *Chama bermudensis* and others). When uninterrupted in its development it has three prominent nodulose carinæ on top (one large keel-like median and two smaller lateral ones) separated by two deep grooves below which are conspicuous curved tranverse lines. Young tubes invariably have three carinæ but seldom show any indications of the transverse sculpture.

The species is readily distinguished by its larger, more elongated operculum, having an elongated, asymmetrical, irregular, dark horn-colored (blackish) chitinous cone-like end, resembling a liberty-cap. The branchiæ number 7 in each lobe and the setæ appear broader and more abruptly tapered and the teeth on the uncini more numerous than in the preceding species. One smaller animal without an operculum has 9 branchiæ in each lobe.

The *P. nigropileata* Ehlers* is a closely related species with the opercular cone more symmetrical and larger.

Zoological Laboratory, January 14th, 1907.

*Magellanische Anneliden, p. 222, 1900; Die Polychæten des Magellanischen und Chilenischen Strandes, p. 219, pl. xxv, figs. 14–23, 1901.

ART. XIV.—*The Titration of Mercurous Salts with Potassium Permanganate*; by D. L. RANDALL.

[Contributions from the Kent Chemical Laboratory of Yale University—cliii.]

IF a solution of a mercurous salt, such as mercurous sulphate in dilute sulphuric acid, is titrated with potassium permanganate in the usual manner the bleaching of the color is rapid at first, but long before the oxidation is complete the solution assumes a golden yellow color and on standing the brown oxides of manganese are precipitated. For this reason no definite end reaction is obtainable. This difficulty is, however, avoided if the permanganate solution is added in excess, the color then bleached with a standard ferrous sulphate solution, and the end point finally reached by a few drops of permanganate. Under these conditions the end reaction is perfectly sharp and the oxidation of the mercurous salt complete, as may be proved by adding hydrochloric acid to the solution.

In the preliminary experiments this process was tested upon weighed portions of commercial chemically pure mercurous sulphate, which was dissolved in dilute sulphuric acid. So much difficulty was experienced in dissolving the salt in quantities suitable for experiment that recourse was taken to the very doubtful procedure of heating the liquid (boiling or prolonged heating on the steam bath) to hasten the solution. Although the end reaction was in every case as sharp as could be desired, and the oxidation complete, the results were low and variable, indicating from 90–93 per cent of mercurous sulphate in the sample used. This was probably due to the partial oxidation of the mercurous salt during the process of solution.

A few experiments in which the salt was dissolved in hot concentrated phosphoric acid, and the solution then diluted and titrated without further addition of acid, gave results much nearer the theory but still very variable.

For the final experiments a large quantity of a mercurous sulphate solution was prepared by shaking up an excess of the salt in water acidified with sulphuric acid, allowing the whole to stand for twenty-four hours, and finally filtering through asbestos. Portions of this solution for standardization or titration were measured out in a 100^{cm^3} burette or weighed out in a dry counterposed beaker. The standard of this solution was obtained by precipitating the measured or weighed portions in the cold with a slight excess of sodium chloride. After twelve hours standing, the precipitated mercurous chloride was collected upon asbestos in a platinum crucible and dried to a constant weight at the ordinary temperature in a vacuum desiccator over sulphuric acid. The method of drying in a vacuum is recommended by Hulett* as much more trustworthy than the usual one of drying in the air bath at 105°–110° C. where there is danger of volatilization†, a statement which the experience of the present writer has fully borne out. In every case the standard of the mercurous solution used was fixed by two or more gravimetric determinations made on the same day as the corresponding series of titrations.

The solutions of permanganate and of ferrous sulphate used were both approximately twentieth normal. The reason why it is desirable to use solutions more dilute than the usual tenth normal strength is obvious when we note that $0{\cdot}1^{cm^3}$ of the above twentieth normal permanganate is equivalent to about one milligram of mercury. For the same reason the titrations must be performed with all possible care and accuracy. All the burettes used in the present investigation had been standardized by the Berlin Reichsanstalt.

As the oxidation of mercurous salt by an excess of permanganate is very rapid, no great care is necessary in regulating the amount of the excess. It is sufficient in practice to continue the addition of permanganate until the solution, colored brown by the oxides of manganese, takes on a distinctly red tint. Under these circumstances the ferrous sulphate can be added immediately and the titration completed. Table I gives the results obtained with mercurous sulphate.

TABLE I.

A

Hg_2SO_4 sol. cm³.	Dilution at titration cm³.	H_2SO_4 1 : 1 cm³.	$KMnO_4$ approx. N/20 cm³.	$FeSO_4$ cm³.	= $KMnO_4$ cm³.	$KMnO_4$ final cm³.	Hg found grm.	Hg theory grm.	Error grm.
100	150	5	14·70	10·	10·90	3·80	·0346	·0354	—·0008
100	150	5	14·72	10·	10·90	3·82	·0347	·0354	—·0007
100	150	5	14·70	10·	10·90	3·80	·0346	·0354	—·0008
100	150	5	14·71	10·	10·90	3·81	·0346	·0354	—·0008

B

Hg_2SO_4 sol. grm.									
505·8	500	5	29·20	10·	10·90	18·30	·1668	·1666	+·0002
500·2	500	5	32·16	13·	14·17	17·99	·1639	·1648	—·0009
510·1	500	5	29·29	10·	10·90	18·39	·1676	·1680	—·0004
499·2	500	5	28·95	10·	10·90	18·05	·1645	·1644	+·0001

* Zeitschr. f. phys. Chem., xlix, 500 (1904). Hulett, however, employed calcium chloride instead of sulphuric acid as the drying agent.

† Treadwell (Lehrbuch der anal. Chemie, vol. ii, p. 114), states that when the drying is carried out at 105° the results are always about 0·4 per cent too low.

For practical purposes the application of the method to mercurous nitrate is of much greater importance. In Schneider's* method for the determination of manganese, permanganic acid is titrated with hydrogen peroxide in the presence of nitric acid. Ibbotson† and Brearley in their modification of this process recommend the use of standard ferrous ammonium sulphate instead of hydrogen peroxide. Blair‡ also studied this process and recommends the use of ferrous ammonium sulphate. In the absence of any data concerning the quantity of nitric acid that can safely be present in the titrations of ferrous sulphate the determinations in Table II were made. The nitric acid used was rendered free from the lower oxides of nitrogen by the prolonged passage of a current of air. The acid used in all the subsequent experiments was purified in a similar manner.

Table II.

$FeSO_4$ cm^3.	Dil. cm^3.	H_2SO_4 1 : 1 cm^3.	HNO_3 cm^3.	Approx. N/10 $KMnO_4$ cm^3.
25	200	5	0	13·37
25	200	5	0	13·39
25	200	5	0	13·41
25	200	5	0	13·38
25	200	5	0	13·38
25	200	0	3	13·38
25	200	0	5	13·40
25	200	0	5	13·41
25	200	0	5	13·40
25	200	0	5	13·38
25§	200	5	0	13·47
25	200	5	0	13·50
25	200	5	0	13·49
25	200	0	5	13·53
25	200	0	10	13·50
25	200	0	20	13·51
20	200	0	30	13·00

When more than 10 per cent by volume (20^{cm^3} in 200^{cm^3}) of the concentrated acid was present the oxidation of the ferrous salt by the nitric acid was evident in the change of color of the solution, low results,‖ and uncertain end reaction. This

* Ding. Pol. Jour., cclxix, 224.

† Chem. News, lxxxiv, 247.

‡ Blair, Jour. Amer. Chem. Soc., xxvi, 793. Also, Chemical Analysis of Iron, vi, Ed., p. 121.

§ Changed $FeSO_4$ solution.

‖ As nitrous acid is at least in part oxidized by direct titration with potassium permanganate, and completely when an excess is used (method of Kinnecut and Nef, Amer. Chem. Jour., 5, 388), only a part of the loss due to oxidation of the ferrous salt by the nitrous acid would appear in the result.

table shows that when the titration is made without unnecessary delay after adding the acid, as was the case here, three per cent of pure nitric acid, the amount used in the subsequent experiments, has no appreciable effect on the estimation of ferrous iron.

In Table III are given the results of a series of determinations of mercurous nitrate by the method described above. A solution was prepared by dissolving the crystallized salt in water containing enough pure nitric acid to present the formation of basic salts. As an additional precaution a current of hydrogen, washed by alkaline permanganate and alkaline pyrogallol, was passed for twelve hours through the solution to remove nitrous acid. Measured portions of this solution, which was standardized gravimetrically as given above, were diluted to 200^{cm^3}, further acidified with pure nitric acid, and titrated in the manner already described.

TABLE III.

$Hg_2(NO_3)_2$ sol. cm^3.	Dil. cm^3.	HNO_3 cm^3.	Approx. N/20 $KMnO_4$ cm^3.	$FeSO_4$= cm^3.	$KMnO_4$ cm^3.	$KMnO_4$ cm^3. final	= Hg grm. found	Hg grm. theory	Error grm.
25	200	5	49·99	9·76	10·64	39·35	·3586	·3594	—·0008
25	200	5	49·68	9·50	10·36	39·32	·3583	·3594	—·0011
25	200	5	49·73	9·50	10·36	39·37	·3588	·3594	—·0006
25	200	5	49·89	9·67	10·54	39·35	·3586	·3594	—·0008
25	200	5	49·70	9·50	10·36	39·34	·3585	·3594	—·0009
		H_2SO_4 1 : 1							
25	200	5	50·29	10·00	10·90	39·39	·3589	·3594	—·0005

In the last experiment sulphuric acid was added instead of nitric acid, yet as the table indicates, without apparent effect on the result.

This investigation has shown :

1. That mercurous sulphate and mercurous nitrate can be readily estimated by potassium permanganate with a very fair degree of accuracy.

2. That ferrous salts can be successfully titrated in the presence of at least three per cent of nitric acid.

In closing the writer gratefully acknowledges the suggestions of Dr. R. G. Van Name which led to this investigation.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Occurrence of Argon with Helium in a Mineral.*—KITCHEN and WINTERSON have found that the mineral malacone is radio-active, and that it gives off argon as well as helium when heated. The origin of the material used for their experiments is not given, but it is stated that crystallized specimens were employed. An analysis indicated the presence of 0.33 per cent of uranium, an amount which was sufficient to account for only a small portion of the radio-activity, and it is suggested, but not shown, that the mineral may have contained some radium. A portion of the mineral was subjected to fusion with potassium acid sulphate, and the evolved gases were collected and analyzed. Disregarding the sulphur dioxide and oxygen resulting from the acid sulphate, the gases collected per hundred grams of mineral were :

Carbon dioxide	33·24^{cc}
Hydrogen	0·57
Nitrogen	0·34
Argon	2·82
Helium	0·94

Although the argon found amounts to only 0·005 per cent of the mineral by weight, its detection is interesting as being the first instance of such an occurrence. The authors say that this fact has been demonstrated by three experiments, so that it is beyond doubt, but they give no description of the analysis of the gaseous mixture, or of the method used for identifying the argon. The authors have made a further analysis of the mineral with the following results :

SiO_2	ZrO_2	Fe_2O_3	MgO	CaO	U_3O_8	Y_2O_3 Ce_2O_3, etc.	H_2O
22·53	67·78	4·93	0·70	0·41	0·33	0·09	1·84 = 98·57

From this they derive the formula $Zr_3Si_2O_{10}$, but this conclusion is not convincing in view of the closely agreeing results on the composition of this mineral by several previous investigators, leading to the formula $ZrSiO_4$ with some water.—*Jour. Chem. Soc.*, lxxxix, 1568. H. L. W.

2. *Researches on High Percentage Ozone Gas.*—In a paper read before the British Association at the York Meeting, 1906, E. LADENBURG has described some observations which point to the existence of an allotropic modification of oxygen similar to ozone, but differing from it in containing a greater number of atoms in the molecule. The object of the research was the

spectroscopic examination of very pure ozone gas. Liquid ozone was formed in the first place by Goldstein's method, which consists in condensing it by cooling with liquid air. By allowing this liquid ozone to vaporize into a vacuum tube, nearly pure ozone gas was obtained, having a very dark blue color. In examining the absorption spectra of the gas, five new bands were observed in the visible red part at 670–667, 638, 628, 622 and 610 $\mu\mu$. These bands appeared only after the greater part of the liquid ozone had vaporized, and they disappeared very soon. It was possible by collecting the gas from the last part of the liquid separately to obtain a spectrum containing the new bands without the ozone bands. Since it was found that when the new bands disappeared the pressure of the gas increased, the conclusion was reached that a new body was present possessing more atoms than ozone. This conclusion was confirmed by finding that the gas had a higher specific gravity than ozone, several results giving an average of 1·774, while ozone would be 1·661. It was not easy to work with ozone, and especially with the new body, since they are very explosive, and the conditions of the explosions could not be determined. However, the following points were determined in regard to the new body: It has a higher boiling-point than ozone, it has more atoms in its molecule, it is of a dark blue color, whether liquid or gaseous, and it is not very stable at ordinary temperatures.—*Chem. News*, xciv, 137.

H. L. W.

3. *The Determinatian of Halogens in Organic Compounds.*—A very simple and rapid method for making the determination under consideration has been devised by Stepanow. The weighed substance in a small tube is placed in an Erlenmeyer flask containing 20 to 40^{cc} of ethyl alcohol of 98 per cent strength. The flask is connected with a long inverted condenser and placed upon a water-bath. Metallic sodium is dropped through the condenser tube, which is kept perpendicular during the violent reaction. The amount of sodium should correspond to about 25 times the theoretical amount required to form sodium halide and sodium alcoholate according to the reaction,

$$R.Hl + C_2H_5OH + Na_2 = R.H + NaHl + C_2H_5ONa.$$

After the sodium has dissolved the contents of the flask are diluted with 20 to 40^{cc} of water and the alcohol is distilled off. The liquid, after cooling, is acidified with dilute nitric acid, and the halogen is determined by Volhard's volumetric method. Test analyses made by the author with chlorbenzol, brombenzol, hexachlorbenzol, *p*-chlortoluol, *p*-chlornitrobenzol and α-bromnaphthaline gave very satisfactory results, showing that the halogens are readily removed from the benzene nucleus by this means. It is known that sodium amalgam and water do not give this result.—*Berichte*, xxxix, 4056. H. L. W.

4. *The Cause of the Phosphorescence of Chlorophane.*—G. Urbain has made a study of the phosphorescences that may be

observed when the cathode rays act upon mixtures of pure lime with pure rare earths. He has shown that this method of observation is capable of remarkable delicacy, so that it is possible with the aid of the spectroscope to detect and identify in this way traces of substances which would be overlooked by all other means of investigation. He has now turned his attention to the study of the cause of the phosphorescence of certain varieties of fluorspar which show this phenomenon to a high degree, and has found in the case of a chlorophane giving a beautiful greenish-white light that the phosphorescence is caused by the presence of various rare earths. By means of spectroscopic analysis he has identified in it the presence of gadolinium, terbium, dysprosium, and samarium. In order to fully establish these conclusions he then prepared chlorophane synthetically by fusing together the amorphous precipitated fluorides, and thus obtained products which fluoresced in the cathode ray tube much more brilliantly than the natural products, and gave identical spectral bands.—*Comptes Rendus*, cxliii, 825. H. L. W.

5. *A Comparison of the Optical Temperature Scale with the Nitrogen Thermometer up to 1600°.*—The Physikalisch-Technische Reichsanstalt reports contain a valuable article by L. HOLBORN and S. VALENTINER on this subject. They conclude that the melting point of palladium, determined by the nitrogen thermometer, is 1575°. The optical method gave 1570° and 1582° according as the black body was observed at stationary temperature with a thermoelement or with changing temperature without the thermoelement. The melting point of platinum was found to be 1790°. The errors arising from the employment of the nitrogen thermometer arise principally from irregular distribution of temperature of the vessel. These need not exceed even at the highest temperature 10°.—*Ann. der Physik*, No. 1, 1907, pp. 1–48. J. T.

6. *Light Impressions on Photographic Plates.*—The authors, P. H. EYKMAN and A. P. H. TRIVELLI, discuss the influence of thin and thick sensitive films in regard to the character of the image produced. They find that while the photographic images produced by ordinary daylight are much influenced by the depth of the sensitive film, the images produced by the Röntgen rays are not affected by the thickness of such films; moreover, wetting with water a sensitive film does not modify in any way its sensitiveness to the Röntgen rays, while this process makes such a film less sensitive to daylight. Many experiments were made in regard to the effect of character of surface and thickness of film on light impressions.—*Ann. der Physik*, No. 1, 1907, pp. 199–203. J. T.

7. *Ratio of the Energy of the Röntgen Rays to the Energy of the exciting Cathode Rays.*—EDNA CARTER reviews the contradictory results obtained by various observers in measuring the energy of the Röntgen rays and makes a new determination, using a bolometer. With a difference of potential of 59 kilovolt,

a deflection of the galvanometer of 32 scale divisions, and the value of the cathode energy $E_K = 4{\cdot}8$ g. cal per second, assuming that 42 per cent of the energy is absorbed in the walls of the tube and that as much energy of the Röntgen rays goes into the anticathode as comes out, the following results were obtained for the case of absorption in platinum:

$$E_R = 5{\cdot}14.10 \text{ g. cal per sec.}$$

$$\frac{E_R}{E_K} = 1{\cdot}07.10.$$

—*Ann. der Physik*, No. 15, 1906, pp. 955–971. J. T.

8. *The Scientific Papers of J. Willard Gibbs.* With Preface by H. A. Bumstead and R. G. Van Name. Vol. I. Thermodynamics. Pp. xxviii, 434. Vol. II. Vector Analysis and Multiple Algebra, Electromagnetic Theory of Light, etc. Pp. viii, 284. London and New York, 1906 (Longmans, Green & Co.).—The publication of the collected works of an eminent scientist serves the double purpose of forming a memorial to the genius of the writer and of increasing the usefulness of his labors by making his writings more accessible to other workers. It is in connection with the second of these purposes rather than the first that one is inclined to consider the present volumes. They form, it is true, a memorial, and a fitting memorial, to the greatness of Professor Gibbs' scientific work, but we feel that a memorial was hardly needed—his greatness is too well established and his work too well known for either to be enhanced at this stage by the publication of volumes of paper and ink. We welcome the collected papers mainly because they make his writings accessible and enable us to see directly for ourselves the basis on which his reputation is founded.

It is hardly too much to say that notwithstanding his tremendous reputation there has hardly been a scientist in the front rank whose work has been as little studied at first hand, as Professor Gibbs. In his earlier years the importance of his papers was not understood at all; afterwards it was known only to a few from a first hand study of the papers. The majority of workers have realized his greatness solely by the far-reaching importance of the results associated with his name: they have regarded him as working in a world of his own creation, as "voyaging through strange seas of thought, alone,"—and they have not read his papers. One cannot of course bring an indictment against the whole scientific world; if Gibbs' papers have been generally regarded as unapproachable, the cause must be looked for in the papers themselves. A large part of this cause is undoubtedly to be found in the somewhat repellant notation and terminology adopted by Gibbs, and in the absence of concrete ideas and illustrations connecting his abstruse mathematical processes with the particular world of thought in which physicists are accustomed to move. For these and other reasons, the papers are to many an unexplored mine of wealth: it is for making this mine of wealth more easily accessible that the editors are to be specially congratulated.

The first, and more important, volume contains all the thermodynamical papers, the principal of these, the famous paper on "The Equilibrium of Heterogeneous Substances," occupying three hundred out of the four hundred and thirty pages of the volume. A very welcome feature in this first volume is the inclusion of a biographical sketch by Professor H. A. Bumstead. Those who, like the present writer, had not the honor of meeting Gibbs, will welcome this opportunity of obtaining some slight understanding of the personality of the great scientist : we wish the biography had been more ample.

The second volume contains all the non-thermodynamical papers. An especially interesting part of this volume consists of eighty papers devoted to a reprint of a pamphlet on vector algebra, originally printed privately for Yale students of physics.

Those who possess the volumes will have nothing but praise for the way in which the editors and publishers have done their work : the former are to be congratulated on the arrangement of the papers : the latter on the printing and appearance of the volumes. Both are to be thanked for their service to science.

J. H. JEANS.

9. *The Electron Theory ;* by E. E. Fournier d'Albé. Pp. xxiv+311. New York and London, 1906 (Longmans, Green & Co.).—The electron, or indivisible atom of negative electricity, has become within the last ten years the most trusted and useful conception which the physicist has at his command for dealing theoretically with the new and startling experimental discoveries of which this decade has been so prolific. In addition to this, it has in many cases helped to correlate and "explain" experimental facts and laws which had been known for a long time but had not previously found a place in any connected theory. The present book is a popular introduction to this new theory. It adopts the electron as a fundamental postulate and ascribes to it the properties which experiment and speculation have shown to be necessary; from these hypotheses are deduced, in successive chapters, the facts of electrostatics, the electric discharge, thermo-electricity, voltaic electricity, magnetism, radiation, electro-optic and magneto-optic phenomena and the relation between conductivities for heat and electricity. As is perhaps inevitable in a popular presentation, there are portions of the book where the triumphs of the theory are stated with a confidence which is probably not shared even by the men who have been most active in its development. But even when allowance is made for this, the results collected in this book make a very impressive demonstration of the service which this theory has done and a promise of what may be expected of its further developments. The work is written with admirable clearness and in an attractive and interesting manner ; it is the best popular presentation of this important theory which the present reviewer has seen. H. A. B.

10. *Lehrbuch der Optik*; von Dr. PAUL DRUDE. Zweite erweiterte Auflage. Pp. xvi+538. Leipzig, 1906 (S. Hirzel).—The preface of this second edition of Drude's Optics was written only eight days before the lamented death of the author and the work was carried through the press by Dr. Kiebitz. The principal changes and additions to the first edition (see this Journal, vol. xiv. p. 68, 1902) are in those portions of the subject to which the recently developed electron theory is especially applicable. The additional material makes about thirty pages; and a subject index is added. H. A. B.

II. GEOLOGY AND MINERALOGY.

1. *Maryland Geological Survey: Pliocene and Pleistocene*; WM. BULLOCK CLARK, State Geologist. Pp. 291, pls. 75, figs. 10. Baltimore, 1906 (The Johns Hopkins Press).—The present volume is the third of a series of reports dealing with the systematic geology and paleontology of Maryland and completes the geological history of the Cenozoic. Reports on certain of the earlier periods are well under way. The descriptive portion of the report, pp. 23–138, is by Geo. B. Shattuck. The succeeding chapters are by W. B. Clark, F. A. Lucas, Arthur Hollick and others. The work throughout, as in the previous volumes of this survey, is marked by its scientific accuracy and readable nature. The illustrations are well chosen and well executed.

Under the general descriptive portion is to be noted the geological map of the four formations of the Pliocene and Pleistocene on a scale of eight miles to an inch and the accompanying maps showing the relations of land and water at the time of the making of each formation. The oldest of these four is the Lafayette, believed by Shattuck to be late Pliocene and to represent a subsidence of the Maryland coast to the extent of 500 feet. No cliff scarp corresponding to this stage has been detected. Following the Lafayette, repeated oscillations of the strand line have occurred, elevation and erosion separating the epochs of submergence, each of which was less than the preceding in vertical range. These movements may be tabulated as follows:

Probably late Pliocene.	Lafayette subsidence to 500 feet.
	Elevation and erosion.
Probably early Glacial.	Sunderland subsidence to 220 feet.
	Elevation and erosion.
Probably middle Glacial.	Wicomico subsidence to about 100 feet.
	Elevation and erosion.
Probably close of Glacial.	Talbot subsidence to 45 or 50 feet.
	Elevation and erosion.
	Subsidence now in progress.

Progressive tilting with uplift toward the west has disturbed to some extent the simplicity of these relations. It is also seen that the Champlain epoch as a single stage of submergence accompanying the close of the ice age is a conception simpler than the facts due to an earlier and necessarily imperfect state of knowledge.

The accurate distinction and delimitation of these closely similar but distinct formations calls for great observational keenness and is of the first importance for the understanding of earth movements now in progress. Dr. Shattuck is consequently to be congratulated upon this piece of work.

The latter half of the volume is devoted to an excellent account of the fossils of the Middle or Late Pleistocene, none having been found in the Pliocene. The fossils are described by Clark, Lucas, Hay, Ulrich, Hollick, and Sellards, and are derived from marine (about 46 species) and land deposits; they include land plants (about 40 species), fresh-water shells (1 Unio) and vertebrates (4 Proboscidia, 2 turtles). An interesting map is given by F. A. Lucas, showing the American distribution of the elephants *E. primigenius*, *E. columbi*, and *E. imperator*. An account is also given of the American mastodon *Mammut americanum*.

J. B., C. S.

2. *Fifth Report of the Vermont State Geologist;* 1906. Pp. viii and 351, 58 pls.—The opening chapter treats of the building and ornamental stones, and is by the State Geologist, Professor G. H. Perkins. Considerable space is devoted to the occurrence of asbestus and its origin. Professor Richardson describes the areal and economic geology of northeastern Vermont, and gives an extensive bibliography treating of the region. G. E. Edson furnishes an historical sketch of the Cambrian age as related to Vermont geology, followed by the geology of St. Albans and vicinity. The Cambrian is represented by the Winooski or Swanton marble and the Noah Parker shale, and the Ordovician by the Chazy (only fossil mentioned is *Maclurea magna*), Trenton (a list of 24 species is given); and an "intraformational conglomerate" holding a mixture of Lower and Upper Cambrian fossils.

Professor Seely has an account of the Cryptozoa of the early Champlain sea, and while considerable space and many illustrations are devoted to their elucidation, these objects remain in as great darkness as before. A second article by the same writer is on the Beekmantown and Chazy formations in the Champlain valley.

Professor Perkins continues his studies on the lignite or brown coal of Brandon. This coal has now furnished a flora of nearly 150 species, consisting essentially of fruits with some woods. The remaining papers are the "Superficial Geology of the Region about Burlington," and "The Champlain Deposits of Northern Vermont," both by C. H. Hitchcock; and "The Drinking Waters of Vermont," by G. H. Perkins. C. S.

3. *Beiträge zur Geologie und Palaeontologie von Ostasien*, etc.; by TH. LORENZ. Zeitschr. d. Deutsch. Geol. Ges., 1906, pp. 53–108, pls. iv–vi.—The author describes the fossils collected by him in Schantung, China, essentially Cambrian trilobites. The new genera are *Lioparia*, *Trachyostracus*, *Macrotoxus*, *Alokistocare*, *Megalophthalmus*, *Amphoton*, *Chondroparia*, *Schantungia*, and another said to be an Ordovician gastropod *Polydesmia*.

The author complains much about the poorly defined trilobite genera and then attempts to place some of them on a better footing. As he nowhere deals with entire trilobites and in most cases does not consider the pygidia, one easily becomes very skeptical about his revision. This is further accentuated by noting that in addition he fails to follow the rules of nomenclature and undoubtedly has made an admittedly difficult subject still harder for subsequent workers to unravel. His primary basis for classification he states as follows: "I have attempted to set up a system in which the different forms can be easily classified. . . . . As principles for distinctions I have adopted the size and position of the eyes, the presence or absence of a dorsal furrow [deep groove surrounding glabella], or the direction of the facial suture. . . . There are porous and non-porous shells. . . . These two types of shell structure—non-porous and porous — are constantly associated without transitional forms."

On the basis of shell structure he erects two groups—"Stem *Stereokelipha*" having a compact shell with various types of surface granulation, and "Stem *Porokelipha*" having a finely porous shell. C. S.

4. *Guide to the Geology and Paleontology of the Schoharie Valley in Eastern New York;* by AMADEUS W. GRABAU. Bull. 92, N. Y. State Museum, pp. 76–386, plates, many text-figures, and map in pocket.—Schoharie valley has long been famous as a locality in which nearly the entire Devonian strata can be studied, but more particularly the Lower Devonian. The section in its entirety, however, extends from the Upper Ordovician well into the Upper Devonian. With the State Geologist we are in agreement in stating that the book "will aid and stimulate students, clarify the geologic problems which the region presents and, as it is the outcome of a careful resurvey of the region, advance our knowledge."

Chapters 1–4 take up the various formations in detail, with illustrations of the more typical fossils found in each. In chapter 5 the characteristic sections in the Schoharie region are described and the fossils listed. Many other sections of the Helderberg mountains and elsewhere are added for comparison. Chapter 8 treats of the Physiography of the Schoharie region in its relation to man. C. S.

5. *Cephalopoda of the Beekmantown and Chazy Formations of the Champlain Basin;* by RUDOLF RUEDEMANN. Bull. 90, N. Y. State Museum, pp. 393–604, pls. 1–38.—As the title indi-

cates, the Cephalopoda of the Lower Ordovician are here described. These number 71 species, of which 24 are new. One new genus is also described—*Orygoceras*. Of these 71 species, 46 are restricted to the Beekmantown, the remainder to the Chazy. In other words, not a single species is common to the two formations.

The derivation of these cephalopods seems in the main to have been from the southwest, i. e., the Pacific-American region. South Europe (Atlantic-Bohemian) and North Europe (Baltic) appear to have furnished little, if anything. The author has done his work well in a difficult subject, all the harder to unravel because of the fragmentary nature of the material. C. S.

6. *Geology of the Penn Yan-Hammondsport Quadrangles;* by D. D. LUTHER. Bull. 101, N. Y. State Museum, pp. 37–58, two maps in pocket.—Describes and maps the areal distribution of the fourteen formations of the Middle and Upper Devonian occurring within these two quadrangles.

7. *A Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales. Vol. II. Pelecypoda. Part I. The Palæopectens;* by E. ETHERIDGE, Jr., and W. S. DUN. Mem. Geol. Surv. N. S. Wales, 1906, pp. 1–39, pls. 1–16. —The aviculopectens of the Carboniferous of New South Wales are rare, small, and closely allied to European and American forms. Those of the Permo-Carboniferous marine beds are, however, of large size, great variety, and limited to eastern Australia. The species are of three genera: *Aviculopecten* (10 species), *Deltopecten* (9 species), and *Entolium aviculatum*.
C. S.

8. *Geology and Underground Waters of the Arkansas Valley in Eastern Colorado;* by N. H. DARTON. Pp. 90, pls. xxviii, figs. 2. Professional Paper No. 52. U. S. Geol. Survey, Washington, D. C. 1906.—This report is similar in form to other professional papers by the same author upon districts within the Great Plains and Rocky Mountain provinces of the United States. The areal geology is represented by large geological maps and the descriptions supplemented by numerous well-chosen photographs. One of the chief values of this report is in the information which it gives to well-drillers as to the occurrence and depth of the water-bearing strata, a matter of great importance in the semi-arid region of eastern Colorado. J. B.

9. *The Geological History of Mount Greylock;* by T. NELSON DALE. Pp. 17, pl. 1, fig. 4. Berkshire Historical and Scientific Society. 1906.—In this paper the author reviews in an interesting and somewhat popular manner the periods in the history of Mount Greylock from the time of the Cambrian transgression. J. B.

10. *A Treatise on Rocks, Rock-weathering and Soils;* by GEORGE P. MERRILL. Pp. xv + 400, pls. 31, figs. 42. New York, 1906 (The Macmillan Company).—The geological public is already familiar with this work which, since its first appear-

ance in 1897, has filled a unique place, in presenting the relation of surface processes to the destruction and origin of rocks. In this new edition the book has undergone some revision, resulting in the addition of several plates and the cutting down of eleven pages of text. J. B.

11. *Facetted Pebbles.*—The article by LISBOA in the January Journal on "The occurrence of facetted pebbles on the central plateau of Brazil" suggests that there may be a considerable difficulty in discriminating between pebbles facetted by natural sand blast and by glacial action. My experience is that characteristic examples of each kind of pebbles may be distinguished without doubt or difficulty. Sand-blast facets usually occur only on one side of a pebble ; in stones of fine grain the facets are ordinarily better made than the facets of glaciated pebbles ; while in stones of coarse grain, such as granites and schists, the facetting often shows a delicate regard for differences of mineral hardness, by which the weaker minerals are slightly excavated or fluted and the harder minerals are left somewhat in relief, in a manner not found on glaciated pebbles. Glaciated facets usually meet in more obtuse angles than those between sand-blasted facets ; and the facets nearly always show striations in sympathy with the longer diameter of the stone ; while striations are characteristically absent on sand-blasted pebbles. Individual specimens of facetted pebbles might sometimes be difficult of identification as to origin ; but a collection of a score or two of pebbles, one set from a district of wind-work, the other set from a bed of till or of tillite (consolidated till), would be easily distinguished. Those shown in Lisboa's paper have decidedly the appearance of sand-blast facets.

It may be noted that sand-blast facets may be plentifully produced in a district of moist climate, such as the New England coast, provided only that a bed of pebbles is exposed to strong sand-bearing wind. This has happened at various points on the coast of Cape Cod, where facetting of fine quality has been done during the later phases of the glacial period and in the present epoch as well. The occurrence of facetted pebbles in Brazil is of especial interest just at present, in view of Prof. I. C. White's recent account of the extraordinary correspondence between the Permian deposits of that country and those of South Africa, both of which include near the base a sheet of indurated glacial deposits or tillite ; but the pebbles described by Lisboa do not appear to belong to this formation. W. M. D.

12. *Die Kristallinen Schiefer. II Specieller Teil ;* von V. GRUBENMANN. 8°, 175 pp. pls. I–IX ; Berlin 1907 (Gebrüder Borntraeger).—The first part of this work, in which the subject matter is treated from the general standpoint, has been already noticed in this Journal (xix, p. 202.) In this, the descriptive portion, the individual kinds of rocks based on the method of classification adopted, are presented. The chief interest lies in the working out of the method of classification. For purposes of consider-

ing metamorphism and its products the author divides the crust of the earth into three zones whose relations to the various factors of metamorphism are shown in this table.

	Temperature	Hydrostatic pressure	Stress	Chief effect of pressure
Upper zone	moderate	small	strong	mechanical
Middle zone	higher	stronger	very strong	chemical
Lowest zone	very high	very great	small	chemical

Each zone is characterized by certain minerals; thus the upper by chlorite, sericite and chloritoid; the middle zone by hornblende, staurolite and muscovite, and the lower by pyroxene, feldspars, etc.; the minerals of the last division are more nearly like those of the igneous rocks. Some minerals, like biotite, are found in all three zones, others appear in two only. Now if a given kind of material, and it makes no difference what its origin, whether igneous or sedimentary, be subjected to metamorphism, while its chemical composition in mass remains the same, it will yield rocks quite different in mineral composition and texture in each of the three zones. Thus a diabase becomes a greenstone schist, an amphibolite or an eclogite in descending order, and in the same way a clay shale becomes a phyllite, a mica-schist or a gneiss. The gneisses are of course mostly in the lowest zone.

The first step in the classification is a purely chemical one; all the material, whatever may be its origin, which can be subjected to metamorphism, is considered and divided into twelve groups based on chemical composition. This grouping is accomplished by following essentially the same methods proposed by Osann for the igneous rocks, and his projection of the analyses is also followed for illustration. This demands that a chemical analysis of the rock must be made in order to definitely place it, though of course comparisons with well-studied types will often answer. To carry out his plan the author has had made under his direction a large number of analyses of selected specimens, the results of which are given.

Each of the groups thus made is then divided into three orders, according as the rock belongs to one of the three zones mentioned above. Thus the crystalline schists are divided into thirty-six orders belonging to twelve groups, each group characterized by a certain general chemical composition and each order by characteristic minerals, textures, etc. The whole scheme has been most carefully thought out and developed and is very clearly presented. Criticism of it will probably be directed to two features. The first is the initial difficulty encountered in requiring a chemical analysis for every rock to be classified, though much of course can be done by comparison with well investigated types. It can be suggested also that the method of microscopic analysis, introduced by Rosiwal and nowadays being so much developed in the study of igneous rocks, will prove just as serviceable in the study of the crystalline schists.

The second objection that will be advanced is the difficulty of telling in a great number of cases to which one of the three zones, or orders, the rock of a certain group belongs to. This is only another instance of the general difficulty of attempting to draw arbitrary lines between rocks, which grade into one another in various directions, and only time and experience can show whether it is too great, in the way proposed, to cause its general acceptance. The author modestly states that his work is not considered final, but as an attempt to introduce a rational and definite method of classification, based on consistent principles, into the crystalline schists. For this he is certainly to be commended and his work should be carefully read and considered by every petrographer. L. V. P.

13. *Rock Minerals: Their Chemical and Physical Characters and their Determination in Thin Sections;* by JOSEPH P. IDDINGS. Pp. xii, 548. New York, 1906 (John Wiley & Sons).—It is now nearly twenty years since the volume of Rosenbusch on the characters of minerals important in petrography was presented in English form by Professor Iddings. This translation has served a most useful purpose in making the work of Rosenbusch accessible to English readers, and has done much to stimulate study in this department. Since that time, the original work has been revised and enlarged until now its scope is so extensive as to put it beyond the use of the ordinary student. Professor Iddings has done well, therefore, in preparing an independent work of his own on the subject, which while giving all the data required, presents them in a form which is most convenient for the special object in view. The result of his labors is now given to the public in this volume of 550 pages, divided almost equally between the general theoretic portion and the description of species.

Part I begins with the chemical characters, discussing briefly the relation of mineral compounds on this side, and giving somewhat more fully the special chemical tests which can be applied to the study of rocks in thin sections. Then follows a chapter upon the general physical properties and crystallography treated quite concisely. The third chapter, occupying about one hundred pages of the work, is given to the optical properties. This the author has elaborated with a great deal of care and with the result of giving an admirable summary for the use of the student. He starts with the fundamental conceptions of wave motion, and the simpler light phenomena, and develops the properties of doubly refracting crystals very clearly and in all necessary detail. This portion of the work is particularly valuable to those studying rocks under the microscope, since the phenomena involved in the determination of species are more or less intricate, and unless the principles upon which they are based are thoroughly understood, the results reached are not likely to be of great value. The rock minerals are taken up in succession, commencing with the feldspars, and are treated as fully as is necessary for the special object in view. The list of species included is long, since, outside of those which are involved as primary rock constituents, many others are important either as accessories, as special developments in particular cases, or as due to alteration and secondary action. The work as a whole can be very highly commended and will doubtless be appreciated at its full value.

14. *Das Salz: Dessen Vorkommen und Verwertung in Sämtlichen Staaten der Erde;* verfasst von J. OTTOKAR FREIHERRN VON BUSCHMAN. II Band. Asien, Afrika, Amerika und Australien mit Ozeanien. Pp. 506. Leipzig; 1906 (W. Engelmann). Herausgegeben mit Unterstützung der Kaiserlichen Akademie der Wissenschaften in Wien aus der Treitl-Stiftung.—The first volume of this extensive work, which is devoted to occurrences of salt in Europe, is stated to be in press; the second volume, now issued, covers the remainder of the world. It gives a very full statement of the occurrence of salt at the different localities from which it is obtained in quantity, with data in regard to the amounts and values. The first two hundred pages are devoted to Asia, beginning with China and going on through India, Japan, etc., to Arabia. Then follows Africa and finally America, with a brief treatment of Australia and Oceanica. Under each the special localities of salt are first discussed, then follow statements as to the amount of import and export with their values, and finally the amount consumed in the country. A concise bibliography is introduced before each general division, adding completeness to a work which is already full of detail.

15. *Chemische Krystallographie;* von P. GROTH. Erster Teil. Pp. v, 626, with 389 figures. Leipzig, 1906 (Wilhelm Engelmann).—The long promised Chemical Crystallography by Professor Groth has finally taken material form,—a fact which is of the greatest interest alike to chemists as well as to mineralogists and crystallographers. For many years the works of Rammelsberg were the ones which were constantly referred to for data in regard to the crystallization of chemical compounds. Since they appeared, however, a quarter-century has passed, and a vast series of new facts and observations have accumulated; what is more important, also, the whole standpoint in regard to the theory of crystalline structure, and the relation between the chemical composition of compounds and their physical properties, has been developed. It is to this latter part of the subject that the author of the present work has made the most important contributions, and his works have done much to broaden the point of view of all the workers in this line. His Chemical Crystallography, therefore, while giving an almost bewildering amount of information in regard to chemical compounds, is much more than a mere compilation of crystallographic and physical data. The fundamental principles alluded to above form the basis of the whole, and the discussions which introduce each group of compounds are most illuminating.

This first part, now issued, includes the elements and the inorganic compounds outside of the salts, the simple and complex halogen compounds, the cyanides and oxides of the metals and the corresponding alcohol compounds. The second part will be devoted to the inorganic oxy- and sulpho- salts, and is promised towards the end of 1907. The organic compounds follow and are to fill parts III and IV, which it is hoped will be brought out in the spring of the successive years following. It is certainly remarkable that one whose activity has extended into so wide a field, and who has carried, in other directions, so heavy a burden of work, has found it possible to marshal into order the immense array of crystallographic and physical data here presented to the public. Few men have been able to publish so much as Professor Groth and to exert so strong an influence upon the development of the science in which they were interested.

III. Botany and Zoology.

1. *Sinnesorgane im Pflanzenreich zur Perzeption mechanischer Reize;* von G. Haberlandt, Professor an der Universität Graz; second edition (enlarged), pp. viii + 207; 9 double plates. Leipzig, 1906 (W. Engelmann).—The first edition of this work was published only five years ago, and the demand for a second edition within so short a time is especially remarkable, because the subject treated falls wholly within the domain of pure science. According to the author the higher plants develop differentiated sense-organs which are quite comparable with those found in animals. These organs differ according to the stimulus which it is their function to perceive, but the present volume confines its attention to organs of touch, those which perceive pressure, friction or mere contact, and which bring about definite movements in the plant as reactions to such stimuli. In organs of this character, which usually consist of individual cells or of groups of cells, anatomical peculiarities are found which lead to a sudden alteration in the form of the enclosed protoplasm when the stimulus is applied. The organs are epidermal in nature, and among the most characteristic are those in the form of papillæ, which consist of projecting epidermal cells. In these papillæ thin places in the wall can be detected, beneath which the sensitive protoplasm is situated. The organs may, however, be either simpler or much more complicated than papillæ, and Haberlandt devotes the greater part of his book to the detailed description of the various types which he has observed, selecting his examples from stamens, from pistils, from petals, from foliage leaves, from the digesting leaves of insectivorous plants, and from tendrils. The concluding chapter is of a general nature and discusses, among other topics, the phylogeny of the sense-organs in plants, the transmission of the stimulus, and the similarity between the organs of touch in plants and those in animals. The plates, three of which are new to this edition, figure the various types of organs described. A. W. E.

2. *Principles of Botany;* by Joseph Y. Bergen and Bradley M. Davis. Pp. ix + 555; 394 text-figures. Boston and New York, 1906 (Ginn & Company).—Bergen's "Foundations of Botany," published in 1901, has been one of the most widely used botanical text-books for secondary schools. The present volume includes the best features of the earlier work, but is enlarged in scope so as to become available for more mature pupils. At the same time, by confining the attention of the student to certain selected chapters, the book may still be used in an elementary course. It is divided into three parts:—I. The Structure and Physiology of Seed Plants; II. The Morphology, Evolution and Classification of Plants; III. Ecology and Economic Botany. The first and third were written by Mr. Bergen, the second by Dr. Davis. The first part is taken almost directly from the "Foundations," although there are several changes in arrangement. The second part, which contains the most new matter, not only describes a series of instructive types from the Algae to the Angiosperms, but discusses a number of topics of general botanical interest, such as the evolution of sex, the alternation of generations, the development of heterospory, and the origin of the seed-habit. The whole is treated with the utmost clearness, but it is possible that some of the subjects introduced may be too abstruse for the average student. In the third part the chapters on ecology have been largely rewritten, and a brief account has been added of the phenomena of mutation and variation, together with the methods of plant breeding. The part concludes with a description of the most important economic plants of both temperate and tropical regions.

A. W. E.

3. *Second Report of the Wellcome Research Laboratories at the Gordon Memorial College, Khartoum;* by Andrew Balfour, Director. Department of Education, Sudan Government, Khartoum. 1906. Pp. 255, with 16 colored plates and 106 figures and maps.—This volume embraces the results of the work of the staff and collaborators of the laboratories during the past two years. This work has been of the greatest practical importance as well as of scientific value, embracing as it does the study of the conditions which render the Sudan somewhat unfavorable for the habitation of civilized races. The interesting account of the work of the mosquito brigade and the regulations to prevent steamers and other boats bringing mosquitoes into Khartoum, indicates what a comparatively simple matter it would be for sections of the United States which are now afflicted with malaria, to eliminate at once the anopheline mosquito and the parasitic disease which it may convey.

The chapter on biting and noxious insects other than mosquitoes deals with the species of tsetse fly which carries the parasite which causes the fatal trypanosomaisis of animals and the one which is the agent of transference of the human trypanosome, supposed to be the cause of the dreaded "sleeping sickness." Bot flies, jiggers, ticks, aphides, plant bugs, and locusts are some of the other insects which affect the human interests of the region.

Dr. Balfour describes and figures a blood parasite of the rat and Jerboa rat, with its probable life cycle in the flea. The prevalence and distribution in the Sudan of the trypanosome disease of cattle and mules are discussed and a large amount of experimental work described. Various animal, human, and vegetable pests are described by F. V. Theobald, who also presents a second report on the mosquitoes, describing new genera, species and localities. The report of the traveling pathologist and naturalist, Dr. Sheffield Neave, contains an account of blood examinations and pathological conditions observed in regions difficult of access.

The final paper of the report, by Dr. William Bean, gives analyses of certain articles of food and commerce of the region, and describes the chemical nature of certain products used or manufactured by the natives.

That so high a class of work can be prosecuted in spite of the heat and dust and other unfavorable conditions of the region is a striking proof of the persistent energy of the laboratory staff.

W. R. C.

4. *Animal Micrology; Practical Exercises in Microscopical Methods;* by Michael F. Guyer, Ph.D. Pp. ix + 240. Chicago, 1906 (University of Chicago Press).—This little book contains practical directions for the preparation of material for microscopical study. The methods usually employed in making histological preparations are described, with important suggestions as to the selection of particular reagents for certain special tissues. The technique of decalcification, maceration, injection, and the mounting of objects of general interest, is followed by an account of special embryological methods. The optical properties of the microscope and the preparation of standard reagents are described in appendices, which also supply many suggestive hints for obtaining microscopic material for zoological courses.

This will undoubtedly prove to be a most convenient addition to the few really helpful handbooks for the zoologist or embryologist, and should be accessible for every student in the laboratory where the microscope is used in the study of biology.

W. R. C.

IV. Miscellaneous Scientific Intelligence.

1. *Carnegie Institution of Washington, Year Book No. 5, 1906.* Pp. 266, with 13 plates. Washington, 1907.—The Year Book of the Carnegie Institution is always of much interest, since the work that the institution is doing is so important, and at the same time yet so novel, that many new problems are presented for consideration. The change of policy announced a year since, in accordance with which the strength of the Institution was devoted more to the supporting of larger scientific

enterprises than to the smaller lines of work, has been continued. During the past year, for example, about $460,000 were devoted to the former end, and less than $100,000 to the latter. The appropriations for the coming year, aggregating $661,300, are divided in about the same ratio between these departments with also $50,000 for administration and $70,000 for publication.

It is a matter of interest to note what these larger projects are to which the support of the Institution is so largely given. They may be briefly enumerated as follows: Botanical Research, directed by Dr. D. T. MacDougal at the Desert Laboratory at Tucson, Arizona; Economics and Sociology, Dr. Carroll D. Wright, Director; Experimental Evolution, Professor Charles B. Davenport, Director, carried on at the laboratory established at Cold Spring Harbor, Long Island; Historical Research, Professor J. F. Jameson, Director; Horticultural work, carried on by Mr. Luther Burbank at Santa Rosa, California; Marine Biology, directed by Dr. A. G. Mayer at the laboratory at Dry Tortugas, Florida; Meridian Astronomy, a new department placed in charge of Professor Louis Boss of the Dudley Observatory, the special object of which is mentioned below; Work on Nutrition, carried on under Professors F. G. Benedict, R. H. Chittenden, L. B. Mendel, T. B. Osborne; Solar Physics, under the direction of Professor George E. Hale, on Mt. Wilson and at Pasadena, California; Terrestrial Magnetism, directed by Dr. L. A. Bauer, covering land observations at many stations in the United States, Canada, the Pacific, and China, in addition to the work of the ship "Galilee"; and finally, work in Geophysics, carried on by Professor F. D. Adams and Drs. G. F. Becker and A. L. Day, the last mentioned in charge of the Geophysical Laboratory recently established near Washington.

The department of Meridian Astronomy is a new one, established by the Trustees at their meeting on December 12, 1905, and having as its object the measurements of the positions and motions of the so-called fixed stars. It contemplates also as an essential part of its program the establishment of an observatory in the southern hemisphere. In connection with the department of Terrestrial Magnetism, the ship "Galilee," between August 5, 1905, and October 13, 1906, accomplished two voyages, aggregating 11,000 and 15,000 nautical miles respectively, and adding a large amount to our present knowledge of the magnetic elements in the Pacific. A third voyage (as stated elsewhere) began on Dec. 22 and is expected to extend to the end of 1907, covering from 25,000 to 30,000 miles.

The new Geophysical Laboratory, for which an appropriation of $150,000 has been made, was begun in July, 1906, and it is expected that it will be ready for occupation not later than July 1, 1907. Some of the important work accomplished already has been published in the October and November numbers of this Journal.

Professor Woodward gives a very interesting account of the careful means taken to arrive at the best conclusion in regard to the proper development of the Institution, with the aid of advice from many scientific men in the country. The decision reached that the Institution should not attempt to enter the fields occupied by existing colleges and universities is certainly wise, as also that it should strive not to scatter its resources too much in the many possible fields of research. He adds, that "while it appears desirable to limit the range of activity of the Institution at any epoch, it appears still more desirable to insist upon a high standard of efficiency, determined by the quality and quantity jointly of the results obtained. To secure this end, the Institution must not only seek to aid mainly eminent investigators, but it must seek to aid them for such periods and to such an extent that their best efforts may be enlisted."

Following the reports of the President and of the Executive Committee, this volume contains a Summary of the work accomplished during the past year both by the larger departments enumerated above and also in connection with the numerous minor investigations.

2. *Report of the Librarian of Congress and Report of the Superintendent of the Library Building and Grounds for the fiscal Year ending June 30, 1906.* Pp. 175, with 6 illustrations. Washington, 1906.—This report by Mr. Herbert Putnam in regard to the Library of Congress will be read with especial interest by all concerned with this line of work. The total number of books and pamphlets at the end of 1906 (inclusive of the Law Library) was 1,379,244, a gain for the year of 34,626 ; the total expenditures for the year 1906 amounted to 587,415 dollars.

3. *Physikalische Chemie der Zelle und der Gewebe ;* von Rudolf Hoeber. Zweite, neubearbeitete Auflage. Pp. 460, mit 38 Textfiguren. Leipzig, 1906 (Wilhelm Engelmann).—This book is intended for those who desire to gain some insight into the aims and tentative results of modern physico-chemical investigation in its application in the domain of biology and medicine. For those to whom the introduction to physical chemistry through the larger works, like those of Nernst and Ostwald, is too difficult or unattractive, the smaller book of Dr. Höber, in its second, revised edition, will be found helpful. The subject of osmotic pressure, the theory of solutions, the ionic theory, equilibrium in solutions, colloids, the action of electrolytes and ferments, among other topics, are succinctly presented. A large number of biological phenomena and processes are discussed in terms of the physico-chemical hypotheses. It must be admitted that in many instances these attempts at interpretation are merely a paraphrase of older explanations. Thus in the chapter on the permeability of membranes various phenomena of muscles, blood corpuscles and other cells are described. The difficult subject of colloids is presented in some detail. As examples of the action of electrolytes the behavior of protoplasm towards ions is

illustrated in such experiences as the responses of muscle and nerve in various inorganic media and the physiological rôle of inorganic salts in general. The problems of absorption, lymph formation, secretion and excretion are considered in connection with the permeability of the tissues.

In throwing light upon the dynamics of living matter, compilations like the foregoing are helpful; but the more purely metabolic phenomena are as yet scarcely elucidated by them. Dr. Höber admits the limitations of his science. His book is planned to encourage those who are making their first acquaintance with the modern aspects of the subject. L. B. M.

4. *A Short Course on Differential Equations;* by DONALD FRANCIS CAMPBELL. Pp. viii, 96. New York, 1906 (The Macmillan Company).—An excellent text-book for use after an elementary course in calculus, giving in compact and clear statement the essentials of the subject with copious well-selected examples and practical apparatus in engineering. Easily the best text-book for an elementary course of thirty lessons that has yet been published. W. B.

5. *Seismological Committee.*—At the recent New York meeting of the American Association for the Advancement of Science a standing committee in the sections of Geology and Physics was established, to be known as a Seismological Committee. The following gentlemen were named as members: G. K. Gilbert, U. S. Geological Survey; Cleveland Abbe, U. S. Weather Bureau; C. E. Dutton, U. S. Army; Otto Klotz, Observatory, Ottawa; L. A. Bauer, Carnegie Institution; John F. Hayford, U. S. Coast and Geodetic Survey; W. W. Campbell, Director of Lick Observatory; A. C. Lawson, Chairman California State Committee on Earthquake Investigation; H. F. Reid, Johns Hopkins University; Ralph S. Tarr, Cornell University; C. G. Rockwood, Jr., Princeton University; W. J. McGee, St. Louis Public Museum; Wm. H. Hobbs, University of Michigan; L. M. Hoskins, Stanford University; T. A. Jaggar, Institute of Technology, Boston.

The functions of the Committee are expected to be, in the main, advisory and its greatest object to disseminate information and bring different institutions having similar objects into harmonious relations. Special objects which it may accomplish are the following:

(1) To be available for and to initiate counsel in connection with legislation which provides for investigation of earthquakes or the means for mitigating their dangers.

(2) To bring into harmony all American and Canadian institutions doing seismological work and to guard against unnecessary duplications of studies.

(3) To organize, if thought best, a correlated system of earthquake stations which should include the outlying possessions and protectorates.

(4) To advise regarding the best type or types of seismometers for the correlated stations.

(5) To disseminate information regarding construction suited to earthquake districts.

(6) To collect data regarding the light as well as the heavy shocks and to put the results upon record.

(7) To start investigations upon large problems of seismology.

(8) To advise with some weight of authority when catastrophic earthquakes have wrought national calamity.

6. *Smithsonian Institution.*—It is announced that Dr. Charles D. Walcott, Director of the United States Geological Survey since 1902, was elected Secretary of the Smithsonian Institution at the meeting of the Regents held on January 23.

7. *American Forestry Association.*—The annual meeting of the American Forestry Association was held in Washington on January 9. Addresses were delivered by the President, Hon. James Wilson, by Dr. E. E. Hale, Mr. Gifford Pinchot and others. The annual report showed that gratifying progress was being made in forestry in the country and a series of resolutions to further this end were adopted.

8. *The Record of the Celebration of the Two Hundredth Anniversary of the Birth of Benjamin Franklin.* Pp. xix, 321, with portraits. Philadelphia, 1906 (The American Philosophical Society). — This sumptuous volume presents an interesting account of a unique occasion, namely, the celebration of the two-hundredth anniversary of the birth of Benjamin Franklin. This was held in Philadelphia in April, 1906, under the auspices of the American Philosophical Society, whose existence was due to Franklin's initiative, and to which he devoted much of his energy for many years. The report of the proceedings contains the addresses delivered at the time, bearing on the different phases of Franklin's activity, together with the documents received from Societies and Academies abroad, many of whom were represented by delegates. Several portraits of Franklin are introduced and also a representation of the Franklin medal designed by Louis and Augustus St. Gaudens.

9. *American Philosophical Society.*—The general meeting of 1907 at Philadelphia will be held on April 18th, 19th, and 20th, beginning at 2 P. M. on Thursday, April 18th.

The Science Year Book, with Astronomical, Physical and Chemical Tables, Summary of Progress in Science, Directory, Biographies and Diary for 1907. (Third Year of Issue) Edited by Major B. F. S. Baden-Powell. Pp. 152 (Diary pp. 365), vi. London (King, Sell, & Olding).—This Year Book gives a large amount of valuable and useful information, both scientific and general. There are astronomical, physical and chemical tables; a summary of the progress in science for 1906; a biographical directory; lists of scientific societies, etc.

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VOL. XXIII. MARCH, 1907.

Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

FOURTH SERIES

VOL. XXIII—[WHOLE NUMBER, CLXXIII.]

No. 135—MARCH, 1907.

NEW HAVEN, CONNECTICUT.

1907

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

Published monthly. Six dollars per year, in advance. $6.40 to countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks (preferably on New York banks).

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XV.—*The Evolution of the Horse Family, as illustrated in the Yale Collections;* by RICHARD S. LULL.

[EDITORIAL NOTE.—This paper has been prepared as a guide to a portion of the paleontological collections in the Peabody Museum of Yale University. The great interest of the subject, however, and the completeness of the Yale material illustrating it seem to make a wider publication desirable.]

PART I.

IT is seldom that the paleontologist is able to show so complete a series representing the evolution of a race of land ani-

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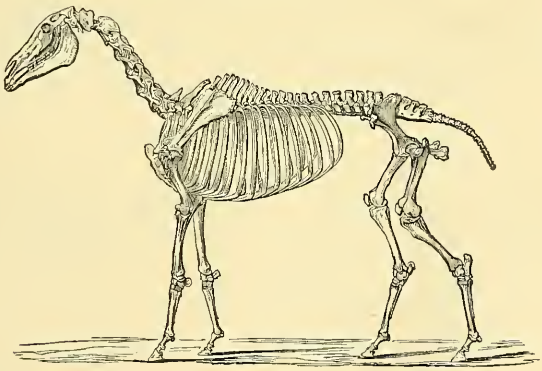

FIG. 1. Skeleton of the modern horse, *Equus caballus*. (After Marsh.)

mals as in the case of the horse, and it is even more exceptional that an institution is fortunate in having so comprehensive a collection as that now in the Peabody Museum at Yale, which was brought together through years of constant watchfulness on the part of the late Professor Othniel Charles Marsh.

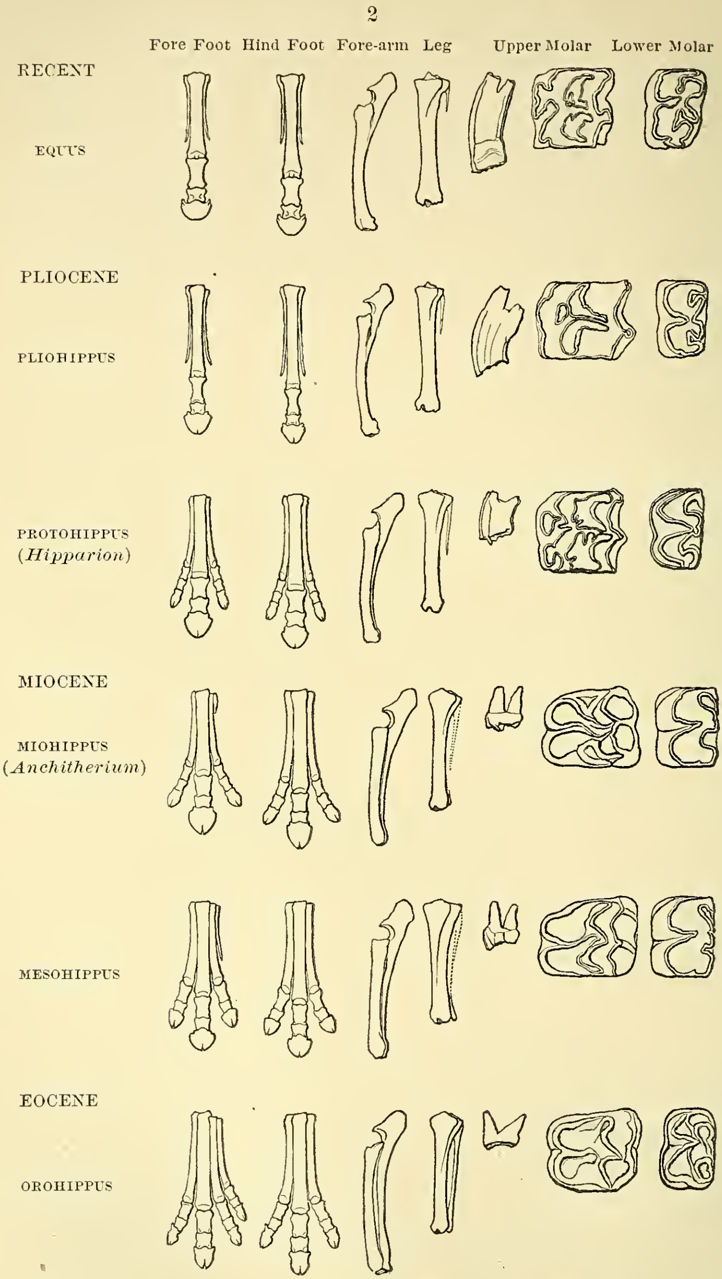

FIG. 2. Genealogy of the Horse. (After Marsh.)

This collection was begun in our western country in 1868, before the completion of the Union Pacific Railroad, and subsequently for several years the explorers had an escort of U. S. cavalry for protection from the assaults of the Indians. In 1876, the collection was seen and studied by Professor Huxley, profoundly altering his views in regard to the place of evolution of prehistoric horses.

The completeness of our record of the evolution of the horse tells us something of the enormous numbers of ancestral forms which must have existed in the more than two million years that have elapsed since the first diminutive horse appeared in North America. While not strongly given to migration, in the course of time these animals wandered over the entire world with the exception of such inaccessible places as Australia and the Oceanic islands.

It would seem that the original stock was of Eurasian derivation, though the great theater of the evolutionary drama was soon transferred to North America, the Eurasian, African, and South American horses which appear from time to time being in all probability of North American origin. As we shall see, the ultimate fate of the horses in both North and South America was extinction, all wild horses of our own time, including the asses and zebras, being confined to Asia and Africa. The apparently wild bands of our western plains and those which roam over the pampas of South America are feral, which means that they are the descendants of domestic horses that have escaped from human bondage, largely from the early Spanish explorers.

The Origin of the Horse.

While we do not know the ultimate ancestor of the horses, we are unquestionably sure of the group of mammals from which they sprang. In this group, the Condylarthra, the animals are five-toed on both hand and foot, also resting a great part of the sole upon the ground. The wrist and ankle bones are arranged in series one above the other in such a manner as to produce a weak structure when exposed to splitting strains.

Phenacodus primævus, one of this group found by Professor Cope, was hailed by him as the "five-toed horse," and its figure has appeared in many text-books as such. It is far too large and in some respects too specialized to be in the equine series, but its feet give one a very good idea of the character of those of the antecedent horse.

The first undoubted horselike animal appearing in the rocks of North America is a little creature not more than eleven inches high, known to science as *Eohippus*. This interesting animal has already made a long stride in the direction of the modern horse, as the number of toes is now reduced to four in front and three behind, and the bones of the wrist and ankle have shifted so as to interlock, which greatly strengthens the foot.

The Evolutionary Changes.

From the Condylarthra and *Eohippus* the course of evolution is largely one of adaptation to the necessities of food get-

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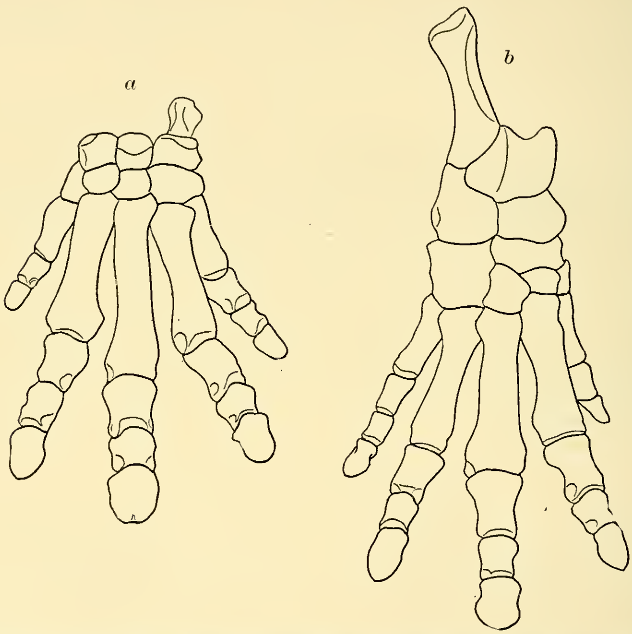

Fig. 3. *a*, Fore foot and *b*, hind foot of *Phenacodus primævus*; drawn from casts from the American Museum of Natural History. One-third natural size. (Original.)

ting and safety. To the one the horse owes the marvelous perfection of the grazing mechanism, as seen in the lengthened jaws and in the teeth; to the other, the fleet limbs and graceful contour of the body and the increase in stature. These adaptations are entirely mechanical, and, while tending toward greater and greater perfection on the whole, are not always of a progressive character; as the loss of side toes is distinctly retrogressive.

Changes in the Feet and Limbs.—The adaptation for speed includes an actual lengthening of the limb, more especially in the lower portions, the thigh and upper arm remaining comparatively short. The muscles which actuate the legs are near the body, their power being transmitted by long slender tendons. This not alone produces a more graceful member, but, as the center of gravity is high, the limb though long moves quickly, like a short pendulum, combining rapidity of movement with a lengthened stride.

The foot changes from its primitive posture, in which more or less of the sole rests on the ground, to that in which the weight is borne on the tips of the toes, the claw, or nail, becoming modified into a hoof. The reduction of the lateral

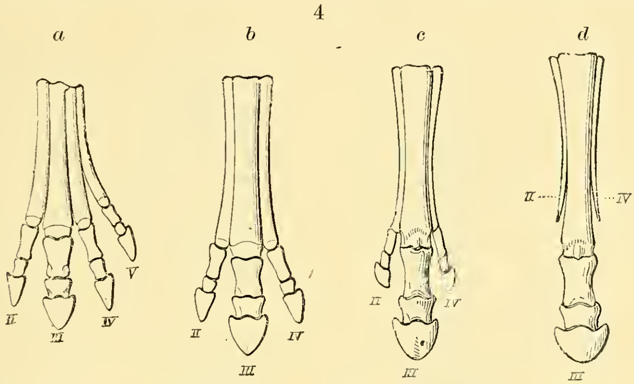

FIG. 4. Fore feet of *a*, *Orohippus* (Eocene): *b*, *Miohippus* (Miocene); *c*, *Hipparion* (Pliocene); *d*, *Equus* (Quaternary). (After Marsh.)

digits invariably follows such a change of posture, especially if the animal is becoming adapted for speed on hard ground. In the horse the axis of the foot lies in the third digit, which grows proportionately longer and stronger as the lateral ones reduce.

The pendulum-like motion of the limbs being all in one plane, the joints between the bones become pulley-like through the formation of interlocking tongues and grooves, which effectually limit any lateral motion. There is also a reduction of the ulna in the fore-arm and of the fibula in the lower leg, as these bones, especially the former, are associated with more varied movement.

In this evolution the hinder foot is the more progressive, as the fore limb retains its general utility for a longer time. Finally, however, after vast ages, the fore foot overtakes the hind one, and thenceforth the degree of evolution in each is the same. Still, it is curious to note that, among living horses, in instances of reversion to ancestral conditions the fore foot is more apt to exhibit well-developed atavistic toes, showing that in it the reminiscent tendencies are stronger.

The Yale collection contains specimens representing three examples of the occurrence of extra toes in the modern horse. They may be monstrosities of the same nature as the occasional sixth finger in man and the multiple digits frequently occurring in the domestic cat. They seem, however, to have a deeper significance and to be true cases of atavism, or reversal to an ancestral condition, although they are abnormal in the

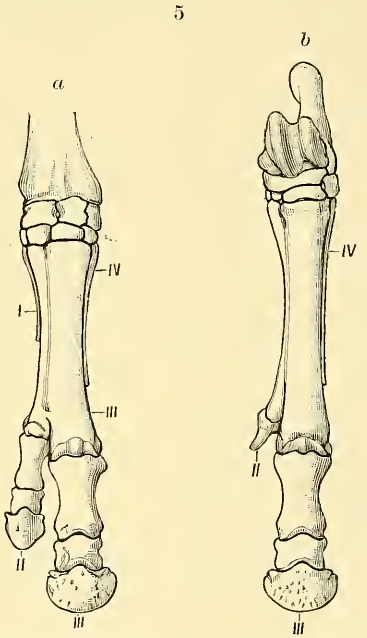

FIG. 5. *a*, Fore foot and *b*, hind foot of Clique, a multitoed modern horse. One-eighth natural size. (After Marsh.)

development of one lateral digit only, as we know of no two-toed fossil horses. Not only has the toe itself reappeared, but in the wrist and ankle are bones with all their old forms and associations, which have not been normally present since Oligocene times. Pliny, the elder, who lost his life in the destruction of Pompeii, A. D. 79, tells us in his Natural History: "It is said, also, that Cæsar the dictator had a horse which would allow no one to mount him but himself, and that its fore-feet were like those of a man." Unquestionably this

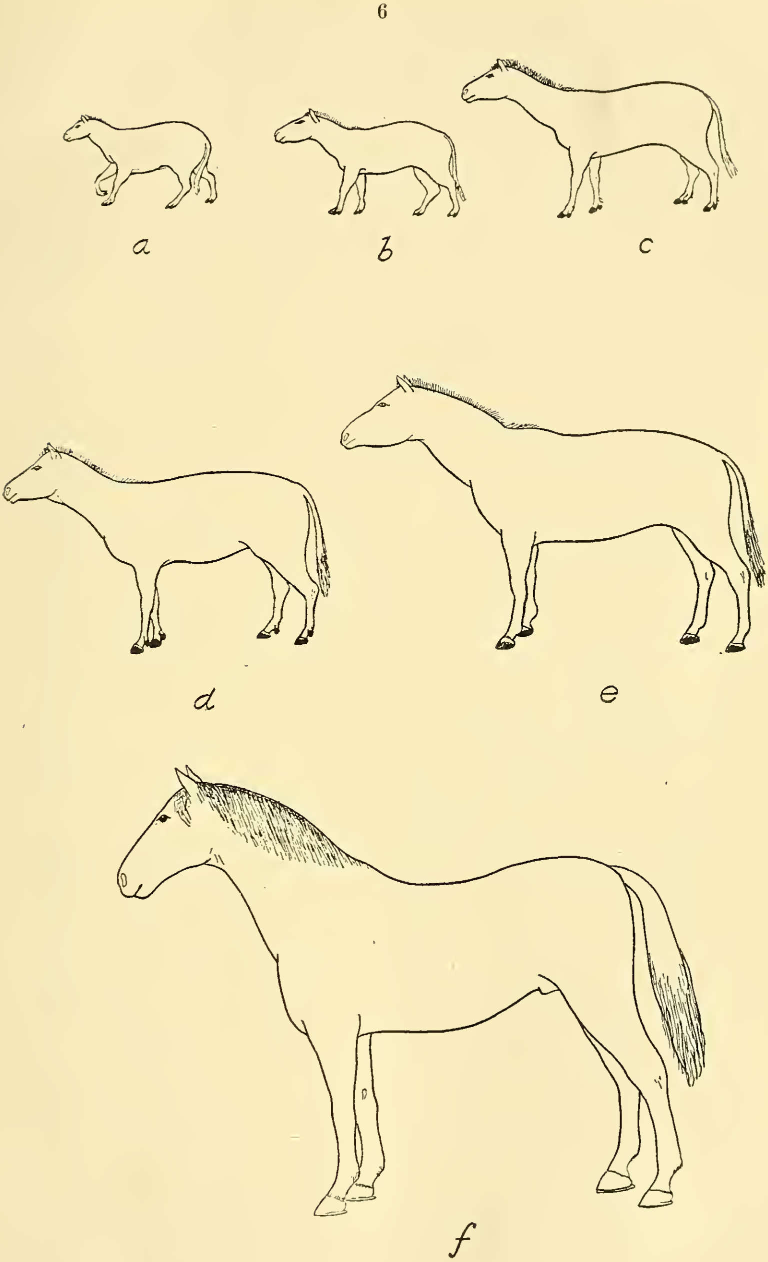

FIG. 6. Prehistoric horses compared with the modern horse in size and contour; *a*, *Protorohippus* (Wind River Eocene); *b*, *Orohippus* (Bridger Eocene); *c*, *Mesohippus* (Oligocene); *d*, *Merychippus* (Miocene); *e*, *Pliohippus* (Pliocene); *f*, *Equus* (Recent). (Original.)

description is somewhat highly colored, but a multitoed horse without doubt forms the basis for the legend.

Changes in the Body.—In the body the evolutionary changes are not so striking, except for an increase in size and length of back. There is also a change of contour, that of the more primitive forms being suggestive of flesh-eating animals rather than horselike.

Of necessity the neck and head elongate apace with the limbs to enable the creature to reach the ground, although the increase in length of the skull is largely in the facial portion, the cranium being conservative in growth. This is of two-fold benefit, since it not only gives the needful room in the jaws for the rapidly increasing armament of the teeth, but by raising the eyes above the earth extends the range of vision while grazing.

Changes in the Teeth.—In the evolution of the teeth we again find both progression and retrogression, as in the modern horse the canine and the first premolar are alike reduced to vestiges and are often entirely absent. The early horses had grinding teeth of a very generalized pattern; indeed, it is often a matter of great difficulty to distinguish the teeth of these horses from those of the ancestors of what are now widely removed orders of mammals. On their crowns these teeth bore little cusps or prominences, which in the quadrangular molars just begin to grow together into the crests that later form the greater portion of the grinding surface. The premolars are at first simple in character, but as time goes on they become successively molar-like, beginning with the hindermost. This is not true of the anterior one, which, as we have seen, is finally reduced to an often disappearing remnant.

During the forest-dwelling period in the history of the horses and while they lived upon succulent meadow grasses, the teeth, though increasing in size with the entire organism, remain short crowned. Upon the expansion of the prairies, however, and the adoption of the harsh grasses as a main staple of food, the tooth of the horse changes in character, becoming elongate, prismatic in shape, and the depressions lying between the crests filling with a substance known as cement, which strengthens the entire tooth. The result is a long columnar structure made up of three sorts of material of different degrees of hardness,—enamel, dentine, and cement, which through differential wear always present a roughened grinding surface.

During the early life of the horse the tooth is continuously growing and, in spite of the fact that it must constantly move outward to compensate for wear, the root penetrates deeper and deeper within the jaw until fully formed. The outward movement still continuing, the tooth now gradually shortens until in extreme old age it is practically consumed. The total length of the tooth is nicely calculated to meet the needs of a full measure of life.

The Geological Occurrence of Horses.

The geological history of the earth is immensely long and it is only very recently, geologically speaking, that the land animals more or less like modern mammals have been evolved. The earth's history begins in the deepest obscurity, the first

	American Formations	South America	North America	Eurasia
Recent		Extinct	Extinct	Equus (also Africa)
Pleistocene	*Equus Beds*	Equus	Equus	Equus
Pliocene	*Blanco* *Palo-Duro*	Equus Hippidion	Equus	Equus
Pliocene Miocene	*Loup Fork*		Pliohippus Protohippus Neohipparion Merychippus Hypohippus Parahippus	Hipparion Anchitherium
Oligocene	*John Day*		Miohippus	Anchitherium
Oligocene	*White River*		Mesohippus	
Eocene	*Uinta*		Epihippus	
Eocene	*Bridger*		Orohippus Helohippus	
Eocene	*Wind River*		Protorohippus	
Eocene	*Wasatch*		Eohippus	Eohippus Hyracotherium
Eocene	*Basal Eocene*		Horses unknown	

glimmerings of life coming to us not as remains showing form and structure, but as graphite, limestones, and iron ores, which are the chemical effects of organic life. This period is of vast duration; then, almost suddenly, myriads of forms of lowly organization appear, out of which are slowly evolved animals and plants of higher and yet higher types.

At length, when the plants had sufficiently spread over the land, there gradually emerged from the waters animals capable of breathing the air, among them creeping amphibians like the salamanders of today. From these arose the lowly reptiles, but during the long period known to geologists as the Paleozoic æon no higher forms of life appear. Then followed the Mesozoic æon, when reptiles flourished, out of which arose the higher animals, both birds and mammals. Mammals lived during the Mesozoic, probably in abundance, but our record of them is very meager, doubtless owing to the conditions under which they existed. In the Cenozoic æon, the age of mammals, the geological record is rich and easily decipherable.

In the basal strata of the Cenozoic age the mammals appear in great profusion, variety, and some of considerable size, indicating a migration from a region as yet unknown. Among these early mammals no horselike ancestors have been yet discovered, undoubted horses first appearing in the genus *Hyracotherium* from the London Clay of England, the ancestor of *Eohippus*.

The sequence of genera is given in the table on p. 169.

Part II.

Synopsis of the Geological History of Horses.

EOCENE PERIOD.

During Eocene times North America was clad with forests in which grew both evergreen and deciduous trees distinctly modern in character. The moist climate gave rise to many streams and lakes, along the shores of which grew sedgy meadows that in turn gave rise to grassy plains. These were the conditions under which the horses made their first appearance, and the increasing development of grass lands gave the initial trend to their evolution.

During the earlier ages of the Eocene period there was but little differentiation on the part of the various mammalian orders, and the ancestral horse is here unrecognized or undiscovered. The earliest known horses appear in the rocks of the Wasatch age, and while they are found in both the Old and the New Worlds the more primitive are of the former, as shown in the genus *Hyracotherium* from the London Clay, known only by the skull.

The genus *Eohippus* has teeth of a very similar pattern, but more advanced in that the cross crests are somewhat more distinct than in *Hyracotherium* and, unlike the latter, the fourth premolar is beginning to assume the form of a true molar. The hand bore four digits, with a vestige of the first (thumb) in the form of a splint bone probably entirely concealed within the skin. The more progressive hind foot had but three toes, with a remnant of the fifth.

Eohippus was a small animal about eleven inches in height at the shoulder and in general suggestive of the carnivores

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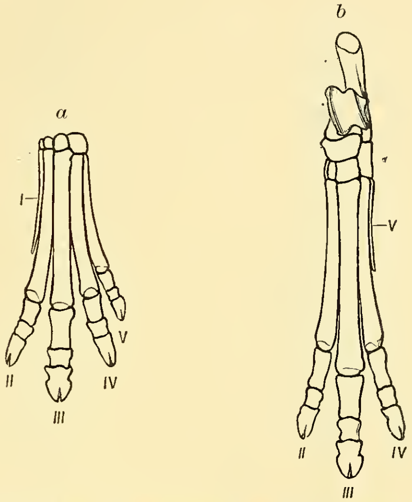

FIG. 7. *a*, Fore foot and *b*, hind foot of *Eohippus pernix*. One-half natural size. (After Marsh.)

rather than of the ungulates of to-day. The back was arched, the head and neck were short, and the limbs of moderate length, showing no especial adaptation for speed. This genus has a remarkable geographical range, having apparently originated in western Europe (England) and migrated by way of Asia and what is now Bering Strait as far southeast as New Mexico. This migration of *Eohippus* shifted the scene of the evolutionary drama to our own country, for, while the remains of succeeding genera are increasingly numerous in North American rocks from the Wasatch on, it is only from time to time that European representatives appear, in each case evidently derived from migratory North American types. The Yale Museum contains the type specimens of *Eohippus pernix* and *E. validus* and numerous jaw, teeth, and limb bones referable to the genus.

During the succeeding Wind River age *Protorohippus* appears, representing the so-called third stage in the evolution of the horse. In stature somewhat larger than *Eohippus*, this animal reached the height of fourteen inches, and while the beginnings of speed are evident from the increasing length of limb, the bodily contour is still primitive. The hand seems to have lost the vestigial thumb and a shortening of the outer-

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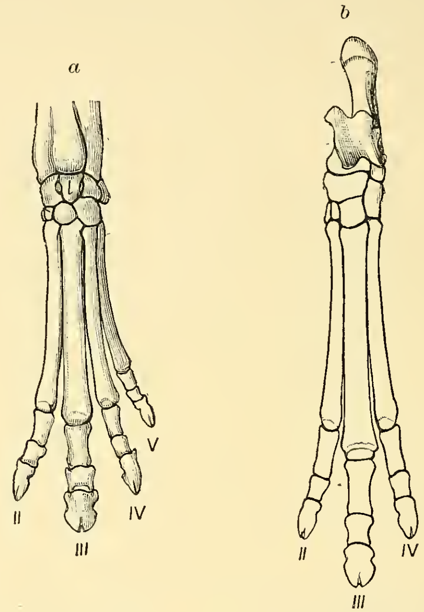

FIG. 8. *a*, Fore foot and *b*, hind foot of *Orohippus agilis*. One-half natural size. (After Marsh.)

most digit indicates that the tendency toward a three-toed condition is already strong. The foot is much like that of its predecessor with three functional toes. The dentition shows progress in the further perfection of the crests, in the fact that the fourth premolar is quite molariform, and that the third is beginning to assume the shape of a molar. *Protorohippus* had a very limited geographical range, being found thus far only in Wyoming and Colorado. In the Yale collection the genus is represented by a cast of the skull of *P. ventricolus* from the mounted specimen in the American Museum of Natural History.

In the rocks of the Bridger age two genera of horses are found, *Helohippus* and *Orohippus*, the former being known only by the teeth. The type specimen of *H. pumilus* Marsh is in the Yale collection. *Orohippus*, on the contrary, is well known, and represents the fourth stage in the evolutionary series. It is but little advanced over *Protorohippus*, which it somewhat exceeds in size. The foot structure is much the same, but the teeth show the most notable improvement over those of its predecessor. The third premolar has assumed the full molar form and the second is beginning to do so. The space, or diastema, between the cropping and grinding teeth is rapidly increasing, owing to the lengthening of the jaws.

The genus *Orohippus* includes a number of species from Wyoming and New Mexico, the Yale collection containing the type specimens of *O. agilis*, *O. ballardi*, *O. major*, *O. pumilus*, and *O. uintanus*, besides numerous other specimens. That of *Orohippus agilis* is especially fine, consisting of a skull, fore foot, and other parts of the skeleton, while a lower jaw and hind foot are probably also referable to this species.

The final Eocene age, that of the Uinta, brings into view the fifth, or *Epihippus*, stage in the horse series, but unfortunately one not well known. Curiously enough, the average size of the species seems somewhat less than that of the preceding genus, although the Yale collection contains a hind foot and other portions of an unnamed form of much larger size, rivaling that of *Mesohippus* of the Oligocene. *Epihippus* has four toes in front and three behind, but the lateral ones are becoming shorter and bear less of the creature's weight than formerly. The premolar teeth are all molariform with the exception of the first, and the crests are almost completely formed. But two species of this genus have been described, both by Professor Marsh, the types being in the Yale collection. They are *Epihippus gracilis* and *E. uintensis* from Utah.

OLIGOCENE PERIOD.

During Oligocene times, much the same conditions prevailed as in the Eocene. The drying up of streams and lakes, due to increasing aridity of climate, gave great impetus to the development of broad meadow lands and to the true prairie as well. Thus there were three conditions,—woodland, meadows, and dry prairie, which seem to have given rise to several parallel lines of evolution, some of which terminated, being overcome in the struggle for existence, while others flourished and gave rise to the horses of the Miocene.

But two genera of Oligocene horses are recognized, *Mesohippus* and *Miohippus*, the former being the more primitive, though the differences between them are slight. *Mesohippus* from the White River beds, the sixth stage, is three-toed in both fore and hind feet, with a rather long splint bone representing the fifth digit of the hand, while in the foot there is no trace of the outer one remaining. The entire series of cheek teeth except the small first premolar is molariform,

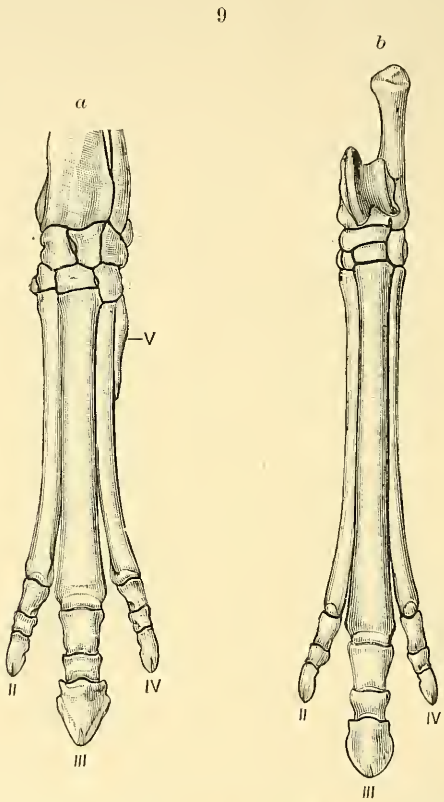

FIG. 9. *a*, Fore foot and *b*, hind foot of *Mesohippus celer*. One-half natural size. (After Marsh.)

while the crests are not only well developed but there is a tendency toward a further complication of the grinding surface.

Mesohippus bairdi, the best known form, averaged about eighteen inches in height, a slender-limbed creature, very well adapted for speed. *Mesohippus intermedius* was much larger and in some ways unprogressive, which, together with the conditions under which it is found, may be taken as indicative of a conservative forest-dwelling form in contrast with the progressive plains-living type. Yale Museum contains a number of fine skulls and other parts of the skeleton of *Mesohippus*, including the smaller Oreodon-bed types as well as the larger species from the Protoceras beds. The former specimens include a nearly perfect skull of a new-born foal of pathetic interest.

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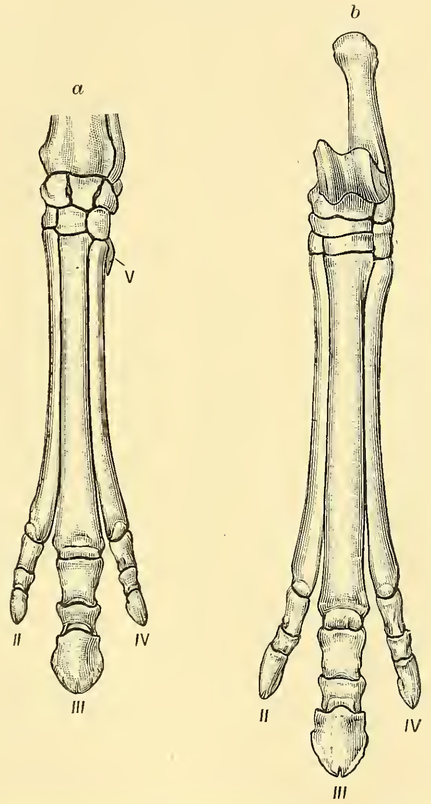

FIG. 10. *a*, Fore foot and *b*, hind foot of *Miohippus anceps*. One-third natural size. (After Marsh.)

Miohippus of the John Day beds represents the seventh stage in the evolution of the horse. It is larger than *Miohippus*, averaging at least twenty-four inches at the withers. Distinctions between the two Oligocene genera are not easily found, the main differences, other than size, being the shorter splint of digit five in the hand, and a somewhat greater complexity of the grinding teeth. *Miohippus*, which may have existed into the Miocene, is contemporaneous with the European *Anchitherium*, a similar genus, to which the species of *Miohippus* were formerly referred. The European genus is a derivative of the latter. *Miohippus anceps* and *M. annectens* were both described by Marsh, and the types are in the Yale Museum. In addition there is a perfect skull from the

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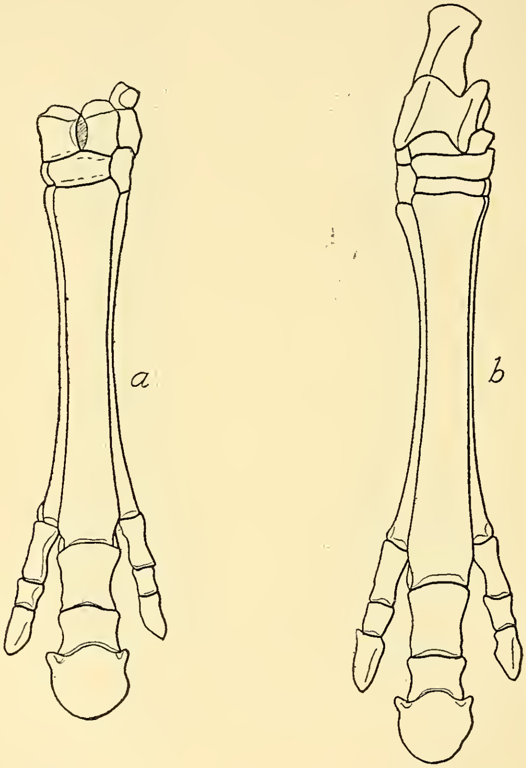

FIG. 11. *a*, Fore foot and *b*, hind foot of *Hypohippus equinus;* drawn from casts from the American Museum of Natural History. One-fourth natural size. (Original.)

Middle John Day (green beds), probably referable to *M. anceps*. The collection contains the fore and hind feet and numerous skeletal elements. The John Day types are confined to Oregon.

MIOCENE PERIOD.

This was a time of continental elevation and great expansion of our western prairies and a consequent diminution of the forest-clad areas. Many mammals otherwise well fitted for survival, such as the titanotheres whose remains are very numerous in the Oligocene beds, were unable to meet the new conditions because of their very perfect adaptation to softer herbage, and thus became extinct. This was also true of certain horses, such as *Hypohippus*, but the great majority were more plastic and in consequence underwent a remarkable development, during this period reaching the culmination in numbers and kinds.

Hypohippus has already been alluded to as one which became extinct during the Miocene, leaving no descendants. It is generally referred to as the "forest horse" from the broad low-crowned teeth fitted only for browsing upon succulent herbage, and from the character of the spreading three-toed feet in which the lateral digits still touch the ground. This would imply an animal fitted for soft ground rather than for speed over the dry prairie soil. The reindeer, whose home is on the mossy tundras, has a broad spreading foot with large lateral toes, while in the fleet-footed prong-horn antelope of our western plains the lateral hoofs have entirely disappeared.

In the hand of *Hypohippus* vestiges of digits one and five may still be seen as small nodules of bone at the back of the wrist. This would imply the descent of this genus from some undiscovered Oligocene ancestor, for in no known instance do we find traces of the first digit in a horse of that period. *Hypohippus* was a comparatively large horse for its time, being forty inches at the withers. It is an admirable example of arrested evolution. There are few specimens of this form in the Yale collection; hence it is represented in the series by a fore foot and lower jaw and by casts of the skull, jaws, and feet of a mounted specimen in the American Museum. *Hypohippus* has been found in the Loup Fork beds of Montana and South Dakota.

Merychippus is of especial interest and is in the direct line of descent, through some of its species giving rise to all subsequent Equidæ. It is three-toed, in some instances with vestiges of the outermost digits of the hand. Digits two and four vary somewhat in development in the different species, though never reaching the ground, so that the feet are functionally one-toed.

It is in the teeth that the greatest interest lies, for herein *Merychippus* is midway in the course of evolution, in the young condition having the short-crowned uncemented teeth of its ancestors, while in the adult state the teeth are long-crowned and cemented as in its successors. The adult teeth are not very long, but are of the columnar or prismatic type and in some instances show a fair degree of complexity in the enamel pattern. *Merychippus* is also the first horse to complete the hinder border of the orbit by sending downward a bony bar to join the zygomatic arch. This bar is represented by a process in its predecessors. The genus ranged from Texas to Montana and Oregon, the Yale collection containing specimens from the Loup Fork deposits along the Niobrara River in Nebraska.

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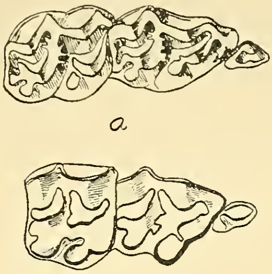

a

b

FIG. 12. *a*, Milk and *b*, permanent premolar teeth of *Merychippus insignis*. Two-thirds natural size. (Original.)

Protohippus of the Loup Fork beds is with difficulty distinguished from *Merychippus*, but has gone farther in that both milk and permanent teeth are fully cemented. The teeth are lengthened and are sharply curved, owing to the shallow depth of the jaws. *Protohippus* was still three-toed, but as far as known the vestiges of digits one and five in the hand have now entirely disappeared. This animal was about thirty-six inches in height at the shoulder and its distribution is similar to that of *Merychippus*.

Pliohippus is found in the Upper Loup Fork beds and ranges up into the Pliocene. It may have been a one-toed horse; for this we have Professor Marsh's authority, though later writers are not inclined to accept the evidence on this point as final. Certain it is that in the type specimen of *Pliohippus pernix* at Yale the lateral toes must have been extremely small, as the splint bones are not much more developed than in the modern horse. Unfortunately the lower ends of all the splints are missing, so that one cannot be sure whether or not they bore an articular extremity. The teeth of *Pliohippus* were larger than those of *Protohippus*, and in some instances still more sharply curved, but the enamel pattern was simpler, with large cement areas.

Pliohippus is the largest of the Loup Fork horses, being forty-eight inches at the withers as compared with sixty-four in a large modern horse. It may be in the direct line of descent to *Equus*, but of this we cannot be sure, as all the links in the chain of descent have not yet been found. Its geographical range covered the western United States, the Yale Museum specimens including the types of *Pliohippus pernix*, *P. robustus*, and *P. gracilis*, coming from Nebraska and

Oregon. The reference of *P. gracilis*, the Oregon specimen, to this genus seems somewhat questionable, as the splint bones are large rather than slender as in the typical species.

Contemporaneous with *Protohippus* and like it a descendant of *Merychippus* is *Neohipparion*, a three-toed horse with very complex teeth in which the anterior-internal column (protocone) is isolated from the anterior cross crest (protoloph), not

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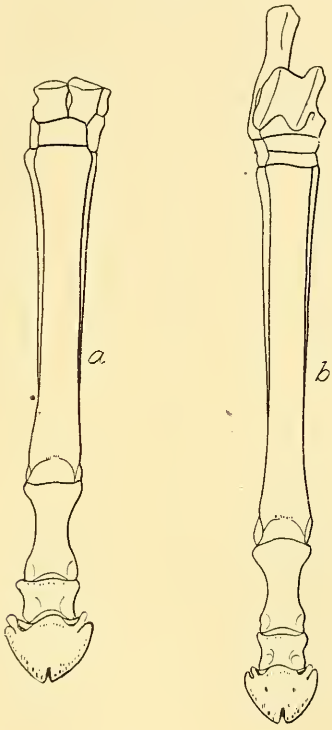

FIG. 13. *a*, Fore foot and *b*, hind foot of *Pliohippus pernix;* drawn from the type specimen, No. 11376, Yale University Museum. One-fourth natural size. (Original.)

connected with it as in all other horses. One can trace the evolution of this feature, for in *Merychippus insignis* the protocone, while attached, tends to become free, yet in *Neohipparion isonesum* the reverse is true in that the protocone, though free, shows a strong reluctance to leave its old association with the anterior crest. In other species of *Neohipparion* this is not apparent, the protocone being oval in section and entirely free in all stages of wear. *Neohipparion* is abundantly represented in the Yale collections, was about forty inches in height at the shoulder, of deerlike aspect, and like the deer admirably adapted for speed.

In the Old World this horse is represented by its descendant *Hipparion*, ranging from the Pikermi beds, which are of

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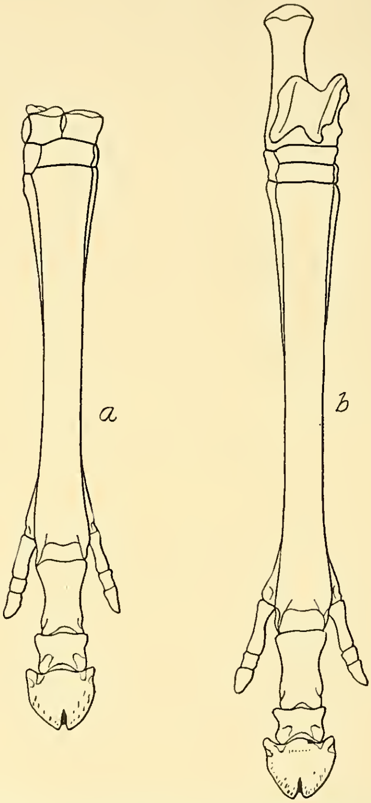

FIG. 14. *a*, Fore foot and *b*. hind foot of *Neohipparion whitneyi;* drawn from casts from the American Museum of Natural History. *Protohippus* is in the same stage of evolution. One-fourth natural size. (Original.)

equivalent age with the Upper Loup Fork, to the Middle Pliocene. *Hipparion gracile*, found in Greece, is also a three-toed horse, though much larger than its American progenitors. This species is represented in the Yale collection by an admirable skull, jaw, and feet and limb bones, from the Museum of the University of Athens.

PLIOCENE PERIOD.

It is probable that the later species of *Pliohippus* were Pliocene in distribution; certainly *Hipparion* of the Old World was, while during this period the true one-toed horses, *Equus* and the curious South American *Hippidion*, first appear. The latter is supposed by some to be a descendant of *Pliohippus*, but this is a matter of doubt. In the Siwalik beds of India is found a one-toed *Hipparion*, and it has been suggested that the modern zebras may be the living descendants of this genus. It is certainly not in the line to the common horse, *Equus caballus*.

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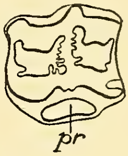

FIG. 15. Upper molar tooth of *Neohipparion affine* Leidy; *pr*, protocone. Two-thirds natural size. (Original.)

Hippidion was extremely short-legged, with a large head and curiously elongated nasal bones, which together with the position of the eyes must have given the creature a very peculiar cast of countenance. The teeth resembled those of *Pliohippus* but were larger and of a more intricate enamel pattern. *Hippidion* was evidently much specialized and does not seem to have survived the time of the deposition of the Pampas beds in Ecuador, Brazil, Bolivia, and Argentina, where it is found.

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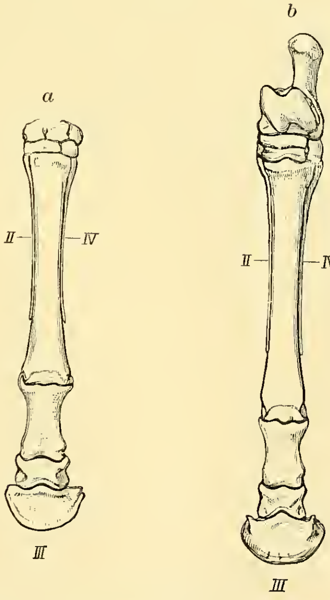


FIG. 16. *a*, Fore foot and *b*, hind foot of *Equus caballus*. One-eighth natural size. (After Marsh.)

Equus, the modern horse, first appears in the Upper Pliocene beds of Eurasia and North America, and represents the culmination of the race. The feet are one-toed but with well-developed splints of the second and fourth digits still remaining. These are sometimes fused with the adjoining canon bone; sometimes they are free, but only in the rare cases of reversion do they bear any traces of the lateral toes. The teeth are long columnar structures of intricate enamel pattern, admirably suited to their owner's needs, while the animal has attained the maximum stature consistent with fleetness.

Fossil members of this genus are very widespread, yet the existing species are entirely confined to Asia and Africa. In North America many fossil species have been described, though reduced to nine by Gidley; in point of tooth structure, one of these, *Equus fraternus*, resembles closely the modern horse, *E. caballus*. *E. giganteus* from southwestern Texas was evidently of great size, "the teeth exceeding those of the largest modern draught horses by more than one-third the diameter of the latter" (Gidley).

In spite of perfection of adaptation the American horses became entirely extinct before the discovery of America by Europeans. This is all the more remarkable in view of the fact that conditions in our West are such that the few horses which escaped from the Spanish explorers have increased so marvelously in numbers, evidently finding these conditions much to their liking. Long before domestication the horse was hunted for food. Professor Osborn states that "one of the bone heaps of the Solutréen period is estimated to include the remains of over 80,000 horses." Even this great slaughter would not be sufficient to cause extinction, for before the invention of fire-arms not one race of large mammals succumbed to the lords of creation.

Paleontological Laboratory,
Yale University Museum,
February 12, 1907.

Art. XVI.—*Clay of Probable Cretaceous Age at Boston, Massachusetts** ; by Frederick G. Clapp.

Discovery of the deposit.—During the past few years a great many deep borings have been made in Boston by the Boston Transit Commission. These have been studied in detail by Professor Crosby,† who has suggested the probable pre-Pleistocene age of clays in certain wells situated elsewhere in Boston. In 1906 the present writer had occasion to examine some samples of recent borings in connection with his study of Pleistocene succession, and a number of samples of probable pre-Pleistocene deposits were seen. Generally the Transit Commission borings have not been sunk over 20 to 60 feet in depth; they penetrate various types of glacial drift, and commonly end in "hardpan", which is nearly always till. Sometimes they pass through a few feet of stratified blue clay, which, judging from its structure and relations, is Glacial or inter-Glacial in age. The underlying bed-rock of the region consists of Carboniferous slate and conglomerate, which are seldom reached by the Transit Commission borings, but when found are nearly everywhere overlain directly by till.

Description of deposit.—No deposits between Carboniferous and Pleistocene in age were found until July, 1905, when a boring made at the Ames Building, on Washington at the head of State street, started at an elevation of 33 feet above mean tide, and was sunk to the unusual depth of 228 feet. A previous test here had reported bed-rock at a depth of 77 feet, directly underneath the drift. Not being satisfied with the original report, the engineers decided to make a new test, with the result that in the 228-foot boring the following strata were penetrated:

Record of boring at Ames Building, Boston.

	Thickness (feet)	Depth (feet)
10. Coarse sand and gravel	17	17
9. Sand	1	18
8. Gravel and sand	5	23
7. Coarse gravel and white clay	3	26
6. Stony sand, gravel and clay with much water (very hard)	16	42
5. Blue clay	18	60
4. Fine sand	5	65
3. Clay, sand, and gravel, with water (till)	12	77
2. Hard dry nearly white clay, with bowlders	136	213
1. Slate (Carboniferous)	15	228

* Published by permission of the Director of the U. S. Geological Survey.

† W. O. Crosby: A study of the geology of the Charles River estuary and the formation of Boston Harbor. In Report of the Committee on Charles River Dam, Boston, 1903, pp. 345-369.

According to the system of the Transit Commission, samples were collected from the boring at intervals of every few feet, and are preserved at the office of the Commission, where they were seen by the writer through the courtesy of Mr. Howard A. Carson, chief engineer. Down to 77 feet from the surface the materials are the ordinary sand, gravel, clay and till of the region, shown by their character to be entirely of Pleistocene age. They are mostly rather wet and yield considerable water. The material below 77 feet is dry, and in a previous boring had been called rock and not entered by the drill. All the samples of this bed were seen by the writer and found to consist mostly of a very fine-grained gray to white clay, which became plastic when wet. It varied from very soft and putty-like to nearly as hard as the underlying slate. The material when examined by Dr. W. T. Schaller of the United States Geological Survey was found to consist of $SiO_2 = 59{\cdot}18$ per cent and $(Al_2O_3, Fe_2O_3, P_2O_5, TiO_2) = 27{\cdot}11$ per cent, thus being a very pure clay.

Two masses, one consisting of sandstone, the other of fine-grained conglomerate, were found in the clay, and each measured about 1½ feet in thickness. These may be interstratified beds of rock, or, as their relations and character seem to indicate, they may be bowlders. No other foreign matter was found in the clay. Since the surface of the Carboniferous bed-rock buried underneath the city of Boston is very hilly and is eroded into deep river channels, it seems possible that bowlders might become detached from a near-by ledge due to action of currents, and incorporated in the clayey sediments during their deposition.

Difference from Pleistocene clays.—This clay is important for the reason that it is unlike the general type of clay found at Boston. All the Pleistocene clays of the vicinity are of blue-gray to brown or buff colors; this clay is light gray to nearly white. The Pleistocene clays contain numerous bowlders and pebbles composed of all kinds of rock found in New England, but in this clay only two bowlders have been discovered, and these consist of rock only found in the vicinity of Boston, and which forms the bed-rock of the region. The Pleistocene clays are interstratified with glacial deposits: this clay rests on bed-rock and is separated from the overlying Pleistocene clay by a bed of till. This clay is much dryer than the overlying Pleistocene clay.

Similar clay in other borings.—In a boring at Dock Square, Boston, also made by the Transit Commission, samples of which were examined by the writer, a number of fragments of white clay (No. 2 in the record) were scattered through the brown Pleistocene clay at depths of 23, 30, and 31 feet from the surface. Some of these fragments are as much as half an inch in diameter. Mr. B. F. Smith, a prominent well driller of Boston, reports a number of wells in the city, in which peculiar soft white deposits were found directly underneath the till. The material is said to cave badly and sometimes contains much water.

To Professor Crosby, who has made extensive investigations regarding the borings of Boston, belongs the credit of being the first to suggest the pre-Pleistocene age of this clay. Professor Crosby writes as follows:*

"We may profitably note the fact that some of the borings reporting bed-rock in the section of Boston south and east of Beacon Hill have clearly not reached any of the hard and thoroughly solid rocks (slate, conglomerate, trap, etc.) such as make up the whole of the bed-rock surface wherever it is exposed in ledges and shallow excavations; but instead the drill has passed from the glacial drift to imperfectly consolidated sands, clays, marls, etc., in part of colors unknown to the drift, and probably representing Tertiary strata underlying the drift and filling deep depressions and valleys in the harder formations or true bed-rocks of the region. The artesian well of N. Ward & Co., on Spectacle Island, 560 feet deep, passed through at least 360 feet of unconsolidated material, only part of which could be regarded as glacial drift; and the deep well at the corner of High and Purchase streets in Boston, reported as reaching the bottom of the drift at about 100 feet, is in soft materials comparable with the Tertiary deposits of Martha's Vineyard and Long Island, to a depth of at least 500 feet."

Conclusions.—Samples of the white clay from the Ames Building boring were compared at the office of the United States Geological Survey with samples of clay collected by Mr. Veatch from a number of borings on Long Island, New York, and found to agree very closely with them in appearance. Mr. Veatch has correlated the Long Island deposits with the Raritan formation of New Jersey.† If this correlation is correct, it is possible that the Boston deposits may be of similar age. This is rendered more probable by the similarity of the material in the Boston borings to some of the clays on Martha's Vineyard, and by the fact that the beds on that island referred to by Professor Crosby as "Tertiary" are said by paleontologists to be in part of Cretaceous age.

Previous most northern known Cretaceous and Tertiary.—Cretaceous and Tertiary deposits have been known for years

* W. O. Crosby, Report of the Committee on Charles River Dam, Boston, 1903, p. 354.

† A. C. Veatch, Outlines of the Geology of Long Island, Prof. Paper, U. S. Geol. Survey, No. 44, 1906, pp. 22 et seq.

at Martha's Vineyard,* and Miocene greensands have been noted at Marshfield, 25 miles southeast of Boston.† In 1905 Tertiary deposits were identified by Mr. Bowman at Third Cliff, Scituate, 20 miles southeast of Boston, underneath drumlin till and earlier glacial deposits.‡ As Tertiary and Cretaceous deposits were once of considerable thickness in this region, it is not improbable that future well-drilling may reveal them below sea-level at points farther north on the New England coast.

U. S. Geological Survey,
Washington, D. C.

* References in N. S. Shaler's Report on the Geology of Martha's Vineyard, 7th Ann. Rept., U. S. Geol. Survey, 1888, pp. 303-363.

† Edward Hitchcock: Final Report on the Geology of Massachusetts, vol. i, p. 91–95, and 427, 1841.

‡ Isaiah Bowman, Pre-Pleistocene deposits at Third Cliff, Massachusetts. Science, vol. xxi, June 30, 1905, pp. 993-994; and (for more complete conclusions) this Journal, vol. xxii, Oct. 1906, pp. 313-325.

Art. XVII.—*A Lower Huronian Ice Age*; by A. P. Coleman.

Of late years the evidence for ice ages far older than the familiar Pleistocene Glacial Period has been growing rapidly, and at least one Paleozoic ice age, that of the Permian or Permo-Carboniferous of India, Australia and South Africa, must be looked on as fully established. All the geologists who visited South Africa with the British Association in 1905 were convinced of the glacial origin of the Dwyka "tillite," or bowlder clay, and of the striated rock surfaces beneath, found from point to point for 600 miles. The evidence for the equivalent glacial beds of Australia and India appears to be equally clear, as shown by Professor David of Sydney University at the late meeting of the Geological Congress in Mexico.

This well established ice age of Paleozoic times makes it far more probable that glacial periods are a normal, if infrequent, feature of the world's past history; and adds weight to the evidence so far recorded of very ancient ice ages, such as those of the Cambrian.

It will be recalled that what is probably an early Cambrian glacial deposit was described by Reusch in the Gaisa beds of northern Norway in 1891;* and reëxamined by Strahan in 1897. The region in which these comparatively small outcrops of bowlder clay were found is, however, in latitude 70°, so that Arctic conditions of a local kind might not be surprising.

More recently Bailey Willis has described before the Geological Society of America an early Cambrian or possibly Precambrian Glacial formation on the Yang-tse river in China, in latitude 30°. The specimens of striated stones which he displayed were characteristic, and the matrix suggested an ancient bowlder clay.†

In 1905 A. W. Rogers of the Cape Colony Survey described a glacial conglomerate in the Table Mountain series. This had been discovered four years before, but was now worked out more in detail and found to extend at least 23 miles. It contains stones of typically glacial appearance. The age of these rocks seems not quite certain, since no fossils have been found in the Table Mountain series, but they are very early

* Norges geologiska Undersögelse; Det nordlige Norges Geologi, pp. 26–34, 1891. Geol. Soc. London, vol. liii, pp. 137–146, 1897. Mr. Strahan's paper is accompanied by plates showing the bowlder clay and the striated rock surface beneath it.

† Year Book No. 3, Carnegie Inst., p. 282; see also Chamberlin and Salisbury's Geology, II vol., pp. 273–4, where photo reproductions of glaciated pebbles are given.

Devonian if not older.* In 1906 Rogers described a still more ancient glacial formation in the Griquatown series of Hay, where striated bowlders occur in a very hard matrix, from which they slowly weather out. Two of these stones kindly sent me by Mr. Rogers are, as I can testify, thoroughly glacial in appearance. The Griquatown series is certainly older than the Cape rocks, apparently Cambrian or Precambrian.† If Precambrian, the series must come near the upper limit, since there are apparently three other series beneath it, the Campbell Rand, the Kheiss, and the Namaqualand schists. It occupies perhaps about the position of the Keweenawan in America.

Since this paper was prepared a very interesting article by E. H. L. Schwarz on "The Three Paleozoic Ice Ages of South Africa" has appeared.‡ Schwarz was associated with Rogers in at least part of the work and is convinced of the glacial character of the lower deposits. This account of them agrees with Rogers' papers cited above, but gives more details.

In an excellent paper before the recent Geological Congress Prof. David described ancient glacial deposits, probably of Cambrian age, in Australia and India, and showed some very glacial-looking material from Australia, but I have seen no printed copy of his paper.

From the foregoing references it will be seen that Cambrian or possibly late Precambrian glacial deposits have been found in various places in both hemispheres in latitudes from 70° to 30°. If they all belong to one period the refrigeration must have been widespread, and one can hardly account for them all as due to local mountain glaciers.

For several years it has seemed to me very probable that there was a still more ancient ice age, at the beginning of the Lower Huronian in the Archean as defined in Canada or the Archeozoic or lowest Algonkian as defined by various American geologists. The so-called Huronian "slate conglomerate" of Ontario has attracted attention ever since Logan and Murray mapped and described it in the typical region north of Lake Huron nearly fifty years ago. Good descriptions of it are given by Logan in the 1863 report of the Canadian Geological Survey; where he refers to the different kinds of rock enclosed as pebbles or bowlders, granite, felsite, certain greenstones and jasper, for example; and describes the matrix as sometimes slaty, sometimes more quartzitic or like diorite or greenstone. At present the matrix would generally be called

* Trans. S. African Phil. Soc., vol. xvi, part 1, May, 1905.

† Trans. Geol. Soc. S. Africa, vol. ix, 1906; The Campbell Rand and Griquatown series in Hay, pp. 8 and 9.

‡ Jour. Geol., vol. xiv, No. 8, pp. 683–691.

graywacke or slate, though sometimes it is schistose or looks like an eruptive rock.

The pebbles or bowlders are in many cases subangular or sharply angular and are found miles away from any known source; and as they may be of any size up to blocks weighing tons, and are frequently very sparsely scattered through an unstratified matrix, a stone or two in several yards, one cannot help suspecting that the transporting agency was ice rather than water. There are parts of the formation where the pebbles or stones are well rounded and crowded in certain bands. In such cases they are probably true water-formed conglomerates; but the prevalent type of the rock with scattered subangular stones or bowlders should not be called a conglomerate, any more than a Pleistocene bowlder clay would receive that name. The appearance of these so-called slate or graywacke conglomerates is closely like that of the Dwyka bowlder clays, for which Penck suggests the term "tillite."

Good examples of these bowlder-bearing rocks are found in the original Huronian region on Echo lake, near Desbarats and on the Palladeau Islands. At the last locality smooth water-worn surfaces give excellent sections of the rock, the scattered red granitic bowlders standing out sharply from the dark greenish gray matrix. The granite bowlders similarly enclosed near Desbarats are twenty miles from the nearest known outcrop of that rock.

Logan describes a similar "slate conglomerate" from Lake Temiscaming, and also a schist conglomerate from Doré river on Lake Superior as belonging to the same formation; and in some cases his measurements made them hundreds or even thousands of feet thick.*

Later explorations in northern Ontario, described in reports of the Bureau of Mines of the province, have brought to light many other areas of the so-called conglomerate, some very characteristic ones occurring near Sudbury and east of Lake Wahnapitae; while schistose varieties, which have undergone more severe squeezing and metamorphism, occur near Shoal Lake, Manitou Lake and on the Lake-of-the-Woods. In fact, rocks of the kind are found from point to point across all northern Ontario, a distance of nearly 800 miles, and from the north shore of Lake Huron in latitude 46° to Lake Nipigon in latitude 50°.

The more schistose of these conglomerates have their pebbles flattened and rolled out into lenses not at all suggesting glacial action; but the fact that all of them, whether schistose or unmodified, occupy, so far as known, the same position, immediately over the Keewatin, and contain pebbles and

*G. S. C., 1863, p. 56.

bowlders of the same rocks, granite, banded jasper, etc., makes it very probable that they belong to the same age and have had a similar origin.

It is evident that for useful study the least metamorphosed examples of the bowlder-bearing rock should be selected, such as those of the typical Huronian region or those between Sudbury and Lake Temiscaming.

In the western region I have never succeeded in loosening stones from their matrix so as to observe whether the surfaces were striated. Until recently the same difficulty was met in the eastern conglomerates; but the new silver mining district at Cobalt has at last furnished a few pebbles and larger stones which have preserved their original surfaces.

The outcrops at Cobalt are well exposed and show the usual variations of the so-called basal Huronian conglomerate. There are some indefinite bands crowded with small stones, often well rounded, while other parts of the outcrops have very few bowlders or smaller stones, and these are often angular. The matrix varies from slaty material, sometimes with a hint of stratification, to graywacke composed of coarse and fine rock fragments, mostly quite unrounded. A few geologists have supposed, as was formerly suggested for the Dwyka of South Africa, that the matrix is a basic eruptive rock; but its fragmental character is clearly seen in the field and in thin sections.

The enclosed stones include large and small blocks of granite, many felsitic and porphyritic rocks, greenstones, and a few bits of banded silica derived from the iron formation of the underlying Keewatin.

Professor Miller, who has mapped the region for the Bureau of Mines of Ontario, guardedly suggests the resemblance of this rock to bowlder clay.* He calls attention to the fact that "the granite bowlders are often two or three feet or more in diameter and distant a couple of miles from exposures of the rock"; but on the whole seems opposed to a glacial origin.

By the exercise of care and patience it has been possible to break from their matrix wholly or partially about twenty of these stones, mostly only an inch or two in diameter, but half a dozen from three to six inches across. As coarse-grained rocks like granite seldom show distinct striations in modern bowlder clays, felsites and fine-grained greenstones were selected to work upon. Of the twenty stones four or five are more or less striated, but only one is heavily and decisively scored. Unfortunately the matrix could not be completely

* Bur. Mines, 1905, p. 41.

removed from this one, but the exposed surfaces show the striations well on one face and distinctly on two others.

Several of the smaller pebbles have the peculiar somewhat uneven but well polished faces with rougher corners so often seen in the smaller stones of bowlder clay.

Though the number of stones available is small, the proportion showing more or less striation is as large as in recent bowlder clay and all the usual features of ice-carved stones are found in them. It may be added that they were taken from undisturbed parts of the formation with no faulting to cause slickensides, and that the stones themselves had not been squeezed nor broken in the matrix.

No striated surfaces were found where the conglomerate rested on the underlying Keewatin; but the only contact of the two rocks examined was unfavorable for displaying such a surface. Mining operations show that the rocks beneath the Huronian have on the whole an uneven, somewhat undulating surface of low hills and valleys, the conglomerate often more or less filling in these valleys.

In the silver region the Lower Huronian has a maximum thickness of about 500 feet so far as known. There are also, as shown by Prof. Miller, conglomerates in the next overlying formation, the Middle Huronian.

The evidence for a Lower Huronian Ice Age may be summed up as follows:

A peculiar rock consisting of graywacke or finer materials showing little or no stratification but containing pebbles or stones, sometimes crowded, but more often scattered a few feet apart, is found from point to point over an area 800 miles long by 250 miles broad. The stones are of all sizes up to diameters of several feet and of all shapes from rounded to angular, many being subangular with rounded corners. The stones are of several different kinds, some fragments of the immediately underlying rock, others having a distant source.

In the Cobalt mining region a few polished and striated stones have been broken out of the matrix. They are closely like stones from the Pleistocene bowlder clay of the same region except that they lack the Niagara limestones of the recent drift.

Hand specimens of matrix and enclosed pebbles are precisely like the Dwyka tillite or conglomerate of South Africa, which is undoubtedly of glacial origin.

Against the glacial theory is the fact that no *roches moutonnées* have yet been found on the underlying Keewatin rocks. All the positive evidence is favorable to the theory of glacial action as the cause of these curious bowlder-strewn rocks.

If the evidence given above is accepted, the occurrence of glaciation is probable over an area too large to be the work of merely local mountain glaciers, and one must assume the presence of ice sheets comparable to those which formed the Dwyka.

The Lower Huronian is the second formation in the geological succession in North America, only the Keewatin coming before it; so that the probable action of ice on a large scale is pushed back almost to the beginning of known geological time. This implies that the climates of the earlier parts of the world's history were no warmer than those of later times, and that in Lower Huronian times the earth's interior heat was not sufficient to prevent the formation of a great ice sheet in latitude 46°.

The bearing of these points on early geological history and on theories of the earth's origin is self evident.

It should be kept in mind, however, that the evidence, though favorable and in some directions strong, is scarcely wide enough to give certainty in a matter of so much theoretical importance.

ART. XVIII.—*A New Species of Baptanodon from the Jurassic of Wyoming;* by CHARLES W. GILMORE.

DURING the summer of 1905 Mr. W. H. Reed, Curator of the University of Wyoming museum, found what appears to be the most complete skeleton of *Baptanodon* yet obtained from the marine Jurassic of this country.

Through the kindness of Mr. Reed the important parts of this specimen were submitted to the writer for study and description. Characters observed in the teeth and anterior extremities indicate a new species, for which the name *Baptanodon reedi* is proposed, in recognition of Mr. Reed's many discoveries in this formation.

Baptanodon reedi sp. nov.

Char. Specific: *Distal end of humerus broad and articulating completely with radius, ulna, and pisiform. Teeth of large size and extending the full length of the jaws. Sclerotic ring small in proportion to length of skull.*

The type specimen, designated as D.B. in the University of Wyoming collection, was found in the Dutton Creek Basin, Fremont Co., Wyoming. It occurred in the same horizon of the marine beds and only a few hundred feet distant from the place where the type specimen of *Megalneusaurus rex** was found. This horizon Knight considered the uppermost band of the Shirley† stage, and the stratigraphic position is quite in accord with the highly specialized features observed in the skeletal structure of this specimen.

The *type* of the present species consists of one-half of the skull (divided longitudinally), one hundred and fifty-three vertebræ in series beginning with the atlas, numerous ribs, proximal part of the left scapula, both humeri, and the proximal portion of the left pectoral extremity.

The writer has had no opportunity of examining more of the skull than the sclerotic ring of one orbit and the anterior portion of the rostrum, and only the parts studied will be considered in this paper. However, a photograph of the right side shows a general resemblance to the other *Baptanodon* skulls known.

The sclerotic ring is remarkably free from distortion and gives a clear conception of the arrangement of the bony plates, which constitute the protective covering of the eye. The ring

* W. C. Knight, this Journal, vol. v, May, 1898.

† W. C. Knight, Bulletin Geol. Soc., of America, vol. xi, May, 1900, p. 385.

appears to have the same number of segments (14) as found in the other members of this genus. It has been removed from the orbital cavity and as viewed antero-posteriorly it might be well described as the union of the bases of two truncated cones. This specimen fully confirms a previous suggestion of the writer* "that this covering extended well to the back of the eyeball as in some birds." The diameter of the internal opening equals that of the external pupillary opening. The ring is about 70^{mm} in thickness, and compared with the eye of *B. discus* is small in diameter, as is clearly indicated by the following measurements:

	Greatest length of skull.	Diameter of sclerotic ring.	Diameter of pupillary opening.
B. discus, No. 878, Carnegie Museum	1082^{mm}	202^{mm}	100^{mm}
B. reedi, D. B., University of Wyo.	1320 "	150 "†	85 "

That part of the *rostrum* studied by the writer measures 262^{mm} in length, and, as in the other *Baptanodon* skulls, the tip of the beak is wanting. The frail nature of the bone, together with the exceedingly refractory matrix, did not admit of the preparation of this part of the specimen, but a longitudinal fracture exposes the dental groove of one side, in which may be counted the bases of thirteen teeth.

These teeth are of a strong, robust nature with enlarged bases. The few teeth protruding from the matrix are subcircular in cross-section, their surfaces being covered with coarse longitudinal striæ which gradually subside before reaching the subacute apex, which is smooth. Mr. Reed informs me that large teeth are present in the grooves of the posterior portion of the rostrum. It would seem, therefore, from this evidence that *Baptanodon reedi* had a series of strong functional teeth extending from the back to the front of the jaws.

Mr. Reed furnishes the following information concerning the vertebral series:

"The vertebræ of this specimen number one hundred and fifty-three. There are four centra missing, namely, the atlas, axis, third and fourth cervicals, but their neural processes are retained in place, and these parts resemble the homologous elements of *Baptanodon marshi*. The diapophysial articular surface on the fifth centrum (counting from the skull) of the series is confluent with the neurapophysial articular surface, and this position holds until the eighteenth centrum is reached. On this vertebra the two surfaces are separated. From this point posteriorly the diapophyses and parapophyses gradually move down on the

* C. W. Gilmore, Memoirs Carnegie Museum, vol. ii, No. 9, p. 328.

† If flattened out like the sclerotic ring of No. 878 this dimension would be about 175^{mm}.

sides of the centra, at the same time constantly approaching one another, for example, on the anterior vertebræ these processes are 16^{mm} apart but on the thirty-eighth they are only 7^{mm}. On the fortieth centrum the dia- and parapophysis are united forming an oblique elongated process, 22^{mm} long and 12^{mm} wide, which occupies a position well down under the side of the centrum. The single process continues as far posteriorly as the sixtieth vertebra : here there is another change. In diameter the single processes on sixtieth to the sixty-sixth vertebræ (inclusive) are nearly double the size of those in front, but they do not project as far from their centra, and, moreover, their articular ends are deeply concave. These processes also occupy a higher position on the sides of the centra than either those that precede or follow.

The single process is found on the sixty-seventh vertebra, but the surfaces of the succeeding centra are so abraded that it is impossible to determine on what vertebra this process is last found.

Beginning with the eightieth vertebra there is a sudden reduction in the diameter of the centra, or from the eightieth to the eighty-fourth the reduction is more than one half the previous diameter of the centra. From this point the centra gradually decrease in size to the one hundred and fifty-third, which measures 5^{mm} in its vertical and 3^{mm} in its horizontal diameter. These smaller vertebræ are oval in outline and only slightly biconcave.

The fifth vertebra in the series measures 60^{mm} in both its vertical and horizontal diameter; the tenth is 90^{mm} in the vertical and 84^{mm} in the horizontal; and the fortieth is 109^{mm} in the vertical and 98^{mm} in the horizontal.

The total length of this specimen from the anterior portion of the snout to the end of the one hundred and fifty-third vertebra is 6270^{mm}."

The finding of such a complete series of vertebræ establishes definitely the points where the various epophysial changes occur, and the more important of these may be summed up as follows :

1. The diapophysial and neurapophysial articular surfaces confluent on the anterior vertebræ separate on the eighteenth centrum.

2. The dia- and parapophysis unite on the fortieth centrum to form a single process.

3. The greatly modified processes on the sixtieth to the sixty-sixth centra (inclusive) may, as Mr. Reed has suggested, represent the point of attachment for the pelvis.

4. The sudden decrease in diameter of the caudal centra begins with the eightieth vertebra.

It is now fairly well established that *Baptanodon*, as in *Ichthyosaurus*, had a downward deflection of the caudal vertebræ into the lower lobe of the caudal fin. In *Ichthyosaurus communis*, Owen determined that the downward trend of the vertebræ commenced with the eightieth centrum; and Mr. Reed informs the writer that as found in the ground this specimen showed such a bend beginning at the point where the caudals decrease in size so rapidly.

Anterior limb.—Figure 1 illustrates the left pectoral extremity as preserved with this specimen. All of the elements remaining were retained in the matrix, and thus afford a good opportunity to study their mutual relationships.

The robust *humerus* has a stout twisted shaft and expanded ends which are so turned as to cut each other at an angle of

1

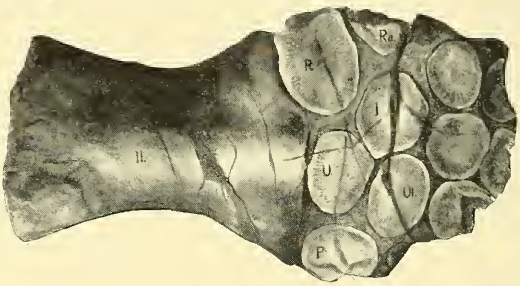


Fig. 1. Left pectoral extremity of *Baptanodon reedi*, seen from below. One-fifth natural size. H, humerus; R, radius; U, ulna; P, pisiform; Ra, radiale; I, intermedium; Ul, ulnare. Type specimen in the University of Wyoming collection, Laramie, Wyoming.

45°. The proximal end is subrectangular in outline and very rugose. It is slightly convex both vertically and horizontally. Vertically this end has an average thickness of about 80^{mm}. The distal end is much compressed, being about 50^{mm} in thickness, but broadly expanded in the other diameter. This end presents two distinct faces for articulation with the elements of the epipodal row. The facet for the radius has a markedly concave border instead of the straight face observed in the other species. The facet opposed to the ulna and pisiform meets the facet for the radius at an obtuse angle and from there extends straight out to the edge of the humerus. It is quite probable that these facets are concave vertically as found on the humerus of *B. marshi*, but to determine this point it would be necessary to separate these elements, and their closely applied surfaces rendered this procedure inadvisable.

The main projection of the proximal end beyond the plane of the distal end is toward the upper side, thus forming a very strong trochanteric ridge which is wholly confined to the proximal half of the shaft.

The *radius* and *ulna*, particularly the former, are closely articulated with the humerus. In general form and size they resemble very closely the corresponding bones of *B. marshi.*

The *pisiform* in *B. reedi* is more elongate than circular in form and articulates completely with the humerus. In these respects it approaches the conditions found in the paddle of the closely allied form *Ophthalmosaurus icenicus*,* although

2

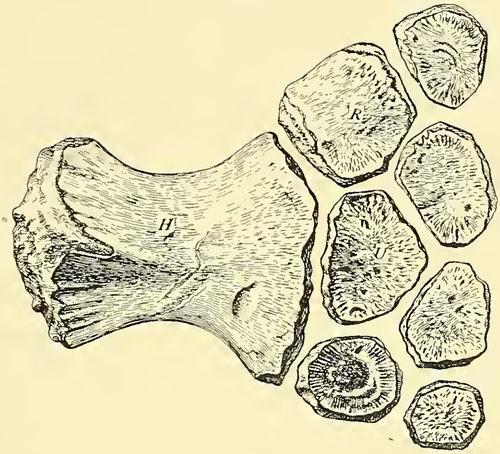


Fig. 2. Right pectoral extremity of *Ophthalmosaurus icenicus* Seeley, seen from above. One-fourth natural size. H, humerus; R, radius; U, ulna; P, pisiform. Paratype. (After Seeley.)

a comparison of figures 1 and 2 shows the elements in the latter genius to be more angular in their general outlines.

The *ulnare* appears more elongated than in *B. marshi*, and the *intermedium* more angular than those observed in other specimens.

The other elements of the paddle are more or less rounded disks and a description of them would hardly add anything to our understanding of this form.

The writer considers the paddle of *B. reedi* as the most highly specialized limb yet found among the American Ichthyosaurians. This is shown by the broadly expanded humerus, which articulates closely and completely with the radius, ulna and pisiform.

* H. G. Seeley, Quart. Jour. Geol. Soc. of London, vol. xxx, pp. 696-707, 1874.

The following comparative measurements are interesting as showing the similarity in proportions between the humeri of the American and English members of the Baptanodontidæ.

	Greatest length of humerus.	Greatest width of proximal end.	Greatest width distal end.
Type of *B. reedi*, Univ. of Wyoming coll.	210mm	140mm	165mm
Type of *B. marshi*, " " " "	190 "	127 "	130 "
Paratype of *O. icenicus*, Leed's collection	164 "	115 "	152 "

Judged from the limb structure alone, the pectoral extremity of *B. marshi* presents the most generalized features of this genus, while, on the other hand, the anterior paddle of *B. reedi* exhibits the most specialized characters. This deduction is based upon the comparative breadth of the distal ends of the humeri and the manner by which they articulate with the epipodal elements. In the former species, as Knight has pointed out, the facet for the pisiform is rudimentary, but in *B. reedi* the humerus has widened sufficiently to admit of the complete articulation of this bone. In the manner of the articulation of these elements the extremity* of *B. discus* figured by Marsh appears to be intermediate in form. The limbs, at least, suggest a direct line of development, and if the geological position of *B. reedi* is correctly determined as the uppermost part of the marine Jurassic, it would be quite in accord with the structural changes observed in these specimens, as the other species are known to have come from lower layers of these marine strata.

In *Baptanodon*, as in other Ichthyosaurians, the evidence furnished by limb structure is most valuable for working out their relationships, although, as Dr. Merriam has suggested in discussing the limbs of the Triassic Ichthyosaurs, "they hardly furnish the whole foundation for a definite classification."

A study of the coalesced atlas and axis of *B. natans*, *B. discus*, *B. marshi*, and *B. robustus* show differences of structure which would indicate that other characters that will serve for specific separation will probably come to light when the detailed structure of these several species is better known. Unfortunately the missing centra of the anterior cervicals of this specimen renders it impossible to compare these vertebræ with the homologous parts of the other species.

U. S. National Museum, Dec. 17, 1906.

*As suggested in a previous paper, the paddle identified by Professor Marsh as a pelvic limb is undoubtedly a pectoral extremity, and it is so considered here.

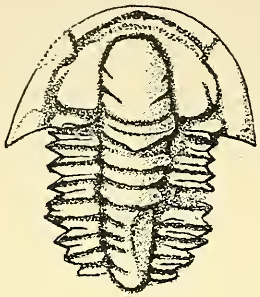
Art. XIX.—*An Almost Complete Specimen of Strenuella strenua (Billings)*; by H. W. Shimer.

The specimen of *Strenuella strenua*, here described, was found at Mill Cove, North Weymouth, Mass., in the Lower Cambrian slates. It is now in the collection of the Boston Society of Natural History, with catalog number 12978.

The cephalon is almost complete. The genal angles are prominent; the free cheeks thin, and the anterior fold (frontal rim), extending around the front of the cephalon between the free cheeks, is narrow, convex, and defined from the rest of the cephalon by a prominent, rounded furrow. The glabella is strongly arched, with two partial but well-marked furrows; it tapers forward very slightly and is abruptly rounded in front. The neck ring is prominent, with anterior furrow broad and deep, and the posterior shallow and narrow; this narrow furrow separates the neck ring from a strong, backward-pointing, triangular projection, which shows no evidence of a spine. The palpebral lobes are slightly curved and separated from the fixed cheeks by a rounded furrow which disappears anteriorly. What, with doubt, was taken for an eye, is a small, lozenge-shaped elevation bordering the free cheek but apparently attached to the palpebral lobe; this was seen only upon the left side. The fixed cheeks are convex but much less so than the glabella; they are not flattened on top.

The axis of the thorax is quite convex, as are also the pleura. The latter rise gently from the axis for slightly more than half their length, when they bend down quite suddenly, thus giving to them a triangular convexity. This down-bending takes place just inside the point where the overlapping of the pleura cease. There is a broad rounded furrow running lengthwise through the middle of each pleural segment and terminating in the straight, outwardly-pointed, broadly spine-like tip. The anterior half of each segment as divided by this median furrow is narrower than the posterior. Nine segments are preserved on the specimen and judging from the shortening and narrowing of the pleural portions of the segments, there were very few if any more before the pygidium.

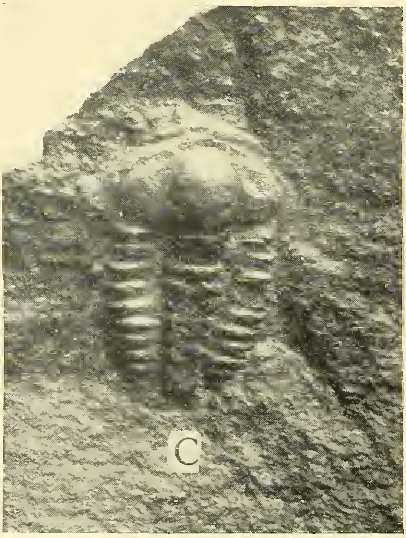
The peculiar pleural segments of this specimen naturally led at first to a comparison with Ellipsocephalus. The close similarity of these segments with those of *E. hoffi* Schlotheim, figured in Zittel's Textbook of Paleontology, is very evident; especially comparable is the broad groove in the middle of each outwardly-pointing segment. But this specimen differs from Ellipsocephalus in lacking the smooth glabella with its obtusely angular front and the rather broad depressed area anterior to the glabella.



A

B

A. *Strenuella strenua* (Billings), a nearly complete specimen. ×2.
B. Transverse section through the 5th pleural segment, to show the convexity of the axis and pleura, the latter being angular. ×2.



C. Photograph of the specimen. ×2.

Referring to the original generic description of Strenuella by Matthew* it is noted that it departs from Agraulos and resembles Ellipsocephalus in the marked elevation of the parts

* Trans. Roy. Soc. Canada, vol. iv, sec. 4, p. 154.

of the head shield, in the long eye-lobes, the depressed anterior limb of the cheeks and in the short and direct posterior extension of the facial suture. It is also noted that it resembles Liostracus in the prominent glabella with the depressed area behind the anterior margin of the head-shield. In all of these points, the specimen discussed here agrees with the generic description of Strenuella; it is apparently the first of the species *strenua* to be described possessing a thorax.

That this specimen does not belong to Walcott's varietal form of *S. strenua nasutus*, is indicated by the following measurements. This variety was founded on a specimen* which has "a broad extended frontal limb." These measurements used for comparison were taken from cuts. The relative widths of the cephalon, glabella, etc., are alike in the species and variety, hence the comparison is made on the length alone.

	From anterior edge of glabella to anterior neck furrow	Width of frontal limb[6]	Proportion[7]
S. strenua[1]	7	3	1 : ·43
" " [2]	7	2	1 : ·29 —
" " [3]	10	2·75	1 : ·27 +
" " [4]	5·5	2	1 : ·36 —
var. *nasutus*[5]	5·5	3	1 : ·55 —

The measurements are in millimeters.

[1] Figure of the type specimen.—Billings, Geol. Surv. Can., Pal. fossils 2 ; 1, pp. 71, 72.

[2] Walcott, U. S. G. S. Ann. Rep. 10, pl. 97, fig. 1*b*. This is said by Walcott to be much like the type of the species.

[3] Grabau, Occas. Papers, Bos. Soc. Nat. Hist., iv, pl. 34, fig. 7*b*.

[4] The specimen here discussed.

[5] Walcott, loc. cit., fig. 2. Type specimen.

[6] Distance from the glabella to the anterior edge of the cephalon.

[7] Letting length of glabella from its anterior edge to the anterior neck furrow = 1.

It thus appears that *S. strenua* has a frontal limb which in all the specimens examined, bears to the length of the glabella from its anterior edge to the anterior neck furrow, the relation of less than one-half to one; while that of the variety *nasutus* is more than one-half to one. The present specimen then agrees much more closely with the type of *S. strenua* than it does with the varietal form *nasutus*.

Geological Department of Massachusetts,
Institute of Technology.

*U. S. G. S. Ann. Rep., 10, 654, pl. 97, fig. 2, 2*a*–*c*.

Art. XX.—*Changes of the Colloidal Nucleation of Dust-free Wet Air in the Lapse of Time;* by Carl Barus.

1. *Introduction.*—The development* of the present investigation was peculiar. At the outset the data appeared like an immediate confirmation of Wood and Campbell's† discovery, which had then just been announced. Maxima of colloidal nucleation appeared where Wood and Campbell had found minima of ionization, and vice versa. By supposing that the ions which are larger than the colloidal nuclei, capture most of the precipitated water, the two sets of results would be mutually corroborative.

Later this cosmical feature of the phenomenon became of secondary importance as compared with an apparently direct effect of fluctuations of the barometer. Nucleation of dust-free air increased when the barometer decreased, and maxima of nucleation were apt to coincide with minima of the barometer. Such a result whether direct or indirect (removal of radio-active matter from porous earth accompanied by falling barometer) would have been of considerable importance, and great care had to be taken in the endeavor to verify it. Unfortunately the correction to be applied for barometer fluctuation in its effect upon the aperture of the coronas, was in the same sense and very difficult to estimate: and in fact upon using two fog chambers side by side, adjusted for different sizes of coronas and accentuating the barometric correction, the variations in one vessel might be made to show a tendency to follow the barometer whereas the other departed from it. The discrepancy in these results may have been an overcompensation, although all the details of the experiments themselves were gradually more and more fully perfected; or the rise in the region of ions may just have balanced the decrease of the number of efficient colloidal nuclei due to the increase of the former. In fact the region where ions predominate may rise, while the regions where the colloidal nuclei are more important may correspondingly decrease, producing a diminished slope of the initial part of the graph, such as is often actually observed. It is necessary therefore to inquire even more carefully into the errors involved, to investigate some data or invariant which if kept constant will mean a corona of fixed aperture in the given apparatus, unless there is actual radiation in varying amount entering from without.

I purpose therefore in the present paper to study the same subject for an artificial barometer; in other words, to accentu-

* Science, xxiii, p. 952, 1906; xxiv, p. 180, 1906.

† Wood and Campbell, Nature, lxxiii, p. 583, 1906.

ate the present phenomena, let the pressure drop from a given upper limit to varying lower limits as well as from varying upper limits to a given lower limit. The results so obtained are enormously different for the same drop of pressure. Much of this would be anticipated; but the question nevertheless arises whether the colloidal nucleation of the gas is actually dependent in so marked a degree on its pressure, or whether this dependence can be quite explained away.

Later in the course of the work, I made additional comparisons with the cotemporaneous ionizations of the air determined by Miss L. B. Joslin, and with the temperature of the fog chamber as distinguished from the temperature of the atmosphere. These results, as a whole, finally showed that a direct dependence of the colloidal nucleation of the dust-free air in the fog chamber on the barometer, on the ionization of the air, on any form of external radiation, or on the temperature of the atmosphere, cannot be detected.

2. *Data.*—The results* refer to a fog and vacuum chamber the volume ratio of which is about $v/V = \cdot 06$, combined with sufficiently wide piping (2 inch bore) and an interposed ($2\frac{1}{2}$ inch) plug stopcock. The former communicates with the filter, the latter with the air pump. At the same temperature the fog and vacuum chambers are initially (before exhaustion) at pressures p and p', finally at pressure p_3, when in isothermal communication after exhaustion; p_2 and p'_2, respectively, would be the pressures at the given temperature if the chambers could be isolated immediately after exhaustion and before the precipitation of fog. P denotes the barometric pressure, and p_m the initial gauge reading within the fog chamber before exhaustion, so that the drop of pressure is (apart from the moisture contents, which will be treated in turn below) $\delta p = P - p_m - p_3$, and the drop of pressure takes place from $p = P - p_m$ adiabatically to p_1, isothermally to p_2 if the fog chamber were isolated as specified, or isothermally to p_3 when fog and vacuum chambers are left in communication.

For a given value of P the same drop of pressure, δp, may thus be obtained in two ways: either by giving a suitable value to p_m, i. e. by starting with a partially exhausted fog chamber and a vacuum chamber at fixed exhaustion p', which implies a nearly fixed p_3; or (keeping p_m constant and nearly zero), by starting with the fog chamber at (nearly) atmospheric pressure, and varying p' of the vacuum chamber and therefore p_3.

Briefly then the condensational effects of a given drop, δp, when lying between different pressures p and p_3, is to be tested, and this is best accomplished by constructing separate

*The tables will be published by the Carnegie Institution. They are sufficiently reproduced for the present purpose by the graphs of this paper.

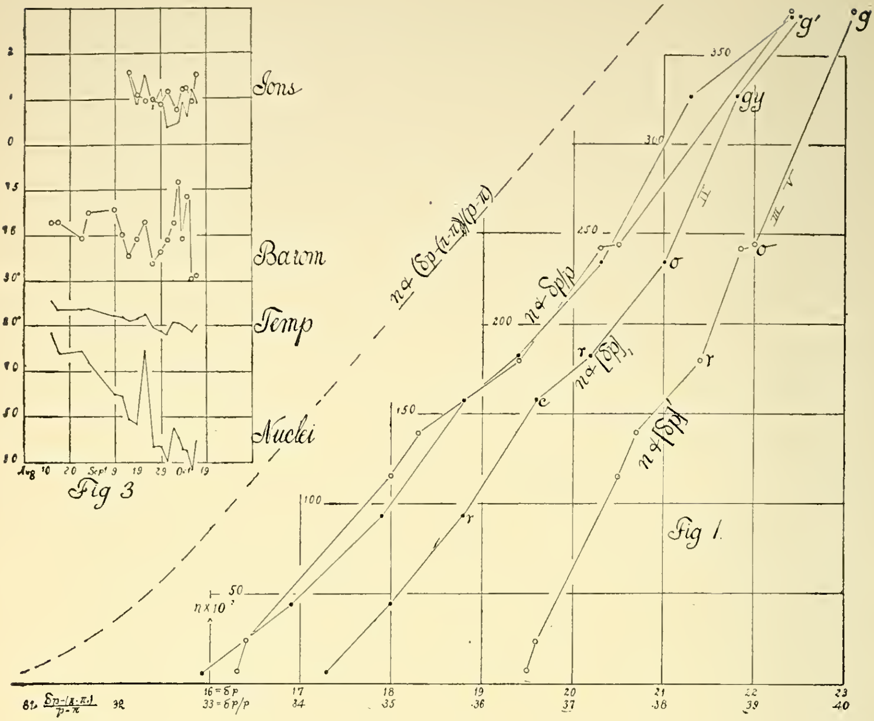


Fig 3

Fig 1.

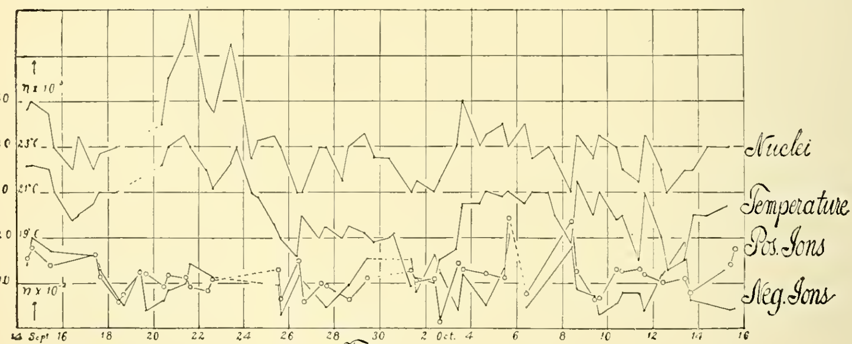


Fig 2

complete graphs for the angular diameter $s/30$ of the coronas, first by keeping p' and p_3 nearly constant and varying p_m (lower pressure limit, p, variable) and second by keeping p fixed and varying p' and p_3 (upper pressure limit variable). From s, the number of nuclei, n, per cubic centimeter, are computed.

An example of the results is graphically given in figure 1, the abscissas being the drop $\delta p = p - p_2$ the ordinates $n \times 10^{-3}$. It will be seen at once that the two curves, ($[\delta p]_1$ denoting that the lower limit of pressure, $[\delta p]'$ that the upper limit of pressure is varied, are strikingly distinct and that the variation of the lower pressure limit $[\delta p]_1$ corresponds, as it should, to a highly increased efficiency of the fog chamber.

3. *Explanation.*—It will next be necessary to endeavor to coördinate the two curves* for $[\delta p]_1$ and $[\delta p]'$. If the absolute temperatures of the air within the fog chamber before and after exhaustion are τ and τ_1 (adiabatic pressure p_1), then apart from the condensation of water vapor at the original vapor pressure π at τ,

$$\frac{\tau_1}{\tau} = \left(\frac{p_1 - \pi_1}{p - \pi}\right)^{(k-c)/k}$$

With a large vacuum chamber the difference between p_1 and p_3 is very small relatively to p_1 and p_3, so that for the present purposes $p - p_3 = p - p_1 = \delta p$ (nearly), whence

$$\frac{\tau_1}{\tau} = \left(1 - \frac{\delta p - (\pi - \pi_1)}{p - \pi}\right)^{(k-c)/k}$$

Since the smaller vapor pressure, $\pi - \pi_1$, is associated with the smaller δp, we may write as a limiting case,

$$\tau_1/\tau = (1 - \delta p/p)^{(k-c)/k}$$

or the degree of sudden cooling from a fixed temperature τ to the adibatic temperature τ_1 depends primarily on $\delta p/p$. This is at least permissible for comparison where a continuous series of experiments is made all at the same temperature, as in fig. 1. The moisture error is thus a constant throughout. Hence the apertures of coronas, s, and the nucleation, n, will be a function of $\delta p/p$ to the degree specified.

I have therefore arranged the date for n with reference to the corresponding values of $\delta p/p$, both for the cases where the upper pressure limits of the drop δp (curve $[\delta p]'$), and the cases where the lower pressure limits of the drop δp (curve $[\delta p]_1$ are varied. This result is also given in the chart, fig. 1.

As a whole, and with due regard to the subtleties involved, the two sets of data practically belong to the same curve, for the departure of either in the long run is seen to be positive as well as negative.

The results of the figure, as has been stated, were obtained in a single series of observations, all at the same temperature. If they be compared with observations made at other times

* Carnegie publication, No. 62, Chaps. II and VI, will show other cases.

they lie distinctly above the graph of the figure no matter whether $[\delta p/p]'$ or $[\delta p/p]_1$ is in question. Hence it is probable that something else besides mere variation of the barometer is in question, and is not accounted for in the correction. Thus it is next necessary to inquire into the effects of vapor pressure.

4. *The effect of pressure.*—The other limiting case

$$\tau_1/\tau = (1-(\delta p-(\pi-\pi_1))/(p-\pi))^{(k-c)/k}$$

may now be used and the data for nucleation, n, expressed in terms of $(\delta p-(\pi-\pi_1))/(p-\pi)$ as the variable abscissa, for comparison. Remembering that the total variation of pressure to bring out the coronal phenomenon does not much exceed 3^{cm} and that the observations below will be made within a single centimeter, the precipitation of moisture may be treated as dependent on τ/τ_1, the ratio of the initial and final absolute temperatures of adiabatic cooling, if the former is nearly constant and if the same medium is retained; though the case is in reality more complicated. The data of figure 1 compared in this way showed even greater coincidence and their mean value is given by the dotted line; but later and earlier series (over ten of which were investigated) differed from them and from each other in a way that was far too large to be referred to errors of observation. Leaving these details for consideration elsewhere, I conclude that by far the greater part of the dependence of the colloidal nucleation upon the barometer is the necessary result of the thermodynamics of the case; but that conclusive evidence of the absence of the effects of other causes either within or without the fog chamber, on the time variation of its nucleation, is outstanding.

5. *New data for colloidal nucleation in the lapse of time.*—Results of the same nature as the preceding were now collected by choosing a particular $(\delta p-(\pi-\pi_1))/(p-\pi)=\cdot 320$ and reducing all data for n to this value. The results so found $(n_{.320}\times 10^{-3})$ should be independent of atmospheric pressure, etc., and respond to external radiation as such exists. The data are shown in figure 2; they do not follow the barometer. The correction of n is about $1\cdot 7$ per $\cdot 001$ of the pressure ratio; but it is uncertain in this region since the graphs are of pronounced curvature.

Hence in succeeding experiments a larger fiducial value $(\delta p-(\pi-\pi_1))/(p-\pi)=\cdot 335$ was selected in turn, as the graphs in this part of the field are more nearly straight. At the outset complete series of results were investigated as in figure 1; subsequently but three observations in the neighborhood of the abscissa $\cdot 335$ sufficed.

The data for $n_{\cdot 335}$ sometimes follow the barometer, sometimes depart widely from it; but coincidence will usually occur only when both accompany the same temperature effect. As a rule there is a rise of nucleation from morning to afternoon, suggesting the phenomenon due to external radiation discovered by Wood and Campbell (§ 1), but in these cases temperature is also apt to rise coincidently. The rise in question fails to occur but four times out of the thirteen observed in August, but seven times out of the twenty-four observed in September, two being neutral, and but 5 times out of the thirteen observed in October. Unfortunately there is no room for these long graphs here; but essential features may be taken from figures 2 and 3.

6. *Effect of the barometer.*—If we look more specifically at the new data beginning with August 10, coincidences of minima and maxima of the nucleation with maxima and minima of the barometric pressure occur only on August 13, 25, 27, and these are not pronounced. In September there is no detailed similarity until September 16, but both curves have dropped somewhat toward the marked minimum. After September 20, however, the apparent agreement of curves is conspicuous up to September 24, and would be decisive if the run of temperature were not similar. During the remainder of the month there is no agreement, rather an opposition, and the two curves are remarkably at variance during the unusually low barometer in the early part of October. The peak of the barometric curves from October 4 to 8 has nothing to suggest it in the nucleation curve. We may conclude, therefore, that a direct barometric effect is absent, that such coincidences as seem to occur are referable to other causes, and that the method used for the elimination of barometer discrepancies is to the same degree vouched for.

7. *Effect of temperature.*—Throughout the observations the tendency of temperature of the fog chamber to rise from morning to afternoon is most probably to be regarded as the cause of a similar tendency in the nucleation. There are exceptions, most of which, however, may be explained away. The curves show a similar general march from August 10 to 23 and from here to Aug. 29. From September 7 to 18 there is much detailed agreement, as for instance on September 8 to 10, 15 to 16. The same is true after September 20, where markedly coincident variation occurs.

So in October the agreement of curves is apt to be very close, as, for instance, the effect from September 30 to October 3, the general fall thereafter and the effect from October 7 to October 9. All of this will appear more strikingly when the observations are averaged for several consecutive days, and most of the lack of synchronism is doubtless due to the difficulty of finding the true value of nucleation.

8. *Effect of ionization.*—To find whether there is any relation of the change of nucleation in the fog chamber in the lapse of time with a state of ionization of the atmosphere, measurements were made of the latter quantity by Miss L. B. Joslin, using Ebert's aspirator apparatus.

These data are constructed in the lower curves of figure 2 together with the cotemporaneous nucleations and temperatures of the fog chamber. It would be difficult to detect any detailed similarity in the two sets of results. Thus the maximum of nucleation on September 20 to 24 is in no way suggested by the ionization.

9. *Mean results.*—The most satisfactory criterion of the variation of n in the lapse of time would perhaps have been the slope of the n lines as given by the three observations in terms of the abscissa $x=(\delta p-(\pi-\pi_1))/(p-\pi)$: but as these points lie on a graph whose curvature is often marked, the curvature would in general be hard to estimate and the ordinate $n_{.335}$ for $x=\cdot 335$ has therefore been preferred.

The endeavor may be made to test the average value of $n_{\cdot 335}$ for longer intervals of time. As the series is often interrupted, two to four-day intervals suggest themselves. Consequently if the data be so compared the following values appear.

If the results of the table are to be further corrected for the

Nucleations (averaged in groups of 2 to 4 days) in the lapse of time, August to October, 1906. See fig. 3.

	Date	$n_{.335}\times 10^{-3}$	Corrected $n_{.335}\times 10^{-3}$	Temperature °C.	Barometer cm.	Positive Ionization $n\times 10^{-3}$	Negative Ionization $n\times 10^{-3}$
Aug.	10–13	77	87	25·8	75·71	---	---
	14–17	72	78	23·8	·71	---	---
	23–26	73	79	23·6	76·07	---	---
	27–29	68	74	23·8	75·50	---	---
Sept.	7–10	57	60	22·3	·44	---	---
	11–13	56	59	22·0	·98	---	---
	14–16	47	49	21·2	76·47	1·60	1·57
	17–20	45	47	21·6	·08	1·09	·90
	21–23	75	79	22·5	75·72	·97	1·55
	24–27	37	37	19·6	76·63	1·00	·79
	28–30	37	37	19·0	·37	·88	1·23
Oct.	1–3	32	30	18·0	·10	1·04	1·11
	4–5	44	45	20·8	75·75	1·17	·40
	6–7	40	41	20·6	74·85	·76	·47
	8–9	36	36	20·3	76·08	1·22	·92
	10–11	35	35	19·7	75·17	1·26	·64
	12–13	27	27	18·7	76·97	·96	1·22
	14–15	40	40	20·2	76·90	1·57	·40

dependence of the precipitation on changes of temperature of the fog chamber, the average correction* may be taken as 2·3 per cent of the values of m at 20° C. Since $n = 6ms^3/\pi a^3$ approximately (where a is the optical constant of coronas and s their angular diameter on a radius of 30^{cm}), for a given s, n varies as m. Therefore n must be increased 2·3 per cent of its value per degree of temperature of the fog chamber above 20° C. In this way the corrected data of the table were found. Both are shown in fig. 3.

The table also contains the data for the corresponding averages of temperature, barometric pressure and ionization, and all data have been further given in the graphs figure 3, with the times (abscissas) laid off on a smaller scale to bring out the relative variations. It is again apparent that no relation of the nucleation curve to the barometer curve or to the ionization curve can be made out. On the other hand, the colloidal nucleations of the dust-free wet air in the fog chamber agree very fully with the cotemporaneous variations of the temperature of the fog chamber (not of the temperature of the atmospheric air without, of which they are also independent). It is even possible to make out the rate at which efficient nuclei are produced when the temperature of the fog chamber increases. Taking the mean trend of both curves (nuclei and temperature), it appears that nearly 8000 colloidal nuclei are generated (*apparently*), in dust-free wet air, by a rise of temperature of one degree centigrade.

10. *Cause of the temperature effect.*—In the above experiments the nucleations were compared at a fixed value, ·335, of the variable $(\delta p - (\pi - \pi_1))/(p - \pi)$. If, however, the corresponding value of the relative drop $\delta p/p$ (which assumes that all the water vapor is expanded adiabatically without condensation) be computed, the latter will vary with temperature in a way correlative with the vapor pressures contained in the former. Hence the nucleations computed for this particular series of values of $\delta p/p$ will also vary, and the rate was found to be about 6000 nuclei per degree. This is so near the temperature effect given in paragraph 9 that there must be a common cause underlying both.

I have not yet completed the details of a comparison of the above nucleations in the lapse of time for a fixed value of the drop of pressure $\delta p/p$, but from what has been stated it appears probable that no interpretable variation within the reach of the fog chamber will appear. In relation to $\delta p/p$ moreover,

* Smithsonian Contrib., No. 1651, p. 135, 1905.

the fog limits both for ions and for colloidal nuclei show no variation of temperature between 10° and 30°.

11. *Conclusion.*—Direct observation shows that the number of nuclei caught in dust-free wet air at low barometer pressure, is greatly in excess of the number caught (caet. par.) at high barometer. This result may be accounted for as a necessary consequence of the thermodynamics of the experiment, however large and unexpected the variations appear.

The comparison of the nucleation of dust-free air with the cotemporaneous changes of atmospheric ionization shows no correspondence whatever. This is curious, because the ions, though much fewer in number, are larger in size than even the larger colloidal nuclei, and therefore capture much of the moisture. One must conclude that the variations of the ionization are not sufficient to be detected in the presence of the other nucleation.

For the same reason, would it be unwarrantable to look for effects due to variations of any external radiations? In other words, it is improbable that Wood and Campbell's phenomena can be detected by the given fog chamber, and the results which seemed at first in accord with it, are due to a rise of temperature.

The results as a whole show that the relative drop in pressure $\delta p/p$ is a suitable variable for the comparison of nucleations in the case of an apparatus like the above; and that the temperature variations obtained in this paper are directly referable to the variable $(\delta p-(\pi-\pi_1))/(p-\pi)$ employed.

The present, and a variety of other results since obtained, will make it necessary to re-standardize the coronas in terms of the number of nuclei represented, and the work is now in progress.

Brown University, Providence, R. I.

ART. XXI.—*The Use of Succinic Acid as a Standard in Alkalimetry and Acidimetry;* by I. K. PHELPS and J. L. HUBBARD.

[Contributions from the Kent Chemical Laboratory of Yale Univ.—cliv.]

SUCCINIC acid as a standard in alkalimetry and acidimetry has had an extended use for some time. We are not aware that the best methods of preparation of pure material for such a purpose, or the limits of accuracy of succinic acid in such a procedure, have been recorded. We give in detail below work concerning these points.

To determine the strength of the solution of ammonium hydroxide used in this work in neutralizing definite weights of succinic acid, a solution of hydrochloric acid, approximately $\frac{n}{10}$, was made up by diluting in the usual way with distilled water pure hydrochloric acid. The solution of hydrochloric acid was standardized by precipitating in a volume of 250^{cm^3} definite portions of it held in a platinum dish with silver nitrate in excess in presence of a few drops of nitric acid, filtering off the precipitate allowed to stand twenty-four hours, after cooling to zero centigrade to remove from solution traces of silver chloride,* filtering off on asbestos under pressure in a perforated platinum crucible, rinsing with water cooled to zero, drying at 100° C., and weighing after cooling in a desiccator. The solution of ammonium hydroxide was titrated against the solution of hydrochloric acid, using tincture of cochineal as the indicator, and by diluting with distilled water in suitable amounts was made of such strength that one cubic centimeter corresponded exactly to one cubic centimeter of the hydrochloric acid solution.

Succinic acid was prepared in four different ways—by the hydrolysis of the pure ester, by hydration of the pure anhydride, by crystallization of the acid from a solution of the succinic acid of commerce in hot water, and by crystallization of the acid from the solution of the acid of commerce in hot water containing nitric acid.

From purified succinic ester, boiling at 213°·3–·5 C. under a barometric pressure of 749^{mm}, pure succinic acid was obtained by boiling it for four hours on a return condenser with nitric acid and water in these proportions—20^{cm^3} of succinic ester, 200^{cm^3} of water, three drops of nitric acid. This solution was evaporated to crystallization, and, after filtering off from the mother liquor, the solid product was recrystallized from distilled water. These crystals were dried carefully in the open air to constant weight, and, it was found that on standing over sul-

* W. A. Roth, Zeitschr. f. Angew. Chem., xvii, 716.

phuric acid in a desiccator this weight remained unchanged. By this procedure the purest succinic acid melting in an open capillary tube at 182°·3 C. was obtained.

For the preparation of the acid from succinic anhydride the anhydride was purified by recrystallizing from absolute alcohol until the crystals obtained after carefully drying melted sharply at 119° C. The pure anhydride obtained in this manner was converted to the acid by dissolving it in distilled water heated to the boiling point, filtering off the crystals formed on cooling the solution, and drying. It was found that these crystals, as in the case of the succinic acid crystals described above, came to constant weight when dried in the air, and that this weight remained unchanged when the product was allowed to stand in a desiccator over sulphuric acid. Samples made in this way melted at 182°·8 C. in an open capillary tube.

Preparations of succinic acid were made from the acid of commerce by dissolving the latter in distilled water at the boiling point, crystallizing by cooling and drying in the air. No loss in weight was found when the air-dried material was exposed in the desiccator. It melted in an open capillary tube at 181°·7 C.

The acid was also made by dissolving the succinic acid of commerce in boiling water, adding nitric acid, crystallizing, and drying the crystals thus obtained. In this manner a product of a slightly higher degree of purity was obtained than that crystallized from water. This product melted in an open capillary tube 182°·3 C.

TABLE I.

No.	Succinic Acid grm.	HCl corresponding to Succinic Acid: Found grm.	Theory grm.	Error grm.
(1)	0·2000	0·1231	0·1235	0·0004 —
(2)	0·2000	0·1231	0·1235	0·0004 —
(3)	0·2000	0·1231	0·1235	0·0004 —
(4)	0·2000	0·1231	0·1235	0·0004 —
(5)	0·2000	0·1231	0·1235	0·0004 —
(6)	0·2000	0·1231	0·1235	0·0004 —
(7)	0·2000	0·1233	0·1235	0·0002 —
(8)	0·2000	0·1233	0·1235	0·0002 —
(9)	0·2000	0·1231	0·1235	0·0004 —
(10)	0·2000	0·1233	0·1235	0·0002 —
(11)	0·2000	0·1234	0·1235	0·0001 —
(12)	0·2000	0·1234	0·1235	0·0001 —
(13)	0·2000	0·1235	0·1235	0·0000 ±
(14)	0·2000	0·1235	0·1235	0·0000 ±
(15)	0·2000	0·1235	0·1235	0·0000 ±
(16)	0·2000	0·1235	0·1235	0·0000 ±

In all of the experiments recorded in the table definite portions of succinic acid were dissolved in distilled water and into the solution the ammonium hydroxide of definite strength was drawn carefully from a burette until the succinic acid was exactly neutralized as shown by the cochineal tincture used to indicate the completion of the reaction. The experiments were conducted so that the final volume in each case was about 250^{cm^3} at the completion of neutralization of the succinic acid. The succinic acid used in experiments (1), (2), (3), and (4) recorded in the table was that obtained by crystallizing the succinic acid of commerce from water at the boiling point, and dried in the air. The material in (5) and (6) was the same product crystallized from water and dried in a desiccator. In experiments (7) and (8) the succinic acid used was that purified by crystallizing from hot water with a few drops of nitric acid. In experiments (9), (10), (11), and (12) the succinic acid used was made from the purified anhydride, dried to constant weight in the air. The material used in experiments (13), (14), (15), and (16) was the succinic acid prepared by hydrolyzing the pure succinic ester boiling at 213°·3–5 C.

It is clear from the work shown in the table that succinic acid may serve admirably as a standard for work in alkalimetry and acidimetry. It is further obvious that for such work succinic acid of a fair degree of purity may be prepared by crystallizing the acid of commerce from water at the boiling point, or preferably by crystallizing from water at the boiling point containing nitric acid. The product obtained by the hydration of the anhydride is of an excellent state of purity. Succinic acid of ideal constitution may be prepared by hydrolyzing the pure ester. While in every case air drying of the samples is sufficient, drying in a desiccator over sulphuric acid involves no risk of the formation of the anhydride.

Since succinic ester in a state of purity may be prepared with ease, succinic acid is conveniently available as a standard in alkalimetry and acidimetry. It is equally reliable with the previously most valued standard—hydrochloric acid standardized gravimetrically as silver chloride.

Art. XXII.—*On Divergence and Curl*; by Edwin Bidwell Wilson.

1. In the work on Vector Analysis,* which I had the honor to write for the late Professor Gibbs, I developed the theory of the divergence and curl of a vector function of position in space in very much the same way as that followed by Professor Gibbs in his lectures.† This discussion may seem to be elementary, natural, and sufficient, if regarded from the point of view of a mathematician developing a vectorial analysis. To the physicist, however, the conceptions of divergence and curl are of prime importance; and no student can make any satisfactory headway in hydrodynamics or electricity without first getting a thorough grasp—a grasp as intuitive and *physical* as possible — of these fundamental conceptions. For this reason it becomes desirable to treat the problem from several points of view. In what follows I set forth some methods which seem from experience in teaching to be useful in sharpening up the meaning of divergence and curl with the connected integral theorems of Gauss and Stokes.

In the treatise cited above, it is mentioned on pages 187 and 194 that certain integral expressions, namely

$$\lim_{dv \doteq 0}\left[\frac{1}{dv}\iint_S f.da\right] \text{ and } \lim_{da \doteq 0}\left[\frac{da}{da.da}\int_0 f.dr\right]$$

may serve respectively as definitions for the divergence and curl of the vector function f. It is the purpose of the present paper to discuss these definitions, first without, and second with the use of linear vector functions. At first sight there appears an apparent anomaly in defining a differentiating operator such as divergence or curl by means of integrations. There is, however, no real reason why integral calculus, whether of vectors or scalars, should not precede a great part of the differential calculus—and for theoretical purposes such precedence is often valuable.

2. Let $V(x, y, z)$ be any vector function of position in space, and let $X(x, y, z)$, $Y(x, y, z)$, $Z(x, y, z)$ be its components, so that

$$V = Xi + Yj + Zk.$$

Visualize V as the *flux* of a fluid, that is, as the product of the density ρ and the velocity in path v. In this manner a

* Vector Analysis, a Text-book for the use of Students of Mathematics and Physics, founded upon the Lectures of J. Willard Gibbs. New York: Charles Scribner's Sons, 1901.

† Vector Analysis, §§ 71–72, pp. 150–157; §§ 81–82, pp. 184–193.

dynamical, or rather a hydrodynamical interpretation is given to $\mathbf{V}$; and this picture, instead of the usual purely geometric figure, becomes the basis of our reasoning. There is no reason why this imagery should not be invoked if it proves of convenience in suggesting results or methods of proof: for to the mathematician it is the analysis and not the representation of it which in the last instance establishes the proof upon a firm foundation, whereas to the physicist the picture itself is frequently taken as convincing and should therefore be as tangible as possible.

If now, S be any closed surface in the fluid and $d\boldsymbol{a}$ a vector element of the surface, the normal flow of the fluid through $d\boldsymbol{a}$ per unit time is the product of the density, the velocity, the area of the element and the cosine of the angle between the velocity and the normal. This flow per unit time is $\rho\boldsymbol{v}.d\boldsymbol{a} = \mathbf{V}.d\boldsymbol{a}$, and the total flow through any closed surface S is

$$\iint_S \rho\boldsymbol{v}.d\boldsymbol{a} = \iint_S \mathbf{V}.d\boldsymbol{a}.$$

On the other hand, if $d\tau$ be any element of volume the amount of fluid contained therein is $\rho d\tau$, and the outflow per unit time is $-d\tau d\rho/dt$.* The total outflow from the whole volume included by S may be obtained by integrating. Equating the two results, we have

$$\iint \rho\boldsymbol{v}.d\boldsymbol{a} = \iint \mathbf{V}.d\boldsymbol{a} = -\iiint \frac{d\rho}{dt}\,d\tau. \qquad (1)$$

If in particular this formula be applied to a single element of volume and if the limit be taken as $d\tau \doteq 0$, the result

$$-\frac{d\rho}{dt} = \underset{d\tau \doteq 0}{\text{Lim}} \iint \mathbf{V}.d\boldsymbol{a} = \text{div}\,\mathbf{V} \qquad (2)$$

may be taken as a *definition of the divergence* of the flux $\mathbf{V}$, provided it be granted, as is physically obvious, that this limit exists and is unique.† Then from (1),

$$\iiint \text{div}\,\mathbf{V} d\tau = \iint_S \mathbf{V}.d\boldsymbol{a}. \qquad (3)$$

The definition contained in (2) is that already referred to in §1, and equation (3) appears as Gauss's Theorem when once the expression for div $\mathbf{V}$ has been obtained in Cartesian coördinates.

* Strictly speaking ρ, $\boldsymbol{v}$, $\mathbf{V}$, x, y, z are all functions of the time t as well as of space. But the entire discussion may be considered as taking place at a given moment of time and hence the variation of t may be disregarded except in the sole expression $d\rho/dt$.

† There can be constructed such functions $\mathbf{V}$ as will violate this condition: but not in the ordinary run of physical experience where ρ and $\mathbf{V}$ are assumed to be continuous and differentiable. Exceptions might occur, for instance, at the interface of two fluids where the divergence need not be continuous across the interface.

To evaluate this expression several methods are available. In the first place one may apply the definition (2) directly to an infinitesimal cube oriented with its edges parallel to the axes. Consider the two faces perpendicular to the X-axis and at a distance dx apart. If the flow across the left face be $\mathbf{V}(x, y, z)$ that across the right face is $\mathbf{V}(x+dx, y, z)$. The sum of the integrals for these two faces is therefore

$$\iint \Big[\mathbf{V}(x+dx, y, z) - \mathbf{V}(x, y, z) \Big] . \mathbf{i} \, dydz = \iint \frac{\delta X}{\delta x} dx\, dydz = \frac{\overline{\delta X}}{\delta x} d\tau.$$

With similar operations for the other faces, it appears that

$$\operatorname{div} \mathbf{V} = \frac{\delta X}{\delta x} + \frac{\delta Y}{\delta y} + \frac{\delta Z}{\delta z}. \qquad (4)$$

A second, and in many ways, a far better method will be given in § 4.

3. If there is in hydrodynamics any one theorem which deserves to rank above all others it is Kelvin's on the constancy of circulation; or, as Heaviside calls it, circuitation. The circulation in a curve would naturally be taken to be the integral around the curve of the flux. This, however, is not the case. The curvilinear integral of the *velocity*

$$\int_c \mathbf{v}.d\mathbf{r} \text{ instead of } \int_c \rho \mathbf{v}.d\mathbf{r} = \int_c \mathbf{V}.d\mathbf{r}$$

is defined as the circulation (or circuitation). To maintain an analytical analogy with the former sections we may set ρ equal to unity, and then the circulation will be numerically (though not dimensionally) equal to the curvilinear integral of the flux $\mathbf{V}$ which becomes the equivalent of the velocity.

To study the simplest case consider the velocity as due to an angular velocity ω about an axis along the unit vector $\mathbf{n}$. Then

$$\mathbf{V} = \omega \mathbf{n} \times \mathbf{r}\, ; \int_c \mathbf{V}.d\mathbf{r} = \int_c \omega \mathbf{n} \times \mathbf{r}.d\mathbf{r} = \omega \int_c \mathbf{n}.\mathbf{r} \times d\mathbf{r}.$$

Now $\mathbf{r} \times d\mathbf{r}$ is the double area of the triangle formed by $\mathbf{r}$, $\mathbf{r}+d\mathbf{r}$, and $d\mathbf{r}$. Let this area, denoted as a vector, be $d\mathbf{A}$, and let the total area of the curve c be $\mathbf{A}$. Then

$$\int_c \mathbf{V}.d\mathbf{r} = 2\omega \mathbf{n}.\int_c d\mathbf{A} = 2\omega \mathbf{n}.\mathbf{A}.$$

If in particular this relation be applied to a closed plane curve or to an infinitesimal closed curve (which may be regarded as plane) of area $d\mathbf{a}$,

$$\int_\circ \mathbf{V}.d\mathbf{r} = 2\omega \mathbf{n}.d\mathbf{a}. \qquad (5)$$

The value of (5) varies with different orientations of da, from zero when da is perpendicular to n to its maximum value $2\omega\,|da|$ when da is parallel to n. Hence if da be that direction for which the integral is a maximum,

$$2\omega n = \frac{da}{da.da} \int_{\circ} V.dr. \tag{6}$$

This is precisely the definition stated in § 1 for the curve of the function V. It has been obtained on the assumption that V is merely the result of angular rotation.

The question of whether (6) may be extended to the general case of fluid velocity is not so easy to answer directly. It is well known that if a small portion of the fluid surrounding any point P be selected, this portion is moving at any instant 1° with a velocity of translation which cannot affect the integral of the total velocity about a closed curve, 2° with a motion of rotation which gives precisely the result contained in (5) or (6), and 3° with a motion of dilatation or strain. The influence of this latter on the curvilinear integral is not obvious; for the magnitude of the displacement due to the strain is of the same order of infinitesimals as that due to the rotation. Nevertheless the strain is taking place symmetrically about the point P, and it is therefore plausible that the total contribution to the integral (5) taken around a closed curve surrounding P should be zero.

If this plausibility be taken as giving the true state, the relation (6) stands and the general definition may be given, namely: The curl of a vector function V is

$$\text{curl}\, V = \underset{da \doteq 0}{\text{Lim}} \left[\frac{da}{da.da} \int_{\circ} V.dr \right], \tag{7}$$

where the integral is taken around a path in that plane which renders its value, relative to the area of the path, a maximum. It is an obvious corollary that the value of the expression taken about a path in any other plane is equal to this its maximum value multiplied by the cosine of the angle between the two planes. Furthermore, if any surface be divided into infinitesimal areas,

$$\text{curl}\, V.da = \int_{\circ} V.dr.$$

If these expressions be summed up all over the surface, the line integrals will cancel themselves out for all interior lines of division, and hence

$$\iint_{S} \text{curl}\, V.da = \int_{\circ} V.dr, \tag{8}$$

where the line integral is taken around the curve bounding the surface S. If finally the expression for curl $\boldsymbol{V}$ be evaluated in Cartesian coördinates by applying (7) to an infinitesimal square situated successively in each coördinate plane,* the equation (8) will be seen to be merely a statement of Stokes's Theorem.

4. An appeal to the theory of linear vector functions, which are all too little studied, will afford a relief from the mere plausibility on which the statements at the end of § 3 were founded, and will give an entirely new basis for the evaluation in x, y, z of the curl and divergence. Moreover the analytic nature of the argument will be more in evidence and less recourse to intuition will be necessary.

Consider a point P whose vector coördinate is $\boldsymbol{r}$. The velocity of this point is $\boldsymbol{V}$ (to follow the notation of § 3). The velocities in the neighborhood of P may be expanded about that point by Taylor's Series. This gives

$$\boldsymbol{V} + d\boldsymbol{V} + \text{higher powers.}$$

By the fundamental relation defining ∇† this becomes

$$\boldsymbol{V} + d\boldsymbol{r} . \nabla \boldsymbol{V} + \text{ higher powers in } d\boldsymbol{r}.\ddagger \qquad (9)$$

After the lapse of a time δt, $\boldsymbol{r}$ has become $\boldsymbol{r}'$, which may be written

$$\boldsymbol{r}' = \boldsymbol{r} + \boldsymbol{V}\delta t + \text{ higher powers in } \delta t.\S$$

The vector $\boldsymbol{r}+d\boldsymbol{r}$ becomes $\boldsymbol{r}'+\delta\boldsymbol{r}'$. If higher powers alike in δt and in $d\boldsymbol{r}$ be neglected,

$$\boldsymbol{r}' + d\boldsymbol{r}' = \boldsymbol{r} + d\boldsymbol{r} + \boldsymbol{V}\delta t + d\boldsymbol{r} . \nabla \boldsymbol{V}\delta t.$$

This shows that there has been a general translation through the distance $\boldsymbol{V}\delta t$ and that the deformation in the neighborhood of $\boldsymbol{r}$ is expressed by the relation

$$d\boldsymbol{r}' = d\boldsymbol{r}.(I + \nabla \boldsymbol{V}\delta t). \qquad (10)$$

* The proof is entirely analogous to that given above for the case of the divergence. It should be noted that the method of procedure in § 2 and § 3 is directly the opposite to that followed in the treatise on Vector Analysis. Instead of starting with the analytic expressions in Cartesian coördinates for the divergence and curl and then obtaining the theorems of Gauss and Stokes, we here start with such definitions of div $\boldsymbol{V}$ and curl $\boldsymbol{V}$ as make these theorems immediately obvious and then apply the definitions to finding the analytic expressions. This last step is merely for the purpose of comparison. It would be possible to remain entirely within the domain of vector analysis.

† Equation (2), p. 404 of Vector Analysis.

‡ The theorem of the total differential is supposed to apply, namely that the remainder of the series may be written as $d\boldsymbol{r}.\Psi$, where Ψ is a dyadic which vanishes with $d\boldsymbol{r}$ and hence may be discarded as an infinitesimal of higher order.

§ It should be noted that δt and $d\boldsymbol{r}$ are wholly independent; each may be made as small as desired without affecting the other. Hence a product $\delta t d\boldsymbol{r}$ is not of the second order when compared with δt or $d\boldsymbol{r}$.

This dyadic $\Phi = I + V \nabla \delta t$, which determines the changes in lines, is strikingly like that which I obtained about a year ago in treating a problem in continuous groups,* and the treatment of this problem will therefore follow the other to some extent. To obtain the expression in volume it is merely necessary to note that $d\tau' = d\tau \Phi_3$.

$$\Phi_3 = (I + \nabla V\delta t)_3 = I_3 + I_2 : \nabla V\delta t + I : (\nabla V)_2 (\delta t)^2 + (\nabla V)_3 (\delta t)^3.$$

Disregarding higher powers in δt, noting that I_2 and I are equivalent and that

$$I : \nabla V\delta t = \nabla V_S \, \delta t = \nabla . V\delta t,$$

we have $$d\tau' = d\tau (1 + \nabla . V\delta t).$$

Hence the rate of increase of volume is $\nabla . V$. As the density has been taken as unity, this is the rate of diminution of density, that is it is the divergence. Hence

$$\text{div } V = \nabla . V = \frac{\delta X}{\delta x} + \frac{\delta Y}{\delta y} + \frac{\delta Z}{\delta z}$$

and

$$\iiint \text{div } V \, d\tau = \iiint \nabla . V d\tau = \iiint \left(\frac{\delta X}{\delta x} + \frac{\delta Y}{\delta y} + \frac{dZ}{\delta z} \right) d\tau$$
$$= \iint_S V . da = \iint_S (X dy dz + Y dz dx + Z dx dy).$$

Thus the expression for the divergence in Cartesian coördinates has been obtained without applying (2) to the infinitesimal cube.

Consider next the curl. The distance each point has moved is

$$r' + dr' - (r + dr) = V\delta t + dr . \nabla V\delta t.$$

Hence the velocity of each point, which is this value divided by δt, is

$$V = V_0 + dr . \nabla V, \dagger$$

where a zero has been affixed to V to denote that V_0 is the velocity at a particular point P. Then

$$\int_0 V . \delta dr = \int_0 V_0 . \delta dr + \int_0 dr . \nabla V . \delta dr,$$

where δ has been prefixed to dr to denote the increment of dr along an infinitesimal curve surrounding the point P. Separ-

* Sur le groupe qui laisse invariante l'aire gauche. Nouvelles Annales de Mathematiques, vol. v, ser. 3, pp. 163–170, June, 1905.

† This is merely equation (9).

ate ∇V into its self-conjugate and anti-self-conjugate parts Ψ and Ω.

$$\nabla V = \tfrac{1}{2}(\nabla V + \nabla V_c) + \tfrac{1}{2}(\nabla V - \nabla V_c) = \Psi + \Omega.$$

Then $$\int_\circ V.\delta dr = \int_\circ V_0.\delta dr + \int_\circ dr.\Psi.\delta dr + \int_\circ dr.\Omega.\delta dr.$$

As Ψ is self-conjugate, $dr.\Psi.\delta dr$ is a perfect differential, and Ω is anti-self-conjugate,

$$dr.\Omega = \tfrac{1}{2} \nabla \underset{\times}{V} \times dr = \tfrac{1}{2}(\nabla \times V) \times dr.$$

Hence

$$\int_\circ V.dr = V_\circ.\int_\circ \delta dr + \tfrac{1}{2}\int_\circ \delta(dr.\Psi.dr) + \tfrac{1}{2}\int(\nabla \times V)\times dr.\delta dr.$$

Or $$\int_\circ V.dr = (\nabla \times V).da,$$

from (5) if da denote the area of the curve around which the integral is taken. This equation shows: First, that so far as concerns this problem the fluid appears to be rotating about every point (as a rigid body to infinitesimals of the first order) with an angular velocity $\tfrac{1}{2}\nabla \times V$. Secondly, that the objections raised in the latter part of § 3 are therefore void. Hence thirdly, that the definition offered in (7) is perfectly valid. Fourthly, that the Cartesian expression for the curl is

$$\text{curl } V = \nabla \times V = i\left(\frac{\delta Z}{\delta y} - \frac{\delta Y}{\delta z}\right) + j\left(\frac{\delta X}{\delta z} - \frac{\delta Z}{\delta x}\right) + k\left(\frac{\delta Y}{\delta x} - \frac{\delta X}{\delta y}\right)$$

without the necessity of appealing to the application of (7) to an infinitesimal square. Finally that

$$\iint_s \text{curl } V.da = \iint_s \nabla \times V.da = \iint_s \left(\frac{\delta Z}{\delta y} - \frac{\delta Y}{\delta z}\right) dydz$$
$$+ \left(\frac{\delta X}{\delta z} - \frac{\delta Z}{\delta x}\right) dzdx + \left(\frac{\delta Y}{\delta x} - \frac{\delta X}{\delta y}\right) dxdy$$
$$= \int_\circ V.dr = \int_\circ (Xdx + Ydy + Zdz).$$

follows properly from the discussions of § 3.

The introduction of the dyadic ∇V has therefore accomplished the justification definitions stated in § 1, has obtained the Cartesian expressions for divergence and curl, and has led naturally and in a very physical fashion to Gauss's and Stokes's Theorems. Thus the program of this paper has been brought to a close.

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SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *A Misconception of Critical Temperature.*—In a discourse recently delivered at the Royal Institution in London, in regard to ore deposits and their distribution and depth, Professor John W. Gregory presents an astonishing view of the condition of water at temperatures above its critical point. It is evidently his opinion that the elements of water are not combined with each other above the critical temperature of liquefaction, for he says:

"Water, although its constituents may come from vast depths within the interior, is limited to a depth of perhaps only six or seven times the depth of existing mines. The lower limit is due to the internal heat of the globe. . . . Now water cannot exist at a temperature higher than its critical point, 687° F. . . . At depths below about 37,000 feet the temperature would be above the critical point of water, which therefore could not exist as such. Its elements would be given forth as separate gases from the slowly cooling magma; the gases would rise, and having passed into a zone with a temperature below the critical would combine to form water."

The author has confused the critical temperature of liquefaction, 358° C., with the temperature of dissociation of water, which is probably about 2500° C. The only change which water undergoes at its critical temperature is the loss of its surface where it is in contact with a gas or vapor, no matter how great the pressure may be. If the view set forth in the quoted extract were true, the maximum temperature to be obtained by the combustion of hydrogen and oxygen would be 687° F., which is near the boiling point of mercury.—*Chem. News*, xciv, 143. H. L. W.

2. *New Determination of Free Sulphur.*—In view of the fact that the methods in vogue for the oxidation of free sulphur in the wet way, such as treatment with hydrochloric acid and potassium chlorate, are long and difficult, even with very finely divided sulphur, E. Berger proposes to use for this purpose fuming nitric acid to which a little potassium bromide is added. The bromine set free dissolves the sulphur and the resulting bromide of sulphur is decomposed at once by the excess of acid. The reagent acts in the cold, in a few minutes, even when the sulphur is in the form of small crystals, and the result of the action is sulphuric acid. To carry out an analysis, the substance containing ·1 or ·2^{g} of sulphur is weighed out in a small capsule, 10^{cc} of fuming nitric acid are put in, and then ·5 to ·1^{g} of pure potassium bromide. After a few minutes the capsule is placed on the

water-bath, its contents are evaporated to dryness, and then evaporated two or three times after the addition of a few cubic centimeters of hydrochloric acid, in order to remove nitric acid. The precipitation and weighing of barium sulphate is then carried out in the usual way. The author has determined sulphur in gunpowder very satisfactorily by this method.—*Comptes Rendus*, cxliii, 1160. H. L. W.

3. *The Detection of Traces of Zinc.*—Bertrand and Javillier have found that when ammoniacal solutions containing calcium and small quantities of zinc are boiled until the ammonia is removed, a precipitate consisting of calcium zincate, $CaZn_2O_3.5H_2O$, is produced, and they have applied the reaction to the detection of zinc when small quantities are present. For example, in examining half a liter of water containing less than $\cdot 001^g$ of zinc, a little dilute milk of lime, or about 50^{cc} of lime water, is added, and then 10 or 15 per cent of concentrated ammonia. The liquid is then filtered if necessary, and is boiled as long as alkaline vapors are evolved. After cooling, the precipitate of calcium zincate, which is contaminated with calcium carbonate, is collected on a small filter. The precipitate is dissolved in hydrochloric acid, the solution is evaporated to dryness to remove the acid, and after taking up in water, the calcium is precipitated as oxalate in presence of strong ammonia. The zinc remains in solution, and by evaporating and calcining in the presence of sulphuric acid, it is converted into sulphate which can be weighed. By dissolving the sulphate in one or two cubic centimeters of water, testing one half with hydrogen sulphide and the other half with potassium ferrocyanide, the presence of zinc may be shown by the characteristic, white precipitates produced. Test analyses made in the presence of $\cdot 001$ to $\cdot 01^g$ of zinc gave satisfactory quantitative results, while as little as $\cdot 0001^g$ in 100^{cc} of water, one part in five million, was detected qualitatively.—*Comptes Rendus*, cxliii, 900. H. L. W.

4. *Compounds of Ferrous Salts with Nitric Oxide.*—Manchot and Zechentmeyer have made a study of the absorption of the gas NO by solutions of ferrous salts. This is an interesting subject on account of the production of one of these black compounds in the well known qualitative test for nitrates. Their experiments were made by determining the volume of the gas absorbed by solutions of ferrous salts at varying pressures. The limit reached at pressures of about 2000^{mm} of mercury and at temperatures near 0° corresponded to one molecule of NO to one atom of iron. Experiments made at gradually increasing temperatures did not show any sudden decrease in the amount of gas absorbed, so that it does not appear probable that any compound with a smaller proportion of nitric oxide exists, as has been supposed to be the case by previous investigators. The authors did not succeed in obtaining the pure solid compounds, and they doubt the purity of those previously described.—*Ann. d. Chem.*, cccxl, 368. H. L. W.

5. *Chemical Abstracts, published by the American Chemical Society.* 8vo, Semi-monthly. Price, $6.00 per annum.—The first two numbers of a new Journal, which will undertake the abstracting of the entire current chemical literature of the world, are at hand. The work is in charge of William A. Noyes, editor, and C. E. Waters, associate editor, together with 129 assistant editors and abstractors. A very wide field is covered, particularly in applied chemistry, so that the new Journal should appeal to a very large circle of readers, as will be seen from the following list of headings under which the abstracts are classified: Apparatus ; General and Physical Chemistry ; Radio-activity ; Electrochemistry ; Photography ; Inorganic Chemistry ; Analytical Chemistry ; Mineralogical and Geological Chemistry ; Metallurgy ; Organic Chemistry ; Biological Chemistry ; Foods ; Nutrition ; Water, Sewage, Sanitation ; Soils and Fertilizers ; Fermented and Distilled Liquors ; Pharmaceutical Chemistry ; Acids, Alkalies, Salts ; Glass and Pottery ; Fuel, Gas, Coke ; Cements, Mortars, Structural Materials ; Petroleum, Asphalt, Wood Products ; Cellulose and Paper ; Explosives ; Dyes and Textile Fabrics ; Pigments, Resins, Varnishes, India Rubber ; Fats and Soaps ; Sugar, Starch and Gums ; Leather ; Patents.

The two numbers for January, 1907, comprise 262 pages, a rate at which the annual volume would cover more than 3000 pages. The work of abstracting appears to be well done in all the departments, so that the new Journal will be a most useful addition to American chemical literature. H. L. W.

6. *Perception of Sound Direction.*—In an interesting paper on this subject Lord Rayleigh finds "that when a sound of low pitch reaches the two ears with approximately equal intensities but with a phase difference of one quarter of a period, we are able so easily to distinguish at what ear the phase is in advance, must have far reaching consequences in the theory of audition. It seems no longer possible to hold that the vibratory character of sound terminates at the outer ends of the nerves along which the communication with the brain is established. On the contrary, the processes in the nerve must themselves be vibratory, not of course in the gross mechanical sense, but with preservation of the period and retaining the characteristic of phase—a view advocated by Rutherford, in opposition to Helmholtz, as long ago as 1886. And when we admit that phase differences at the two ears of tones in unison are easily recognized, we may be inclined to go further and find less difficulty in supposing that phase relations between a tone and its harmonics, presented to the same ear, are also recognizable."

"In observing fog signals at sea it is of course of great importance to be able to estimate the bearing. If a sound is of sufficiently long duration (5 or 6 seconds), it is best by turning the body or head to bring it apparently to the right and to the left, and to settle down into the position facing it where no lateral effect remains. If, as for most fog signals, the duration be decidedly less than this, it may be preferable to keep still; but we are then liable to serious errors, should the signal happen to come from nearly in front or nearly behind; a judgment that the signal is to the right or left may usually be trusted, but a judgment that it comes from in front or behind is emphatically to be distrusted. If, for example, the sound seems to come from a position 45° in front of full right, we must be prepared for the possibility that it is situated 45° behind full right. A combination of three or four observers facing different ways offers advantages: a comparison of their judgments, attending only to what they think as to right and left and disregarding impressions as to front and back, should lead to a safe and fairly close estimate of direction."—*Phil. Mag.*, Feb. 1907, pp. 214–232. J. T.

7. *The Ionization of the Atmosphere over the Ocean.*—A. S. Eve of McGill University concludes as follows:

(1) The ionization of the atmosphere over the Atlantic ocean appears to be approximately the same in magnitude as in Europe or North America.

(2) The amount of radium contained in sea water is very minute, and is $\frac{1}{500}$ to $\frac{1}{2000}$ part of the average amount determined by Strutt in various sedimentary and igneous rocks.

(3) Specimens of sea water obtained from mid-Atlantic, and a sample of sea salt, indicate that a gram of sea water contains about 5×10^{-16} grams of radium.

(4) The emanation from the radium in sea water, and the penetrating radiation from the active matter contained in it, are sufficient to account for the ionization observed over the ocean.

(5) Emanation arising from radium on land, and carried to sea by the wind, is the only known cause which will account for the ionization effects observed over the ocean. The ionization observed is larger than would be anticipated from such a cause, but it is possible that the rate of recombination of ions over the sea may be less than over the land."—*Phil. Mag.*, Feb. 1907, pp. 248–258. J. T.

8. *Diurnal Periodicity of the Spontaneous Ionization of Air.*—The conclusions of Alexander Wood and Norman S. Campbell, working in the Cavendish Laboratory, are as follows:

(1) The ionization in a closed vessel undergoes a permanent increase for a considerable time after the gas contained in it has been enclosed, but this increase depends on the nature of the vessel, being comparatively large for lead vessels and tin vessels and negligible for zinc vessels.

(2) Superimposed on this variation of the ionization is a periodic variation having two maxima and two minima each twenty-four hours.

(3) In their main features the curves representing this periodic change are the same as the curves representing the variations of atmospheric potential, and it is hoped in a later paper to establish a connection between the two variations. For a possible connection the reader is referred to Richardson's letter to Nature April 26, 1906, p. 307."—*Phil Mag.*, Feb. 1907, pp. 265–276.

J. T.

II. Geology and Mineralogy.

1. *United States Geological Survey. Twenty-seventh Annual Report, 1905–1906, of the Director*, Charles D. Walcott. Pp. 104, pls. 24.—This report contains a detailed account of the work done during the fiscal year in the geologic, topographic, hydrographic, publication and administrative branches. It is of interest to note the amount of the appropriations to the several divisions, as these are in some measure indicative of the lines along which the work of the Survey is being at present chiefly pushed. The plan of operations for the year involved an expenditure of $1,513,482.30 ; $202,000 were also allotted to a special investigation of the fuel resources of the United States, the necessary equipment being maintained in Forest Park, at St. Louis. A small allotment of $12,500 was also made for the testing of structural materials.

The Director recommends an increase in the appropriation for geology of $50,000, it being important, for example, that the present small owners of lands holding iron-ores should, in view of the buying up of ore lands by large corporations, be able to obtain reliable information regarding the occurrence and value of iron-ore deposits. The Government itself is directly interested, since extensive deposits of iron-ore occur upon the public lands. Further "the Government is the largest holder of coal lands in the world. These lands have up to the present been on the market, yet the Government has spent less in determining the value of its property than many private companies. It has been demonstrated that many millions of dollars can be saved to the Government by a geologic examination of its coal lands at a cost of less than 1 per cent of the amount saved."

The urgent requests for topographic maps also have led the Director to recommend an increase of $50,000 for the topographic branch, the total asked for being $400,000. The hydrographic branch was hampered by the reduction during the past year of the appropriation from $200,000 to $150,000. It is hoped in view of the value of an accurate knowledge of the water supply of the country that this appropriation may be restored to its original amount. By June, 1906, the connection of the Reclamation Service with the Geological Survey had practically ceased, this service having now become sufficiently established on its own footing.

Under the subject of *General Scientific Investigations* is to be noted progress in the preparation of a geologic map of the whole United States on a scale of 1 : 2,500,000, and, in coöperation with the Governments of Canada and Mexico, a geologic map of North America on the scale of 1 : 5,000,000. As in previous years, $80,000 were spent in the investigation of Alaskan geology and mineral resources. J. B.

2. *Publications of the United States Geological Survey;* CHARLES D. WALCOTT, Director.—The recent publications of the Survey are noted in the following list (continued from p. 65):

Twenty-seventh Annual Report of the Director of the United States Geological Survey to the Secretary of the Interior 1905–6. Pp. 104, with 24 plates. See p. 225.

MONOGRAPH Volume L. The Cretaceous Flora of Southern New York and New England; by ARTHUR HOLLICK. Pp. 219, with 40 plates, and numerous figures. See p. 233.

FOLIO No. 142. Geologic Atlas of the United States. Cloud Peak—Fort Mc Kinney Folio, Wyoming. Description of Cloud Peak and Fort McKinney Quadrangles; by N. H. DARTON: Glacial Geology by R. D. SALISBURY. Pp. 16, with 7 colored maps and 21 figures.

PROFESSIONAL PAPER, No. 52. Geology and Underground Waters of the Arkansas Valley in Eastern Colorado; by N. H. DARTON. Pp. 90, with 27 plates and 2 figures.—See p. 149, Feb., 1907.

BULLETINS, No. 302. The Areas of the United States, the States, and the Territories; by HENRY GANNETT. Pp. 9 with colored map.

No. 306. Rate of Recession of Niagara Falls; by G. K. GILBERT, accompanied by a Report on the Survey of the Crest; by W. CARVEL HALL. Pp. 31, with 11 plates and 8 figures.

No. 307. Manual of Topographic Methods; by HENRY GANNETT. Pp. 86, with 8 plates and 4 figures.

No. 310. Results of Primary Triangulation and Primary Traverse, Fiscal year 1905–6; by SAMUEL S. GANNETT. Pp. xiii, 248, with one plate.

WATER SUPPLY AND IRRIGATION PAPERS, No. 189. The Prevention of Stream Pollution by Strawboard Waste; by EARLE BERNARD PHELPS. Pp. 29, with 2 plates and 2 figures.

Mineral Resources of the United States; Calendar year 1905, DAVID T. DAY, Chief of Division of Mining and Mineral Resources. Various advance chapters from this work have been issued. These include, among others, the following:

The Production of Gold and Silver in 1905; by WALDEMAR LINDGREN and others. Pp. 1–229.

Total Output and Value by States of the Mineral Products of the United States in 1905; compiled by WM. TAYLOR THOM. Pp. 15–30.

3. *Rate of Recession of Niagara Falls;* by G. K. GILBERT, *accompanied by a report on the survey of the crest,* by W. CARVEL HALL. Bull. No. 306, U. S. Geological Survey. Washington, 1907. Pp. 31, pls. 11, figs. 8.—In this bulletin it is pointed out that the present is a time of transition from natural to more or less artificial conditions in the flow and consequently the recession of Niagara Falls. For this reason an accurate survey of the crest-line was ordered in 1905 and this bulletin incorporates the data thus obtained into the discussion on the rate of recession.

Among other conclusions Dr. Gilbert finds reason to believe that a portion of the survey of 1842 was in error. The rate of recession of the American Falls is also studied and is considered an important part of the problem of the time required for cutting the entire gorge, as there were two epochs in the history of the river when the volume was very small, so that the conditions affecting erosion were somewhat similar to those illustrated by the American Fall. The rate of recession of the Horseshoe Fall from 1842 to 1905 is found to be 5 feet per annum, with an uncertainty of 1 foot. For the American Fall the rate of recession from 1827 to 1905 was less than 3 inches per annnm. J. B.

4. *Michigan State Geological Survey;* ALFRED C. LANE, Director. Geological Report on Bay County, by W. F. COOPER. From the Annual Report for 1905, pages 135–426, with 17 plates. Lansing, Michigan, 1906.—Bay County, Michigan, is situated on the western and southern shore of Saginaw Bay. It yields no rock outcrops, so that early surveys have given little attention to its geology. The presence, however, of valuable coal deposits at depths varying from 100 to 200 feet and more has led to an extensive series of test-holes from which valuable facts are obtained. The complete geological section, further, is yielded by a well sunk by the North American Chemical Company at South Bay City, extending to a depth of about 3,500 feet. This reveals, below one hundred feet of Pleistocene sands and clays, a series of strata from the Saginaw formation to the Dundee, or Corniferous, limestone. The chart giving the carefully tabulated results of this deep drilling presents many points of geological interest and importance. Mr. Cooper gives an account of this section in detail, and then goes on to discuss the coal formation with details as to the special layers from which workable coal is obtained. The Upper Verne coal, which has had a greater economic development than any other seam in Bay County, from a record of two hundred and three test-holes, is found to have an average thickness of nearly twenty-nine inches, and taking into account the fact that in two hundred and fifty-nine drill holes in the same region the seam does not occur, an approximate thickness for the whole of twelve inches is inferred. From this it is calculated that the total amount of coal present in this seam is not far from 500,000,000 tons. The records of the drill-holes, four hundred and sixty-two in number, are given in detail, with maps illustrating their distribution. Other chapters discuss the Quaternary, the physical geography and drainage, also the economic geology, including salt and fire-clay industries, and particularly the water supply.

5. *Illinois State Geological Survey*, H. FOSTER BAIN, Director. Bulletin No. 3. Composition and Character of Illinois Coals; by S. W. PARR. With chapters on the distribution of the Coal Beds of the State, by A. BEMENT, and tests of Illinois Coals under steam boilers, by L. P. BRECKENRIDGE. Pp. 86, with 5 plates and and 16 figures. Urbana: 1906 (University of

Illinois).—Earlier bulletins of the Illinois Survey (Nos. 1 and 2) were noticed on page 543 of volume xxii (Dec. 1906). The present bulletin gives a preliminary account of the composition and distribution of the Illinois coals called out by the many demands for information on this subject. The coal fields of Illinois are not only the most important mineral product of the state, but include nearly 43,000 square miles, covering a larger area than the coal fields in any other state. The production in 1905 was 38,000,000 tons, and the rate of production is so rapid that it is calculated that in another quarter of a century the annual production will be some 135,000,000 tons. Special facts in regard to the distribution of the coal beds are given in a chapter by A. Bement, while the chemical composition and character are discussed in detail by S. W. Parr.

6. *Postglacial Faults of Eastern New York*; by J. B. Woodworth. New York State Museum bulletin 107, Geological Papers. New York State Education Department. Pp. 28, pls. 5, figs. 8, 1907. —Professor Woodworth has studied a number of areas on the eastern side of the Hudson Valley which exhibit steeply dipping step-faults of a reversed character upon which the movements are of postglacial age, the eastern side having risen with respect to the west. One fault zone aggregated 13·00 inches of movement in 11·67 feet and others somewhat less. When the rarity of exposure of such faults is considered, it is to be concluded that a far greater number in reality exist and the importance of these movements becomes apparent. Some discussion of Postglacial faults of Quebec, New Brunswick and Massachusetts is also given. J. B.

7. *Lunar and Hawaiian Physical Features Compared*; by William H. Pickering. Memoirs of the American Academy, Vol. xiii, pp. 151–178, pls. 16. 1906.—In this interesting paper Professor Pickering gives the results of his studies on the forms of the Hawaiian craters, made in 1905, with the object of comparing them with the lunar craters, noting resemblances and differences. The Hawaiian craters, unique upon the earth, appear to bear more resemblances to those of the moon than do the usual terrestrial volcanoes, suggesting the origin of most lunar craters by rise and fall of a central lava column with caving in and engulfment of the walls. Amid much that is valuable, however, it must be noted that, on page 152, hypotheses of origin for the larger craters and the Maria, which at best are founded upon slender evidence and are opposed by very great theoretical physical difficulties, are stated without qualification as facts. Further, on pages 175, 176, it is stated that "rills" and valleys are believed by the writer to be due to water erosion, and ridges, it is thought, may be lateral moraines. Numerous spots which increase in size and darken during the progress of the lunar day are believed to be due to vegetation. The reviewer would suggest, however, in view of the impossibility of observing minute details in the lunar features and the very slight resemblance at

best to those of the earth, that such conclusions, involving the presence of liquid and solid water, and life upon the moon are subject to final acceptance or rejection as problems of physics and biology. The testimony of physics is that no way is known by which water in any form could permanently exist upon the moon except in an extremely minute amount, and of biology that organic evolution operating through all geologic time has been unable to develop any kind of vegetation upon the higher terrestrial mountain summits under conditions which there are strong reasons for believing are much more favorable for life than the most favored portions of the lunar surface. These points are to a considerable extent apart from the main thesis of the paper and would not call for special criticism were it not for their far-reaching importance and the fact that in the past few years the pseudo-scientific columns of some papers have given a certain popular currency to these hypotheses stated without reserve as being facts.

In conclusion it may be said that this paper marks a step in advance in the study of lunar features, but the reviewer is of the opinion that a better understanding of these selenological enigmas is finally to come from a rigorous analysis, following a method of multiple hypotheses, which shall use to the fullest extent exact mathematical and physical methods. J. B.

8. *Origin of Laterites*—In the Geological Magazine for December, 1906 (Vol. iii, No. 12, 536–547), Mr. Malcolm Maclaren discusses "The Origin of Certain Laterites." The peculiar features about laterites which require explanation are their restriction geographically and in altitude, their general superficial occurrence and their internal structure—porous, vesicular, pisolitic, or concretionary, their composition as regards the aluminous, ferruginous, or maganiferous hydrates, the general presence of titanium dioxide and the absence of kaolin or silica. The results of the author's field work, supplemented by microscopic examination and chemical analyses, leads to the conclusion "that laterite must be regarded not as the direct product of the decomposition of a rock *in sitû*, but essentially as the *replacement* of such a decomposition product, for though the ground waters may have derived their mineral content from the underlying rock, they may also have brought it from sources widely separated. A laterite may thus result from the individual or combined decomposition of basalts, gneisses, or schists, and there may, in its hardened upper surface, be no particle of the rock whose former place it now occupies."

The conclusions announced by the writer are as follows:

"1. Lateritic deposits are restricted geographically, because they require for their formation—

(*a*) Tropical heat and rain with concomitant abundant vegetation.

(*b*) Alternating wet and dry seasons.

"2. Their restriction in altitude is only apparent. Their present lines of altitude merely mark ancient or existing basin floors or plains.

"3. They are derived from mineralized solutions brought to the surface by capillarity, and are essentially replacements (either mechanical or metasomatic) of soil or of rock decomposed *in situ*, or of both.

"4. In the humid regions of India the tendency of change in laterites is towards hydration and not towards dehydration.

"The foregoing replacement hypothesis would appear to supply a fairly reasonable explanation for all the eccentricities of laterite."

Abundant references are given in this article and these seem to have been examined with critical discrimination by the author.

H. E. G.

9. *Contribution a l'Étude des Roches alcalines de l'Est-Africain;* par H. Arsandaux. Ex. des Comp. rend. sci. de la mission Duchesne-Fournet, 4°, pp. 96, 12 tab., 9 pl. Paris, 1906.—That remarkable tectonic feature, the great Rift Valley of Africa as it runs northward into Abyssinia, at Addis Abbeba widens out into a huge depressed triangular area, called the Afar region. On the west this is bounded by the escarpment of the Abyssinian highland, which continues north to Berbera on the Red Sea; in a similar way it is bounded on the southeast by the Somali plateau. The third side of the triangle on the northeast is the coast line of the Red Sea. French Somaliland comprises the southern part of this area. This depressed region is dotted over with volcanoes, some of which are still active, and is mostly covered with extrusive igneous rocks. These, especially along the southern border at the edge of the Somali plateau escarpment, have been studied by the author on his journey from Jebuti on the Red Sea to Addis Abbeba in Abyssinia, and to this are added his later petrographical and chemical investigations of the material collected, which form in fact the main part of the work.

These rocks are of acid alkalic character and of three prominent types, rhyolites with aegirite and riebeckite or comendites, pantellarites with aegirite-augite and cossyrite and trachytes. The author gives 13 analyses of these rocks but unfortunately they are only partial ones, the less prominent oxides not having been determined, and this, especially in the TiO_2, makes a comparison with the rocks of Pantellaria less satisfactory than could be wished. The author classifies the rocks according to the new quantitative classification, which he uses with some modifications of his own. His results are of value in adding further confirmation to the existence of the remarkable petrographic province of East Africa, in giving it much greater extension and in presenting additional evidence of the highly alkalic nature of its rocks, in which soda predominates. They are of interest also in showing that such types as those of Pantellaria, which have been considered local rarities, may, as the exploration and petrologic study of the world progresses, be found to exist in other regions as common types occurring in enormous masses. L. P. V.

10. *The Viscous vs. The Granular Theory of Glacial Motion;* by OSWIN W. WILLCOX. Published by the author. Price, post-paid, 30 cents. Long Branch, New Jersey, pp. 23, 1906.—The summary of contents, as stated by the author, is as follows: "A leading argument against the viscous theory of glacial motion, based on the assumption that crystalline character is incompatible with viscous fluidity, is shown to be without force in view of the existence of crystalline liquids."

"An exact definition of fluid, viewed as a datum of mechanics, is given, and it is pointed out that certain glacial phenomena are rendered intelligible by the use of this definition, and are not, as has been held, incompatible with a viscous nature of ice."

"It is pointed out that advocates of the granular theory of glacial motion have ignored a vital question: the relation between the rates of accumulation and dispersal of free energy within a glacier."

"It is shown that if the conditions postulated by the granularists actually prevailed in nature, the forward advance of a glacier would be incredibly limited."

In this paper, as the preceding paragraphs indicate, Dr. Willcox brings a number of interesting facts and theories from organic chemistry, mechanics, and technological practice to bear upon the old problem of the nature of glacial motion. While this treatment from another viewpoint is undoubtedly valuable many will doubt the final statement quoted, and ask to what extent such apparently opposing principles may coöperate. J. B.

11. *The Decomposition of the Feldspars;* by ALLERTON S. CUSHMAN and PREVOST HUBBARD, U. S. Department of Agriculture. Office of Public Roads. Bulletin, No. 28, pp. 29, figs. 6, 1907.—Those interested in chemical geology should have their attention called to this important paper, as well as a previous one by Mr. Cushman, since they are published in a series of Government reports which geologists might easily overlook.

The results of the investigations may be summarized as follows: Water acts immediately upon finely powdered feldspars. The reaction does not proceed far, however, owing to the clogging effect of the unremoved decomposition products. The insoluble hydrated aluminum silicate holds tenaciously the soluble alkalies with the result that the analysis of a solution obtained by extracting or leaching a weighed quantity of powdered feldspar would fail to measure the extent to which decomposition had taken place. The authors consider that these absorbed soluble alkaline silicates are undoubtedly available for plant food and indicate that the common methods of making soil analyses, by leaching with dilute acids, and dividing the soil on that basis into available and unavailable portions, are in error.

The authors find, however, that the decomposition of feldspar powder can be made to go farther by mechanical abrasion in the presence of water, by treatment with dilute solutions of certain electrolytes and by electrolysis. Some of these effects have been known for many years, but the authors find that the extraction of the alkali of ground feldspar can be made practically complete in the laboratory by properly combining these modifying factors. As a result the Department of Agriculture has applied for a patent covering the fundamental principles of the extraction of potash from finely ground feldspathic rocks by process of electrolysis, so that any officials or citizens of the United States may use such methods without the payment of royalty. J. B.

12. *Minerals from Lyon Mountain, Clinton County, N. Y.* by HERBERT P. WHITLOCK. Pp. 55–96, with 11 plates. Reprinted from N. Y. State Museum, Bulletin 107, Geological papers.—The species described in this paper occur as secondary minerals with the magnetite deposits of the Chateaugay mines at Lyon Mountain. The most interesting species is calcite, of which a number of complex forms are described and figured. Other species included are pyrite, quartz, hematite, albite, amphibole, zircon, epidote, and titanite.

13. *Synopsis of Mineral Characters alphabetically arranged for Laboratory and Field Use;* by RALPH W. RICHARDS. First Edition. Pp. v, 99, with 17 figures. New York (John Wiley and Sons).—This little book of one hundred pages, with flexible covers—in a form suitable for the pocket—contains a list of the more important mineral species in alphabetical order, with their prominent characters well selected and arranged. The vocabulary also includes names of prominent rocks and descriptive mineralogical terms. The work should prove valuable to many persons who desire to have beside them a digest of the larger mineralogies, so as to be aided in the immediate identification of species.

14. *Crystallized Native Copper from Bisbee, Arizona;* by A. H. PETEREIT (communicated). The cut, shown on page 233, represents one of ten specimens of native copper from Bisbee, that were exhibited at the recent meeting of the American Association for the Advancement of Science, which was held at the Museum of Natural History, New York City.

The crystals are beautifully grouped on a limonite matrix. Some of them are one inch long and numbers of them stand free and either terminated in a sharp point or like the head of a nail; some are also twinned. They are either of a bright copper-red color, or are coated with native silver. Hundreds of these delicate crystals are grouped on a single specimen, and from a very beautiful whole. They all come from a single pocket in the celebrated Copper Queen Mine, at Bisbee, Arizona.

A new crystallized Copper.
About four-fifths natural size.

III. Paleobotany and Zoology.

1. *The Cretaceous Flora of Southern New York and New England;* by Arthur Hollick.—Monograph L, U. S. Geol. Survey, 219 pp., xl pls. Washington, 1906.—The demonstration that the "Island Series" of Ward, lying above Newberry's Amboy clays and below the Cliffwood, New Jersey clays, is well marked and of great extent, constitutes the main stratigraphic contribution of this volume. In it are figured and described some 222 species, many of which are new. Most are dicotyledonous leaves from various points in northeastern New Jersey, Staten Island, Long Island, Block Island, and Martha's Vineyard. The plants of these island localities chiefly indicate Lower Cretaceous strata of Raritan (= Albian) equivalence, the New Jersey localities extending somewhat higher into the Cenomanian and possibly into the Senonian, or true Upper Cretaceous.

The most striking biologic feature of the volume is the very beautiful and varied series of Magnoliaceæ so well represented at Gay Head and at Glen Cove (L. I.). The disks referred to *Williamsonia* with much reservation, we are, however, convinced, are not such. The floral imprint, Pl. V, figure 28, has a slender bractless peduncle unlike any *Williamsonia;* so, too, figure 29 of the same plate, in which the cyclic organs may well be sepals or petals rather than sporophylls, as further suggested by the allied species, Pl. V, figure 32. That none of these inflorescences can be truly cycadean, is also to be questioned because of the singular lack of associated cycadean leaves; for the leaves shown on Pl. VI, figures 1 and 3, and referred to *Podozamites*, can scarcely be cycadophytes at all, their venation being strictly parallel instead of dichotomous. In regard to *Podozamites lanceolatus*, Pl. II, figure 1, the suspicion is certainly strong that it is a pauciform-leaved Kauri pine, perchance the foliage pertaining to the scales named *Dammara borealis* from the same locality; while Pl. V, figure 31 may possibly indicate part of an Actinostrobus cone. In this absence of cycads, if not, therefore the heads of Compositæ, are not the discoid flowers of the Island series magnoliaceous and of the same species as the varied and partly primitive liriodendrid leaves with which they are so intimately associated? It may well be that *Strobilitites perplexus*, Pl. II, figure 43, which as Hollick suggests is magnolia-like, and the disk shown on Pl. V, figure 32, are respectively the seed-cone and the petals of *Liriodendropsis simplex;* all are from Gay Head. Indeed, it does not seem impossible that by means of a careful study of occurrences, one or more of the several species of flowers in question may be eventually placed with the foliage to which it presumably belongs. At least, there is an apparent absence of cycads which in so far as it is real brings the Island Series into still stronger contrast with the certainly older Arundel of the Potomac System of Maryland and the Dakota of the Black Hills, both of which may be synchronous with the Komé, although of slightly more archetypal cast.

Monograph L is in admirably clear form and most excellent in every way, although we think that a locality map, with illustrations of important localities, would have been neither superfluous nor unwelcome. G. R. W.

2. *Life and Work of Bernard Renault* (Presidential Address); by D. H. Scott. Jour. Roy. Micr. Soc., 1906, pp. 129–145.—Renault ranks as one of the most productive and greatest of all students of paleobotany; and the rich results of his structural studies together with his rare devotion to the investigation of fossil plants, after earlier training and labor as a professor of chemistry, command universal admiration. Doubtless the redintegration of *Cordaites* by Renault and Grand'Eury stands easily as the most remarkable achievement of paleobotanical science.

G. R. W.

3. *The Present Position of Palæozoic Botany;* by D. H. Scott. Progressus Rei Botanicæ (Progress of Botany. Verlag von Gustav Fischer in Jena), 1906, Bd. I, pp. 139–217, with 37 figures in text.—This extensive review by Dr. Scott will be found almost indispensable, recording as it does the significant advances made in the most important division of the *newest* branch of paleontology,—Paleobotany. Likewise some of the great gaps in our knowledge of fossil plants and consequent fields of inquiry are pointed out.

It is only within the past dozen years that the study of the fossil plant record has assumed primary importance; and to-day, as must be apparent to anyone who surveys the field of biologic data, it is clear that in furnishing proof of the course of evolution, paleobotanic evidence possesses inherent value equal to that afforded either by the invertebrates or the vertebrates.

G. R. W.

4. *The Seed, a Chapter in Evolution;* by F. W. Oliver. Presidential Address to the Botanical Section, British Association for the Advancement of Science. Report, York meeting, 1906, pp. 1–14.—Every botanist will find this address of an extreme interest, which passes wholly beyond the limits of our brief notice. The evolution of the seed was one of the most pregnant new departures ever inaugurated by plants. Conquest of the ancient world was as now slow in those earlier stages as yet only glimpsed in the Pteridosperms. The far-flung forests of Lepidodendrons and Calamites were not at once reduced to Lycopods without a struggle; for *Lepidocarpon* shows a great, if ineffectual, advance in the direction taken by the eventual victors. Probably seed plants asserted themselves wherever physical changes overwhelmed old habitats; just as with more pronounced dominance of the angiosperms, a future age may have to content itself with dwarf gymnosperms like those the Japanese are so fond of producing in their pot-cultivations.

In glancing back at the earliest seed structures thus far discovered one is struck by their complexity. The pollen chamber, the large elaborate integument, and the complicated vascular arrangements, all these earlier improvisations and incidental features, protective or otherwise, have passed away or ended in essentially simpler but more exact structural devices. Once universal, aquatic fertilization has yielded to xerophyllous siphonogamy. Instead of sperms discharged into a water chamber abutting the archegonia, male cells are now carried through a plastic tube to the egg; as Professor Oliver graphically puts it, much as we now journey from Baker Street to Waterloo with accuracy and despatch by a sub-potamian tunnel, whereas our primitive ancestors first penetrated the forest and then swam the river! Seeds, in short, are in their nearer aspects the adjustment of filicinean organs to intraseminal limits, and in their far broader significance the response of the plant to the genesis of seasonal periodicity from aquatic generalized tropical conditions.

G. R. W.

5. *The Araucarieæ, Recent and Extinct;* by A. C. Seward and Sibille O. Ford. Phil. Trans. Roy. Soc. London, 1906, Ser. B, Vol. cxcviii, pp. 305–411, pls. 23, 24.—In this admirable and exhaustive account of the Kauri and Norfolk Island pines the conclusion is reached that the morphologic *tout-ensemble* primarily suggests descent from Lycopods, and that the relationship of the "Araucariales" to other gymnosperms, which by nearly common consent are now regarded as the descendants of seed ferns, is presumptively purely homo-plastic. Although of much value from the conservative standpoint, and at least a needed check on undue haste, the validity of this interpretation will probably be contested by most botanists, while all will recognize that the ultimate solution must rest on paleontologic evidence, which it is safe to predict will not long be wanting. G. R. W.

6. *Note sur une Florule Portlandienne des environs de Boulogne-sur-Mer;* par P. Fliche et R. Zeiller. Bull. Soc. Géol. de France, 1904, 4e sér., T. IV, pp. 787–811, pl. ix.—In this paper are described several new species of pine and a *Sequoia*, as well as a new species of small *Cycadeoidea* trunk, *C. pumila*, not unlike the Wyoming *Cycadella*. All are from the Middle Portlandienne. The cycadean trunk is in the Beaugrand collection of the Museum of Boulogne-sur-Mer. Regarding the conifers it is stated that: "These are the most ancient occurrences of *Sequoia* and *Pinus* certainly known at present, it being clearly apparent that the latter genus already played a rôle of some importance, since marked by at least two clearly defined species." G. R. W.

7. *Sur les plantes rhetiennes de la Perse recueillies par M. J. de Morgan;* par R. Zeiller. Bull. Soc. Geol. de France, 1905, 4e sér., T. V, pp. 190–197.—Aside from its notable abundance of conifers, this Rhætic flora of Persia includes in addition to the ubiquitous forms a remarkable mixture of European and Indo-Chinese plants, although the *Glossopteris* types of the latter region do not appear to have advanced into Persia. G. R. W.

8. *Affinities of certain Cretaceous Plant Remains commonly referred to the Genera Dammara and Brachyphyllum;* by Arthur Hollick and Edward C. Jeffrey. [Contribution from the New York Botanical Garden, No. 79.] Amer. Nat., 1906, Vol. xl, pp. 189–216, pls. 1–5.—It is found that certain of the cone scales referred by Heer to the existing *Dammara* in reality belong to a hitherto unrecognized, primitive, and xerophyllous genus *Protodammara;* also that various associated leafy shoots and branches from the Atlantic coastal plain Cretaceous hitherto variously referred to *Brachyphyllum*, are, together with certain accompanying lignites, strictly Araucarineous and probably Protodammaran. But of far greater importance than these elementary botanic facts are the methods that were used in their accurate determination from such difficult material,—maceration, separation, staining, imbedding, and sectioning. The description of these processes is given, and by reason of

their evident wide application in the study of fossil plants the present paper is of unusual interest and value to every paleobotanist. G. R. W.

9. *Additions to the Paleobotany of the Cretaceous Formation of Long Island. No. II;* by ARTHUR HOLLICK. Bull. N. Y. Bot. Garden, 1904, pp. 403–418, pls. 70–79.—Although not very well conserved, these plant impressions from the Cretaceous clays and shales of Northport, Manhasset Neck, Oyster Bay, etc., add several new species to or otherwise extend the Cretaceous mixed and transition floræ of the Atlantic coastal region. G. R. W.

10. *Tertiary Lignite of Brandon, Vermont, and its Fossils;* by G. H. PERKINS. Bull. Geol. Soc. America, 1905, Vol. xvi, pp. 499–516, pls. 86, 87.*—Describes macroscopically numerous seeds unaccompanied by other fossils, and presumably of Middle Tertiary age. *Pinus*, *Nyssa*, *Juglans*, *Illicium*, *Hicoria*, *Cinnamomum*, and *Aristolochia* are represented, as well as some seeds called *Sapindoides*,—evidently a quite recent flora with some extinct species. (This material is in part structurally conserved.) G. R. W.

11. *On Sutcliffia insignis, a new Type of Medulloseæ from the Lower Coal-Measures;* by D. H. SCOTT. Trans. Linn. Soc, 1906, 2d Ser., Botany, Vol. vii, Pt. 4, pp. 45–68, pls. 7–10.—This new megaphyllous genus of the Medulloseæ is based on a short but well-conserved stem section from the colliery of Shore-Littleborough, Lancashire, recently reopened in the interests of Paleobotany (!), by the generosity of the owner. *S. insignis* is monostelic, with a somewhat complicated system of large surrounding "meristeles." But little secondary wood is present, the stem probably being young. The foliar bundles are in all cases concentric, with a tendency to take on a unilateral form; and the xylem elements are of very large size, in this respect suggesting a not altogether remote resemblance to the centripetal xylem in the leaf traces of *Cycadeoidea*. As at once characteristically synthetic and perchance the most primitive of medullosan stems, *Sutcliffia* is of decided interest. G. R. W.

12. *Fossil Plants of the Group Cycadofilices;* by DAVID WHITE. Smithsonian Misc. Coll. (Quarterly Issue), 1905, Vol. xlvii, Pt. 3, pp. 377–390, pls. liii–lv.—Mainly a compilatory description. Figures specimens of *Sphenopteris* (*Lyginodendron*) *Hœninghausii* from the Pottsville near Quinnimont, West Virginia, and of *Neuropteris* (the foliage of *Medullosa*) from the Pottsville at Warrior, Alabama. G. R. W.

13. *The Seeds of Aneimites;* by DAVID WHITE. Smithsonian Misc. Coll. (Quarterly Issue), Dec. 10, 1904, Vol. xlvii, pp. 322–33, pls. xlvii and xlviii.—This paper is of primary interest, as containing the first description of seed-bearing ferns, or "Pteridosperms," from America. As determined from specimens from the Thurmond formation (Lower Pottsville) of the mountain-side

* See also p. 147.

back of Nuttall, West Virginia, the fern genus hitherto named *Adiantities* includes the very different and pteridospermic genus *Aneimites*, bearing small winged seeds terminally in the position of leaflets. (The announcement that *Lagenostoma Lomaxi* is the seed of *Lyginodendron* was made by Oliver and Scott, May 7, 1903.) G. R. W.

14. *On the Microsporangia of the Pteridospermeæ, with Remarks on their Relationship to Existing Groups;* by ROBERT KIDSTON. Phil. Trans. Roy. Soc. London, 1906, Ser. B, Vol. cxcviii, pp. 413–445, pls. 25–28.—The primitive cycad-like stems called by Williamson *Lyginodendron Oldhamium* and the cycad-like seeds called by him *Lagenostoma Lomaxi* have already been found to belong to the fern-like foliage from the Westphalian originally described in 1829, by Brongniart, under the name *Sphenopteris Höninghausi.* In the paper under review, Kidston now completes a remarkable chain of evidence by determining that the well-known and once supposedly Marattiaceous fern fructifications known as *Crossotheca* are the accompanying microsporangiate fruits. *Crossotheca Höninghausi* is here illustrated, as well as a new species *Crossotheca Hughesiana*, the specimens being carbonized impressions in nodules derived from the "10 feet ironstone measures" forming the roof of the "thick coal" of the Westphalian series of Cosely, near Dudley. The sori, synangia, and triradiately marked microspores of large size and decidedly fern-like rather than pollinial structure, are quite clearly indicated, agreeing closely with the fine series of Crossothecas from the clay nodules from the Permian of Mazon Creek, Illinois, described by Sellards (this Journal, vol. xiv, September, 1902). G. R. W.

15. *Beiträge zur Flora der unteren Kreide Quedlinburgs Teil I.—Die Gattung Hausmannia Dunker und einige seltenere Pflanzenreste;* von P. B. RICHTER. Leipzig, 1906 (31 pages, 4to, with 7 heliotype plates).—The Neocomian plant impressions of the Quedlinburg region discovered by Professor Richter are of unusually fine preservation and very numerous. As a fine example of a transition flora of Middle and Upper Neocomian age these plants promise much of interest, 80 per cent being ferns, 6 per cent conifers, and about 3 per cent cycads. *Otozamites* is not present and *Pterophyllum* is rare. *Baiera* and *Ginkgo* are absent, but *Moriconia cyclotoxon*, hitherto only known from the Upper Cretaceous, is present. Forms definitely referable to angiosperms fail. The fine examples of small fan-shaped *Dipteris*-like and more or less netted-veined ferns of the ancient, very generalized and important genus *Hausmannia* are beautifully illustrated in the first instalment of this Quedlinburg flora, the completion of which will be awaited with interest.

G. R. W.

16. *Ueber Dictyophyllum und Camptopteris spiaralis;* von A. G. NATHORST. Kungl. Svenska Vetenskapsakad. Handl., 1906, Bd. xli, No. 5, pp. 5–24, with 4 text figures and 7 plates.—

This paper adds much to, and indeed goes far toward satisfactorily completing the botanical knowledge of *Dictyophyllum* and *Camptopteris*, though these are already fairly well known genera. The series of exceedingly beautiful specimens mainly from the Rät of Bjuf, Pålsjö, and Hör, in Skone, southern Sweden, described by Professor Nathorst, clearly entitles these forms to rank among the most interesting and striking of ferns. *Dictyophyllum* and *Camptopteris* had horizontally trailing and repeatedly forking stems, from the upper side of which the long petioled, bilobately palmate to fan-shaped, bipinnate and netted-veined leaves arose. The attachment of the leaves is indicated by the old leaf base scars, with horse-shoe supply bundles, on the upper side of the stems or rhizomes. The arms of the bilobate fork or Y-shaped rachis of *Dictyophyllum* are of varying and moderate length, those of *Camptopteris* very long with spiral insertion of the secondary segments or pinnæ. Leaves of *D. spectabilis* and *D. exile* were a full meter wide. Fine examples of the fertile leaves show the large annulate sporangia covering the entire under surface of the netted-veined laminæ, a clear grouping into sori scarcely appearing, although some small number of sporangia as 5 to 7 to the sorus is suspected.

Relationships are to the rare existing fern *Dipteris* and to *Hausmannia*, so well and fully figured from the Quedlinburg Lower Cretaceous specimens, by Richter. G. R. W.

17. *Bemerkungen über Clathropteris meniscoides Brongniart und Rhizomopteris cruciata Nathorst;* von A. G. Nathorst. Kungl. Svenska Vetenskapsakad. Handl., 1906, Bd. xli, No. 2, 14 pp. and 3 pls.—In this brief but important paper is figured the supposed type of Brongniart's *C. meniscoides*, a fragment of an enormous netted-veined palmate frond ; also several smaller but somewhat similar leaves, which are decided to belong to the branches and crosslike stems known as *Rhizomopteris*. These specimens are from the Rät of Skone, which has yielded so many interesting plants. None are fertile, relationships apparently being to *Dipteris;* although if any of the great group of fossil fern leaves of which *Dipteris* is sole survivor were ever found persistently infertile one would at once begin to wonder if such might not be the leaves of Pteridosperms or Cycadophytes (or even of some primitive angiospermous type). G. R. W.

18. *The Occurrence of Germinating Spores in Stauropteris oldhamia;* by D. H. Scott. The New Phytologist, 1906, vol. v, No. 7, pp. 170–172.—This is the second example thus far observed of germination in fern spores from the Lower Coal Measures. The sporangium illustrated is quite filled with well-defined germinating spores, and is of the multiseriate annular type, indicating a Botryopteridean affinity. According to Dr. Scott, these germinating spores "conform to the Fern-type, and leave little room for doubt that the mode of reproduction of *Stauropteris oldhamia* was essentially that of a true Fern."

G. R. W.

19. *A New Fern from the Coal Measures: Tubicaulis Sutcliffii* spec. nov.; by Marie C. Stopes.—Mem. and Proc. Manchester Lit. Phil. Soc., 1906, Vol. l, Pt. iii, pp. 1–30, pls. 1–3.—Now that the great majority of Paleozoic plants with fernlike foliage are known to have been seed-bearing or are at least under suspicion(!) of exhibiting some form or other of heterospory, each demonstrable pre-Mesozoic fern has come into unexpected importance. In fact the entire fern phylogeny has proved of vastly greater complexity than once supposed, and there has never been a time when attention has been so eagerly directed to Paleozoic fern characters and problems as now. The paper by Miss Stopes is therefore most satisfactory in presenting the principal anatomical characters of the stem, petioles, and associated small annulate sporangia of a true fern from the Lower Coal Measures of the Bullion mine at Shore. *T. Sutcliffii* is one of the simpler basal members of the Botryopterideæ; this genus has not been hitherto recognized below the Permian. G. R. W.

20. *On the Internal Structure of Sigillaria elegans of Brongniart's "Histoire des végétaux fossiles"*; by Robert Kidston. Trans. Rôy. Soc. Edinburgh, 1905, Vol. xli, Pt. iii, pp. 533–550, with three plates.—Sigillariæ with structure conserved are known from the Lower Coal Measures to the Lower Permian. Ribbed and non-ribbed forms occur throughout, but appear to exchange places in relative abundance, ribbed forms predominating in lower horizons and non-ribbed forms in higher. Likewise the pithless type of sigillarian stem, with a solid cylinder of primary, followed by secondary wood, appears to be primitive and to give way in upper horizons to the non-ribbed form with a prominent pith enclosed by a zone of inner separate primary xylem bundles, with a continuous cylinder of secondary xylem. G. R. W.

21. *On the Megaspore of Lepidostrobus foliaceus*; by Rina (Mrs. D. H.) Scott. The New Phytologist, 1906, Vol. v, Nos. 5 and 6, pp. 116–119.—Mrs. Scott has determined that *Lepidostrobus foliaceus*, hitherto considered to be homosporous, is really heterosporous, the megaspores being of a peculiarly winged bizarre type, to which *Triletes*, the general name for megaspores, with the specific name *diabolicus*, was first temporarily given. G. R. W.

22. *Sur une Algue Oxfordienne (Glœocystis oxfordiensis n. sp.)*; par O. Lignier. Bull. Soc. Bot. France, 1906, quat. sér., T. vii, pp. 527–530.—A very clear instance of a unicellular zoöglean alga derived from a fragment of a silicified *Araucarioxylon* trunk. Budding, encysted, and grouped forms are clearly present. G. R. W.

23. *Die Brillenkaimane von Brasilien*; von Friedrich Siebenrock. Denkschr. d. math.-naturw. Klasse d. k. Akad. d. Wiss., Vienna, 1905, Vol. lxxvi, pp. 19–39, with 9 text figures.—The present notes on *Caiman sclerops*, *C. latirostris*, and *C. niger* are illustrated by remarkably handsome stipple-board drawings of crania and various features of dermal armature. G. R. W.

24. *Experimental Zoology;* by Thomas Hunt Morgan. Pp. xii+454. New York 1907 (The Macmillan Company).—During the past decade a considerable proportion of the zoologists in all parts of the world have extended the purely observational and descriptive study of animals to include a consideration of the behavior of the organism under artificial conditions. Such an intense interest has recently been aroused by the results obtained by these studies, that the experimental side of the study of zoology is receiving a rapidly increasing share of the energy of the younger generation of zoologists, as the pages of almost any of our biological journals will attest. Our knowledge of the structure and normal functions of animals has now advanced to the point where it seems profitable to inquire more closely into those factors which naturally operate in the development of the individual and those which have brought about the so-called evolution of the race. The zoologist is no longer content to know of what parts the animal is constructed and the normal function of each of these parts, but he must also ask as to the ultimate causes which have produced the results which he observes. The precise factors which operate in the organic world can perhaps be best learned by experiment, for by this means the behavior of an organ or organism under a great variety of artificial conditions will be most likely to furnish the clue to the nature of these factors. The hypotheses formulated from such studies can then be subjected to further tests, and, if sound, will aid in establishing the science of biology upon the comparatively secure foundation now occupied by the two preëminently experimental studies—physics and chemistry.

It is particularly opportune, therefore, that the results of a large number of the more recent workers in a definite portion of this field have been summarized in this book by Professor Morgan. Other portions of the field, such as experimental embryology, experimental psychology, and experimental study of regeneration (this last also by Professor Morgan), have recently been treated in convenient volumes, while there remains for the present book a discussion of the experimental studies in changes in form of animals. The subject matter naturally divides itself into the six principal topics: Experimental study of evolution, of growth, of the results of grafting, of the influence of the environment on the life cycle, of the determination of sex, and of the secondary sexual characters. Each topic receives critical discussion in Professor Morgan's characteristic and well-known style, and the book is sure to prove a stimulus for further experimental work. W. R. C.

25. *The Fauna and Geography of the Maldive and Laccadive Archipelagoes;* being the Account of the Work carried on and of the Collections made by an Expedition during the years 1899 and 1900: edited by J. Stanley Gardiner. Pp. 1041–1079; v-viii. Volume II, Supplement II, with text-figure 154 and Index I and

II. Cambridge (The University Press).—The parts of this important work, edited by Mr. Gardiner, have been frequently noticed in this Journal, as they have been issued (cf. xvi, 203 *et al.*) The present part forms the second supplement of the concluding volume and contains two reports, one on Chilopoda and Diplopoda, by R. I. Pocock, and the second by J. Stanley Gardiner on The Distribution of the Land and Marine Animals, with a list of the Land Plants and Some Remarks on the Coral Reefs. Two indexes close the work, the first giving a list of genera and species, and the second of general characteristics. The work, which is now concluded, is one of the most comprehensive and important thus far published devoted to the Natural History and Geology of a group of coral islands.

IV. Miscellaneous Scientific Intelligence.

1. *Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution for the year ending June 30, 1905.* Pp. liv, 576, with numerous plates and text illustrations.

Report of the Acting Secretary of the Smithsonian Institution for the year ending June 30, 1906. Pp. 91.—The recently issued Annual Reports from the Smithsonian Institution (see also p. 74) are of special interest, in view of the appointment, announced a month since, of Dr. Charles D. Walcott as Secretary of the Institution in the place of the late Professor Langley. The Report for 1905 is of the usual type, with a General Appendix of 450 pages, containing reprints of a series of interesting scientific papers more or less popular in character. The Report for 1906, by Dr. Richard Rathburn, Acting Secretary, is limited to the account of the activities of the different functions of the Institution, all of which have been in vigorous performance of their work through this interregnum. The report of the astrophysical observatory, by Mr. C. G. Abbot, acting director, details briefly observations made at Washington and Mount Wilson, particularly in the estimation of the solar constant. Mr. Abbot remarks, in conclusion, that "the results of the year's work have furnished the strongest evidence yet secured that the solar radiation reaching the limits of the earth's atmosphere varies frequently and notably in amount. According to present information, the mean value of the solar constant of radiation is not far from 2·12 calories per square centimeter per minute; its range of fluctuation is irregular and sometimes reaches 15 per cent, and its periods of fluctuation are variable." He also adds in another place: "The research on a possible variability of the solar radiation has been continued so long, and has given promise of leading to results of such definiteness and importance, as to justify its publication as Volume II of Annals of the Astrophysical Observatory. Considerable time has been occupied by the aid acting in charge in preparation of the text for this volume, which it is hoped to publish during the coming fiscal year."

2. *United States Coast and Geodetic Survey;* O. H. TITTMANN, Superintendent. Terrestrial Magnetism: Results of Magnetic Observations made between July 1, 1905, and June 30, 1906; by L. A. BAUER. Appendix No. 3, Report for 1906. Pp. 107–209.—Distribution of the Magnetic Declination in the United States for January 1, 1905; by L. A. BAUER. Appendix No. 4—Report for 1906. Pp. 213–226.

These advance Appendixes from the Report of 1906 give the prominent results of the recent magnetic work of the Survey. Appendix No. 4 is particularly noteworthy as it presents a new *isogonic chart* for the United States for January 1, 1905, with also secular change tables for one or more stations in each of the states and territories. This chart has a special value because based on more accurate data than were available for any of its predecessors. Accurate observations have been obtained at thirty-five hundred points, distributed with fair uniformity over the country. As the result of these, there is a much greater degree of accuracy in the isogonic lines; they thus show a much larger number of peculiar features, particularly as to the turns and twists, corresponding, in many cases, to the prominent physiographic features of coast lines, mountain ranges, rivers, etc. The completeness of the magnetic survey as now conducted will be appreciated from the statement that the three magnetic elements have been determined on the average for one station to every nine hundred square miles, or thirty miles square, over the whole country. Considering the area involved, which is nearly equal to that of Europe, the United States possesses the most complete magnetic survey of any country. A new feature of the present chart is the extension of the isogonic lines over the contiguous oceanic areas, these resting upon all available recent sea determinations, chiefly from the vessels of the Coast Survey, of the United States Navy and of the British Navy.

3. *Carnegie Institution of Washington.*—The titles of volumes recently issued by the Carnegie Institution are contained in the following list (continued from p. 75):

No. 44. Researches in Experimental Phonetics. The study of Speech Curves; by E. W. SCRIPTURE. 4to. Pp. 204, with 13 plates and 138 figures.

No. 47. Rythmical Pulsation in Scyphomedusæ; by ALFRED G. MAYER. Pp. 62, with 36 figures and 6 tables.

No. 48. In Investigation of Evolution in Chrysomelid Beetles of the genus Leptinotarsa; by WILLIAM LAWRENCE TOWER. Pp. x, 320, with 30 plates and 31 figures.

No. 56. Energy Changes involved in the Dilution of Zinc and Cadmium Amalgams; by THEODORE W. RICHARDS and GEORGE S. FORBES. Pp. 68, with 10 figures.

No. 59. The Pawnee: Mythology, Part I. Collected under the auspices of the Carnegie Institution; by GEORGE A. DORSEY. Pp. 546.

No. 61. The Electromotive Force of Iron under varying conditions, and the Effect of Occluded Hydrogen; by THEODORE WILLIAM RICHARDS and GUSTAVUS EDWARD BEHR, Jr. Pp. 43, with 6 figures.

No. 65. Investigations of Infra-Red Spectra: Part III, Infra-Red Transmission Spectra. Part IV, Infra-Red Reflection Spectra; by WILLIAM W. COBLENTZ. Pp. 128, with 93 figures.

4. *The Carnegie Foundation for the Advancement of Teaching. First Annual Report of the President and Treasurer.* Pp. 84. 1906.—The President, Dr. Henry S. Pritchett, and the Treasurer, T. Morris Carnegie, of the Administration of the Carnegie Fund for providing pensions to retiring officers of universities and colleges in the United States, have recently made their first report. It gives a statement as to the general policy adopted, the educational standards defining the terms college and university, with the special application to the prominent institutions affected, and the list of officers and widows on whom allowances are conferred. Fifty-two colleges and universities are included in the list of accepted institutions; of these one-half are in the New England states, New York and Pennsylvania. It is fully appreciated, at least by all those connected with the higher educational institutions, that this liberal endowment, with a continance of the wise administration it has at the outset, is sure to accomplish a great work for the cause of the higher learning in this country.

5. *A New Meteorite from Selma, Alabama.*—DR. G. P. MERRILL gives an account, in the Proceedings of the United States National Museum, of a new meteorite stone found near Selma, in Dallas County, Alabama. Its fall is with considerable probability identified with a fire ball observed on July 20, 1898, although the stone was not found until recently. The total weight is reported as 310 pounds, and it belongs to a class characterized by spherulitic chrondules. The stone has been purchased by the American Museum of Natural History in New York City.

OBITUARY.

SIR MICHAEL FOSTER, Professor of Physiology at Cambridge for twenty years, from 1883 to 1903, died on January 29, at the age of seventy-one years.

Professor D. I. Mendeléef, the eminent Russian chemist whose name will be always connected with the development of the Periodic Law of the Chemical Elements, died on February 2, at the age of seventy-three years.

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Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

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FOURTH SERIES

VOL. XXIII—[WHOLE NUMBER, CLXXIII.]

No. 136—APRIL, 1907.

NEW HAVEN, CONNECTICUT.

1907

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

Published monthly. Six dollars per year, in advance. $6.40 to countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks (preferably on New York banks).

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

Art. XXIII. — *Some Topographic Features Formed at the Time of Earthquakes and the Origin of Mounds in the Gulf Plain*; by Wm. H. Hobbs.

About two years ago a symposium seems to have been started upon the origin of the mounds of the Lower Mississippi and the Gulf Plain. To this discussion no less than nine persons have contributed in Science,* besides which there have appeared in other journals a number of special articles and references to the subject.† The latest contributor, Mr. M. R. Campbell, seems disposed to class together low mounds from

* A. C. Veatch, The question of the origin of the natural mounds of Louisiana, Science, N. S., vol. xxi, No. 531 (March, 1905), pp. 350–351; J. C. Branner, Natural mounds or "Hog-wallows," ibid., vol. xxi, No. 535 (March. 1905), pp. 514–516; E. W. Hilgard, The prairie mounds of Louisiana, ibid., No. 536 (April, 1905), pp. 551–552; W. J. Spillman, Natural mounds, ibid., No. 538 (April, 1905), p. 632; A. H. Purdue, Concerning the natural mounds, ibid., No. 543 (May, 1905), pp. 823–824; D. I. Bushnell, Jr., The small mounds of the United States, ibid., vol. xxii, No. 570 (Dec., 1905), pp. 712–714; A. C. Veatch, On the human origin of the small mounds of the Lower Mississippi Valley and Texas, ibid., vol. xxiii, No. 575 (Jan. 1906), pp. 34–36; E. J. Farnsworth, On the origin of the small mounds of the Lower Mississippi Valley and Texas, ibid., No. 589 (April, 1906), pp. 583–584; R. T. Hill, On the origin of the small mounds of the Lower Mississippi Valley and Texas, ibid., No. 592 (May, 1906), pp. 704–706; J. A. Udden, The origin of the small sand mounds in the Gulf Coast country, ibid., No. 596, pp. 849–851.

† E. M. Shepard, The New Madrid earthquake, Jour. Geol., vol. xiii, 1905, pp. 51–60; N. M. Fenneman, Oil fields of the Texas-Louisiana Gulf Coastal Plain, Bul. No. 282, U. S. Geol. Surv. 1906, pp. 124; A. C. Veatch, Geology and underground water resources of northern Louisiana and southern Arkansas, Prof. Pap. No. 46, U. S. Geol., Surv., 1906, pp. 55–59; M. R. Campbell, Natural mounds, Jour. Geol., vol. xiv, 1906, pp. 708–717.

whatever district and adopt for all the same explanation. Amid all the variety of ingenious theory, it is a little surprising that of those who have addressed themselves especially to the problem, one only has given weight to a possible birth of the mounds at the time of earthquakes in the district. Mr. A. C. Veatch, the best recent authority upon the geology of the district, has considered the possibility of this origin for certain of the mounds, but believes the dune and ant-hill theories the best supported. Shepard has, however, been able to show conclusively that the low mounds of the "sunk country" are "sand blows"—mounds three or four feet in height with diameters of 20 to 100 feet, frequently slightly hollowed at the center—mounds which came into existence during the earthquake at New Madrid in 1811–12.

Veatch has concisely stated the general characteristics of the so-called "natural mounds" of the Gulf Plain in the following words, the italics being the present author's:*

"They (the mounds—*ed.*) occur irregularly throughout the coastal plain in northern Louisiana, northeastern Texas, Arkansas, and southeastern Missouri, except in the present flood plains. They are best developed on the Port Hudson terraces, but extend also over the hill lands. They are not restricted to any geologic formation or any range of elevation. *The material of which they are composed is commonly a very fine loam, which is reported by the agriculturists to be coarser and quite distinct from the surrounding soil, which is commonly clay. Oil-well drillers in southern Louisiana and southeastern Texas report the material in these mounds to be entirely different from the surrounding soil and exactly the same as the fine sand found beneath the 50 to 100 feet of surface clay.* The apparent difference in composition is, however, not so great as it seems at first sight and is in part due to the greater elevation and consequent better drainage of the mounds. Careful mechanical analysis will be necessary to determine the true character and degree of this difference."

Udden has shown* that of 59 mounds near Olivia, Texas, the greater number are less than 30 feet in diameter and 7 inches in height, and, further, that it is the larger mounds which show the distinct pittings at the center.

The object of the present article is to draw attention to the fact that the region in question is one of notable seismicity, and to point out that sand and water fountains, as well as mud volcanoes, with their products, "sand" or "mud" cones and "craterlets," are almost universally produced in connection with great earthquakes. The derangement of the ground

* Professional Paper, U. S. Geological Survey, No. 46, p. 155.
† Science, June 1, 1906, p. 850.

water at such times results in: (1) local ejection of sand and water (sand blows and mud cones), (2) draining through vertical pipes of swamps or ponds ("funnels" and "craterlets"), (3) in draining following upon an ejection of sand, mud and water (pitted cones), or (4) squeezing out following the sudden draining of the district. The best descriptions of such phenomena have perhaps been given in connection with the earthquakes of Calabria, 1783;* New Madrid, 1811–12;† Iceland, 1896;‡ India, 1897;§ and Chemakha, Turkestan, 1902.‖

The mounds referred to in the above mentioned examples generally consisted of sand mixed with small quantities of various other substances (mica, lignite, etc.) generally foreign to the surface layers of the soil, and it reached the surface borne by large volumes of water which left the material so charged with water as to resemble a quicksand. During the

1

Fig. 1. "Mud volcano" formed at Chemakha during the earthquake of February 13, 1902. (After Weber.)

Indian earthquake of 1897 material of this nature spread out from many openings and blanketed large tracts of country with quicksand. In other instances, as near New Madrid, in 1811, the water and sand welled out throughout the length of extended fissures and the arrangement of "sand-blows," like the newly developed springs, appears to have been upon fissure lines. During the Chemakha earthquake, and in some other

* Lyell, Principles of Geology, vol. ii, pp. 113–144.

† E. M. Shepard, The New Madrid Earthquake, Jour. Geol., vol. xiii, pp. 45–62, 1905.

‡ Th. Thoroddsen, Das Erdbeben in Island im Jahre 1896, Pet. Mitth., vol. xlvii, pp. 53–56, 1901.

§ R. D. Oldham, Report on the great earthquake of 12th June, 1897, Mem. Geol. Surv. India, vol. xxix, 1899.

‖ V. Weber, The earthquake of Chemakha of Jan. 31 (Feb. 13), 1902. Mem. du Comité Géol., N. S., No. 9, 1903 (in Russian).

instances, the material ejected was a salty mud, which upon desiccation yielded hard mud cones ranged upon fissure lines (fig. 1). At Chemakha, moreover, a second displacement upon the line of the fissure produced a distinct fault wall a meter in height which cut the dried mud cones.

In Italy, a notable earthquake country, gas and water yield mud volcanoes in the period between earthquakes, but the action in them is usually either more or less vigorous during seismic shocks in the neighborhood. A series of such mud volcanoes runs in a nearly straight line entirely across Sicily from Siculiana upon the south coast to Paternó upon the flanks of Ætna. Mud volcanoes are also numerous in the Apennines, though no attempt has yet been made to determine their arrangement or their relation to structural lines. This is, therefore, a most promising field for future studies in structural geology.

The whole subject of the extensive derangement of the ground water during earthquakes has been difficult of explanation by the centrum theory, and has not received the attention which it deserves or which it is likely in the near future to attract. The introduction of the crustal block or compartment theory of earthquakes affords an explanation, both simple and natural, of these derangements. If the elastic waves which we describe as earthquakes arise from the mutual friction upon the edges of earth blocks, which through an abrupt jolting movement seek to readjust themselves to the stress system, looked for consequences are: (1) the squeezing out of water from the trunk channels of circulation within those districts where blocks are depressed, (2) a sucking down of the water of swamps and ponds wherever blocks are elevated, (3) a sucking down following upon a squeezing out of water (often actually observed with the formation of cratered sand cones) when the slight elevation of a block succeeds to its depression, and (4) a squeezing out of water following a sudden draining of a district when a slight settling follows the elevation of a block.* Quite analogous appears to be the forcing of fire damp into the galleries of Belgian coal mines, which, from quite recent studies of Van den Broeck, appears to take place chiefly when the *Mistpoeffers* are heard and when there are earthquakes in moderately distant districts.†

It is a fact of much significance that in the "sunk country" of the Lower Mississippi the springs are often surrounded by little cones of sand admixed with lignite, and that the inhabit-

* Gerland's Beitraege zur Geophysik, vol. viii. Heft 2, 1907.

† E. Van den Broeck, 5th Int. Congress of Hydrology, Climatology and Geology, Liège, 1898, pp. 1–13.

ants of the district claim that the better quality of water is found by boring in the mounds of the valley. In the words of Shepard:*

"Further, we find today that large volumes of water are constantly coming to the surface as springs in this district; that these springs are numerous along the lines of fissure: that deep artesian wells around this region bring up this same variety of sand with lignite, some, as at Memphis, when first sunk, ejecting large chunks of the lignite; that the sand and lignite brought up in the deep wells are similar to the same substances brought up by the innumerable springs that feed the lakes and streams of this district, and that they are apparently the same as that which surrounds the blow holes and fault scraps, and which covers, as with a vast sheet, the considerable areas in the sunken district."

The association of oil with the mounds of the Gulf Plain is further of interest, and especially because it is the low mounds of the spindle-top type in which the petroleum is found. Fenneman states that the chance of finding oil under the elevated spots in the plain is vastly greater than elsewhere. He further says:†

"There is some reason for thinking that such structures are ranged along lines of slight crustal deformation or disturbance. If such lines exist they probably trend northeast and southwest. This probability may well be recognized in prospecting for new fields."

The northeast-southwest direction is the one which, according to Lyell, was by far the most common direction of the fissures produced at the time of the New Madrid earthquake. In view of the vast deposits of sulphur which have been found to underlie portions of the Gulf Plain, it is worthy of mention that the earthquake of New Madrid was possibly unique in the respect that the shocks were accompanied by emissions of sulphurous vapors (probably sulphureted hydrogen) causing great discomfort and rendering the river water for days unfit for drinking purposes.

Sand blows, mud volcanoes, craterlets, etc. are clearly closely related phenomena and are to be ascribed to the vertical movement of water, gas, sand, etc. along the widened portions of earth fissures. Their connection with larger tectonic movements as the resulting derangement of the ground water system, is only beginning to be appreciated. Perhaps the most striking and significant single characteristic of the mounds

*L. c., p. 58. †L. c., p. 124.

thus produced is that they have a composition essentially different from that of the layers of soil underlying their margins, and that the materials are derived from a lower horizon (see extract from Veatch above). The report of the Naples Academy of Science upon the great earthquake of Calabria (1783) states that some plains, like that of Rosarno, were covered with circular hollows generally filled with sand but sometimes with a concave surface. At other times, the surface was convex. Upon digging down in them it was found that they were funnel-shaped pipes, and that the moist, loose, micaceous sand in the center marked the tube up which the water had spouted (see fig. 2). At other places in the same district, cones of sand were built up, and the localization of cones and funnels upon fissure lines was recognized.*

2

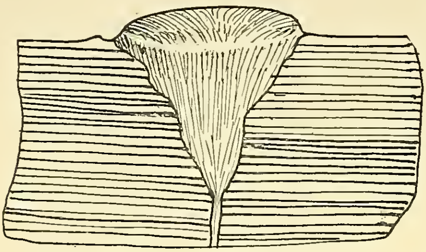

FIG. 2. Funnel-shaped pipe of sand formed during earthquakes of Calabria in 1783 (after Lyell).

According to Veatch and Fenneman, the Gulf mounds differ in composition from the material of the surrounding plain, and they appear, further, to be often pitted at their summits. Attention should therefore be directed more particularly to the composition of the mounds, taking account also of their less common ingredients, and their relation to underlying formations should be discussed. Apparently also there is a possibility of determining the underground structure of such mounds where they have been dissected. Especial interest attaches, in this connection, to the sandstone pipes which occur in the Carboniferous limestone of the eastern coast of Anglesey, for which as yet no explanation has been offered. The surface of the limestone is here pierced by a large number of circular pits opening out in trumpet form and from 1 to 7 feet in diameter. Each can be seen to be, or to have been, filled with a plug of fine white sandstone, descending into the limestone at right angles to its bedding.†

"These plugs can be seen in various stages of denudation. Some have been worn flush with the surrounding limestone, and some of the smaller ones have been excavated so as to leave an almost empty pit or pothole with a little sandy matter in the

* Lyell, Principles of Geology, vol. ii, pp. 127–128.

† Edward Greenly, On sandstone pipes in the Carboniferous limestone at Dwlban Point, East Anglesey, Geol. Mag., Dec. IV, vol. vii, pp. 20-24, 1900.

bottom. In one part of the shore, however, the plugs have been left standing, each in its circular pit, some 4 or 5 feet above the level of the surrounding rock; and the foreshore here presents a most extraordinary appearance, great masses suggestive of gigantic fossil corals, or of the Paramoudras of the Chalk, standing up from the rocky ledges, while others, torn out by the sea, lie prostrate in all directions." (See fig. 5.)

The limestone at the locality is overlaid by about two feet of sandstone with which the sandstone material of the pipes is continuous though with no sign of collapse in the bed of sandstone (figs. 3, 4). In fact, in most instances the surface of the sandstone is gently domed upward above the pipes and occasionally has also a domed crack as well. Within the pipe the bedding of the sandstone sags downward and a concentric structure is clearly revealed by the brown weathering. There is, moreover, a tendency to radial jointing within the plugs. The enclosing limestone of the plugs is full of cracks at its upper surface and these cracks are filled with sandstone. The pipes belong to three different horizons within the same formation, and with much probability represent fossil sand-blows like those described from near New Madrid. Structures of a similar character, the writer is informed by Professor A. H. Purdue, are found in the Ozark mountains of Arkansas.

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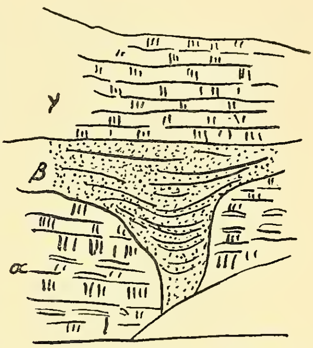

Fig. 3. Sandstone pipes in Carboniferous limestone, East Anglesey (after Greenly). α, cherty limestone; β, sandstone; γ, cherty limestone.

Whereas during the New Madrid earthquake certain of the fissures opened spouted the sand and water only locally to build up cones; from others the same materials welled out throughout the entire length of the fissures so as to produce broad blankets of quicksand. Just as the sandstone pipes of Anglesey illustrate the indurated relic of the one phenomenon, so do the sandstone dikes described by Diller,* Hay,† Crosby,‡ and Case§ the other. Without exception these authors have

* J. S. Diller, Sandstone dikes, Bull. Geol. Soc. Am., vol. i, pp. 411–442, pls. 6–8. 1889.

† Robert Hay, Sandstone dikes in northwestern Nebraska, ibid., vol. iii, pp. 50–55, 1892.

‡ W. O. Crosby, Sandstone dikes accompanying the Great Fault of Ute Pass, Colorado, Bull. Essex Inst., vol. xxvii, pp. 113–147, 1895.

§ E. C. Case, On the mud and sand dikes of the White River Miocene, Am. Geol., vol. xv, pp. 248–254, 1895.

explained the dikes by the upward movement of sand in fissures generally at the time of earthquakes.

Any consideration of the mounds found within the Gulf Plain should take account of the "mud lumps" which are constantly forming in the Mississippi delta. These hillocks make their appearance as small isolated cones of mud which often appear above tide and have craters at their summits

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FIG. 4. Large sandstone pipe shown in cliff in limestone, Anglesea. (Photograph by Edward Greenly, Esq.)

from which a spring of dirty water issues. Later in their history their conical form is lost and the water issues from their slopes. This water is often loaded with salt, oxide of iron, or lime carbonate, and carries mud and sand. Marsh gas, carbon dioxide, and nitrogen are also given off from them in quantity. Lyell states* that the tubular cavities up which the springs

* Lyell, Principles of Geology, vol. i, pp. 443–449. E. Reclus, New Physical Geography, vol. i, pp. 211–212, 1894.

rise are about 6 inches in diameter, vertical, and as regular in form as though bored with an auger." A most important contribution to our knowledge of these unique phenomena, in which it has clearly been shown that the material of the mud lumps is of a different nature from that surrounding them, has been very recently made by Hilgard.* He has shown that the sticky mud is the "blue delta clay" or "blue clay bottom" derived from a much lower layer of Coast Pliocene, or Port Hudson age, above which the delta deposits are laid down. As

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Fig. 5. Principal sandstone pipe where weathered out upon shore, Anglesea. (Photograph by Edward Greenly, Esq.)

the latter are deposited they imprison a thin overlying stratum of very thin mud which results from the clarifying of the river-water when it meets the sea-water outside the bar. The settlement of the delta region under its increasing burden of sediment is the plausible cause to which Hilgard appeals for the forcing up of the mud lump clay, and its associated thinner mud. The lumps are thus in reality true "mud volcanoes." The very stickiness of this blue clay, upon which the river's scour makes little impression, in the opinion of the writer, makes it necessary to assume that a current either of water or of gas, or both, is forced up *from beneath* the "blue clay bot-

* E. W. Hilgard, The exceptional nature and genesis of the Mississippi delta, Science, vol. xxiv, pp. 861–866, Dec. 28, 1906.

tom." The gas which is emitted from the lumps is, as Hilgard believes, in volume quite insufficient to alone carry on the action. Fissure springs are best suited to explain all the conditions, and the known existence of strong fresh-water springs at numerous off-shore points beneath the Gulf, and especially off the mouth of the Mississippi,* indicate the continuation beneath the Gulf of the artesian water stratum characteristic of the lower flood plain.

Moreover, there is other evidence that such fissure springs are in definite alignment. A fact which Lyell considered so important as to print in his rare italics is, "*they* (the lumps—*ed.*) *were always situated off some one of the mouths of the river.*† To this Hilgard has given support by a statement, also in italics, "*Mudlump formation is at present the normal mode of progression of the visible delta into the gulf.*"‡ It would thus appear that as the mud lumps become clogged, new ones develop along the extension of the same fissure through a steady migration seaward of the process. The peculiarly straight but divergent channels of the unique "birdfoot" portion of the delta support this hypothesis.

While the mud lumps are perhaps not developed at the time of sensible earthquakes, it is a question whether the settlement of the Mississippi delta takes place gradually or *per saltum*. The tendency at the present time is to look upon such bradyseismic movements as different in degree rather than in kind from those accompanied by earthquakes—a tendency which the increasing knowledge of subterranean sounds (*brontidi*) is strengthening.

Many mud volcanoes owe their activity to the high temperature of the subsurface layers of the earth's crust, which supplies steam to raise the mud and eject it with violence.§ The Minbu mud volcanoes of India are of a different type and have a special interest for the present study because they indicate that the petroleum beneath the mounds of the Gulf Plain may well have played a part in their formation. According to Cadel:‖

"The Minbu salses, for such they are in reality, are due to the escape of carbureted hydrogen from the oil-bearing strata on the top of the anticline, which rises through the clay beds mixed with a little water and oil and slowly bubbles up at certain spots.

* C. H. Hitchcock, Fresh-water springs in the ocean. Pop. Sci. Month., pp. 682, 683.

† L. c., p. 446. ‡ L. c., p. 863.

§ See, for example, D. P. Barrows, The Colorado Desert, Nat. Geog. Mag., vol. xi, p. 340, 1900. Also D. T. Macdougal, The delta of the Rio Colorado, Bull. Am. Geog. Soc., vol. xxxviii, p. 10, 1906.

‖ Henry M. Cadel, A Sail down the Irrawaddy, Scot. Geog. Mag., vol. xvii, p. 263, 1901.

As the gas and water rises, it brings up a little gray mud, which, on exposure to the air, dries and hardens while the water evaporates, producing first a low crater basin with a dry rim of mud, then a cone with a crater on the top, in the center of which the gas finds vent."

It will be noted that we have here an evolution of topographic forms identical with those illustrated by the sand phenomena of earthquakes as above outlined. Other petroleum mud cones occur upon the Apennines at Sassuolo and San Venanzio, at Tanan and Baku in the Caucasus, and upon the Island of Trinidad, while Macaluba in Sicily rests upon beds of clay containing gypsum, salt, sulphur, bituminous matter, etc. or much the same mixture as that to be found beneath the gulf mounds. The smell of sulphur which accompanies the eruptions of Macaluba is of interest because it offers a possible explanation of the sulphurous odors with which the air was charged during the great New Madrid earthquake of 1811–12.

The small amount of attention which "mud volcanoes" have attracted we owe perhaps to their name, which classifies them with volcanic phenomena, but with which they have little in common. Generally born at the time of earthquakes, they show a sympathetic response to seismic shocks within their neighborhood, and are properly classed as phenomena consequent upon the derangements of the ground water and gas systems by earthquakes. Our knowledge of the brontidi now makes it possible within a seismic province where mud volcanoes are frequent (Italy, for example), to determine what relation exists between their periods of activity and the perception of subterranean rumbling. It seems certain that *where mud or sand cones are now forming, orographic blocks are being depressed*, which accounts for their common occurrence within delta regions. The study of bradysisms has clearly shown that nearly all coast lines of the continents are today rising, *the marked exceptions being the deltas of the great rivers.** The whole Mississippi flood plain, with the exception of Lake County, Tenn., and the opposite shore of the river, would appear to be included within the area which in the isostatic adjustment about the Gulf is being depressed.†

Further light is likely to be shed upon the origin of the Gulf Plain mounds through the careful mapping of them within definite districts. If, as seems likely, they have been

* Arturo Issel, Le oscillaziani lenti del suelo o bradysismi. Saggio di geologia storica. Atti della R. Università di Genova, vol. v, pp. 417, map, 1885.

† W. J. McGee, A fossil earthquake, Bull. Geol. Soc. Am., vol. iv, pp. 411–413, 1893.

formed as a result of derangements in the ground water system during earthquakes, they are doubtless aligned upon fissures and located where these fissures are widened—in the majority of cases doubtless at fissure intersections. Such an alignment has already been indicated by Fenneman, but has not been worked out in detail. Their importance as points of segregation of petroleum greatly adds to this interest and places them at once in relation to the famous "mud volcanoes" of Baku, the lineal alignment of which was long since indicated by Daubrée.* There is thus at least the possibility of gaining some knowledge of the earth's fissure system beneath the Gulf Plain notwithstanding its deep blanket of unconsolidated material.

University of Michigan,
Ann Arbor, Michigan, January 22d, 1907.

* A. Daubrée, Les eaux souterraines a l'époque actuelle, vol. i, pp. 383–385.

ART. XXIV.—*Contributions to the Geology of New Hampshire, No. III. On Red Hill, Moultonboro;* by L. V. PIRSSON, with analyses by H. S. WASHINGTON.*

Introduction.—This article embraces the results of a field and laboratory study of the igneous rocks which compose the mountain in Moultonboro, N. H. known as Red Hill. This eminence is one of the most prominent objects in the lake district of the state and, situated nearly on the shores of both Lake Winnepesaukee and Lake Asquam, its top commands one of the most beautiful panoramic views in New England. For this reason and because it is easily climbed it is frequently visited by tourists and the summer residents of the region. The origin of its name, in spite of several ingenious theories advanced by writers on the region, is involved in mystery; there is nothing red about its rocks or its foliage which especially distinguishes it from the other mountains of the region, and like many another place name it is probably due to some long forgotten trivial circumstance connected with the early settlement of the country.

Both the mountain and the country surrounding it have been visited several times by the writer for study and the collection of material. On one occasion a week was spent in this work, during which it was encircled and the contact studied at a number of places, its peaks and crest line visited and traverses of the mass made in several directions. It was during this visit that I was accompanied by Dr. Washington, who studied the field occurrences with me.

Historical.—The earliest mention of the geology of Red Hill, which I have been able to discover, was by Prof. O. P. Hubbard,† who speaks of it as a mountain consisting of reddish syenitic granite whose sides are covered with decomposed fragments of the same rock. He says it is cut by two trap dikes, one in width seven feet, the other twenty-five, whose trend and location are somewhat vaguely given.

Prof. C. T. Jackson‡ describes the mountain as composed of a beautiful syenite whose feldspar is an ash-gray color when fresh, but weathering to a reddish color. He also mentions a trap dike of a porphyritic texture on the west side and speaks of the well crystallized hornblende in the syenite; says that bog iron occurs on the mountain in small quantity and

* In addition to making the analyses, Dr. Washington accompanied me during the greater part of the field-work and has since placed his collected material and sections at my disposal, thus conferring obligations upon me which I am glad to take this opportunity of acknowledging.

† This Journal (2), xxxiv, p. 111, 1838.

‡ Geology of New Hampshire, 1844, p. 71.

also iron pyrites and tourmaline, the last mineral being mistaken for coal. The writer has not found any tourmaline and its occurrence in such amount that it could be mistaken for coal seems improbable.

The next description of Red Hill is by Prof. C. T. Hitchcock,* who calls the rock a true syenite and collates it with that of the Belknap Mts. at the other end of Lake Winnepesaukee. He states that its contact with the enclosing gneiss may be seen at the north end in Sandwich. Hitchcock also mentions that the enclosing gneiss is cut by feldspathic dikes at a distance from the syenite. The latter is thought to have come up through a fault along a synclinal axis. Mention of glacial phenomena in relation to the mountain is also made.

The first petrographical work on the Red Hill syenite was done by Hawes,† who described the syenite as consisting of orthoclase and hornblende. Details of these and of other accessory minerals are given and the presence of some interstitial quartz is mentioned.

Later Bayley‡ gave a detailed petrographic description of some hand-specimens of the syenite which had been sent to him, accompanied by a chemical analysis of the rock by Hillebrand. He showed that the rock was not quartzose, as supposed by Hawes, but contained nephelite and sodalite and should therefore be classed with the nephelite syenites. His work will be referred to in detail later.

From what has been stated above, it will be seen that up to the present the geology of Red Hill has never been studied in any adequate manner, while the recognition by Bayley of the alkalic nature of the massif, combined with the mention of trap dikes by those who had visited it, seemed to point to an assemblage of igneous rocks which it would be of interest to investigate in the field and in the laboratory. This has been done with the results set forth in the following pages.

The Map.—The topographic base of the accompanying geologic map has been compiled by the writer from various sources including his own notes. The geologic outlines laid down upon it are in some places correct, in others as nearly correct as the heavy mantle of drift and of debris which covers parts of the area permit.

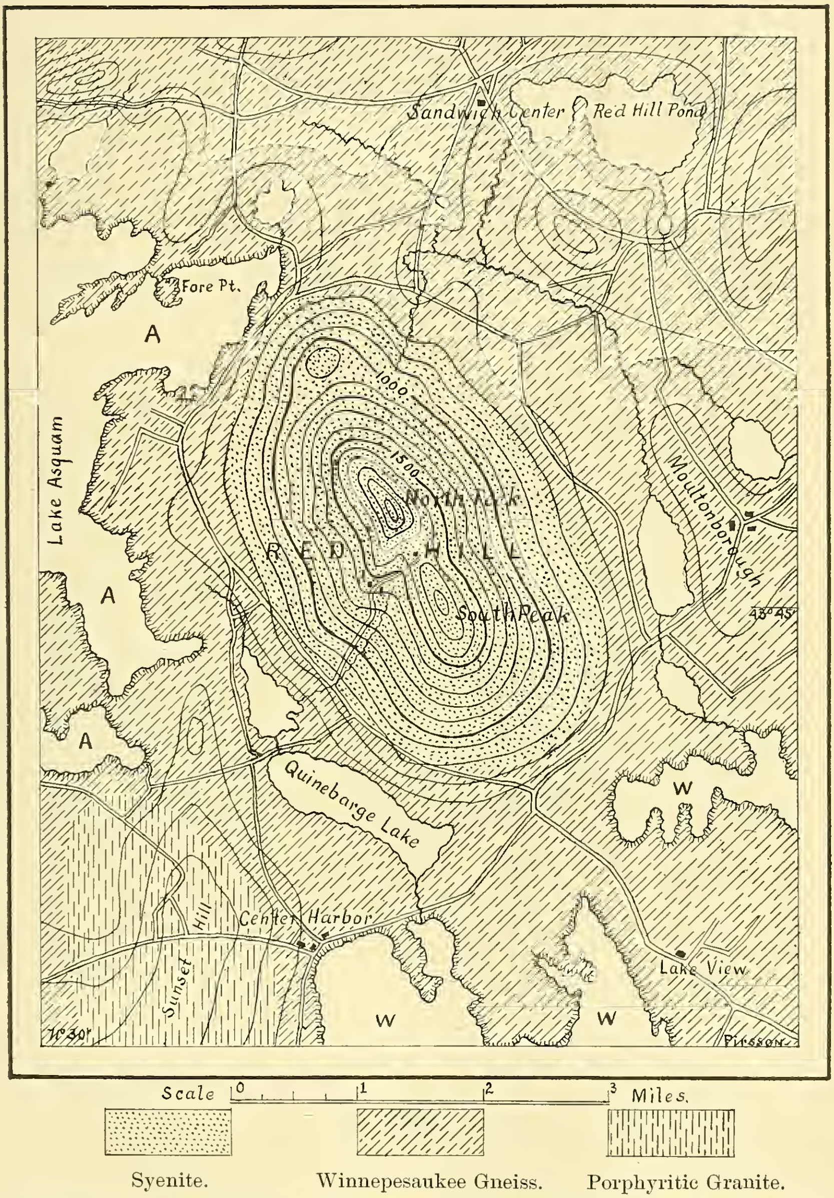
General Geology.

Topography.—Red Hill is a quite regular oval mass about 4 miles long by 2·5 broad at its base. Its highest point is a little over 2000 feet above sea-level and about 1500 above the

* Geology of New Hampshire 1877, vol. ii, p. 605, vol. iii, p. 132.

† Ibid., Pt. IV, 1878, Mineralogy and Lithology, p. 206.

‡ Bull. Geol. Soc. Am., vol. iii, p. 243, 1892.



Syenite. Winnepesaukee Gneiss. Porphyritic Granite.

Geologic and topographic map of Red Hill, Moultonboro, N. H. Contours equal 400 feet; A A A, parts of Lake Asquam; W W, parts of Lake Winnepesaukee; *d*, Horne farm house.

lakes and low country which lie at its foot. This general regularity of outline is modified by a valley cut in the middle of each long side, the one on the western side being the most pronounced. These two valleys heading against one another have cut out a low place in the crest line and divide the mountain into north and south peaks. The drainage of the western valley gives rise to a small brook; its upper slopes are cultivated and form two farms, access to which is had by a road coming up the valley to the saddle. The lower farmhouse, formerly belonging to a family by the name of Horne, is situated about midway up this road; it has long been the point at which parties ascending the mountain for the view are accustomed

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Red Hill from Shepards Hill across Lake Asquam.

to leave their vehicles, and from this point a good trail ascends to the north and highest peak.

The lower and gentler foot slopes of the mountain are usually not much cultivated but are free from forests and used as hayfields and pastures; above these the slopes are much steeper and covered with a thick forest growth which in many places springs up amid the slide rock bowlders and debris which mask the underlying rock. In other places, especially around the north end, the declivities sharpen into such steepness that the mass is exposed in cliffs and heavy ledges. Good exposures of the rocks are, however, not common on account of the forest growth and the heavy mantle of glacial drift which covers the lower slopes and hides the contact with the country rock. The accompanying sketch (fig. 2), taken from Shepards Hill at a distance of about five miles, shows the mountain from the west across Lake Asquam. To the left is seen the north spur which extends towards Sandwich, on the right the lower south peak and between it and the higher north peak which forms the center of the view is the low cut saddle mentioned above.

General Geology.—In its broad features Red Hill may be described as a mass of intrusive nephelite syenite which has broken up through granitic gneisses which enclose it on all sides. The form and mode of intrusion cannot now be definitely determined, but from certain considerations which will presently be given, it appears probable that the mass was of the nature of an intruded stock whose dome-like upper surface solidified beneath a heavy cover. Following this came secondary intrusions of magmas, on the one hand more siliceous and on the other more ferro-magnesian than the main mass, which appeared as dikes both in the nephelite syenite itself and radiating outward from it in the cracked and shattered gneisses. Since then erosive agencies have removed an enormous but unknown amount of material, cutting away all of the cover and the surrounding gneisses and leaving the syenite, on account of its superior resisting qualities, projecting as it now does above the general level of the enclosing rocks. It has, however, been also bitten into by erosion, which has given it its present contours, though it seems probable, as will be shown later, that no relatively great amount of it has been carried away.

And lastly during the Glacial Period it was over-ridden by the ice sheet as shown by the polishing and scoring of its upper surfaces and by the number of erratic bowlders coming from more northerly sources in the White Mountains which lie scattered upon its top and upper slopes.

The enclosing Gneiss.—No special study has been made of the gneiss through which the syenite has been intruded. On the geologic map of the Hitchcock survey it appears as the "Winnepesaukee Gneiss." It has been observed at several places, however, and sections cut from these and consideration of the specimens show that it is an ordinary granitic gneiss consisting chiefly of orthoclase and quartz with considerable oligoclase and variable amounts of biotite and muscovite. In some places it is of medium coarseness of grain, in others much finer and with diminished amounts of biotite it assumes an aplitic facies. Its minerals exhibit clearly the effect of dynamic stresses, the quartz is strained, broken and shows undulatory extinction, the twinning lamellæ of the oligoclase are also bent, curved and faulted, and both it and the orthoclase show at times some undulatory extinction. The mortar structure is also quite pronounced. The biotite, though shredded out, is that of ordinary granite and commonly contains small zircons surrounded by pleochroic halos. The muscovite appears chiefly in the feldspars and along cleavage cracks and is clearly an alteration product, though not distinctly in the sericitic form. Apatite crystals of the ordinary kind occur.

Although as stated, the gneiss has not been made the object of especial study, and not enough is known about it to warrant definite conclusions as to its origin and character, from what has been seen, combined with the facts mentioned above, it would seem very probable that it is an ordinary biotite-granite which has suffered dynamic shearing from which, with little or no recrystallization, it has assumed the gneissoid structure.

Contact Facies of the Syenite.—The actual contact of the gneiss and the syenite is practically everywhere hidden by debris and glacial drift. Hitchcock mentions one locality where it may be seen, as previously stated, but this was not found by the writer. In a number of places, however, and especially at the foot of the eastern slopes, in the pasture fields, the contact can be carried to within a few yards, notably at one point just south of a little cemetery where many exposures of the bed rock are seen. Here, about 200 feet above the road, the gneiss is full of seams, patches, and dikes of pegmatitic alkali-feldspar, which change within short distances to aplitic dikes. In addition to the feldspathic dikes there are also many of dark-colored trap-like ones filling narrow fractures in the gneiss and trending outwards in directions generally normal to the plane of contact. Immediately above this the syenite is in place; it is fine-grained and quartzose; as one follows it up the slope it becomes coarser in grain and eventually assumes the normal type of the massif. Precisely similar phenomena were found at the foot of the eastern slopes of the north peak, where heavy outcropping ledges in the fields give good exposures, and again at the north end of the mountain. The gneiss is filled with aplitic dikes, often only a few inches wide, which run in various directions and frequently anastamose. There are also the same lamprophyric dikes and the general trend of the larger dikes is away from the peak.

Near the contact the syenite is very fine-grained, becoming coarser at a distance. These endomorphic changes in it will be more fully described and discussed in the following petrographic part of this work: it is sufficient to say here that the facts mentioned above indicate very clearly that the gneiss is the older rock, through which the syenite has broken up and against which it has distinct contact phenomena.

The Central Syenite.—The petrographic description of this rock will be given later, but a few facts in regard to its geologic relations may be properly mentioned here. The chief type composing the mass is a coarse-grained light-gray feldspar rock of a granite-like texture rather thickly dotted with stout black hornblendes about $\frac{1}{4}$ inch long. This is found in and about the central saddle, on the south peak, and at the steep slopes at its foot, it forms the north spur and occurs elsewhere. The north peak, however, towards its top has a somewhat different character, the rock is finer-grained, the feldspars thin tabular and more or less arranged in parallel position producing a trachytoid texture and somewhat schistose fracture. In the exposures near the Horne farm in the west valley places may be found where these types merge into one another, without any contact, within a few inches or less, and blocks in the stone walls at this place show the same thing. On the other hand, an exposure in the road below this house seems to indicate the finer trachytoid type as a dike in the coarser eugranitic one though the evidence is not clear. Again the rock in the quarry pit opposite the Horne farmhouse, which, as will be seen on examining the illustration and map, is near the center of the exposed mass, is richer in nephelite than in any other locality; the trachytoid type of the north (and highest peak) is very poor in it, while at the contact with the gneiss the nephelite dies out entirely and is replaced by quartz. These facts appear to indicate that as a whole the mass of syenite is of low silica content at the center; that this rises as one goes away from it and becomes quickly very marked near the contact, the texture remaining the same but the grain diminishing; that the same is true in a vertical direction, but that here the rock assumes a different and trachytoid texture. The possible reasons for this change in silica will be discussed later. The vertical variation is of interest geologically since it shows the influence of the former roof, long since removed by erosion, and it is clear that, if the endomorphic effect of this upper cover is still to be seen, the erosion of the syenite mass in a vertical direction has not been excessive and suggests thus, in a vague way it is true, the original upper limit of the intrusion and the amount of erosion the district has suffered since it took place.

Salic Dikes.—The study of the area has shown that, in addition to those already mentioned as occurring at the eastern contact, a considerable number of other dikes are exposed which are genetically related to the syenite intrusion. As is so commonly the case in examples of this kind, they are of two classes, aplitic and lamprophyric, or in field usage, felsites and traps, sometimes porphyritic and sometimes not. In the quantitative classification the former are liparase and the latter camptonase or in Rosenbusch's system aplite in its narrower sense, paisanite, syenite porphyry and for the traps camptonite. They occur in the syenite itself as noted by previous observers and in the surrounding gneiss, and sometimes at long distances, from the mountain. The following list covers the chief occurrences of salic dikes observed.

The rock in the quarry in the field opposite the Horne farmhouse is cut by an aplitic dike about six inches wide of a light gray. It is an arfvedsonitic liparase or paisanite, described later. Trend E. and W.

A block in the stone wall at this locality is from a dike of syenite porphyry, dark gray with feldspar phenocrysts. A gelatinization test with nitric acid shows that it is a nephelite-syenite porphyry.

Another dike of syenite porphyry cuts the granite gneiss of Fore Point on Lake Asquam opposite the north end of Red Hill. The dike is about 10 feet wide and is exposed in the ledge only a short distance. The rock is much crackled and jointed and weathered to a brownish gray. It is fine-grained, dense in texture, thickly dotted with small feldspar phenocrysts.

Fragments of a similar porphyry with less abundant phenocrysts and weathered to a red-brown color occur in the debris on the top of North Peak, indicating a dike or dikes of this rock, but the outcrops themselves could not be found.

On the shore of Hoag's Island in Lake Asquam, beyond the western boundary of the map, there is a dike of a weathered grayish-brown felsite (bostonite). It is three feet in width, cuts the gneiss with a trend to Red Hill and has a somewhat schistose or platy fracture.

Femic Dikes.—Rocks of lamprophyric character, heavy, dark, basaltic or trap-like are much more numerous than the lighter colored felsitic ones mentioned above. Their occurrence at the contact at the eastern foot of Red Hill has been already mentioned. Their presence in the nephelite syenite has been already alluded to by geologists who have previously visited the mountain, as detailed in the historical summary, but the locations are described in so vague a way that it has been found impossible to identify them with any certainty. The following have been noted by the writer in traversing the region, though no special attempt has been made to hunt them up and map them. Since the region in general is heavily covered with glacial drift, it is safe to say that for each one which has been found there are dozens which have not been seen.

Just above the Horne farmhouse the syenite exposed in the roadway is cut by a dike, four feet wide, of a black rock, weathering brown, dotted with rather frequent dull white feldspar phenocrysts and small amygdules of calcite.

Another dike of similar size and character occurs in the road about 200 yards from the former up the mountain side.

A dike of a more grayish color cuts the syenite about one quarter of a mile above the Horne farmhouse on the well worn trail leading from it to the top of the North Peak.

One of similar character to the last was found about half way on the old trail from the highest farmhouse in the saddle to the North Peak.

Dikes of this kind occur also on the mountain side below the Horne farmhouse.

Outside of the syenite they are also common in the gneiss, and a considerable number have been found in the exposures along the shores of Lake Asquam; on Fore Point there are several and the little capes of Long Point next southwest from it and shown on the map contain several more. They occur at considerable distances from Red Hill: thus they have been found in the gneiss of Shepard's Hill, one in the hotel roadway and others near the Norton house, and at the summit of Mt. Livermore, in these cases some six miles distant from the mountain.

They are all very narrow, from one to three feet in width, are very dark, quite compact, without noticeable phenocrysts and very commonly are dotted with white amygdules of calcite. In nearly all cases where the trend can be observed it is directly towards Red Hill. The microscopic study shows that they are all much alike, composed of plagioclase feldspar and brown hornblende and are the rocks which have been called camptonites.

Breccia Intrusion.—In the sugar-maple grove just above the Horne farmhouse and north of the road there is an intrusion of a singular rock. The mass is not more than 100 yards in diameter and is surrounded on all sides by the normal nephelite syenite and is therefore judged to be an intrusion in it, although the exposures were such that the actual contact could not be found. It consists of a fine-grained, black rock filled with fragments of nephelite syenite. Usually the fragments are no more than single feldspars of the syenite which then appear much like phenocrysts, but from this they increase in size till they are considerable masses. They are so twisted and broken and strung along in flow lines and bordered with angular pieces of feldspar that at first glance it appears as if a mixture of two magmas in the fluid condition had occurred with subsequent crystallization. In some places there are more inclusions than of cement; in other places the reverse is the case, and variations of this sort may be shown in a single hand-specimen. Furthur details in regard to this are deferred for consideration in the petrographical part of this work.

Petrography.

It is a well-known fact that in those places which have been centers of intrusion of alkalic magmas there are commonly a considerable variety of igneous rocks represented and this applies more especially to those which are of high sodic content. It was thought that this might prove to be the case when the study of Red Hill was begun, as up to this time its investigation had not been undertaken by any petrographer; the work of Bayley having been carried out on material sent him by a local resident, and there being no evidence in his writings that the locality was visited by Hawes, who did some field work and collecting in other parts of the White Mountain region.

The study of the region has shown, however, that there is not a marked complex with many types represented. The main massif consists of miaskose which grades in one direction into umptekose and in another into nordmarkose, or in the terminology generally used at present it is composed of a foyaite type of nephelite syenite which passes into umptekite and nordmarkite varieties of alkalic syenite. These types are described in the present paper, while another, that will shortly appear, will be devoted to the dikes of the region, which include porphyritic miaskose (nephelite-syenite porphyry), liparose (paisanite), nordmarkose (bostonite), camptonose (camptonite), etc., and to a general discussion of its petrology.

Hornblendic-grano-miaskose (*Foyaite*).

The occurrences and extent of the main type of syenite has already been described and for purposes of petrographic study and analysis the material exposed in the quarry or pit in the field across the road from the Horne farmhouse has been selected. As stated, it is the type which apparently composes the greater volume of the massif.

Megascopic.—Holocrystalline; medium-grained from 2-5^{mm}, average 2-3; pale gray, rather sparsely dotted with black hornblendes very short, thick, columnar, whose cross sections average 5 by 3^{mm} and sometimes grouped; nephelite, smoke-gray to greenish and oily, abundant and retreats and darkens on weathering, giving pitted surfaces. Very rarely an occasional flake of biotite is seen in some specimens; no other minerals of megascopic importance.

Microscopic.—The following minerals were observed in thin sections: iron ore, apatite, zircon, titanite, wöhlerite, biotite, ægirite, ægirite-augite, diopside, cataphorite-arfvedsonite, various alkalic feldspars; nephelite, sodalite, cancrinite and several alteration products.

The iron ore is irregularly distributed; in sections from the type in the quarry it is nearly wanting, occurring only in occasional grains in the hornblende, but in specimens from other places it sometimes is seen in the feldspars and in groups. It is nowhere abundant. The average size of grain is about $0 \cdot 25^{mm}$, and it does not vary greatly. The apatite in its occurrence is much like the iron ore which it is apt to accompany. It is in short stout prismoids, colorless and presents no unusual features; the larger crystals are about the size of the ore grains, many are smaller.

The zircon and titanite are not very common but in rough crystals or grains which have a general but sparse distribution. The crystals vary from 0·2 to $0 \cdot 4^{mm}$ in diameter. The titanite is very pale to colorless and but for its optical properties might easily be mistaken for zircon.

The biotite is also variable in its distribution; in the type material from the Horne quarry it was observed only in small shreds and flakes enclosed in the hornblende, but in other places it was seen in more considerable amounts, sometimes in distinct tablets in the feldspars and sometimes in minute fringes about ore grains. It is deep colored and very light absorbent or pleochroic, from yellow or orange to deep brown, almost black or opaque.

The pyroxenes are of several kinds; they are never an important constituent like the hornblende. One variety is a pale green, almost colorless diopside with wide extinction angle occurring in small prismoids. In one case it had a gray color and appeared similar to the augite found in the syenite of South Norway. In some other cases it was distinctly green and slightly pleochroic through assumption of the ægirite molecule. The last case is where it is replaced by ægirite with the usual characters of that mineral. Where one variety of these pyroxenes occurs the others are not found; in the type material only the ægirite is present. The ægirite is commonly attached to the hornblende and generally in distinct grains embedded in its periphery and with parallel orientation so that the vertical axis *c* and the face (100) are in common.

The hornblende is the most important ferromagnesian mineral. Megascopically it is very black, of a good cleavage with shining luster. In some places in the rock, where the grain is so coarse as to almost produce a local pegmatitic facies, the crystals, of a rather stout columnar habit, may be $10\text{-}20^{mm}$ in length by $3\text{-}5^{mm}$ in breadth, but usually they are not more than a quarter of this size.

Fragments before the blowpipe fuse at a white heat with intumescence to black, shining, magnetic beads coloring the flame intensely yellow, showing it to be an alkalic hornblende with much iron and soda and with hydroxyl present.

In thin sections this hornblende shows olive-brown, olive-green and yellow-brown colors and they may vary considerably in the same crystal; the interior being of a lighter color with deeper-toned rims. The pleochroism is very strong; $\mathfrak{a}$, light yellow-brown, $\mathfrak{b}$, deep olive, at times practically opaque; $\mathfrak{c}$, deep olive-brown to olive-green; the absorption is very marked, $\mathfrak{b}>\mathfrak{c}>\mathfrak{a}$. The angle of $c \wedge \mathfrak{c}$ is large, 30° or more, refractive index high, double refraction very low. Twinning on 100 observed. In some sections the green color predominates but always with a somewhat olive tone. It very much resembles hornblendes in the alkalic rocks of the Highwood Mts. described by the author.* In Brögger's† table of the alkalic hornblendes there are three groups, the barkevikites with brown colors with small angle of $c \wedge \mathfrak{c}$ and greatest absorption in $\mathfrak{c}$, the cataphorites with reddish colors, large angle $c \wedge \mathfrak{c}$ and absorption greatest in $\mathfrak{b}$, and the arfvedsonites, greenish-blue colors, angle $c \wedge \mathfrak{c}$ very large (75°+) and greatest absorption in $\mathfrak{a}$. The present type does not agree with the statement of any of these but shows apparently properties intermediate between all three. So also do the Highwood hornblendes.

In this connection the writer cannot help noting that it would be a great gain in the accuracy of petrographic work if there were only some definite and accepted standards of color (transparent colors) for comparison. Thus Brögger describes cataphorite in the grorudite from the quarry at Grussletten by Grorud as follows: $\mathfrak{b}$, brown-red or deep wine-red, nearly the color of a thick layer of smoky topaz (rauchtopaz); $\mathfrak{c}$, light grayish to reddish-yellow; $\mathfrak{a}$, light greenish-yellow to greenish-blue. In specimens of this rock from the above locality which I had the pleasure of collecting under Prof. Brögger's guidance, the sections show the cataphorite exactly as he has described it, and I should give the colors as follows: $\mathfrak{b}$, brown with a tone of yellow; $\mathfrak{c}$, pale olive-brown or pale olive-green; $\mathfrak{a}$, pale yellowish-brown; absorption $\mathfrak{b}>\mathfrak{c}>\mathfrak{a}$. The characterstic thing about this hornblende to me is its pure brown colors in which I see no tone of red. And wine-red to me would be the color shown by an almandine garnet, while the color of smoky topaz would be a brown or yellow-brown, which Dana calls wine-yellow, a term which describes also the cataphorite. This illustration, which is in no way intended for a criticism, is merely introduced to show how differently petrographers describe the same colors and the difficulties such differences may occasion.

In fact the comparison of the two minerals shows to the writer that the hornblende of the Red Hill rock is probably near cataphorite, at times inclining to arfvedsonite.

* Bull. U. S. Geol. Surv. No. 237, pp. 66 and 95, 1905.
† Grorudit-Tinguait Serie, 1894, p. 37.

The feldspars are entirely of alkalic character, no soda-lime varieties having been observed. They consist of orthoclase and albite which unite in forming microperthite and cryptoperthite intergrowths, both of which are found together and often indeed in the same individual. The albite lamellæ have as usual the vertical axis and the face 010 in common with the orthoclase; in many cases where they are of large size they show twinning according to the albite law. In a section perpendicular to the bisectrix c and approximately parallel to 010 the albite lamellæ form elongated lenticular bodies of irregular shape and often anastamosing; their elongation is in the general direction of the vertical axis. When this section is observed with a low power there is a general appearance of uniformity, though it has a wavy moiré aspect, and it extinguishes at 11° from the trace of the basal cleavage 001 in the obtuse angle β. When studied with a high power the lamellæ, spoken of above, appear; they form a very large proportion, perhaps one half of the host, their birefringence is higher and they extinguish at about 16° from the cleavage; this latter shows they are albite or perhaps albite with a little of the anorthite molecule present. The host extinguishes at 6°, which shows it to be orthoclase. It is to be noted that 11° is the mean between 6° and 16°. It is noticed in the study of these mixed feldspars that the cleavage parallel to 010 is often well developed in the section while that of 001 is comparatively rare, and it is suggested that this may be due to the fact that they possess the face (and cleavage) 010 in common while the basal cleavage is not a uniform direction through the interpenetrating masses. While the feldspars are usually free from inclusions, in some cases they were noticed to contain slender microlites of ægirite. In the type material they are quite fresh, in other places somewhat kaolinized.

The nephelite presents no unusual features: it is in some places altered in part to a micaceous, scaly mineral, in others weathered to dull earthly kaolin; in most of the specimens of fresh rock it is fresh and clear, only in places it is bordered, edged or so associated with cancrinite as to suggest the latter as a secondary mineral. Much of the nephelite tends to rough crystal form of the common thick tabular habit.

The sodalite is much like the nephelite in preservation, generally fresh, and often the last to crystallize, filling angular interstices. The SO_3 of the analysis shows that the nosean molecule must also be present in small amount. In the hand-specimen the sodalite is white to gray, sometimes with a greenish, sometimes pinkish tinge; the characteristic bright blue it shows in many rocks and which is mentioned by Bayley (loc. cit.), has nowhere been found in the rock mass by the writer.

Wöhlerite.—The occurrence of this rare mineral for the first time in an American locality is of great interest, and it has therefore been reserved for special notice. As is well known it is a mineral characteristic of the nephelite-syenite pegmatite dikes of South Norway and has been made the subject of a special study by Brögger.* At Red Hill it is not found everywhere distributed through the rock mass, but appears to be confined to those places where the increasing size of grain or the arrangement and characters of the minerals suggests that they have crystallized under the influence of mineralizing vapors which were there especially active. The specimens which mostly contained it were not taken from the quarry which afforded the type material but from blocks in the stone wall near it. Under the heading of "texture" it is mentioned that one type in particular contains the mineral.

3

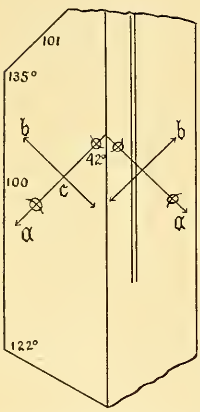


Fig. 3. Wöhlerite from Red Hill, N. H.

In the hand-specimen it is seen as minute honey-yellow, resinous-looking masses or particles, averaging about 0·5^{mm} in diameter. They are commonly associated with the hornblende though sometimes wedged among the feldspathic minerals. The general appearance in fact is much like that of minute titanite crystals. They are too small and irregular or broken to present definite crystal outlines or faces. Under the microscope at first glance they recall large apatite crystals in their general form, relative abundance and tendency to be grouped in and about the ferromagnesian minerals. They have been observed partly embedded in hornblende, and on the other hand, one was seen containing a zircon; therefore their period of crystallization was last among the accessory group, such as apatite, zircon, etc., and previous to the completion of the crystallization of the ferromagnesian group.

Several of the crystals were fortunately cut nearly parallel to the face 010 and perpendicular to the obtuse bisectrix c; this is the most characteristic section through the mineral and permits of its ready identification. The appearance of these crystals is shown in the adjoining figure (fig. 3). They were found to have the following characters. Colorless or very faint, scarcely perceptible, yellow and nonpleochroic. Relief rather high, a little above apatite; refractive index about 1·7. Birefringence in the section 0·011; highest observed in others, 0·025. A bisectrix c emerges almost perpendicular to the sec-

* Zeitschr. für Kryst, vol. xvi, p. 351, 1890.

tion; the direction of 𝔞 and its angle, as actually measured with the vertical axis *c* given by the twinning line and lamellas, are shown in the figure. These, with the interfacial angle of 101 on 100, are the characteristic properties of wöhlerite and positively identify it.* The manner in which the hyperbolas around 𝔠 pass out of the field indicates a large obtuse angle. Nearly all the crystals are twinned, some like those in the figure, others much more irregularly. Some of the crystals show the negative unit orthodome 101, and some a positive orthodome, of which the development and measurements were poor, and hence no symbol is assigned: it may be $\bar{1}01$. In general the crystals are colorless, but one or two instances were noticed where they showed the characteristic pleochroism in tones of yellow; such sections showed higher birefringence and were therefore cut near 100; this is another characteristic of the mineral. The crystals were broken by stray cracks which could not be oriented as definite cleavages. Their general form is thick tabular on 100. They are all fresh, only in one instance was the mineral noticed altering into a somewhat brown, earthy substance. The only occurrence of this mineral other than in the pegmatite dikes of South Norway that I have been able to find mentioned in the literature is from inclusions in phonolite at Pertuis, France, by Lacroix in his Mineralogie de France, though another doubtful one is recorded by Breithaupt and Cotta at Ditro.

Mode.—The determination of the actual mineral composition of a coarse-grained rock, such as this, by the Rosiwal method presents some difficulties when it is attempted under the microscope. The following process was adopted in this case. The total area of a very large thin section exposing about 4 by $3{\cdot}5^{cm}$ of rock surface was carefully determined and found to contain 1350^{mm^2}. In this the total area of all of the ferromagnesian minerals was computed and found to be 81^{mm^2}, which equals 6 per cent. If we reckon these areas as equivalent to corresponding volumes and assign a specific gravity of 3·3 to the hornblende and 2·6 to the feldspar, we have feldspathic minerals = 92·7 per cent, ferromagnesian 7·3 per cent. If in the norm given beyond we allot the anorthite molecule to the femic minerals, since actually the lime silicate is in the

* The different handbooks are not in agreement on the position of the axial bisectrices of this mineral. Dana, Hintze and Lévy and Lacroix give 𝔠 = *b*, Rosenbusch and Iddings give 𝔞 = *b*. This is apparently due to Brögger (Zeitschr. für Kryst., vol. xvi, p. 359, 1890), who states, following Des Cloiseaux, the former but in the figure, plate xviii, gives the latter orientation, an error probably due to the engraver confusing a and c in German script. The first named authors have followed the text, the others apparently the figure, which last is undoubtedly wrong, as may also be seen under hiortdahlite, p. 373.

hornblende, we have 92·5 and 7·5 per cents respectively, agreeing close with the calculation by measurement. The proportions of albite, orthoclase, nephelite and sodalite must be very close as given in the norm. Allowing one per cent for the accessory minerals, ægirite, biotite, etc., the actual mineral composition is as follows:

Accessory Minerals	1
Orthoclase	36
Albite	37
Nephelite	14
Sodalite	5
Hornblende	7
Total	100

Texture.—The texture of the rock is typically granitoid. Outside of the accessory minerals which crystallized first and therefore tend to be automorphic, the others appear to overlap. Ægirite and diopside are enclosed in hornblende. The feldspars and nephelite tend to automorphism but interfere. The sodalite overlaps these, but is distinctly the last to crystallize, filling angular interspaces between the feldspars and nephelite. In one specimen of the rock—that which contained the wöhlerite previously described—a remarkable texture was observed, which may be described as *interdented*. It is shown in fig. 4 adjoining. The albite lamellæ of the microperthite intergrowths of one crystal extend out in optical continuity and project into neighboring crystals, often enlarging as they do so and forming knobs or hooks. The hornblende does the same with the feldspar. If it were not for the hornblende one might imagine this to be a secondary formation, albite formed by the breaking up of a soda-orthoclase. The hornblende forbids this idea for it has the same structure, and the writer is inclined to attribute it to local pneumatolytic conditions producing a more nearly simultaneous process of crystallization of all these minerals.

4

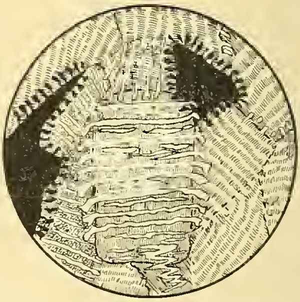


Fig. 4. Interdented texture. Black, hornblende; white, albite; shaded, orthoclase.

Chemical Composition.—The analysis by Dr. Washington of selected material from the Horne quarry gave the results shown in No. I of the adjoining table.

TABLE OF ANALYSES.

	I	II	III	IV	V	VI
SiO_2	58·30	59·01	58·77	63·71	0·972	0·983
Al_2O_3	21·38	18·18	22·53	16·59	0·210	0·178
Fe_2O_3	1·05	1·63	1·54	2.92	0·007	0·010
FeO	2·04	3·65	1·04	0·66	0·028	0·051
MgO	0·22	1·05	0·19	0·90	0·005	0·026
CaO	0·95	2·40	0·74	3·11	0·015	0·043
Na_2O	8·66	7·03	9·62	8·26	0·140	0·113
K_2O	6·06	5·34	4·89	2·79	0·065	0·056
H_2O+	0·45	0·50	0·90	0·19	----	----
H_2O-	0·35	0·15	0·07	----	----	----
TiO_2	0·10	0·81	0·31	----	0·006	0·010
ZrO_2	0·02	tr	0·11	----	----	----
P_2O_5	0·04	tr	----	----	----	----
MnO	tr	0·03	tr	----	----	----
BaO	none	0·08	none	----	----	----
SrO	----	tr	----	----	----	----
SO_3	0·08	----	----	----	---	----
Cl	0·35	0·12	----	----	0·010	0·003
	100·05	99·98	100·71	----		
O=Cl	0·08	0·03	----	----		
Total	99·97	99·95	100·71	100·19		

I Miaskose, nephelite syenite, Horne Quarry, Red Hill, N. H., H. S. Washington analyst.
II Umptekose, alkalic syenite, Red Hill, N. H., (Bayley, loc. cit) Hillebrand anal.
III Miaskose, neph. syenite, Salem, Mass., (Washington Jour. Geol., vi, p. 803, 1898,) Washington anal.
IV Umptekose, umptekite, Umpjavr, Kola (Ramsay, Fennia, xi, p. 205, 1894), Petersson anal.
V Molecular proportions of No. I.
VI Molecular proportions of No. II.

This is a typical analysis of a lendofelic rock, and needs no special comment. Its nearest geographical relative, the miaskose (nephelite syenite) of Salem Neck contains more soda but less potash, and otherwise is much like it.

Classification.—The position of the rock in the quantitative classification is seen in the following calculation of its norm.

It is therefore persalic, lendofelic, peralkalic and dosodic, and its position in the scheme is given by the coördinates 1, 6, 1, 4. It is also in the donelic section of the subrang. It has a normative mode, a granular texture and hornblende—cataphorite—as a varietal mineral. It is therefore *hornblendic-grano-miaskose.*

In the system of classification hitherto prevailing this rock is a nephelite syenite and belongs to the foyaite subdivision in Rosenbusch's sense.

Or	36·14	
Ab	37·20	
An	2·78	
Ne	13·92	
So	4·85	Sal = 94·89
Di	1·08	
Ol	1·05	
Mt	1·62	
Il	0·91	Fem. = 4·66
Rest	0·94	
Total,	100·49	

$$\frac{\text{Sal}}{\text{Fem}} = \frac{94 \cdot 89}{4 \cdot 66} = \frac{7}{1} = \text{I, Persalane}$$

$$\frac{\text{L}}{\text{F}} = \frac{18 \cdot 77}{76 \cdot 12} = 0 \cdot 24 = 6, \text{ Russare}$$

$$\frac{Na_2O' + K_2O'}{CaO'} = \frac{215}{10} = 21 \cdot 5 = 1, \text{ Miaskase}$$

$$\frac{K_2O'}{Na_2O'} = \frac{65}{140} = 0 \cdot 46 = 4, \text{ Miaskase}$$

Hornblende-tracho-umptekose (*Umptekite*).

In ascending Red Hill by the route usually followed, the road to the Horne farm and path thence to the north peak, when the farmhouse has been left behind, one soon begins to ascend over crumbling ledges of the syenite, and, towards the top, exposures of the rock are frequent. This portion of the massif, the upper part of the north peak, consists of a somewhat different type of rock from that just described, and it appears to be the one investigated by Bayley, so far as one can judge from his description and from the localities where he states his specimens were collected. His account is so complete that the study of the material affords nothing new that is of especial value, particularly as the rock is made up of the same minerals described above, and differs from it only in their relative proportion and in its texture. Only these characters then need to be considered here and its position in the quantitative classification.

Mode.—With respect to the minerals there is a larger quantity of femic and alferric minerals present, as may be seen in the specimens and as shown in the calculated norm. While hornblende is still by far the predominant one, there appears to be a somewhat greater amount of biotite. A pale green nonpleochroic pyroxene is found in some sections, in others ægirite. Bayley* speaks of a bright green hornblende, which has not been observed by the writer; he does not mention ægirite, which is widely distributed in the Red Hill rocks, though nowhere abundant, but the doubt which arises as to whether the ægirite could have been confused with hornblende must be yielded in favor of so close and accurate an observer.

* Loc. cit., page 246.

The study of the sections also convinces one that there is less of lenad minerals, nephelite and sodalite, than in the foregoing type, an impression confirmed by the calculation of the norm.

Bayley states that there is about 80 per cent of feldspars and 15 per cent of hornblende, etc. in the rock, and the norm confirms this. We may then say that the mode of the rock is made up of the following minerals in the proportions indicated.

Orthoclase	32
Albite	43
Nephelite	7
Sodalite	2
Hornblende	12
Accessories	4
Total	100

The accessories include biotite, diopside, ægirite, magnetite, titanite, zircon, apatite, etc.

The texture of this type is prevailingly trachytoid, with feldspars of a more or less pronounced flat, tabular form. No sharp line between this and the foregoing type can be drawn in the field from the exposures. And among the loose blocks transitional forms of every degree may be found. Hand-specimens may be prepared showing the coarse granitoid texture at one end merging quickly into a quite fine trachytoid one at the other. Such transitions may also be observed in place, and it was thought at first that the trachytoid type occurred in dikes in the other variety, but there are no evident contacts to be seen and it is much more probable that the one type passes irregularly into the other.

Chemical Composition.—This is shown by Hillebrand's analysis quoted from Bayley, which has been given in the foregoing table. It will be seen that it differs from the preceding type in containing a little more silica, considerably more lime, iron and magnesia and less alumina and alkalies. It is of interest to note that the proportion of $Na_2O : K_2O$ is 0·46 in No. I and 0·49 in No. II, practically the same relation. Also that the alumina (molecular ratios) divided by the alkalies gives 1·02 in No. I and 1·05 in No. II. The change then is in the increase of lime, iron and magnesia and a little silica; there has been no other marked differentiation.

Classification.—The calculation of the norm from Hillebrand's analysis is given below in No. II, and the norm of No. I is repeated for comparison.

	No. I	No. II		
Or ..	36·14	31·14		$\frac{\text{Sal}}{\text{Fem}} = \frac{85{\cdot}61}{13{\cdot}49} = 6{\cdot}3$ = II, Dosalane
Ab ..	37·20	42·97		
An ..	2·78	3·06		$\frac{\text{L}}{\text{F}} = \frac{8{\cdot}44}{77{\cdot}17} = 0{\cdot}11$ = 5, Germanare
Ne ..	13·92	7·10		
So ..	4·85	1·34	Sal. = 85·61	
Di ..	1·08	7·45		$\frac{Na_2O' + K_2O'}{CaO'} = \frac{169}{11} = 15$, 1, Umptekase
Ol ..	1·05	2·20		
Mt ..	1·62	2·32		$\frac{K_2O'}{Na_2O'} = \frac{56}{113} = 0{\cdot}5$, 4, Umptekose
Il ..	0·91	1·52	Fem. = 13·49	
Rest,	0·94	0·76		
Total,	100·49	99·86		

The increased amount of femic minerals carries the rock well over into dosalane; the diminished amount of lenads places it in the perfelic order while the rang and subrang remain the same. In No. IV of the table of analyses is given that of the type of this subrang, Ramsay's umptekite from Kola. Rosenbusch classifies it under the same type, which he makes one of the varieties of the alkalic syenites.*

Contact facies of Nordmarkose.

It has been previously stated in the description of the geology of Red Hill that the best exposures for studying the contact were found at the foot of the mountain slopes on the east side. The rock of the massif collected at these points is dark gray to dark greenish gray, fine-grained, and generally of a clearly persalic character, though varying in places so that it probably becomes at times a dosalane.

The stndy of the sections shows that nephelite and other lenad minerals are absent and replaced by a minute amount of interstitial quartz. Hornblende of an olive-green, strongly pleochroic character is the dominant mineral, sometimes accompanied or even replaced by a pale green augite. The great mass of the rock is made up of alkalic feldspars, microperthites as previously described, in isodiametric grains. The fabric is a granular one. The rock is clearly perfelic and peralkalic, and the character of the feldspars is so evidently like that of the types previously described that it must be dosodic also. This makes its coördinates I. 5. 1. 4, and it is therefore grano-nordmarkose, at times perhaps passing into the previons type—grano-umptekose. It would be the pulaskite or nordmarkite of Rosenbusch.

[To be continued.]

* Elemente der Gesteinslehre, 1898, p. 113.

Art. XXV.—*Developmental Stages in Streptelasma rectum, Hall;* by Thomas C. Brown.

In the course of studies on the phylogeny of the Zaphrentidæ, E. and H., my attention was attracted by the point recently made by J. E. Duerden as to the primary septal condition in rugose corals, whether tetrameral or hexameral. The question is, are there only four primary septa in rugose corals as suggested by Kunth and until recently accepted by the majority of workers, and recently shown by Gordon for *Streptelasma profundum*, or are there six primary septa as suggested by Ludwig and the Count de Pourtales and claimed as definitely proven by Duerden.

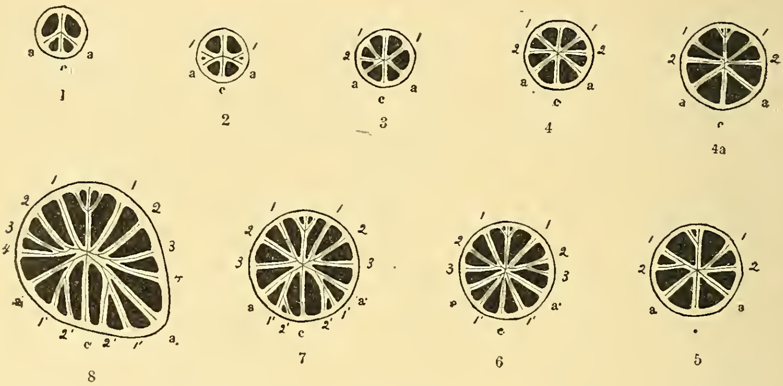
As this question involved the foundation on which all my work must be based, I decided to investigate it. Duerden's view seemed by far the most acceptable, as it brought the rugose corals into line with all the other corals and zoanthids as having an original hexamerous character.

In Science for August 24, 1906, Duerden states that in six species of Rugosa he has definitely proved the existence of six primary septa. These species are *Streptelasma rectum* Hall, *Cyathaxonia cynodon* E. and H., *Hadrophyllum glans* (White), *Hadrophyllum pauciradiatum* E. and H., *Microcyclus discus* Meek and Worthen, and *Lophophyllum proliferum* E. and H. One of the striking facts about these six species is that they all occur comparatively late in the geological distribution of the Rugosa. Four are Devonic and two are Carbonic species, and of the four Devonic species three are almost disc-like in shape and therefore present extreme difficulties when one attempts to get the earliest stages. I therefore selected the fourth Devonic species, *Streptelasma rectum* Hall, to test the validity of Duerden's statements, and with somewhat startling results.

The collections in the Paleontological Laboratory of Columbia University are particularly rich in this species, and from some two or three hundred corallites I selected the most perfect individuals for the investigation. Some of these were found with perfect tips and some with the end slightly fractured. Following the method described by Duerden in his latest paper in the Annals and Magazine of Natural History for September, 1906, an individual corallite held by the large calicular end was ground off at the tip very gradually on a plate of glass with fine emery and each successive stage of development was carefully noted and sketched. These successive stages are enlarged and shown in the accompanying figures. All these figures except fig. 1 and fig. 4a are the successive stages in the development of a single individual.

Fig. 1 shows the tip of an individual with only the four primary septa present. These septa, however, are not disposed at right angles. The alar septa are inclined toward the cardinal, thus leaving the counter quadrant spaces considerably larger than the cardinal quadrant spaces.

Fig. 2 shows the slightly fractured tip, the first view of the individual that was followed throughout its stages of development. Here the four primary septa are present and two secondary septa have appeared, one in either counter quadrant. These are distinctly not equal to the primary septa and are not radially placed, but are short and are joined by their inner



border to the dorsal side of the alar septa. As they develop, this point of attachment moves inward until they do, in some individuals, become equal in size with the primary septa and are radially arranged. There are in the Columbia collections a series of individuals that show the gradations from the condition shown in fig. 2 to six equal and radially disposed septa as shown by Duerden in his earliest stage.

Duerden in his latest paper states that: "In the above and other species (*Lophophyllum proliferum*, *Streptelasma rectum*, *Cyathaxonia cynodon*), in which the septal constitution has been established by the process of grinding, it may be objected that if earlier stages than those first represented could be obtained, four primary septa might then be disclosed, and the other two would be seen to be but later additions to a tetrameral group; in other words, that the earliest septal stage is not that represented as such. Were this the case, the dorsolateral pair here regarded as protosepta would be really the first pair of metasepta. Against this reasonable objection it can be affirmed that in all cases as soon as any of the primary septa are determinable they are already six in number, all fully developed, practically equal in size, and radially disposed at equal distances apart. Two pairs never appear in advance of a third pair. Moreover, there is never any hint of the third pair being inclined at its origin towards the others, after the manner of development invariably characteristic of the first and later pairs of the metasepta."*

The foregoing statements of observations indicate that Duerden is wrong in these contentions. In the first place an earlier four septal stage can be found: secondly, the third pair of septa do appear later and are therefore the first pair of second-

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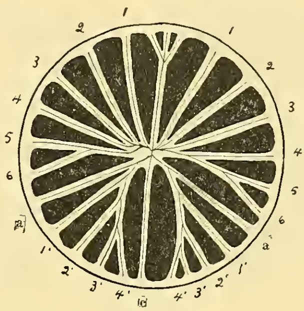

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ary septa (metasepta): thirdly, this first pair of secondary septa are inclined towards the alar septa on their dorsal side and develop in the same manner as any other pair of metasepta.

Fig. 3 shows the appearance of a second secondary septum in one counter quadrant. Fig. 4 shows two secondary septa in each counter quadrant. Fig. 4a is the same stage from another individual and shows that a pair of tertiary septa (exosepta) have already appeared, one on either side of the counter (dorsal directive) septum. Attention is especially called to this very early appearance of the first pair of tertiary septa adjacent to the counter septum. Fig. 5 shows the appearance of the third secondary septum in one counter quadrant and the appearance of a tertiary septum in the same quadrant. In fig. 6 we see a tertiary septum present on either side of the counter septum, three secondary septa in either counter quadrant, and one secondary septum in each

* Annals and Magazine of Natural History, series 7, vol. xviii, p. 236, Sept. 1906. The Morphology of the Madreporaria. The Primary Septa of the Rugosa, J. E. Duerden.

cardinal quadrant. In fig. 7 two secondary septa have appeared in each cardinal quadrant, and in fig. 8 four are present in each counter quadrant. In fig. 9 there are three in each cardinal quadrant and five in each counter quadrant. Fig. 10 has four secondary septa in each cardinal quadrant and six in each counter quadrant. Attention is called to the grouping of the septa in this and the preceding figures. Each successive septum to appear in each quadrant respectively is attached by its inner border to the side of the previous septum, giving in this stage an arrangement of the septa similar

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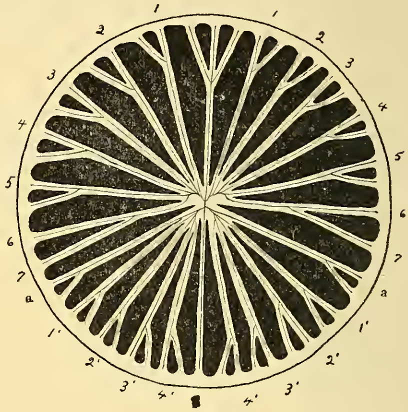

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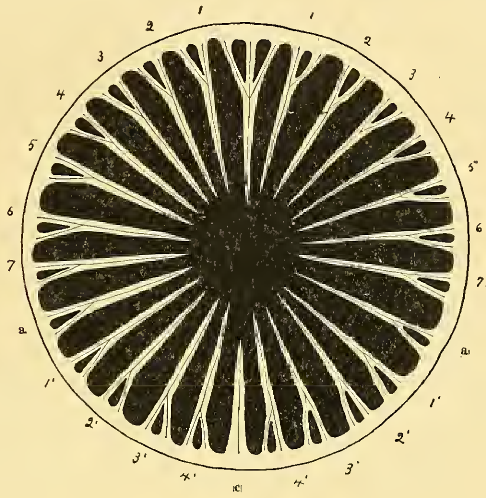
to the adult condition in the genus Hadrophyllum.* Fig. 11 has the same number of secondary septa but they are all more fully developed, and in addition three more pairs of tertiary septa (exosepta) have been added in the counter quadrants and two pairs have appeared in the cardinal quadrants. In fig. 12 a seventh pair of secondary septa have appeared in the counter quadrants, making the total number of secondary septa present in the adult corallite. Two more pairs of tertiary septa are added in the counter quadrants and three more in the cardinal quadrants. Fig. 13 is a section from near the base of the calyx. All the primary and secondary septa project freely into the cup. The cardinal septum is hardly as large as the others. The alar septa and all the secondary septa are about equally developed and each has a tertiary septum abutting against it. The counter septum is a little stronger developed and longer than any of the others and has a tertiary septum on either side.

*See, also, J. E. Duerden, Biological Bulletin, vol. ix, No. 1, pp. 35, 36, June, 1905. This also corresponds to adult in *S. profundum*.

In the above discussion it is definitely shown that in *Streptelasma rectum* only four septa are present in the earliest stages and that all others come in later, therefore it is contended that Duerden is wrong in claiming primary hexamerism for all rugose corals. The possibility of proving primary hexamerism in such disc-like forms as Hadrophyllum and Microcyclus is questioned, and the presence of six septa in the earliest recognizable stages of *Lophophyllum proliferum* (if a still earlier stage cannot be obtained), can easily be explained as a differential development, that is, by the theory of accel-



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eration or retardation of one part of an organism with respect to the rest of the organism.*

Duerden states that: " This idea of acceleration is altogether hypothetical, and its author does not produce a single acceptable fact in its support. He considers that a departure from the original tetrameral type is likely to occur in a form such as Lophophyllum, which appears in Carboniferous times, that is, towards the close of the geological distribution of the rugosids. This argument, unsatisfactory in itself, now fails altogether in view of the fact that comprised in the list of corals given above, in which six primary septa have been definitely established, there are representatives of almost all ages in the chronological extension of the rugose corals."†

* See C. E. Gordon, this Journal, vol. xxi, pp. 109–127, Feb., 1906.
† Ann. and Mag. of Nat. Hist., loc. cit., p. 239.

This criticism seems altogether unwarranted, since Duerden does not produce a single species from the Ordovicic showing the primary hexameral arrangement. His *Duncanella* from the Siluric has six pairs of septa in the earliest stages obtainable, and his statements concerning *Streptelasma rectum* from the Devonic are incomplete and misleading. The only species for which primary hexamerism has not been disproven are from the Devonic and Carbonic, very late in the geological distribution of rugose corals.

The statement stands unquestioned that a type occurring late in geological time, at least a considerable time subsequent to the earliest occurrence of a type at all similar, is likely to be far from primitive in at least some respects.

That the counter quadrants of a rugose coral are accelerated in development over the cardinal quadrants is shown by the above discussion of *Streptelasma rectum*. One tertiary septum has appeared in each counter quadrant before even a single secondary septum has appeared in the cardinal quadrants. Three secondary septa appear in each counter quadrant before the appearance of the first secondary septum in the cardinal quadrants. In all seven secondary septa appear in each of the counter quadrants, while only four come in the cardinal quadrants. Duerden's statement that "the smaller septa (exosepta) [tertiary septa] arise almost simultaneously at a rather late development stage, and are thus of no significance as regards septal sequence,"* is somewhat too sweeping a statement. In *Streptelasma rectum* these do not arise simultaneously but come in in the same order as the secondary septa. The first one in each counter quadrant appears long in advance of any of the others, and when the others do appear they follow the same sequence as the secondary septa. They develop more rapidly in the counter quadrants than in the cardinal, four having appeared in the former when there are only two in the latter.

It therefore appears that the presence of six primary septa in rugose corals and subsequently developed tetramerism is not established. For this species at least primary tetramerism has been proved and the probability is that all the rugose corals are primarily tetrameral and the appearance of six septa in the early stages of geologically late species is due to the early development of the first pair of secondary septa.

After the above paper was completed, my attention was called to a paper by Mr. R. C. Carruthers in the November number of the Annals and Magazine of Natural History on "The Primary Septal Plan of the Rugosa." In this paper the author reviews briefly the principal papers on the question of a prim-

* Ann. and Mag. of Nat. Hist., loc. cit., p. 240.

ary hexameral or tetrameral condition in the Rugosa, referring especially to the recent publications before cited by Professor J. E. Duerden and Professor C. E. Gordon. As a result of his studies he has come to the conclusion that Gordon's observations are correct, but in the light of his (Carruther's) interpretation of those observations they do not contradict but rather help to support Duerden's contention that the primary stage of the rugose corals is a hexameral one.

In his studies on a small Zaphrentid found abundantly in the Carboniferous shales of Scotland, Carruthers has found that there are three stages of development that a rugose coral passes through before the six primary septa are formed and take their places as equally developed septa.

These stages he describes as follows:

"Stage I.—A single septum is seen to stretch across the calicle from wall to wall. This may conveniently be referred to as the 'axial septum.' In later stages this axial septum breaks up to form the main and counter septum of the mature coral. . . .

"Stage II.—Two new septa are next seen to arise, one on each side of the 'main' end of the axial septum. Though remaining attached to the wall of the calicle and to the axial septum, they gradually spread outwards, and eventually form the 'alar' primary septa of Kunth.

"Stage III.—Shortly after the alar primaries have developed another pair appears, in the same manner as before, but at the opposite or 'counter' end of the axial septum. These also spread outwards, though very rarely to the same extent as the alar septa. There is now a distinct pause in the formation of new septa, and no more appear for some time. . . ."

These careful observations and the plate illustrating the paper prove, as the present writer has attempted to prove in the above paper, that an earlier stage than the six septa stage of Duerden can be found in the rugose corals. The only question now is as to the interpretation of the observed facts. Mr. Carruthers' observations differ from those of the writer in one point, namely, the manner of coming in of the second pair of lateral septa, which he calls the counter lateral or second lateral pair of primary septa, and which I call the first pair of secondary septa. He has observed this pair of septa to first appear as very short septa, one en either side of the counter or "axial" septum, and as they developed and enlarged the point of attachment moved along the median septum until they became radially or nearly radially placed. Strange as it may seem, this is the very method by which in my first studies I attempted to derive this pair of septa, but with the material at hand could not find individuals that showed this manner of growth. In

* Ann. Mag. Nat. Hist., 7th ser., vol. xviii, No. 107, pp. 356–363, Nov., 1906.

the individual figured this pair of septa were distinctly attached to the dorsal side of the alar septa and the point of attachment moved inward as the septa developed. I have before me individuals which show distinctly this arrangement and also one or two that appear as if they might have developed after the manner described by Carruthers.

The question at issue, however, is, are there four or are there six primary septa? Carruthers states that at the close of his stage III there is a distinct pause and that no more new septa appear for some time. No such pause was observed in the development of *Streptelasma rectum.* In the majority of individuals of this species a second pair of secondary septa have made their appearance before the first pair of secondary (Carruthers' second pair of lateral primary) septa are fully developed.

The figures in the plate illustrating Carruthers' paper are in agreement with my observations, fig. 2 being almost identical with fig. 1 of this paper, and showing the four primary septa all equally developed and no indication of any others. Fig. 3 also shows the four primary septa well developed, and any indication of a third pair of septa that it may show can be interpreted as a first pair of secondary septa, and no other interpretation seems plausible.

On one other point I beg to differ from Carruthers and to agree with Duerden, and that is in regard to the orientation of figures. Duerden in his papers* has proved that cardinal and ventral, counter and dorsal are synonyms, and that the orientation of Kunth and his followers cannot now be used in view of recent studies on the morphology and relationships of the Zoantharia. Carruthers makes the cardinal side the dorsal side because, as he says, the first pair of primary lateral or alar septa appear at this side of the corallite in advance of any lateral septa at the counter side. Since in modern corals the first lateral pair of entocœls appears on the dorsal surface, the dorso lateral pair of exocœls arises before the ventro-lateral one, and of the six primary tentacles the dorsal pair appear first, he argues that that side of the polyp which develops first is the dorsal side and, therefore, the cardinal side of rugose corals is dorsal. In the present paper it has been shown that the counter quadrants in every respect develop in advance of the cardinal quadrants, and this would still be true in every respect excepting the second lateral pair of septa, even though the corallite was considered to have six primary septa.

Since this second lateral pair of septa differ in no way from any other pair of secondary septa, it is still contended that there are only four primary septa, and that the cardinal septum is ventral and the counter septum dorsal.

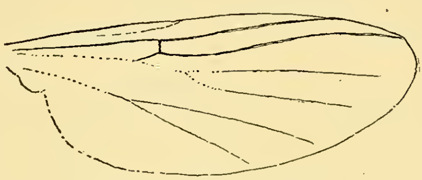
Paleontological Laboratory, Columbia University.

* See especially J. E. Duerden, The Morphology of the Madreporaria VI. The Fossula in Rugosa Corals, Biol. Bull., vol. ix, No. 1, June, 1905.

Art. XXVI.—*A New Fly (Fam. Mycetophilidæ) from the Green River Beds;* by T. D. A. Cockerell.

Sackenia gibbosa sp. nov.

Length fully 6^{mm}, wings about $4\frac{1}{2}$; thorax $1\frac{1}{2}^{mm}$ long, strongly gibbous in front; head not quite 1^{mm} long; antennæ arising about 425 μ above mouth, and 1530 μ long (the tip may possibly be broken off); abdomen slender, largest about the third and fourth segments; third and fourth segments each about 620 μ long; fifth 680 μ long, sixth 510, seventh 340; legs long, covered with minute bristles; hind tarsi about



Wing of *Sackenia gibbosa*.

2630 μ; tibial spurs strong, those of hind legs about 340 μ long.

Color as preserved brown, the thorax darker than the abdomen; wings hyaline, with a cloud on costal margin a little beyond middle, and a small dark spot a little beyond that; there is a faint indication of a cloud near the end of the basal third of the wing, also in the costal region.

Measurements of wing in μ.—Auxiliary vein shadowy but quite visible, terminating on the costa about 340 apicad of cross-vein between first and second longitudinal; cross-vein 170 long, its upper end 255 below costa; distance from cross-vein to end of first longitudinal 2380; second longitudinal beyond cross-vein arched, so that at 680 beyond cross-vein it is 289 from first, but at end of first it is only 170 from it; end of second longitudinal to apical point of wing about 425; second longitudinal, basad of cross-vein bent downwards, so that at 340 basad it is 255 from first longitudinal; cross-vein from base of wing 2040; first two longitudinals much stronger than the others; point of junction of fifth and sixth longitudinals (vii_1 and vii_2) about 340 basad of level of cross-vein; point of junction of third and fourth (v_{1+2} and v_3) obliterated, but at 935 apicad of cross-vein they are 255 apart, and show no noticeable bending; on level of ending of first longitudinal, the third and fourth are 425 apart, and the third 595 from the second.

In red shale (Eocene), Green River, Wyoming, a specimen preserved in lateral view, with its reverse; in Yale University Museum, collector unknown.

By the form of the auxiliary vein (ending on costa beyond the cross-vein), and the points of union of the longitudinals, as well as the shape of the abdomen, this agrees with the genus *Sackenia* Scudder, based on a species (*S. arcuata* Scudd.) from Chagrin Valley, White River, Colorado. However, with the exception of the auxiliary vein, it might as well be a *Mycetophila* of the type of *M. nodulosa* Williston.* The third and fourth longitudinals appear to agree exactly with *Mycetophila*, and do not resemble so much those of the original *Sackenia*. The fifth and sixth would do about equally well for either. The antennæ, if not broken, are not so long as in type *Sackenia*.

From all the other Mycetophilidæ known from the Green River shales, excepting *Sciophila hyatti*, this is readily distinguished by its larger size. The *Sciophila* differs in the venation, the second longitudinal vein being much more widely separated from the first, and ending practically at the tip of the wing.

Univ. of Colorado, Boulder, Colo.

* Trans. Ent. Soc., Lond., 1896, pl. viii, f. 20.

Art. XXVII.—*Marignacite,* a New Variety of Pyrochlore from Wausau, Wisconsin;* by S. Weidman and Victor Lenher.

In the north-central part of Wisconsin, within the general pre-Cambrian area, there are widespread occurrences of igneous rocks intrusive in the Huronian sedimentaries.† Chief among these intrusives is a complex magma, consisting of various phases of granite, quartz-syenite and nepheline-syenite. Pegmatitic modifications are a characteristic feature of the granite-syenite magma, both nepheline and quartz-bearing pegmatites being developed in considerable quantity. In several phases of the quartz-bearing pegmatite, a small octahedral mineral was observed that proved upon investigation to be a variety of the rare group of pyrochlore minerals, the principal constituents of which are the metals of the rare earths.

The minerals associated with the pyrochlore in the pegmatite consist mainly of quartz, alkali-feldspar and acmite. Other minerals in the pegmatite veins of the locality are lithia-mica, lepidomelane, varieties of acmite-pyroxene high in alumina and potassium, rutile, fluorite, and several zirconium-bearing minerals. The pegmatite and associated-granite and syenite are closely related in composition, and are characterized by a relatively high content of alumina and soda. In most respects the granite and nepheline-syenite are similar to the well-known occurrences of nepheline-bearing and associated rocks of Arkansas, Ontario, Canada, Essex County, Mass. and the Christiana region of southern Norway.

The pyrochlore was found in the pegmatite occurring along the road in the S.W. 1/4 of Sec. 22, T. 29, R. 6 E., about nine miles northwest of Wausau. It occurs only in small crystals of nearly perfect octahedral form, varying in form up to about 1/8 inch (3^{mm}) in diameter. The mineral was found in small quantity, and although after its identification further search was made for it, only a small additional amount was secured. It is likely, however, that the pyrochlore will be found elsewhere in the pegmatite veins of the immediate locality although very probably only in small quantity.

The only form of the mineral observed was the simple octahedron (fig. 1). Some of the crystals occur in aggregates (figs. 2 and 3) and some show a slighly distorted form, but no combinations with other crystal forms were observed. Under

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† Geology of North Central Wisconsin, Bull. No. XVI, Wisconsin Geological and Natural History Survey.

the microscope inclusions of quartz and feldspar were seen. This examination showed the mineral to be homogeneous, with none of the characteristic features of alteration or of replacement.

Chemical Analysis.—The pyrochlore used for analysis was first picked out by hand from the crushed rock. As the latter was somewhat disintegrated, many of the small octahedral crystals were readily separated from the associated minerals by crumbling the rock under pressure of the hand. Before the mineral was powdered each crystal was examined with a hand lens and all adhering minerals were rubbed off so far as possible. After being powdered and passed through a 100-mesh sieve, the powdered material was subjected to separation by a specific gravity solution of silver-thallium nitrate, and by this method the adhering and included particles of quartz, feldspar and acmite were separated from the pyrochlore. The relatively high specific gravity of the pyrochlore furnished conditions favorable for the separation by the specific gravity method, and for this reason, as well as others later described, the mineral analyzed is believed to have been essentially pure.

The analysis of the pyrochlore made upon 3·15 grams, and the molecular ratio of the constituents, is as follows:

Analysis of Pyrochlore (Marignacite) from Wausau, Wisconsin.

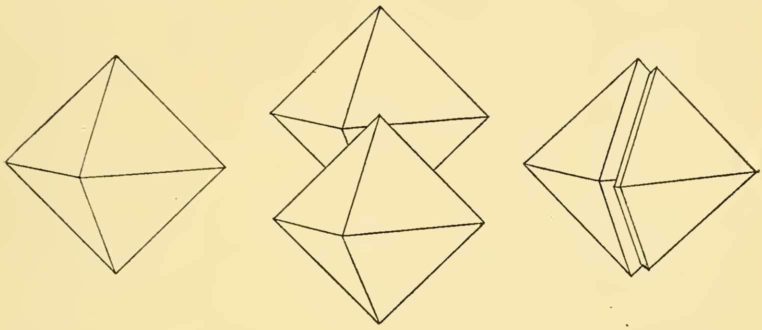
	Analysis	Molecular Ratio
Cb_2O_5	55·22	·198
Ta_2O_5	5·86	·013
SiO_2	3·10	·051
TiO_2	2·88	·036
Fe_2O_3	0·50	·003
FeO	0·02	
Ce_2O_3	13·33	·040
Yt_2O_3	5·07	·022
ThO_2	0·20	·001
CaO	4·10	·073
MgO	0·16	·004
Na_2O	2·52	·041
K_2O	0·57	·006
F	none	——
H_2O at 110°+	5·95	·331
H_2O at 110°−	0·45	
	99·93	

Al_2O_3, MnO, SnO_2, WO_3, Di_2O_3, La_2O_3, Er_2O_3, occur in traces, while F, ZrO_2, BeO, UO_2, Li_2O, could not be detected. The mineral shows no radio-activity.

The mineral has a hardness of 5 to 5·5, a specific gravity of 4·13. The cleavage is indistinct, the mineral is brittle and breaks with a conchoidal fracture. The lustre is resinous on fractured surfaces. The streak is light brown to yellowish brown. The color varies from a light to dark brown in the hand specimen, while under the microscope a yellow brown to red brown is shown.

It is sub-translucent to transparent. The index of refraction is relatively high and anomalous double refraction is characteristic. Before the blowpipe it is infusible and unchanged. In the borax or salt of phosphorous bead, it dissolves with a yel-

1 2 3



low color while hot, and is colorless when cold. The mineral is very refractory to the acids, and is only slightly attacked by fused sodium carbonate. It is attacked in the cold by hydrofluoric acid, and can be decomposed by fusion with either potassium acid sulphate or potassium acid fluoride.

For analysis the mineral can be decomposed either by fusion with potassium acid sulphate, in which case the silica and metallic acids can be separated from the earths, etc., or it can be decomposed by treatment with hydrofluoric acid, when the metallic acids pass into solution, leaving the earthy fluorides insoluble.

Silica was estimated in the residue obtained from repeated extractions of a bisulphate fusion by volatilization with hydrofluoric acid in the presence of sulphuric acid. The columbic and tantalic acids were tested for tin, molybdenum, tungsten, titanium and the earths. The titanium was separated from them by a bisulphate fusion, and the metallic acids were separated by the Marignac method of crystallizing the double potassium fluorides from each other. It is perfectly well appreciated that the results for columbium and titanium are only closely approximate, for as shown by Hall,* Smith,† and Warren,‡ it is impossible by present methods to obtain a perfect separation of these two elements. Six crystallizations were made to separate the columbium and tantalum.

The earths after being precipitated together were treated in acid solution with ammonium oxalate. The oxalates were ignited, dissolved in nitric acid, and the excess of acid removed by evaporation. The nitrates were treated with a saturated solution of potassium sulphate. The thoria was separated by means of the thiosulphate and ammonium oxalate methods. The ceria was purified by suspending the hydrate in a solution of potassium hydroxide and treating with chlorine. The weighed oxide was of a salmon color, and when dissolved as nitrate its solution showed no absorption bands. Didymium and lanthanum could be detected only in traces. In the soluble yttrium group, the nitrate solution showed the erbium bands quite markedly. Fluorine, zirconium, beryllium, uranium, and lithium were carefully tested for, but found to be absent. The basic portion of this mineral is largely composed of the cerium and yttrium metals, while silica and the oxide of titanium appear to the extent of nearly 6 per cent. From the careful manner with which the mineral used for analysis was selected and purified and from the microscopic character of the fragments used, it appears as though the silica and titanium oxide were normal constituents of the mineral.

Fluorine could not be detected by even the most careful examination. The high content of water, 5·95 per cent, given off above 110 degrees and the absence of fluorine may be due to the fact that fluorine and hydroxyl are mutually interchangeable in this group of minerals, as they are in the lithia fluorine micas, and in triploidite and related minerals of the wagnerite group. The isomorphism between hydroxyl and fluorine was first demonstrated by the late Prof. Penfield, who showed its existence for the first time in triploidite, and later in many other minerals in which these radicals occur.

The analyses of marignacite and the several members of the pyrochlore group given in the table show the presence of either or both of these radicals in each of the completed analyses. While a careful determination of the hydroxyl in the analyses of these minerals has apparently not been carried out, it seems reasonable to apply the principle of isomorphism of these radicals in this group.

The presence of an appreciable content of silica, 3·10 per cent, in the pyrochlore from Wausau, perhaps needs further

* American Chemical Society, xxvi, 1235.
† Ibid. xxvii, 1369.
‡ This Journal, xxii, 520, 1906.

discussion. As already stated, the pyrochlore is associated in the rock with quartz, feldspar and varieties of aluminous acmite containing 5 per cent Al_2O_3 and above, and these minerals to a slight extent were necessarily included in the powdered material prepared for the specific gravity separation. Previous to powdering the material, however, each pyrochlore crystal was examined and all material clinging to the latter was rubbed off so far as possible. The relatively high specific gravity of the pyrochlore, namely 4·13 as compared with 2·6 of quartz, 2·6 of feldspar, and 3·5 of acmite, should furnish a favorable means for separation by the method adopted. The fact that the chemical analysis shows only a trace of alumina indicates the essential absence of feldspar and aluminous pyroxene in the material analyzed. And if these minerals were successfully removed from the powdered material in the process of separation by the specific gravity method, it seems reasonable to believe also, that the quartz was removed at the same time and to the same extent. Hence it seems probable that the silica is a normal constituent of this mineral.

If the SiO_2 is an original constituent of this pyrochlore, it differs in this respect from other varieties of pyrochlore. Silica is shown in the analysis of some of the members of the columbate-tantalate groups, but it is usually considered of secondary origin. However, if the silica with the titanium oxide are normal constituents, they indicate an interesting relation in the composition of this pyrochlore to many of the titano-silicate minerals, such as tscheffkinite, johnstrupite, mosandrite, rinkite and also to dysanalyte. In content of cerium oxide this pyrochlore from Wausau is higher than in any of the other pyrochlores and in its high content of cerium oxide it also resembles the titano-silicates referred to. This pyrochlore with appreciable content of SiO_2, believed to be a normal constituent, therefore, shows an interesting relation in composition between the titano-silicates on the one hand and of the columbate-tantalates on the other.

In the table the analysis of the pyrochlore from Wausau is shown in comparison with the analyses of the typical varieties described by various investigators. By comparison of the several analyses in the table it may be seen that the pyrochlore from Wausau differs from the others in the proportion of each of the several acid and basic radicals. The principal difference in composition with respect to individual constituents appears to be the relatively higher content in the Wausau pyrochlore of cerium and yttrium, and the lower content of lime and iron as compared with the other members of the pyrochlore group. The presence of silica in the Wausau pyrochlore is also a distinctive feature, as already stated.

The name *marignacite* is proposed for this variety of pyrochlore in honor of Marignac, who besides making other valuable contributions to chemistry, developed the method for separating columbium and tantalum through the agency of the difference of solubility of their double fluorides in hydrofluoric acid, which is today the most satisfactory method of separating these two elements.

Analyses of Varieties of Pyrochlore.

	1	2	3	4	5	6
Cb_2O_5	58·27	61·64	55·22	34·24	26·22	7·74
Ta_2O_5			5·86	29·83	27·39	68·43
TiO_2	5·38	0·52	2·88	1·61	4·20	
SiO_2			3·10			
Fe_2O_3			0·50		0·26	0·42*c*
FeO		3·01	0·02	2·19	6·32	
CaO	10·93	16·61	4·10	8·87	6·00	11·80
MgO		1·62	0·16	0·15		1·01
Na_2O	5·31	3·58*f*	2·52	1·37	3·15	3·15*d*
K_2O		0·36*g*	0·57	trace		
ThO_2	4·96		0·20			
Ce_2O_3	5·50	6·89*b*	13·33		12·34	0·17*e*
Yt_2O_3			5·07			0·23
Di_2O_3					0·63	
La_2O_3					0·71	
UO_2	5·53*a*		none	15·50	8·33	1·59
SnO_2			trace	0·30		1·05
WO_3			trace			0·30
BeO						0·34
ZrO_2		3·39	none			
F	3·75	trace	none		1·90	2·85
H_2O 110°+ } H_2O 110°− }	1·53		5·95 / 0·45	4·49	1·45	1·17
Total	101·16		99·93	98·55	98·90	100·25

a, with FeO; *b*, with La,Di; *c*, with 0·13 Al_2O_3; *d*, with 0·29 K_2O; *e*, with Di; *f*, calculated as Na; *g*, calculated as K.

1. Pyrochlore from Brevik, Norway, anal. C. F. Rammelsberg; cited by Brögger, Zeitschr. Kryst. xvi, p. 512.
2. Koppite, from Schelingen, Baden, G. H. Bailey, J. Ch. Soc. xlix, p. 153, 1886.
3. Marignacite from Wausau, Wisconsin, anal. V. Lenher, 1906.
4. Hatchettolite from Mitchell Co., N. Carolina, O. D. Allen; this Journal, xiv, p. 128, 1877.
5. Pyrochlore from Batum, G. P. Tschernik, Zeitschr. Kryst. xxxix, 624, 1904.
6. Microlite, Amelia Court House, Virginia, Dunnington, Am. Ch. J., iii, p. 130, 1881.

ART. XXVIII.—*On the Arsenate Process for the Separation of Magnesium and the Alkalies*; by PHILIP E. BROWNING and W. A. DRUSHEL.

[Contributions from the Kent Chemical Laboratory of Yale University—clv.]

AMONG the methods which have been employed for the separation of magnesium from the alkalies the following are perhaps in most general use :

The barium hydroxide method, whereby the magnesium is precipitated as the hydroxide by barium hydroxide.

The mercuric oxide method, whereby the magnesia is precipitated by freshly prepared mercuric oxide acting upon the chlorides.

The ammonium carbonate method,* whereby the magnesium is precipitated as the double carbonate of magnesium and ammonium by a large excess of ammonium carbonate.

The amyl alcohol method,† whereby the magnesium chloride is dissolved in boiling amyl alcohol and the chlorides of sodium and potassium, not lithium, remain undissolved.

None of these methods, when employed with a view to the subsequent estimation of the alkalies, is free from objectionable features, such as difficulties of filtration, numerous transfers of filtrates, introduction of large amounts of reagents difficult of removal, and incomplete separation of the entire alkali group.

The work to be described is an effort to avoid some of the objections mentioned, by the precipitation of magnesium as the magnesium ammonium arsenate and the removal of the arsenate from the filtrate by reduction and volatilization of the arsenic salt. C. v. Hauer‡ suggested this general procedure and it has found other mention in the literature.§ The removal of the excess of arsenic was accomplished by ignition of the residue, obtained after evaporating the filtrate from the ammonium magnesium arsenate, with ammonium chloride. The method, however, has been criticized as inaccurate for the estimation of magnesium, and tedious. Recent work upon the precipitation of magnesium ammonium arsenate and upon the volatilization of arsenic compounds, suggested the possibility of obviating the difficulties which have kept this method from general use.

It is possible, with careful manipulation, to remove the arsenic by precipitating with hydrogen sulphide, but this procedure required an additional filtration and several transfers of

* Wulfing, Ber. xxxii, 2214. † Riggs, this Journal [3], xliv, 103.
‡ Jahrb. der k. k. geolog. Reichanstalt, iv, 863.
§ Fresenius-Cohn, Quant. Anal., 6th edition, vol. i, 613.

liquid and was therefore abandoned in favor of the separation by volatilization.

The reagents used in this work were prepared as follows: The potassium chloride by igniting pure potassium chlorate and crystallizing; the sodium chloride by recrystallizing the so-called pure sodium chloride. Solutions of these salts were made approximately tenth normal and standardized by evaporating measured portions with sulphuric acid in a weighed platinum crucible, and weighing the residues after ignition at the full heat of a Bunsen burner, as the normal sulphates.

A solution of magnesium chloride was obtained by dissolving a weighed amount of pure magnesium in hydrochloric acid and diluting sufficiently to make the solution approximately tenth normal. The solution was standardized by estimating the magnesium in measured portions as the pyroarsenate.

To obtain ammonium arsenate, arsenious oxide was sublimed and oxidized by an excess of nitric acid. After the completion of the oxidation, the excess of nitric acid was removed by evaporation, the residue treated with a slight excess of ammonium hydroxide, and the solution thus obtained diluted sufficiently to make it approximately fifth normal.

From a mixture of known amounts of standardized solutions of the chlorides of magnesium and potassium or sodium, the magnesium was precipitated in a distinctly but not strongly ammoniacal solution by 40 per cent to 80 per cent excess of ammonium arsenate, with brisk stirring. When only a small amount of magnesium is present in a relatively large amount of solution, the precipitate forms slowly and becomes complete only on long standing. In a previous paper* from this laboratory, it has been shown that the precipitation of amounts of arsenic so small as not to be precipitated immediately by magnesium mixture may be brought about by freezing the solution after adding that reagent, and remains complete when melting takes place. This procedure was found equally applicable in the precipitation of magnesium. A similar result was obtained by adding alcohol amounting to 15 per cent to 20 per cent of the mixture and filtering as soon as the precipitate settled completely. The precipitate was collected under moderate pressure in an ignited and weighed perforated crucible containing a close felt of fine asbestos. It was washed with 40 to 50^{cm^3} of ammoniacal water, after which it was dried at 125° C. to 140° C. and carefully ignited and weighed as magnesium pyroarsenate.

In a previous paper from this laboratory,† it has been shown that arsenic may be removed by distillation with potassium

* Gooch and M. A. Phelps, this Journal, xxii, 488, 1906.
† Gooch and I. K. Phelps, this Journal, xlviii, 216, 1894.

bromide and hydrochloric acid in a distilling apparatus. This suggested a method for the removal of the arsenic from the filtrate obtained after separating the magnesium ammonium arsenate. In some preliminary qualitative experiments, solutions containing from 0·1 to 0·2 grms. of ammonium arsenate were treated with 10^{cm^3} of hydrochloric acid (sp. gr. 1·20) and 10^{cm^3} of hydrobromic acid (sp. gr. 1·36) or 1 to 3 grms. of ammonium bromide, and evaporated in an open dish and the residues were ignited until fuming ceased. One such treatment was usually found to be sufficient; in fact, simple evaporation on a steam bath with the mixed acids, or with hydrobromic acid (not with hydrochloric acid alone), proved to be sufficient to remove the arsenic. Similar treatments made in the presence of definite amounts of the sodium or potassium chloride gave the results shown in Table I.

TABLE I.

	Ammonium arsenate calculated as As_2O_3 grm.	NaCl or KCl converted to Na_2SO_4 or K_2SO_4 and calculated as Na_2O and K_2O. Taken grm.	Found grm.	Error grm.
1	0·2	0·1171	0·1172	0·0001 +
2	0·2	0·1171	0·1170	0·0001 −
3	0·4	0·1873	0·1870	0·0003 −
4	0·2	0·0468	0·0473	0·0005 +

Some evaporations made with hydrochloric acid and sulphurous acid resulted in the removal of the arsenic, but three to five repetitions of the process were generally necessary.

The complete method as recommended for the estimation of magnesium and its removal from the alkalies, and the subsequent estimation of the alkalies, is as follows:

The magnesium is precipitated in a distinctly but not strongly ammoniacal solution by a 40 per cent to 80 per cent excess of ammonium arsenate. The completeness of the precipitation may be hastened by freezing the solution in an ice and salt mixture or by adding alcohol to about 15 per cent to 20 per cent of the total volume of the solution, which may vary from 100^{cm^3} to 250^{cm^3} according to the amounts of salt present. The magnesium arsenate obtained is filtered on an asbestos felt contained in a perforated platinum crucible, the crucible and felt having been previously ignited and weighed, and is dried, ignited and weighed as the pyroarsenate.

The filtrate is transferred from the filter flask to a platinum dish, and after the addition of 10^{cm^3} of hydrochloric acid (sp. gr. 1·20) and about the same amount of hydrobromic acid (sp. gr. 1·3), or 1 to 3 grms. of ammonium bromide evaporated to dryness under a draught-hood, the residue is gently ignited to remove the ammonium salts. The residue is then transferred to a weighed platinum crucible with a small amount of water, a little sulphuric acid (1–1) added, and the solution evaporated to remove the water and excess of sulphuric acid, by placing the crucible on a triangle in a porcelain crucible used as a radiator. After the sulphuric acid has ceased to fume, the crucible is removed from the radiator, and after ignition at the full heat of the Bunsen burner the alkali is weighed as the normal sulphate.

The results follow in Table II.

TABLE II.

	$(NH_4)_3AsO_4$ used calculated as As_2O_3 grm.	Dilution. cm^3.	NaCl or KCl_1 converted to Na_2SO_4 or K_2SO_4 and calculated as Na_2O or K_2O Taken grm.	Found grm.	Error grm.	$MgCl_2$ converted into $Mg_2As_2O_7$ and calculated as MgO Taken grm.	Found grm.	Error grm.
1	0·1	100	0·1194	0·1191	0·0003 –	0·0199	0·0197	0·0002 –
2	0·2	150	0·1194	0·1196	0·0002 +	0·0399	0·0397	0·0002 –
3	0·45	250	0·1194	0·1195	0·0001 +	0·0998	0·0998	0·0000
4	0·45	250	0·1194	0·1194	0·0000	0·0998	0·0997	0·0001 –
5	0·45	250	0·2389	0·2385	0·0004 –	0·0998	0·0999	0·0001 +
6	0·4	250	0·0478	0·0481	0·0003 +	0·1198	0·1193	0·0005 –
7	0·35	250	0·0956	0·0957	0·0001 +	0·0998	0·0996	0·0002 –
8	0·35	250	0·0956	0·0957	0·0001 +	0·0998	0·0994	0·0004 –
9	0·45	250	0·0909	0·0915	0·0006 +	0·0998	0·0993	0·0005 –
10	0·1	100	0·0545	0·0549	0·0004 +	0·0006	0·0004	0·0002 –
11	0·1	100	0·1181	0·1184	0·0003 +	0·0040	0·0038	0·0002 –
12	0·1	100	0·1181	0·1184	0·0003 +	0·0040	0·0038	0·0002 –
13	0·1	100	-----	-----	-----	0·0040	0·0038	0·0002 –
14	0·1	100	0·1181	0·1184	0·0003 +	0·0040	0·0040	0·0000
15	0·2	100	0·1181	0·1183	0·0002 +	0·0040	0·0039	0·0001 –
16	0·45	250	0·1181	0·1179	0·0002 –	0·1002	0·1004	0·0002 +

In experiments 1 to 10, the precipitate of magnesium was allowed twelve to twenty-four hours to settle. In experiments 11, 12 and 13, 15 per cent alcohol was used to hasten the complete precipitation of the magnesium, and in experiments 14, 15 and 16 the salt and ice mixture was used for the same purpose.

ART. XXIX.—*The Chemical Composition of Molybdic Ocher;* by WALDEMAR T. SCHALLER.*

Summary.—It is shown that the natural molybdic ocher, called molybdite, is not the trioxide of molybdenum, as stated in the literature, but a hydrous ferric molybdate with the formula, $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$.

The composition of natural molybdic ochre is given in all the text books on Mineralogy as agreeing in composition with the artificial product, molybdenum trioxide, MoO_3, which may be obtained by oxidizing the natural sulphide, molybdenite. So far as the writer is aware, but one analysis was ever made of the natural ocher, and while that suggested the desirability of further examination, such has never been made. This is doubtless due to the fact that whereas the yellow molybdic ocher is very widespread in its occurrence, it seldom occurs in sufficient quantity and of such purity as to warrant any chemical investigation. The writer was fortunate enough to receive a sample of supposed autunite from the Foote Mineral Company which, on investigation, was found to be molybdic ocher. As the mineral occurs in a pure state some qualitative tests were made and it was found that beside the molybdenum, considerable ferric iron and water were present. The material was then examined under the microscope and found to be pure and especially free from limonite. Some artificial crystals of MoO_3 were prepared, and on comparing the two substances under the microscope, such differences were found in their properties as to indicate that the mineral examined was not molybdite, but a new species,—a hydrated ferric molybdate. The investigation thus opened was extended, and through the generosity of several people, it has been possible to make analyses of the natural molybdic ocher from four different localities, and to show that the natural ocher is not MoO_3 but $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$.

A summary of the literature on molybdite is so well given by Hintze that only such points as bear directly on the question at hand will be mentioned. Owen† described a deep yellow iron molybdate from Nevada City, California, and W. J. Taylor‡ described a similar occurrence from Heard County, Georgia, but neither article contained quantitative data of any value. Owen found 35 per cent Fe_2O_3, but Genth§ in a later publication, made a determination on the same mineral and obtained 24·3 per cent Fe_2O_3. He says, "That which could

* Published by permission of the Director of the U. S. Geological Survey.
† Proc. Ac. Phila., vi, 108, 1852.
‡ This Journal, xix, 429, 1855. § Ibid., xxviii, 248, 1859.

be scratched off the quartz was not quite pure and contained a trace of limonite . . . . . The sample examined gave 24·3 per cent of sesquioxide of iron, some of which was *certainly* mechanically mixed with it." Yet it would necessitate a mixture of nearly one-third limonite to give 24·3 per cent Fe_2O_3, while according to Genth, the sample only "contained a trace of limonite." The analytical result was correct, but the interpretation wrong. The sample doubtless contained a trace of limonite, as the 24·3 per cent is slightly higher than the figure required for the formula $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$, which gives 22 per cent Fe_2O_3.

Physical Properties.—The mineral has a fibrous structure and also forms radiating groups. Its color is yellow and the lustre often silky. All of the fibers examined gave parallel extinction. The double refraction is strong and the direction of elongation is always an axis of minimum elasticity. The pleochroism is strong but is masked by the very strong absorption. Normal to the elongation of the fibers, the transmitted light is pale yellow, parallel to the elongation the color is a much stronger yellow. The absorption parallel to the elongation is so strong that thick fibers frequently appear almost black and opaque. These same properties are mentioned by Lacroix* for molybdite from Corsica.

Crystals of MoO_3, prepared by roasting molybdenite in an open crucible, show very decided differences in their physical properties from those of the natural mineral. They are not fibrous but platy and are colorless, non-pleochroic and show no difference in absorption in different directions.

Chemical Analyses.—The largest sample obtained comes from Westmoreland, New Hampshire, and was very kindly furnished from the Brush Collection of Yale University by Prof. Wm. E. Ford. Nearly a gram of material was obtained and this was divided into portions of a quarter gram weight. Macroscopically, the specimen looks more earthy and not so finely crystallized as those from some of the other localities, but under the microscope, the material, with its characteristic optical properties, was seen to be homogeneous, free from limonite, and to contain a small quantity of molybdenite scales. The first figure given for the water content, 16·98 per cent, was obtained by weighing the water direct, using the method of glass tubes as advocated by Penfield. The other two figures represent the loss up to 200°, at which temperature all of the water of the mineral is given off. The residue was dissolved in HCl, and after filtering off the insoluble matter, the iron was precipitated by ammonia, filtered off, dissolved in HCl, and reprecipitated and weighed, while hydrogen sulphide was passed

*Min. de France, iii, 8.

into the combined ammoniacal filtrates until the characteristic red color was produced. The solution was then acidified with H_2SO_4 and after heating on the steam bath, to allow the molybdenum sulphide to settle, it was filtered through a Gooch crucible. This was then dried, and the sulphide changed into the trioxide at a low heat and weighed to constant weight. The filtrate from the molybdenum sulphide was made alkaline with ammonia, hydrogen sulphide again passed into the solution, which was then re-acidified with H_2SO_4 and a small amount of molybdenum which had escaped precipitation in the first case recovered. The filtrate, on testing, showed no more molybdenum. Neither was any residue found on evaporating it to dryness and tests that were made showed the absence of calcium and magnesium. The weighed iron oxide was fused with sodium bisulphate and determined volumetrically with a result that agreed with the gravimetric determination. The results obtained are as follows:

	1	2	3	Av.	Ratio	
H_2O	16·98	17·95	17·93	17·62	7·43	$7\frac{1}{2}$
Fe_2O_3	21·08	21·07	----	21·08	1·00	1
MoO_3	57·02	57·49	58·55	57·69	3·04	3
Insol.	4·66	----	----	4·66		
				101·05		

The average analysis, with the insoluble matter deducted and reduced to 100 per cent, is compared with the figures calculated for $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$.

	Analysis	Calculated
H_2O	18·28	18·57
Fe_2O_3	21·87	22·01
MoO_3	59·85	59·42
	100·00	100·00

Partial water determinations were made on two samples as follows, the amount of water being represented by the loss in weight, the crucible being heated at the temperature given till six hours further heating produced no difference in weight.

Total loss up to 110° = 14·04%
" " " " 125° = 15·50
" " " " 185° = 17·64
" " " " 200° = 17·93

This shows that of the total seven and a half parts of water, 5·92, or six parts, are given off at a little above 100°, while a higher temperature is required to drive off the remainder.

For the material from the other localities,* the quantity was so small that exact values cannot be expected, but the analyses all show a general agreement with the calculated values. The samples analyzed are as follows:

No. 1 is from Telluride, Colorado, and is from the sample furnished by the Foote Mineral Company, of Philadelphia.

No. 2 was very kindly furnished by Prof. A. J. Moses, of Columbia University, who states that the sample is probably from California, though the locality is not known for certain. Two samples were sent, one yellow, which was seen to be pure, and one brown, which was seen under the microscope to consist of a mixture of the pure yellow mineral and limonite. This sample at once suggested that it was similar to that analyzed by Owen, who obtained 35 per cent Fe_2O_3. It also showed the ease with which a mechanical mixture of molybdite and limonite could be detected under the microscope. The opaque brown limonite was scattered through some of the yellow molybdite, and caused it to appear almost opaque, besides which there were numerous patches of earthy limonite. The brown sample was not analyzed.

No. 3 is from Renfrew, Ontario, and was very kindly furnished by Prof. C. Palache, of Harvard University. Most of the material is massive and earthy appearing, though seen under the microscope to consist of minute fibrous crystals. The material did not look promising, but analysis showed values agreeing well with the other. Owing to an accident, only the iron and molybdenum could be determined. These values are not given. On one of the specimens sent by Prof. Palache, there was a small amount of the finely crystallized fibrous material which seemed to be very pure. This was scraped off and analyzed, and though only about fifty milligrams were available, the results given under No. 3 were obtained.

The methods of analyses were like those mentioned with the analyses of the New Hampshire material. By heating in a closed tube, to obtain the water, some of the molybdenite which was usually mixed with the mineral doubtless oxidized to the oxide, thus increasing the amount of molybdenum present. The results obtained are:

	No. 1 Colorado	No. 2 California	No. 3 Ontario
H_2O	15·8	15·4	15·5
Fe_2O_3	19·0	15·8	17·3
MoO_3	59·3	47·7	55·7
Insol.	[5·9]	24·0	9·4
	100·0	102·9	97·9

* The characteristic optical properties of the ferric molybdate were also determined on specimens from Stanhope, New Jersey; Gold Creek, Deer Lodge Co., Montana; Aldfield Township, Pontiac Co, Quebec.

Deducting the insoluble matter and reducing the analyses to 100 per cent, we obtain:

	No. 1	No. 2	No. 3	Calc.
H_2O	16·8	19·5	17·5	18·6
Fe_2O_3	20·2	20·0	19·6	22·0
MoO_3	63·0	60·5	62·9	59·4
	100·0	100·0	100·0	100·0

The ratios give:	Fe_2O_3	:	H_2O	:	MoO_3.
Anal. 1,	1·0	:	7·3	:	3·4
Anal. 2,	1·0	:	8·6	:	3·3
Anal. 3,	1·0	:	7·8	:	3·5

The analyses agree sufficiently well to show that the mineral is uniform in composition and the analysis of the material from New Hampshire serves to establish its formula.

In considering the mode of formation of the hydrous ferric molybdate, it may be well to call attention to the fact that the interaction of molybdic acid, $H_2MoO_4.H_2O$, on limonite may be written so as to yield a product with a formula that is identical with the new formula and exactly balances the equation: $2Fe_2O_3.3H_2O+6(H_2MoO_4.H_2O) = 2(Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O)$.

Pyrognostic Properties.—On heating the mineral in a closed tube abundant water is easily given off and the mineral becomes a dark olive color which on further heating again becomes lighter in color. On heating the mineral in a crucible, the color changes are very marked. At first, the yellow mineral darkens and becomes a dark gray, appearing almost black and with a slight olive tint, then it becomes a light yellow again, and on further heating changes to a deep orange color. If the mineral now be allowed to cool, the orange changes to yellow and back to orange again on reheating. If the dark colored material be allowed to cool, it retains its dark gray color and on reheating passes through yellow to the orange. On heating for some time at a higher temperature, the mineral, on cooling, becomes a permanent bright green. By further heating all of the molybdenum is volatilized and the dark red ferric oxide remains. The mineral is readily soluble in hydrochloric acid, and dissolves slowly in ammonia, taking on a brown color (probably due to the separating ferric hydroxide). After a while, all the molybdenum of the mineral goes into solution, leaving the insoluble ferric hydroxide.

Artificial ferric molybdate.—Chemical dictionaries mention but two hydrous ferric molybdates, neither of which is crystalline, and which approximate in formula to $Fe_2O_3.4MoO_3.7H_2O$, and $Fe_2O_3.5MoO_3.16H_2O$. On adding a solution of ammonium molybdate to an excess of a solution of a ferric salt, no precipitate is formed, but on reversing the process and adding the ferric salt to the ammonium molybdate, a voluminous yellow precipitate appears. A precipitate thus prepared was air-dried for about a week and analyzed with the following result:

		Ratio
Fe_2O_3	15·9	1·0
MoO_3	61·6	4·3
H_2O (by diff.)	22·5	12·5
	100·0	

These results are between those of the two salts above quoted. It was found, however, that a large amount of free molybdic acid contaminated the material and the impossibility of air-drying the non-crystalline mass sufficiently accounts for the high water content. It is therefore believed that neither of the two salts above mentioned and described in chemical dictionaries has any existence, but that they are mixtures of a salt of the formula $Fe_2O_3.3MoO_3+n(3H_2O)$ with molybdic acid and water.

A preliminary experiment of heating precipitated ferric hydroxide and molybdic acid in the correct molecular proportions with an excess of water in a glass bomb failed to give any result. After heating to about 150° for several hours, there was no indication of any reaction and on higher heating the bomb exploded.

An attempt was next made to crystallize the yellow amorphous precipitate. The precipitate was heated with water in a glass bomb up to 180°–200° for several days, and when examined, was found to consist of a mass of fine yellow crystals and a greenish amorphous mass. By shaking up the tube, the green part settled very quickly, while the minute yellow crystals settled so slowly that a nearly perfect separation of the two products could be made. The yellow crystalline part was examined under the microscope and found to consist of three products, all crystallized. The most abundant salt occurs in minute pale yellow tablets of quadratic outline and sometimes with an octagonal shape suggesting combinations of the cube and octahedron, and which seem to be isotropic. They were too small to test for interference figures. The second most abundant salt occurs in pale yellow fibrous prisms and also in radiated fan-shaped masses that show the characteristic absorption of the natural mineral, and are probably to be identified with it. The third salt also occurs in prisms which, however, are not fibrous, do not show any absorption, and seem to be colorless. They may be molybdic acid, but the first two salts are probably hydrated ferric molybdates. It is the writer's intention to continue the study of the artificial formation of these salts, especially to obtain, in a state of purity, that one which corresponds in composition to the natural mineral.

Occurrence of natural MoO_3.—The existence of the trioxide of molybdenum as a natural mineral has not been demonstrated, and what is commonly believed to be MoO_3 is shown to be a hydrated ferric molybdate, $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$. There is also the possibility that the hydrous oxide $MoO_3.2H_2O$, or molybdic acid, has a natural occurrence. If either of these should be shown to exist, the name molybdite should be applied to the species and the salt $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$ should receive a different name; but until it is shown conclusively that an oxide of molybdenum does exist in nature, the name molybdite must be retained for the hydrated ferric molybdate.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Preparation of Pure Helium.*—Several years ago Jacquerod and Perrot called attention to the fact that helium diffuses through the walls of tubes or bulbs of fused silica at high temperatures. These investigators have now made use of this remarkable phenomenon in purifying the crude gas obtained by heating the mineral cleveite. They found, in the first place, that silica is perfectly impermeable to other gases, with the exception of hydrogen and perhaps carbon monoxide, up to the temperature of 1067°. The apparatus used for the operation consisted of a bulb of silica provided with a capillary tube of the same material. The bulb was surrounded by a cylindrical vessel of platinum, from which the quartz capillary passed by a gas-tight joint. The space between the bulb and the walls of the platinum vessel was exhausted, and then crude helium was placed in this space at a pressure a little above that of the atmosphere in order to hasten the diffusion. To this helium was added 5 to 10 per cent of oxygen in order that any hydrogen and carbon monoxide present might be changed to water vapor and carbon dioxide. At the same time the quartz bulb was exhausted by means of the mercury pump. The apparatus was heated by means of an electric furnace to about 1100°. Under the conditions employed, with a bulb of 42^{cc} capacity the diffusion was quite slow, amounting to about 1^{cc} of helium per hour. On the other hand, when the apparatus had been once set up the method worked very simply, and the purification appeared to be perfect. A spectroscopic examination of the gas showed only the characteristic lines of helium, extremely brilliant. The nitrogen bands, which are so easily seen, were entirely absent. Only the red hydrogen line, extremely faint, was observed, and this probably came from traces of hydrogen held by the aluminium electrodes of the Plücker tube employed.—*Comptes Rendus*, cxliv, 135.

H. L. W.

2. *Calcium as an Absorbent of Gases.*—By means of a special arrangement with an electric furnace, Soddy has found it possible to heat reagents *in vacuo*, in sealed soft-glass apparatus, to a far higher temperature than the softening point of glass. Calcium heated in this manner is an absorbent for all the known gases with the exception of those of the argon group. If the initial gas pressure does not exceed a few millimeters, all the common gases are rapidly and completely absorbed by calcium at temperatures between 700 and 800°. Barium and strontium behave in a similar way. By admitting known volumes of air and absorbing all but the argon, the interesting observation was

made that it was not possible to force a discharge through argon at a pressure of less than $\frac{1}{50}$mm. Helium was found to be non-conducting at a pressure of $\frac{1}{20}$mm when pure, but in the presence of any common gas, such as hydrogen or oxygen, one-hundredth of this amount serves to reveal the D_3 line. This behavior of the inert gases explains why they appear to "run out" in spectrum tubes so quickly, for when the traces of common gases always present are absorbed by the electrodes, the inert gases are left in the pure and non-conducting state.—*Chem. News*, xciv, 305. H. L. W.

3. *New Method for Determining Halogens in Organic Compounds.*—E. CHABLAY has described a simple method, based upon a new principle, for making these determinations. The apparatus is a tube similar to a large test-tube. If the substance is a liquid, from 0·1 to 0·5^g of it is weighed in a bulb of thin glass and this is placed in the bottom of the tube and broken. The tube is then plunged into a freezing-mixture of solid CO_2 and acetone, then ammonia gas is passed in until 5 or 6^{cc} have been liquefied. A fragment of clean metallic sodium is then added, the liquid is agitated, the reaction being moderated by plunging the tube into the refrigerating mixture if necessary. Further additions of sodium are made until the blue color of the sodammonium is permanent. This usually requires only one or two minutes. The excess of ammonia is allowed to evaporate, moist air is passed into the tube to decompose the remaining sodium, the residue is dissolved in water and the halogen determined by Volhardt's volumetric method. If the substance is solid and soluble in liquid ammonia, the same method of treatment is employed; if insoluble in the ammonia, it is dissolved in 2 or 3^{cc} of ether, benzol, or toluene and the solution is allowed to drop very slowly from a funnel into the sodammonium liquid. The author has applied the method to a large variety of pure organic substances with very satisfactory results.—*Comptes Rendus*, cxliv, 203. H. L. W.

4. *Hydrates in Aqueous Solution;* by HARRY C. JONES. 8vo, pp. 264. Published by the Carnegie Institution of Washington, February, 1907.—This is a monograph on the evidence of the existence of hydrates in solution, their approximate composition, and certain spectroscopic investigations bearing upon the hydrate problem. Professor Jones has been assisted in this work by F. H. Getman, H. P. Bassett, L. McMaster, and H. S. Uhler. The investigations are the outcome of observations, made in the Johns Hopkins laboratory, that very concentrated solutions of certain salts showed abnormally low freezing points. As these facts were not explained by the then existing theories of solution, Professor Jones advanced the explanation, that in these concentrated solutions a part of the solvent is combined with the dissolved substance, and no longer plays the rôle of solvent. No less than four distinct lines of evidence have been furnished experimentally, all of which point to the correctness of

the theory. The arguments in favor of the theory appear very strong, and whatever may be the outcome in regard to its general acceptance, it is certain that a valuable and important mass of facts has been accumulated in these extensive investigations.

H. L. W.

5. *Die Entwicklungsgeschichte der Chemie;* von A. LADENBURG. 8vo, pp. 417. Braunschweig, 1907 (Friedrich Vieweg und Sohn).—This is the fourth edition of the well-known lectures on the history of the development of chemistry from the time of Lavoisier to the present. The first edition appeared thirty-eight years ago, in 1869. At that time the great chemists Liebig, Wöhler, Bunsen, Kolbe, Kekulé, Dumas, Wurtz, Frankland, and Williamson were living, some of whom had been the author's teachers, and all of whom he knew personally. This circumstance gives to the book a great degree of authority in regard to the early history of chemistry. To the original fourteen lectures a new one has been added with each new edition, to bring the history up to the time of writing, so that the present enlarged and improved edition comprises seventeen lectures or chapters. The book deals largely with the development of chemical theories. The copious references to the literature are an important and useful feature of the work. H. L. W.

II. GEOLOGY AND MINERALOGY.

1. *Geological Survey of Canada;* ROBERT BELL, Acting Deputy Head and Director. Summary Report for the Calendar Year 1905. Pp. 144, with 3 colored maps. Summary Report for the Calendar Year 1906. Pp. 206. Section of Mines: Annual Report for 1904. Pp. 162.—The Summary Reports for 1905 and 1906 have been recently received with also the Report of the Section of Mines for 1904. The reports are very largely given to economic developments, for which the demand is now greater than ever. The Director calls attention to the fact that during the twenty years since 1886 the mineral production of Canada has increased about seven times, or from $10,000,000 to nearly $70,000,000. At the same time the appropriations, both for the Geological Survey and the Mines Branch of the Department of the Interior, have only increased from $115,000 to $174,000. Considering the very wide extent of country to be examined from the Provinces on the Atlantic to British Columbia and Alaska on the Pacific, it is evident that any adequate development, such as the best interests of the country call for, demands a much larger force than is possible with the present limited support. It is also obvious that the economic work, important as it is, should not crowd out that more strictly belonging to pure geology.

It is stated that in 1905 some thirty-seven parties were at work in the field, and in 1906 a somewhat smaller number. The leaders of the different parties give in brief their individual reports, and a survey of them serves to show the great variety of work in progress. Among these may be mentioned one by Dr. Robert Bell on the Cobalt Mining District, giving a brief account of the geology of the region, accompanied by striking illustrations of the silver nuggets which have been produced.

The Survey has also issued sheets Nos. 59, 60, 61, 62, 63, 64, 65, 74, 75, 76, 82, 83 of the Nova Scotia geological map. Further, the following special reports have appeared :

Report on the Chibougamau Mining Region in the Northern Part of the Province of Quebec ; by A. P. Low. Pp. 61, with one colored map.

Preliminary Report on the Rossland, B. C., Mining District ; by R. W. Brock. Pp. 40.

2. *The Cruise of the Neptune. Report on the Dominion Government Expedition to Hudson Bay and the Arctic Islands.* 1903–1904 ; by A. P. Low. Pp. xvii, 355. Ottawa, 1906.—This report contains a narrative of the voyage of the *Neptune* during 1903–04, to the northern parts of Hudson's Bay and the northeastern Arctic islands, extending as far as Cape Sabine in Smith Sound, in latitude 79°. The scientific staff was led by Dr. A. P. Low, who was commander and geologist. The general account of the voyage, illustrated by numerous excellent reproductions from photographs, is most interesting. To this are added chapters discussing the Esquimos, the geology, the whaling, and the navigation of Hudson's Bay. The lists of scientific collections are given in appendixes and a large pocket map is also added.

The two chapters devoted to a summary of the geology of the northeastern coast of America and the Arctic islands deserve careful reading. The account given is based chiefly upon the observations made by the *Neptune*, although full credit is given to the necessarily fragmentary and imperfect observations of the earlier explorers. The region covered is remarkable as giving a nearly continuous series from the Archean to the Tertiary, while various phases of the glacial age are represented as well as Postglacial deposits. It is stated that :

"The Paleozoic rocks are well represented on the islands by thick deposits extending upwards in a continuous series from the Cambro-Silurian to the upper beds of the Carboniferous. Rocks older than the Galena-Trenton are only found in the northern part of Ellesmere island, where a series of beds appears to connect the Upper Huronian formations with the lower members of the Cambro-Silurian. Mesozoic rocks are found on the northern Parry islands, on the Sverdrup group and on the western and northern sides of Ellesmere island. Tertiary formations occur on the northwestern islands, on the northern part of Ellesmere, as well as on the northern and eastern parts of Baffin island.

The former presence of a continental ice-cap is attested along the northwestern shores of Hudson bay and in the southern part of Baffin island, by the rounded and polished rock surfaces, which are everywhere well marked by the ice striae, often in several sets showing changes in the direction of the ice movement. On the east side of Baffin the rock surfaces show signs of rounding and smoothing by ice, but the striae are not well marked, and the glaciation does not appear to have been nearly so intense as to the south and westward. Passing northward up the western side of Davis strait and Baffin bay, the evidence of intense glaciation becomes less and less, that on Ellesmere the present condition of the local ice-covering would appear to represent nearly as great an amount of glaciation as ever occurred there."

3. *Geological Survey of Brazil.*—A Geological Survey of Brazil has recently been established and placed under the charge of Dr. Orville A. Derby, well known for his valuable contributions to the geology and mineralogy of the country. This important enterprise is due immediately to the wise foresight of the new President, Dr. Affonso Augusto Moreira Penna, inaugurated on the 15th of November last, and Dr. Miguel Colman du Pine Almeida, appointed by the President to the portfolio of Industry, Highways and Public Works. Dr. Colman was formerly Secretary of Agriculture of the state of Bahia, where he proved himself one of the most able and far-sighted of the younger generation of Brazilian engineers and administrators. The new department, denominated *Serviço Geologico e Mineralogico do Brazil,* will be located in Rio de Janeiro. The leading feature of its program is the rapid reconnaissance of the general geology of the country with detailed investigation of the districts, that on account of their mineral wealth, deficiencies of water supply or other reasons, offer special scientific and economic interest for investigation. Owing to the lack of proper topographic maps no systematic map work will for the present be attempted.

Dr. Derby is remarkably well fitted for the post to which he has been appointed, since he has been active in scientific work in Brazil for many years and is well acquainted with all the local conditions. He organized and long directed the geographical and geological survey of the state of São Paulo. Dr. Derby, it is stated, will be assisted by such native and foreign resident geologists as have made valuable contributions to the geology of Brazil.

4. *Geological Commission, Cape of Good Hope;* by A. W. Rogers, Director of Survey. Tenth Annual Report, 1905. Pp. 296, 31 illustrations.—The work done by the survey during 1905 is well shown by the following list of papers :

Geological Survey of parts of the Divisions of Uitenhage and Alexandria, by A. W. Rogers ; Geological Survey of the Coastal Plateau in the Divisions of George, Knysna, Uniondale and Humansdorp, by E. H. L. Schwartz ; Geological Survey of Glen Grey and parts of Queenstown and Wodehouse, including the Indwe Area, by A. L. Du Toit ; Geological Survey of parts of

Hay and Prieska, with some notes on Herbert and Barkly West, by A. W. Rogers; Geological Survey of portions of the Divisions of Vryburg and Mafeking, by A. L. Du Toit; Geological Survey of the Divisions of Tulbagh, Ceres and Worcester, by E. H. L. Schwartz; A Raised Beach Deposit near Klein Brak River, by A. W. Rogers.

These papers are accompanied by illustrations and geological maps, which add much to their effectiveness. While the work is all of the nature of detailed reconnaissance, the survey deserves great credit for the large amount of high grade work done on an appropriation of less than $10,000. New facts are given regarding the interesting line of volcanic rocks, both lavas and breccias, which accompany the fault separating the Uitenhage beds from the Zuurberg. Further evidence of glaciation is presented, showing a cold climate during the deposition of the Griqua Town beds.

From the standpoint of the physiographer, the work of Mr. Schwartz on the coastal plateau is of particular interest. Origin of topographical features is discussed somewhat in detail, and the terraces, one submerged, two others at elevations of 700 and 1500 feet, respectively, are described. The 700 ft. "uplands coastal plateau," which has been previously described as a peneplain, is now considered to be a plain of marine denudation, and is compared with the similar plains of marine erosion in Europe.

H. E. G.

5. *Seismic Geology*.—Recent geological work on areas of complicated rock structure, taken in connection with a detailed study of earthquake regions, seems likely to result in a change of mental attitude toward dynamic forces. It seems as if the effort to escape the theories of catastrophism in geology had carried us so far in the opposite direction that little room is left in geological thinking for the undoubted occurrences of sudden dislocations and for the production of topographic forms, other than by the normal processes of erosion. In a recent work on Seismic Geology by Wm. H. Hobbs,* the necessity for this new view is clearly brought out. The centrum theory for earthquakes seems now to be generally abandoned because only of limited application, and the ordinary cause for earthquakes is to be found in movements of orographic blocks. Professor Hobbs has brought together a number of instances of dislocations of the earth's surface as the result of macroseisms, beginning with the Calabrian earthquake of 1783 and ending with the California earthquake of April 18, 1906,—a list which in itself is imposing, but which, undoubtedly, would be much extended if scientific observations had been more generally made. The following generalizations are announced concerning surface dislocations at the time of earthquakes.

* *Some Principles of Seismic Geology*, by William Herbert Hobbs, with an Introduction by Eduard Suess. From Gerlands Beiträge zur Geophysik, viii, pp. 219–292, 1 pl. and 10 figs. Leipzig, 1907 (Wilhelm Engelmann).

"1. Appreciable surface dislocations appear to be formed only at the time of macroseisms, and the throws upon these plains stand in some relation to the magnitude of the disturbance."

"2. The evident dislocations produced are, generally of two orders of magnitude, those of the higher order being very limited in number, while those of the lower order are often quite numerous."

"3. Earthquake dislocations are normal faults with hades approaching the vertical."

"4. A considerable lateral shift along the larger planes of dislocation has sometimes been observed, and is probable in other instances."

"5. The crustal movements indicated at the surface at the time of earthquakes appear to be due to an adjustment in position of individual blocks."

So closely connected are fractures and seismic phenomena that the fracture system suggests earthquake activity, while, on the other hand, seismic methods may be used for locating fracture systems. Hobbs has called attention to a number of regions where this intimate correlation is brought out by observed facts. In the chapter on Seismic Geography of the Eastern United States and Canada, attention is called to the correspondence between a map of the lineaments of the Atlantic Border Region (Bull. Geol. Soc. Am., vol. xv, pl. 45, 1904), showing the prominent fault lines, and a map of the Distribution of Earthquakes in the United States (F. de Montessus de Ballore, Les Etats-Unis sismiques ; Archives des Sci. phys. et nat. de Genève, vol. v, pl. 3, 1898), where a complete concordance is shown. This illustration is particularly striking because of the fact that the two maps were made entirely independently and with different purposes in view. Another important conclusion is suggested by the study of the relation of earthquakes to fault lines, viz., that the local value of gravity seems to be altered as the result of local displacements which produced earthquakes. The far-reaching importance of this conclusion as an aid in the explanation of uplifted blocks, trough lines, and ocean valleys, is evident. The law of distribution of seismicity, as stated by Montessus, Milne, and others, considers earthquakes as directly related to regions of marked change of relief, and is restated by Professor Hobbs in a single sentence, viz., "Seismicity is localized on earth lineaments —faults—and is greatest at their intersection."

The Geotectonic and Geodynamic Aspects of Calabria and Northeastern Sicily; by WILLIAM HERBERT HOBBS, with an Introduction by the COUNT DE MONTESSUS DE BALLORE. Pp. 293–362, with 10 pls., 3 figs. Leipzig, 1907 (Wilhelm Engelmann).—As stated by the author, this article is a study in orientation ; it is a geological study of a well-known earthquake region, as compared with the usual investigation along physical and commercial lines. The attitude of the author gives a clue to the value of this work. After some twenty years' experience in the complex crystalline rocks of New England, Professor Hobbs reached the conclusion that the well-recognized methods of interpretation of structure by folds was not applicable. His view, that the region is one marked by a well-defined fracture system which has determined the character of the topography and the boundaries of rock formations, met with strong opposition. As a method of testing his conclusions, the Calabrian district, where the geology is well-known and the fault lines and distribution of earthquakes have been made out, was chosen for study. A detailed study of this region, concluded by careful mapping, has shown a most marked concordance between the topography and the fault lines on the one hand and between the fracture system and earthquakes on the other.

The views advanced by Professor Hobbs may well seem radical, but the field evidence, as presented, seems so conclusive, and a study of the literature has been so thorough, that, in the absence of satisfactory data to the contrary, we must recognize that faulting is a much more important factor in dynamical geology than we have been accustomed to admit, and that earthquakes, as indicative of the location of fault lines, are worthy of the most careful and systematic study on the part of geologists.

H. E. G.

6. *Die Fossilen Insekten und die Phylogenie der rezenten Formen. Ein Handbuch für Paläontologen und Zoologen;* von Anton Handlirsch. Lieferungen I–IV, 640 pp. and 36 double plates. Price per part, 8 marks; the book is to consist of from 8 to 10 parts with 50 plates. Leipzig, 1906 (W. Engelmann).—In this very valuable treatise there will be brought together all that is known in regard to fossil insects. The author has now been at work several years in an investigation based primarily on the materials in the museums of Europe and America, and this has been made possible through the support of the Royal Academy of Natural History of Vienna.

The chief object of this elaborate study is the establishment of a classification of the Hexapoda based on the morphology and chronology of recent and fossil forms. Among fossil insects, it is seldom that more than the wings are preserved and upon these the paleontologist has in the main to depend. Until recently no adequate account of the venation of wings among living insects, as a basis for classification, was accessible; the work of Comstock and Needham, however, has supplied this great lack. Further, the application of the knowledge of recent forms to fossil specimens could be made only by an entomologist of general training, and paleontologists will ever be grateful to Handlirsch for the extended and successful work he is now seeing through the press. The final results of his studies will appear in the concluding chapters of this book, the completion of which must be awaited for another year. As will be seen later, he has divided the fossil material into two categories,—material that is well preserved, thus revealing the essential characters, and poor material, which is not to be despised but to be used cautiously in determining the evolution of the Hexapoda. He has taken as his motto: "Better a little certain than much doubtful."

The plan of the work is as follows: The introduction contains an account of the more important morphologic characters and their phylogenetic application. Main reliance is placed on the morphology of the wing and on convergent evolution. The introduction closes with a description of the hypothetic primordial insect, the Protentomon.

In Part I (pp. 13–51) are described the orders of recent insects along with descriptions of the various terms used throughout the work. Here are also given schematic figures to illustrate the venation of the various types of wing. Part II (pp. 55–393) treats of the Paleozoic forms, and throughout the work all the species will be illustrated as far as possible. Part III (pp. 394–640, as far as published) takes up the Mesozoic insects. Part IV will treat of the Tertiary forms; V, of the Quaternary; VI will give a summary of the paleontologic results attained; VII will present a short historical summary of the proposed system, and the closing part, VIII, will include the new classification of the Hexapoda and the author's conclusion on the phylogen of the Arthropoda.

The work teems with new names of all grades and may cause alarm to some; yet when one considers for a moment the extraordinary differentiation among living insects (there are about 360,000 described), it is seen that even with these hundreds of new generic names a beginning only in paleo entomology has been made. Fossil insects, as a rule, are but accidentally entombed and the fact that nearly every wing reveals a new species and often a new genus indicates how little of the myriads of insects that lived at any given time is preserved; the present work treats of all extinct Hexapoda.

Carboniferous.—There are no fossil insects known previous to the Coal Measures or Pennsylvanian, the so-called insects of the Silurian having proved to belong to a trilobite or are lusus naturæ. Those of the New Brunswick Little River group, supposed to be of Devonian age, are here referred to the Upper Pottsville (Pennsylvanian), a conclusion in harmony with the paleobotanical results of Mr. David White.

In the Upper Carboniferous the first undoubted insects appear both in North America and western Europe. The climate is assumed to have then been mild and damp, and free from frost into the arctic regions. The insect-bearing beds were probably the deposits of swamps and forest moors, and from them are here recorded 546 good species and 267 poor ones. The former are arranged in 252 genera, and while the greater number of these have but from one to four species, yet there are a few having a goodly number, as *Phyloblatta* with 89; *Sysciophlebia*, 45; *Orthomylacris*, 11; *Mylacridium*, 16, and *Poroblattina*, 19. Of the clearly ascertained species 220 are restricted to North America, the remainder to Europe. Not a single species seems to be common to two localities and of the 252 good genera only 11 are common to America and Europe, all belonging to the order Blattoidea. These are: *Aphthoroblattina*, *Asemoblatta*, *Blattinopsis*, *Dictyomylacris*, *Eumorphoblatta*, *Olethroblatta*, *Phyloblatta*, *Poroblattina*, *Syscioblatta*, *Sysciophlebia*, and *Xenoblatta*. In another publication, however, the author remarks: "In such groups as first exist in single individuals, no sort of conclusion as to their actual horizontal distribution can be obviously drawn, and it consequently follows that there is a striking agreement in the Paleozoic fauna in both continents," America and Europe.

The ordinal evolution is as follows: The stem group of all winged insects, Palaeodictyoptera, has 116 species. In these the structure was of the simplest order, and they were apparently without adaptation to the definite modes of life which we are accustomed to see in nearly all existing insects. Out of these were evolved all the higher orders of Hexapoda. The other more prominent orders are: Protorthoptera (primitive Orthoptera, or locusts), with 43 good species; Protoblattoidea (ancestors of cockroaches and mantids), with 39; Blattoidea (cockroaches), with 320; Protodonata (primitive Odonata, or dragon-flies), with 6, and Megasecoptera (ancestral panorpatids, or scorpion-flies), with 18 species. But a single one of the Paleozoic orders,—Blattoidea, passes into the Mesozoic. Many of these Carboniferous insects attained considerable size, and some are known much more than half a meter across the wings.

Permian.—The climate at the beginning of the Permian is thought to have been like that of the Carboniferous; later it changed remarkably, for in the Southern Hemisphere there was then an extended glacial period across South America, Australia, South Africa, and even to India. It also exerted its influence upon the Northern Hemisphere, where the mild, damp Carboniferous conditions passed at least locally into a desert climate.

Our knowledge of the Permian insects is restricted to the Upper Permian deposits of Russia and to the Lower Permian of North America and Europe. The Fairplay, Colorado, beds, which Scudder was disposed to regard as of Triassic age, the present author regards as belonging to the Permian, as there is nothing which in the least points to Triassic development.

The Permian insects here described number 112 good species in 45 genera, besides 36 poor ones. Nearly all the genera are represented by one or two species, but *Phyloblatta* has 44 and *Sysciophlebia* has 13 species. Of Carboniferous genera continued into the Permian there are *Phyloblatta*, *Sysciophlebia*, *Dicladoblatta*, *Poroblattina*, and *Nearoblatta*. Of these the first two genera are also common to North America and Europe.

In the Permian there are none of the most primitive insects, the Palaeodictyoptera, while the order Protorthoptera is represented by a single form, and the Protoblattoidea by two. On the other hand, Blattoidea are well represented by 98 species. In the higher or true Permian of Russia the first Plecoptera, or May-flies, are found, in 4 species, and the first transitional forms to the hemipteroids in the Protohemiptera and Palaeohemiptera.

Triassic.—The number of good species is 21 in 20 genera. Nineteen of these relate to the cover wings of Coleoptera and 2 are Neuroptera. This marked paucity of insects in the Triassic is explained on the ground that the climate was then arid and consequently there was a scarcity of insect life. These fossils occur in Germany, southern Sweden, Queensland, and Massachusetts.

The American *Mormolucoides articulatus*, the author states, is certainly a water-inhabiting larva. Its insect nature is indicated by the division of the body into three parts,—head, thorax with 3 segments, and abdomen with 9 segments. The postabdomen is terminated by short cerci. It is more probable that this form is the larva of a megalopteron- or neuropteron-like insect.

Lias.—Of good species there are 266 in 145 genera. In addition there are 149 poor species. Nearly all these are dwarf forms found chiefly in Switzerland, Mecklenburg, and England. There are as yet no butterflies and but few Hymenoptera, while the caddice-flies and scorpion-flies were abundantly represented. There were also dragon-flies, bugs, small cicadas, grasshoppers, locusts, and cockroaches. C. S.

7. *Geology and Coal Resources of the Cape Lisburne Region, Alaska;* by ARTHUR J. COLLIER. Bull. No. 278, U. S. Geol. Surv., 1906, 54 pp., 9 pls.—This bulletin is especially interesting in establishing the fact that workable coals of Lower Carboniferous (Mississippian) and of Upper Jurassic age occur in this far northern region. The Paleozoic coals are noncoking semibituminous in beds up to four feet of clean coal. These are at the bottom of the section, and the plants indicate a Lower Mississippian age "slightly younger than the Ursa flora." Above is a great series of marine beds with many corals, also indicating Mississippian age. The Upper Jurassic section is very thick, not less than 15,000 feet, in which the author notes 39 coal beds varying in thickness from a few inches to 30 feet. The total thickness of all the coals is 137 feet. They are of low grade, but better than average lignite, and are noncoking. The flora indicates Upper Jurassic age "not younger than the Wealden." C. S.

8. *Die Trochilisken;* von A. KARPINSKY. Mem. Comité Géol. St. Petersbourg, new ser., liv. 27, 1906, 166 pp., 3 pls.—Under this little-known term, first used by Pander, are described and discussed with great care those minute Devonian fossils known in America as *Calcisphæra*, *Mœllerina*, and in part as *Saccamina*. Their nature is as uncertain as their names, since authors have regarded them as calcareous algæ, Foraminifera, and the eggs of armored fishes. All occur in marine or brackish-water deposits. Karpinsky recognizes two genera,—*Sycidium* (3

species) restricted to Europe, and *Trochiliscus* (syn. *Calcisphæra* in part and *Mœllerina*), with 3 or more species, common to Russia and North America.

"Compared with known organic remains, the Trochilisks agree best with the Characeæ and especially with the calcareous covering of the spore buds (oogonia). They can not, however, be united with any living or extinct genus of Characeæ, nor can they be regarded as ancestral to living forms, but appear to represent an extinct side branch of that old and peculiar group of plants the Charophyta; this completely isolated type of plants was differentiated not later than Jurassic time" (pp. 87, 88). C. S.

9. *Echinoderma;* by Miss M. GRANT. Zool. Record, xlii, 1905, January, 1907, 92 pp.—This very useful record of the Echinoderma literature prepared in previous years by Dr. Bather is here continued by Miss Grant. As the Zoological Record is to be amalgamated with the International Catalogue, future lists will be looked for in the last-named publication. The Echinoderma literature here catalogued embraces 381 papers. C. S.

10. *Revision der Ostbaltischen Silurischen Trilobiten;* von FR. SCHMIDT. Mem. de l'Acad. Imp. Sci. de St. Petersburg, viii ser., Vol. XIX, No. 10, November, 1906, 62 pp., 8 pls.—This part closes Akademiker Schmidt's extensive revision of the East-Baltic trilobites. The next and final number will give a summary of the results attained, including corrections and additions. It will appear toward the close of 1907.

Here are described *Megalaspis* and its 24 forms occurring in the lower half of the Ordovician, 9 of which also occur in Sweden or Norway. A pygidium of *M. heros* is figured, having a length of $6\frac{1}{4}$ inches, indicating an animal about 18 inches long. The illustrations are good photographs of the specimens. C. S.

11. *A Contribution to the Genus Fusulina, with Notes on a Fusulina-Limestone from Korea;* by H. YABE. Jour. Coll. Sci., Imperial Univ., Tokyo, Japan, 1906, 36 pp., 3 pls.—This article in English treats of *Fusulina*, *Schwagerina*, *Doliolina*, and *Neoschwagerina* (new). *Sumatrina* Volz is regarded as a synonym of the last-named genus, here defined as new. If this is true, the matter will then stand the other way around, because of the law of priority. *Triticites* Girty is regarded as a probable synonym of *Fusulina*.

There is also given a review of the known species of these genera, with their distribution for all countries. C. S.

12. *Palaeontologia Universalis*, Fasc. II, ser. ii, May 1906.—This part contains sheets numbered 95–111, and gives the original description and figures, with additional remarks and illustrations by authors, of 17 species of Mollusca.

There is also a complete index to the first one hundred sheets of this publication. C. S.

13. *The Primary Septa of the Rugosa;* by J. E. DUERDEN, and *The Primary Septal Plan of the Rugosa;* by R. G. CARRUTHERS. Ann. Mag. Nat. Hist., Sept. and Nov., 1906, pp.

226-242, 306-363.—In this and other publications, Duerden maintains that the Paleozoic corals begin their calcareous structures with six primary septa, as in modern corals. The opinion generally held is that ancient corals begin with four primary septa, therefore the name Tetracoralla. This view of tetramerism has lately been reasserted by Gordon in this Journal (Feb., 1906). Carruthers shows that "the primary septal plan of these Rugose corals is hexamerous" and "that Gordon's careful observations are in no way inconsistent with the presence of a primary hexamerous plan in the Rugosa, but, on the contrary, support that view." Gordon maintains that in the Ordovician *Streptelasma* there are four primary septa, and that the presence of six in the Carboniferous *Lophophyllum* is due to accelerated development having pushed two secondary septa into the nepionic or brephic stage of growth. Carruthers shows that in Ordovician *Streptelasma* and Carboniferous *Cyathaxonia*, *Lophophyllum*, and *Zaphrentis*, they first develop a single septum, thus dividing the corallum into two halves; this he calls stage I. In stage II, these same corals develop two new septa, "one on each side of the 'main' end of the axial septum" and "eventually form the 'alar' primary septa of Kunth." This stage then has four septa, to which in stage III is added quickly another pair at "the opposite or 'counter' end of the axial septum," when the individuals may be said to have attained final brephic growth. The discussion is of the greatest importance and out of it will come a final classification of the Anthozoa. C. S.

14. *La Faune Marine du Trias Supérieur de Zacatecas;* par CARLOS BURCKHARDT. Boletin 21, Inst. Geol. de Mexico, 1905, 44 pp., 8 pls.—Until this bulletin appeared last summer, during the meetings of the Tenth International Congress, no marine Triassic strata were known in Mexico. Previously the record indicated terrestrial deposits with a flora of uppermost Triassic (Rhaetic) age. In the work under review are described 5 species of ammonites (*Sirenites*, *Protrachyceras*, *Clionites*, and *Anatomites*) and 21 species of *Palaeoneilo*. Elsewhere Frech has described a new genus, *Cassianella*, of this fauna.

On the basis of the ammonites, the author, James Perrin Smith, and Ed. von Mojsisovics have correlated the fauna of Zacatecas with the Upper Triassic (Carnian) of California and the Julian stage of the Austrian Alps. *Sirenites smithi* is closely related to *S. lawsoni* of California, while the genera *Clionites* and *Anatomites* have allied species in the same state. The forms of *Palaeoneilo* remind one of the American Devonian and basal Mississippian, but no particular importance can be ascribed to these bivalves, because the same genus is also reported in the Alpine Triassic and in the Upper Jurassic of Russia. The other Paleozoic reminder, one of the Aviculidae described by Frech as *Cassianella*, also occurs in the region about San Cassiano of the Tyrolese Alps.

This Mexican marine Upper Triassic invasion is a shallow-water invasion of short duration, for during Lower and Middle Jurassic times Mexico appears to have been land. This fact may explain the very isolated occurrence of the Triassic fauna as a preserved remnant of a wide removal during the land interval. Over it repose marine strata of Upper Jurassic age, and from that time to the close of the Mesozoic, Mexico was apparently continuously beneath the sea. C. S.

15. *La Faune Jurassique de Mazapil;* par CARLOS BURCKHARDT. Boletin 23, Inst. Geol. de Mexico, 1906, 192 pp., 43 pls. —This work should be studied in connection with *Géologie de la Sierra del Mazapil et Santa Rosa;* by CARLOS BURCKHARDT. Guide Géol. au Mexique, Tenth Internat. Geol. Congress, 1906, pt. xxvi.

In this handsome and welcome quarto volume are described 85 (45 new) species of ammonites in 16 genera (*Idoceras* new). Of these, 7 are definitely identified with central European forms (*Opellia flexuosa costata*, *Aspidoceras contemporaneum*, *A. bispinosum*, *Idoceras laxevolutum*, *I. balderum*, *Haploceras filiar*, *Phylloceras apenninicum*), 1 with the boreal fauna of Russia (*Perisphinctes nikitini*), 2 with India (at Spiti, *Aspidoceras avellanoides*, *Haploceras ordonezi*), and 1 in the Cordilleras of Argentina (*Aspidoceras cyclotum*). There are likewise 14 species more or less closely related to forms from other regions. Of these, 11 go with central European regions and 3 with Argentina.

The Upper Jurassic strata of the Santa Rosa and Caja Mountains about Mazapil in the State of Zacatecas are well developed. These are divided into two main groups correlated with the Kimmeridgian and Portlandian of Europe. The former is again divided into four zones,—shales with *Waagenia*, zone of *Haploceras filiar*, zone of *Aucella pallasi mexicana*, and basal zone of *Idoceras*, while the Portlandian is divisible into three zones,—whitish calcareous shales with *Hoplites* of the group Calisto, gray phosphatic limestones, and red phosphatic limestones with *Aspidoceras cyclotum* and *Perisphinctes* cfr. *danubiensis*. The thickness of these strata appears not to exceed 260 feet.

The general aspect of the ammonites here described reminds one greatly of those of central Europe. This is seen not only in the species common to the regions on both sides of the Atlantic, but also in the identical succession of the faunas. In comparing the formations of Mazapil with those of southeastern France, the author states : "The analogy of the Mexican series with that of Europe is striking. In both cases, above the Lower Kimmeridgian there are deposits with a great development of *Haploceras filiar* and *Oppelia* of the group of *O. flexuosa*. In the two regions the remarkable genus *Waagenia* also appears in the higher beds, and these in turn are overlaid, in Mexico as well as in France, by the zone with *Oppelia lithographica* and by the Lower Portlandian" (178). The fact that the Mazapil ammonites also have affinities with those of the Cordilleras of Argentina is not thought to indicate a direct communication between this area and Mexico. C. S.

16. *La Fauna de Moluscos del Senoniano de Cardenas, San Luis Potosi;* por Emilio Böse. Boletin 24, Inst. Geol. de Mexico, 1906, 95 pp., 18 pls.—This quarto volume should be studied in connection with the pamphlet *De San Luis Potosi a Tampico;* by Emilio Böse. Guide Géol. au Mexique, Tenth Internat. Geol. Congress, 1906, pt. xxx.

In this work are described the Mollusca of the Cardenas series (Lower Senonian) of the Upper Cretaceous found near the edge of the Mexican plateau between Cardenas and Las Canoas, on the railroad from San Luis Potosi to Tampico. Of species there are 41 (27 new); *Plesioptygmatis* is the only new subgenus.

The Cardenas limestone series reposes on other limestones with *Rudistes*, referred to the Turonian or middle Cretaceous portion of the Upper Cretaceous. It has an approximate thickness of 1800 feet and is divisible into three formations yielding the following fossils: Beginning at the base are the Gryphaea beds with *Gryphaea vesicularis*, *Exogyra costata*, and *Ostrea aguilerae.* These are followed by the Orbitoides limestones having also *Ostrea* cfr. *goldfussi*, *Inoceramus* cfr. *cripsii*, and corals. The upper member is the Coralliochama limestone with *C. boehmi*, *Radiolites austinensis*, *Biradiolites* (3 species), *Exogyra costata*, *Ostrea glabra* and 3 other species, *Anomia argentaria*, *A. gryphorhynchus Lima* (2 species), and gastropods of the genera *Natica* (1 species), *Turritella* (3), *Nerinea* (1), *Cerithium* (4), *Actaeonella* (10), and banks of corals.

"Our fauna is apparently isolated among the Cretaceous deposits of America. As American elements we do not find more than *Inoceramus* cfr. *simpsoni*, *Anomia argentaria*, *A. gryphorhynchus*, *Ostrea glabra*, *Exogyra costata* and the genus *Coralliochama*."

"From the foregoing we see that probably the fauna of the lower division of the Blue Mountain Series [Jamaica] represents one similar to ours; but the necessary paleontological proofs are wanting; only a careful study of the fauna can solve the problem.

"Our fauna is in intimate relation with those of Europe and especially with those having the mediterranean facies [as those of Gosau], but to it have been added some types of the fauna of the North. As already stated, however, our faunas are not always identical with those of Europe, but generally they are somewhat distinct in character; there must have been a relatively rapid migration from Europe to America, and as all our species lived near the coast this migration should have been effected largely by means of a continent or a series of islands instead of the present Atlantic; perhaps a study of the fauna of Jamaica will demonstrate later that that place was one of the stations on the road over which the animals came."

"In Europe the Gosau strata represent a mediterranean facies and are notably distinguished in their paleontological character from the Senonian of the North of Europe. In America we observe a surprising analogous circumstance. We have known for some time that the Cenomanian strata of Mexico and Texas represent a mediterranean facies, but the Senonian also represents an analogous facies in Mexico (and Jamaica ?). In northern United States, that is to say, in New Jersey, is found, according to Credner, a facies of the Senonian which corresponds closely with that of the northern part of Europe; on the other hand, the fauna described represents in this work a facies which corresponds fairly well with that of Gosau, in the way that the facies of the Senonian of northern America corresponds with that of the north of Europe." C. S.

17. *An almost complete specimen of Strenuella strenua* (*Billings*); addendum by H. W. SHIMER (communicated).—A peculiar oversight prevented the author of the article in the March number (p. 199) from seeing Shaler and Foerste's figures of this species under the name of *Ptychoparia mucronatus* S. and F. in Bull. Mus. Comp. Zool., xvi, pl. 2. They here give four figures,—a thorax of 13 segments minus the pygidium, attached to a partial, unidentifiable cephalon, two cephala without free cheeks, and a free cheek. The thorax shows a median row of mucronate tubercles. The free cheek figured as belonging to this species has a much longer genal spine than the present specimen. The latter (xxiii, p. 200), which shows very closely the relationship of the different parts, has no tubercles upon the first and last segments, which alone preserve this portion unbroken. The relation of the plural to the axial segments is similar in each. It thus appears that *S. strenua* is quite variable in the shape of the free cheeks and in the ornamentation of the axis.

18. *Black Sands of the Pacific Slope in 1905*; by DAVID T. DAY and R. H. RICHARDS. Pp. 84. Advance chapter from Mineral Resources of the United States for 1905. The call sent out in March, 1905, by the U. S. Geological Survey to placer miners at different points in this country, alluded to in an earlier number of this Journal (xx, 410), has now resulted in the bringing together of a large amount of material, the discussion of which is given very thoroughly in this pamphlet. The examination of the samples received has shown that the following minerals, in the order named, are most commonly found in these sands: Magnetite, gold, ilmenite, garnet, zircon, hematite, chromite, platinum, iridosmium, mercury, amalgam, olivine, and iron silicates, pyrite, monazite, copper, cinnabar, cassiterite, and corundum. Other heavy minerals are only exceptionally found.

With respect to the occurrence of *platinum*, information with regard to which was the primary object of the undertaking, the following statement is made; "Platinum was found in 120 localities. The investigation showed that the largest field of platinum, and the most profitable field for commercial exploitation, is comprised in Coos, Jackson, Curry, and Josephine counties, Oregon, and in Del Norte, Siskiyou, Humboldt, and Trinity counties, California. Outside of this region platinum is also found to a notable extent in Plumas and Butte counties, Cal., and, although the proportion of platinum per cubic yard of gravel is not so great, the large dredging operations in Butte County make this an important locality. Platinum was also found occasionally on the Snake and the Columbia rivers and on various beaches of the Washington coast. It was found in place in chromite near Anacortes, Wash., as well as at the previously known locality, the Rambler mine, in Albany County, Wyoming."

It has also been found that magnetite is a prominent constituent of the black sands of the Pacific slope, constituting a greater supply of useful iron ore than that from any other available source in that region. This magnetite usually contains from 5 to 10 per cent of titanium, but this offered no obstacle to the production of high-grade cast iron in the electric furnace, and in a modification of this electric furnace the cast iron could even be decarburized to a very soft iron of high quality.

By the use of careful concentration methods it has further proved possible to separate gold and platinum from the sands with comparative ease, while a partial separation of various other minerals can be made at the same time, so as to render available for the market at low cost: monazite, zircon, ilmenite, chromite, garnet, and cassiterite. This pamphlet gives a detailed statement in regard to the samples from the many different localities represented, and also an account of the various methods by which they have been examined.

19. *Mineralogia Groenlandica;* af O. B. Böggild. Saertryk af Meddelelser om Grönland, xxxii. Pp. xix, 625, with one colored map, and 117 figures. Copenhagen, 1905 (Bianco Luno).—Greenland has proved to be a most interesting source of minerals from the time of the investigations of Giesecke, one hundred years ago (1806–1813), to the present. Recent investigations, particularly those with which the names of Steenstrup, Johnstrup, Flink, Ussing, and of the author of the present work are closely connected, have served to bring to light a wonderful series of new species and interesting occurrences, especially on the southwest coast at Kangerdluarsuk and Narsarsuk, near Julianehaab. The cryolite locality at Ivigtut and the region about Disco, with its remarkable supply of telluric iron, have also furnished much that is new and important. Dr. Böggild has now brought together all the information that has been developed in regard to these and other localities, and has presented it in a concise and systematic form in the present handbook. It will serve, therefore, as a very convenient source of information in regard to some of the very interesting mineral occurrences that are known. The species are arranged after Groth's tables, and the occurrences of each of the localities are given with admirable fullness.

The closing chapters of the work are devoted to a geographical list of all the Greenland localities, followed by an alphabetical index. There is also a map, which is important for those who are not minutely acquainted with the geography of the country. The preface, by N. V. Ussing, is in English, as is also the short summary of contents with which the work closes.

III. Miscellaneous Scientific Intelligence.

1. *British Museum Publications.* — The following important works have recently been received :

The History of the Collections contained in the Natural History Departments of the British Museum. Vol. II. Separate Historical Accounts of the Several Collections included in the Department of Zoology. Pp. 782.—This history of the zoological collections of the British Museum contains much that is of more than a local interest. There are eleven chapters, prepared by separate authors. Of these that by R. Bowlder Sharpe on the Birds is much the longest (pp. 79–516), for this department was one to which attention was given very early. Unfortunately many of the older specimens known to have been in the Museum no longer survive.

Catalogue of the Madreporian Corals in the British Museum (Natural History). Volume VI. The Family Poritidæ. II. The Genus Porites. Part II. Porites of the Atlantic and West Indies, with the European Fossil Forms. The Genus Goniopora, a Supplement to Volume IV. By Henry M. Bernard. Pp. vi, 173, with 17 plates.—The fifth volume of this work (see v. xxi, 474) was given to the Poritids of the Indo-Pacific region. The present volume goes on with the account of the genus embracing the forms so far known living in the North and South Atlantic, in the West Indies and the Gulf of Mexico, also fossil forms from the Paris and Mediterranean Basins.

A Synonymic Catalogue of Orthoptera ; by W. F. Kirby. Volume II. Orthoptera Saltatoria. Part I, Achetidæ et Phasgonuridæ. Pp. viii, 562.—The first volume of Dr. Kirby's Catalogue of the Orthoptera was issued in 1904 (see v. xix, 332). The present volume includes the Crickets and Long-horned Grasshoppers ; the Locustidæ, or the Short-horned Grasshoppers, will form the third and concluding volume.

Catalogue of the Lepidoptera Phalænæ in the British Museum. Volume VI. Catalogue of the Noctuidæ in the Collection of the British Museum ; by Sir George F. Hampson. Pp. xiv, 532. Plates xcvi–cvii.—This sixth volume of the Catalogue of Moths (see v. xix, 472) is devoted to the Cucullianæ, the third of the fifteen subfamilies; 692 species belonging to 111 genera are described.

2. *Report of the Surveyor to the Governor of the Territory of Hawaii for the Eighteen Months ending December 31, 1906.*—This report of the Surveyor, Mr. Walter E. Wall, to Governor G. R. Carter, closes with the following paragraph, emphasizing the need of a geological survey to which the general Government should well give liberal support.

" As to the survey needs of the Territory which this office has not the force to meet, a geological survey which would include a study of the water resources of the country appears most important. The richest soils of the country are in general the driest ones, and while private enterprise has done and is doing much to develop water resources and has reduced to cultivation much of this dry land, a more comprehensive study of the matter is needed. Waters are still running to waste that are needed for power and irrigation; tunnelling has developed considerable water and might develop much more with the help of better geological information; the conservation of storm waters is still in its infancy. While the Survey Department is not equipped for the study of this matter, it is in a position to coöperate with and assist any survey, Federal or Territorial, that might be intrusted with this important work."

3. *The Bureau of Science, Manila.*—The Fifth Annual Report by Dr. PAUL C. FREER of the Philippine Bureau of Science for the year ending August 1, 1906, has recently been issued. It will be remembered (see xxi, 336) that the Bureau in its present form has resulted from the merging of the Bureau of Mines with that of Government Laboratories, which took place at the close of 1905. This arrangement gives a wide scope to the work done by the Department, and a summary of this is given in the present paper. In its systematic work the Bureau aims to investigate the distribution and nature of the fauna and flora, and also the geologic and petrographic resources of the islands. There are, further, divisions of biology, of chemistry, and of serums and prophylactics, in all of which much useful work has been done. The division of Mines is immediately engaged in the investigation of the coal areas, which promise in the future to satisfy the local needs of the islands and make them independent of the present Japanese supply. The occurrence of asbestus deposits of considerable magnitude is also alluded to. The Philippine *Journal of Science* has now completed its first year, more than fulfilling the promises made at its start. In consequence of the widely diverse character of the papers included, the advisability is suggested of publishing in three independent sections, one for biological work connected with tropical diseases, a second for general scientific papers, and a third for systematic botany and botanical subjects.

4. *Bulletin of the Imperial Earthquake Investigation Committee.* Volume I, No. 1. Pp. 51, with 15 plates. Tokyo, 1907. —The Japanese Earthquake Investigation Committee has recently inaugurated the publication of a Bulletin which is to serve as a quick method of presenting short notes and preliminary reports on subjects which should be given to the public without delay. The present number, the first of the series, contains six papers by Dr. F. Omori. One of these deals with the time of the occurrence at the origin of a distant earthquake, another with the methods of calculating the velocity of propagation of earthquakes, and two others are given to the San Francisco earthquake of April, 1906; the first discussing its cause, and the second the seismographic observations.

The Commission also continues the publications which are devoted to papers of greater length and detail. Recent issues include No. 22 B, Art. 1–3, pp. 1–50, and Art. 4, pp. 51–74. The last named, by K. Honda and T. Terada, is on the Geyser of Atami, Japan, whose periodic eruptions exhibit some remarkable features for which an explanation is offered.

5. *Field, Laboratory, and Library Manual in Physical Geography;* by C. T. WRIGHT. Pp. xii and 178, with 46 figures. 1906 (Ginn & Co., New York and Boston).—A distinct feature of this very practicable book by a High School teacher of Physical Geography is its three-fold division into "Library Manual", "Field and Laboratory Manual" and "Note Book". The Library Manual includes lists of text-books and reference books and a category of special terms to which the references relate. It is noteworthy that the lists of references as distinct from the lists of texts includes a commendably large proportion of books which emphasize the scenic phases of the subject in addition to the strictly scientific. The scenic aspects of Physical Geography are too often overlooked at the expense of interest and influence in the later relations of the student.

The second division of this manual does not rely throughout upon meagre cross-section exercises on topographic maps, the mainstay of more than one recent manual, but includes serious exercises on evaporation and condensation in relation to rainfall, winds and temperature in relation to zones of climate, the apparent motions of the sun in relation to latitude, and geologic processes as factors in the evolution of topographic forms.

The ontographic section on plants, animals, and man, although not Physical Geography, is suggestive, and is desirable inasmuch as many students do not continue academic studies beyond the High School and are never otherwise brought into contact with this interesting aspect of Geography. I. B.

6. *Symposium on Water Supplies in Michigan.* Reprinted from the Eighth Annual Report of the Michigan Academy of Science; by FRANK LEVERETT, VICTOR C. VAUGHAN, G. S. WILLIAMS, M. O. LEIGHTON, and ISRAEL C. RUSSELL. Pp. 99-136, 1906.—This paper includes a discussion of the geological conditions governing the occurrence of the water supply of Michigan, the pollution and purification of municipal supplies and ideals concerning them. Numerous data of general interest to geologists are presented in compact form in the first section by Frank Leverett, with reference to the chemical composition of the lake waters and the water of streams, lakes and ponds, as well as that from underground sources. In the last section, "Ideals concerning Municipal Water Supplies", Prof. Russell presents some interesting theoretical considerations on the whole subject of water supply. I. B.

7. *Astronomical Observatory of Harvard College,* EDWARD C. PICKERING, Director.—Recent publications from the Harvard College Observatory are included in the following list (see v. xxii, 75):

ANNALS. Volume LII, Part I. Eclipses of Jupiter's Satellites 1878–1903. Pp. 148, with 13 tables. Volume LV, Part I. Second Catalogue of Variable Stars; by ANNIE J. CANNON under the direction of EDWARD C. PICKERING. Pp. 94, with 6 tables. Cambridge (1907).

Volume LX, No. III. Positions of Phoebe 1898–1904. Pp. 85, with 12 tables.

Appendix to Annals, LX, No 11. P. 1, with 1 table.

CIRCULARS. No. 119. Observations of Phoebe in August and September, 1906. P. 1, with 1 table.

No. 120. Thirty-one New Variable Stars. Pp. 4, with 4 tables.

No. 121. Novo Velorum. Pp. 2, with 1 table.

No. 122. Thirty-six New Variable Stars. Pp. 4 with 2 tables.

No. 123. Photographs of Faint Stars. Pp. 3.

No. 124. Stars having Peculiar Spectra. 18 New Variable Stars. Pp. 4, with 1 table.

8. *Publications of the Washburn Observatory of the University of Wisconsin.*—Part 3 of Volume x (pp. 1–106) has recently been issued. It is devoted to observations of double stars made in 1897–1906 by the Director, GEORGE C. COMSTOCK. These observations are in continuation of the series published in Part I of the same volume.

OBITUARY.

M. HENRI MOISSAN, Professor of General Chemistry at the Sorbonne, died at Paris on February 20 at the age of fifty-five years. He had accomplished much brilliant chemical work, notably in the isolation of fluorine and the study of its properties, also in high-temperature researches and the use of the electric furnace.

M. PIERRE EUGÈNE MARCELLIN BERTHELOT, the eminent French chemist, died in Paris on March 17 in his eightieth year.

Professor WILHELM VON BEZOLD, Director of the Prussian Meteorological Institute, died on February 17 in his seventieth year.

M. MARCEL BERTRAND, well known for his work on the geology of the French Alps and the origin of mountains, died on February 13.

Dr. NICOLAS SOKOLOV, Geologist in charge of the Russian Comité Géologique, and corresponding member of the Imperial Academy of Sciences at St. Petersburg, died on February 15.

Dr. JOHN KROM REES, Professor of Geodesy and Astronomy in Columbia University and Director of the Observatory since 1881, died on March 9 in his fifty-sixth year.

Professor HENRY DAVIS TODD, of the departments of Physics and Chemistry in the U. S. Naval Academy at Annapolis, died on March 8 at the age of sixty-nine years.

Mr. W. J. RHEES, keeper of archives of the Smithsonian Institution, died at Washington on March 18 in his seventy-sixth year. He had been connected with the Smithsonian since 1852.

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VOL. XXIII. MAY, 1907.

Established by BENJAMIN SILLIMAN in 1818.

THE AMERICAN JOURNAL OF SCIENCE.

FOURTH SERIES

VOL. XXIII—[WHOLE NUMBER, CLXXIII.]

No. 137—MAY, 1907.

NEW HAVEN, CONNECTICUT.

1907

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

Published monthly. Six dollars per year, in advance. $6.40 to countries in the Postal Union; $6.25 to Canada. Remittances should be made either by money orders, registered letters, or bank checks (preferably on New York banks).

THE

AMERICAN JOURNAL OF SCIENCE

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Art. XXX. — *Wave-cut Terraces in Keuka Valley, Older than the Recession Stage of Wisconsin Ice*; by Frank Carney.

The tracing of the shore phenomena of the high-level lakes which characterized the recession of the Wisconsin ice sheet in New York State, particularly by Fairchild,* is one of the most interesting and fascinating of the contributions to glacial geology. Other geologists have performed similar tasks here and elsewhere in the basin of the Great Lakes.† The post-Wisconsin deformation or tilting of these ancient beaches has attracted the attention of many investigators,‡ Dr. G. K. Gilbert having given the subject special study.§

So far as the writer is aware, however, no study has been given to the evidence of static water bodies that presumably

* H. L. Fairchild, this Journal, vol. vii, 1899, "Glacial Lakes Newberry, Warren and Dana in Central New York"; Bulletin Geological Soc. Am., vol. x, pp. 27-68, 1899; New York State Museum, 20th Rep. of the State Geologist, 1901, "The Iroquois Shore Line," pp. r106-r112.

† G. K. Gilbert, Geol. Survey of Ohio, Rep. of Progress, 1870, pp. 488–90; same, vol. i, 1873, pp. 549–555, 559–560, 569–570; Sixth Rep. of the Niagara Commission, pp. 61–84, 1890; T. C. Chamberlin, Geol. Survey of Wisconsin, vol. ii, pp. 219–229, 1877; J. W. Spencer, Bull. Geol. Soc. Am., vol. i, pp. 70-86, 1899; same, vol. ii, pp. 465–476, 1891; same, vol. iii, pp 488–492, 1892; A. C. Lawson, Geological and Natural History Surv. of Minnesota, 20th Annual Rep., pp. 230–289, 1891; F. B. Taylor, American Geologist, vol. xviii, pp. 108–120, 1896; Bull. Geol. Soc. Am., vol. viii, pp. 31–58, 1897; same, vol. ix, pp. 59–84, 1898; Frank Leverett, Monograph XLI, U. S. Geol. Survey, pp. 371–383, 1902.

‡ F. B. Taylor, American Geologist, vol. xiii, pp. 316–327, pp. 371–383, 1894; J. W. Spencer, this Journal, xli, pp. 201–211, 1891; G. K. Gilbert, Smithsonian Report, 1890, pp. 236–244. (For more extended bibliographies under footnotes, see R. S. Tarr, Physical Geog. of New York State, pp. 240–265, 1902.)

§ G. K. Gilbert, 18th Ann. Rep., U. S. Geol. Surv., 1898, pp. 595–647.

existed in this region in front of the advancing Wisconsin ice, nor to those which on *a priori* grounds probably existed in connection with both the retreat and advance of preceding ice-sheets. There is very slight reason for thinking that the topographic relations of the lowland area north from the Niagara escarpment and the Allegheny plateau section of central and western New York have changed much since the beginning of the Pleistocene period. Such being the case, then the duration of the pre-Wisconsin ice-dammed lakes determined the emphasis of the shore phenomena attained. Existing evidence of these old shore lines must, in most cases, stand for sharp initial development, as the vigorous Wisconsin ice with its great amount of debris tended to obliterate such minor details of pre-Wisconsin topography.

Landwarping.

Geologists early recognized the proof of instability in the altitude of land areas. It was further recognized that the range of vertical variation is not constant for any great horizontal distance. The Great Lakes area has already been shown to be rich in the evidence of such deformations.

That the oscillations in the altitude of northeastern North America incident to the late Wisconsin* stage and the succeeding stage of the Hochelagan formation† represent the entire range of such variations during the Pleistocene period is not necessarily true. With marine fossils in clays and sandy clays 540 to 560 feet above present sea-level,‡ and stream-cut channels at least 630 feet below present sea-level,§ we have an interval of altitude that probably dates from the earliest ice-epoch or even earlier. The surprising erosion in the Seneca Lake Valley at Watkins, N. Y., reported by Tarr, has increased significance when connected with the deductions made by Fairchild concerning the ancient valley that leads into the Sodus Bay arm of Lake Ontario.‖ These deeply buried valleys far inland, and mature but riverless valleys seaward, suggest landwarping of like nature, but of far greater antiquity than that proved in the investigations of the Iroquois beach.

The Alteration of Shore Lines by Later Ice-Invasions.

Partial or complete effacement of the constructional and destructional products of wave and current work in these pre-

* DeGeer. Proc. Boston Soc. Nat. Hist., vol. xxv, pp. 454–477, 1892.

† J. B. Woodworth, New York State Museum, Bulletin 84, p. 204, 1905.

‡ J. B. Woodworth, ibid., pp. 215–216, 1905; ibid., Bulletin 83, pp. 46–50. 1905.

§ R. S. Tarr, American Geologist, vol. xxxiii, p. 277, 1904. Professor Tarr reports a well boring at Watkins, N. Y., 1080 feet deep without reaching rock.

‖ Bulletin Geol. Soc. Am., vol. xvi, pp. 70–71, 1905.

Wisconsin ice-dammed lakes would be expected. The sweep of an ice-invasion, followed by the destructional work of the slowly falling bodies of water marking the period of ice-recession, would necessarily modify, remove or cover such features as terraces in unconsolidated materials, as bars, spits, cusps, etc.; whereas the cliffs and terraces in rock would be much less altered.

The potency of ice as a factor in erosion does not make an identical appeal to all observers; this is when the sculpturing

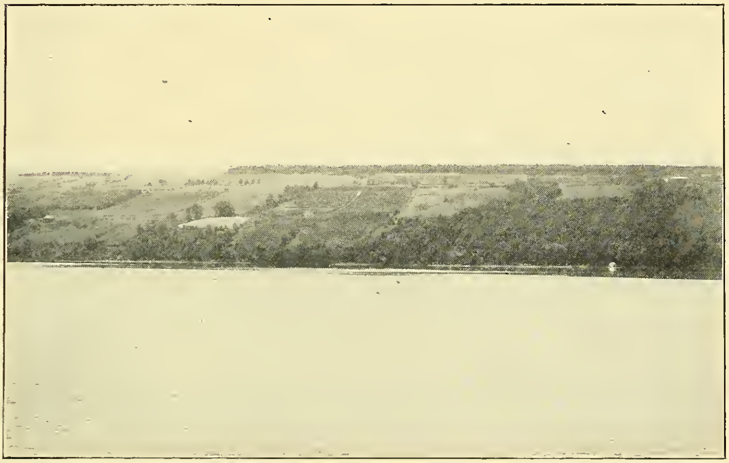

Fig. 1. View just north of Dunning's landing. Terraces No. 2 and No. 3 show here. The steepened slope nearest the lake may represent the lowest terrace altered by ice-erosion.

of bed-rock is under consideration. So it is possible that all will consent to the general, though not complete, removal by erosion of the constructional products of lake waves and currents. As a matter of field study, however, it may as well be granted that these constructional forms have been entirely obliterated; the differentiation of a bar, or delta belonging to some pre-Wisconsin lake, from the water-laid portions of glacial drift would require an environment unusually free of other deposits. But we must grant that cliffs and terraces formed in rock would be less affected by glacial erosion.

The extent to which these cliffs might be modified by erosion would depend upon their topographic relations. Ice abrasion is more effective on the slopes opposed to ice motion; it is more effective also along the lower contours of the walls of the valleys trending with the direction of the moving ice. Hence in a series of terraces along a valley wall, the lowest one would be the most modified by glacier ice.

The beach structures of these former lakes have suffered further from wave work of more recent water bodies, especially of the high-level lakes. The degree of effacement through this agency depends upon the coincidence of the surface-planes of the two bodies of water, or upon their approximation to coincidence; if these planes intersected at a very slight angle, the vertical range of beach agents would at least partially overlap for a considerable horizontal distance; if the planes were actually coincident, then the extent of the defacement would depend largely upon the relative duration of the two bodies of water.

Probably the most effective agency in the obliteration of these shore structures is the deposit of drift made by an ice sheet. Within the belts of thickened drift the burial must be quite complete, the chances of survival being greater with the higher beaches. But at all levels the mantle of ground moraine would in any event partially cover the weaker expressions of wave and current work. And even the pronounced cliffs and terraces might be covered in places.

Furthermore, normal subaerial weathering has tended to render less obvious such remnants of these old beaches as have survived the factors above described; the least changed would be the forms cut in the more resistent rocks.

Forms which Simulate Wave-cut Terraces.

1. Variation in the texture of rocks is manifest in differential weathering;* sharp slopes simulating cliffs may be thus produced. The resemblance, however, leads to confusion only when the plane of the lake surface coincides with, or is parallel to and vertically within a few feet of the hard layer or horizon of rock which marks the bench; such a ledge, in the absence of a terrace or other evidence of a beach, cannot be defined finally as a wave-cut cliff. The attitude of a bench resulting from weathering, in reference to the horizon, depends upon the dip and strike of the hard layers; because of this fact, it is not difficult to distinguish the wave-cut cliff, except when the bench is discontinuous, showing only in short segments, a condition not unusual in the coarse sandstone horizons because of the horizontal variations in texture.

2. Streams held against a slope, or against a rock salient, by ice, often form a bench somewhat simulating a wave-cut terrace and cliff.† Such benches have been investigated by Fair-

* T. L. Watson, N. Y. State Mus., 51st Ann. Rep., vol. i, p. r76, 1897.
† G. K, Gilbert, Bulletin Geol. Soc. Am., vol. viii, p. 285, 1897.

child,* who shows how the banks of glacial drainage streams differ from the wave-cut cliff.† The latter is not so localized as the former, nor, in general, so marked in development.

Considerable effort was devoted to explaining the terraces in question as the result of differential weathering. The other explanation, ice-stream work, was easily eliminated. The third interpretation discussed in this paper suggested itself after it became apparent that neither of the other two was pertinent.

Stratigraphy of Bluff Point.‡

The succession of formations as given in Bulletin 101 of the N. Y. State Museum (which appeared after the close of the

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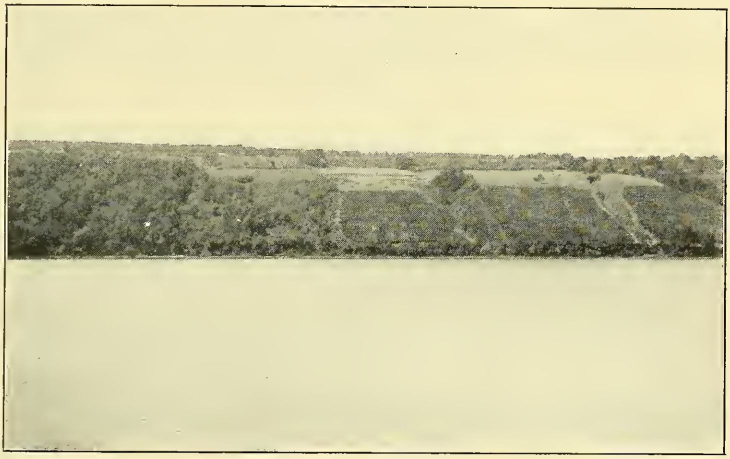

FIG. 2. View of west shore of Penn Yan branch about two miles north of Dunning's landing. Shows terrace No. 2, and what is apparently the lowest terrace altered probably by ice-erosion.

field season during which this study of wave-cut terraces was prosecuted), a report prepared by Luther, has been used by the writer in checking up his field notes on the stratigraphy of the area involved; these notes concern only the lithological aspect of the formations exposed, and since the slopes of Bluff Point are rather sharp, the rock section is almost complete.

The compact sandstone layer, referred to by Clarke and Luther, about 125 feet above the base of the Cashaqua as revealed in the Naples region,§ appears near Keuka Park and

* N. Y. State Mus., 22d Rep. of State Geologist, pp. r23–r30, 1902.
† Ibid., 21st Rep. of State Geologist, pp. r33–r35, 1901.
‡ The Penn Yan Quadrangle will serve as an index map for this region.
§ N. Y. State Mus., Bulletin 63, p. 31, 1904.

persists southward about one and one-half miles; much of this distance it forms a prominent bench.

The next formation that might include beds for registering differential weathering effects is the Hatch shales and flags, which attain a thickness of about 300 feet.* Along the slopes of Bluff Point the sandy layers of this formation, though irregular in both horizontal and vertical distribution, are conspicuous. The greatest thickness of shale noted in any exposure is about 12 feet; the base of this horizon is 261 feet (corrected aneroid reading) above lake-level; it could not be demonstrated that this horizon of shale had much horizontal extension. Likewise the arenaceous layers, the heaviest noted being under 2 feet, do not persist horizontally.

Next in rising section is the Grimes sandstone, estimated by Luther to be 75 feet thick.† This formation is above the terraces in question, so its characteristics do not concern us.

It appears, therefore, that there is no factor in the stratigraphy of this area to account for the marked benches. No conditions could be more favorable for registering the differential effects of weathering than the topography formed by this peninsula of rock dividing the two arms of Keuka Lake.

Cliffs in Keuka Valley.

The succession of post-Wisconsin high level lakes that formerly occupied this region has been worked out by Fairchild. He designates the overflow channels of the principal stages, correlates the deltas, and points out some localities of wave-work.‡

The terraces and cliffs which occasion the present paper have been studied in some detail along the flanks of Bluff Point. Terraces apparently of the same age have been noted elsewhere on the walls of Keuka valley, but have not been critically examined.

The most obvious reason for not associating these cliffs and terraces with the work already done is the fact that they are overlain and intersected by lines of Wisconsin drift. This drift is in place, and so far as observed, shows no evidence of wave-work along the planes of the terraces in question; furthermore, the drift is particularly well developed where it crosses the terraces (fig. 3).

These terraces, designated by numerals, are described in regular order ascending from present lake-level:

No. 1. This is not a clear case. For some distance south-

* D. D. Luther. N. Y. State Mus., Bulletin 101, p. 47, 1906.

† Ibid., p. 49, 1906.

‡ This Journal, vol. vii, pp. 255–56, 258. 1899; Bulletin Geol. Soc. Am., vol. x, pp. 4–41, 1899.

ward from Keuka Park is a bench and terrace; the relation here is conspicuous enough, but the cliff consists of the hard beds in the Cashaqua already alluded to; it stands about 70 feet above the lake, but descends southward. There is, however, a persistent suggestion of a bench southward to vicinity of Dunning's, not a continuous shoulder, but a recurrence of over-steepened short slopes forming a plane that ultimately dips beneath the water. That the intervals of these benches are connected genetically with the more continuous shoulder and terrace to the north is not established. Furthermore, the

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Fig. 3. Shows a lateral moraine which crosses the middle and highest terraces, and descends to lake level south of Ogoyago.

discontinuity southward of the better developed cliff is possibly due to the vigorous ice-erosion that altered the lower horizons of the walls of these longitudinal valleys.

No. 2. This bench and terrace first shows about two and one-half miles north of Dunning's Landing. It is remarkably continuous (figs. 1, 2), and generally sharp in development. At one locality towards the north, where the eastern slope of Bluff Point blends into the northern slope, the twelve foot horizon of shale, mentioned in preceding section, was noted; here the shale is nearer the top of the bench; not much importance, however, is attached to this vertical position, further than to note that it could have no genetic association with the bench. The original relationship of terrace and cliff, so far as analysis of a particular cross-section is concerned, has been given much indefiniteness by the agents of degradation; whereas this relationship is still conspicuous when viewed from a distance.

As a distinct feature of the slope, this terrace disappears where the valley wall becomes very steep towards the southern end of the Bluff. The till at the end of the Bluff is made up largely of local material; there is other evidence also of vigorous corrasive work by the glacier on the slopes near the end of Bluff Point.

No. 3. On the supposition that these terraces represent a body of water that fell successively to the levels indicated, terrace No. 3 is the oldest; but the difference in the degree of weathering attained, or in the sharpness of profile, is not noticeable. This terrace apparently does not extend as far north as No. 2; there is, however, some obscurity in this direction due to its disappearing beneath a wide band of drift. Furthermore its identification is not obvious quite as far south as Ogoyago; so terrace No. 3, in linear extent, falls short of the next lower terrace.

Time Periods of these Cliffs.

The measure of post-Pleistocene time has been attempted through several lines of observations: The years involved in the carving of the Niagara and other gorges, in the construction of flood plains, etc., have been estimated relatively to units which do not admit of very accurate determination because of the interdependence of degradational activities, a variation in any one of which would give the units quite different values. Time-ratios of the continuity of certain phases of geological activities are less objectionable.

From a study of the extent to which erosion has effected the several sheets of till, certain ratios have been deduced using the erosion period of the Late Wisconsin drift as a time-datum. The approximate value of this ratio, which may be subject to alteration through the acquirement of new facts, for the Early Wisconsin is 2; for the Iowan, 4; for the Illinoian, 8; for the Kansan, 16.* The drift of the Mississippi Basin has furnished most of the data concerning these epochs of glaciation. It has already been established that the glacial period in the East

* Chamberlin and Salisbury, Geology. vol. iii, pp. 413–421, 1906. Here is found a succinct presentation of the data on which are based the relative time-periods of the stages of the Glacial Period.

was also composite;* but a parallelism of epochs has not been worked out.

For the purposes of the present paper, however, it is assumed that the Lake Region of New York had been glaciated previous to the Late Wisconsin stage, an hypothesis already used by others;† and that the interval or intervals of deglaciation were not shorter than the time-ratios held tentatively for the Mississippian area.

Illustrations of the wave-cutting work done by some of the Finger Lakes since they were lowered to their present levels are common in geological literature.‡ One who is acquainted with Seneca Lake will recall the high cliff on the east shore near Watkins, at the head of the lake; and other localities along this lake show quite as marked wave-work. Along the present shore of Keuka Lake the cliffs are not so well developed, but benches of 20 feet or more are not uncommon.

If lakes occupied these longitudinal valleys during the interims of glaciation, cliff-cutting could have proceeded to such an extent as to make survival in certain localities, at least, probable. Even the shortest inter-glacial period, on the assumption that the stages of the ice age represent oscillations of the ice from continuously ice-covered dispersion areas, was much longer than post-Wisconsin time, which has sufficed for defining exact shore lines. But terrace No. 3 has an altitude that is impossible if the body of water with which it is genetically connected discharged over any of the present cols leading into the Susquehanna area; all of the overflow channels reported for the Keuka valley are too low. It may be said, however, that many of these interlocking valleys of the St. Lawrence-Susquehanna basins, through which the waters of the high-level ice-front lakes spilled, have local characteristics which are not normal to the regular development of valleys; the conditions here alluded to will be discussed in a separate paper, since the problem constitutes a unit of investigation. Nevertheless there is nothing incompatible between the altitude of terrace No. 3 and a land ice-locked basin for a body of water.

Deformation of these old Shore Lines.

From data supplied by Gilbert, it has been estimated that the post-Wisconsin deformation of the Iroquois shore line in

*R. D. Salisbury, Geol. Surv. of New Jersey, Ann. Rep. for 1893, pp. 73, etc.; J. B. Woodworth, N. Y. State Mus., Bulletin 48, pp. 618–670, 1901; F. Carney, Journal Geology, vol. xv, 1907.

†R. S. Tarr, American Geologist, vol. xxxiii, p. 284, 1904; H. L. Fairchild, Bulletin Geol. Soc. Am., vol. xvi, p. 66, 1905.

‡Natural Hist. of N. Y., Part IV, Geology, p. 192, 1843; R. S. Tarr, Elementary Geology, p. 279, 1898; LeConte, Elements of Geology, p. 236, 1905.

Cayuga valley is 2·7 feet per mile.* Fairchild measures the warp of the Dana beach in the Seneca valley at 3 feet per mile.† In reference to the shore phenomena with which we are concerned the latter beach is more pertinent in location, and slightly less dissimilar in age. The pre-Wisconsin shore lines embody whatever tilting is shown by the post-Wisconsin water-levels, plus any earlier deformation that remained uncorrected by later land movements.

The shore lines shown in figs. 1 and 2 have obviously a greater tilt than has been reported for the post-Wisconsin beaches. No instrumental measurements of the deformation have been made, though an attempt was made by a long series of aneroid readings, checked with a bench aneroid,‡ to approximate a degree of correctness; but the line of contact between cliff and terrace is so obscured by products of weathering and glacial drift that it is impossible to get any results from this method, although the line is distinct enough when viewed from a distance. It is apparent to the eye that the highest, and presumably the oldest, terrace is the most warped.

The existence of these wave-cut cliffs, older than the Late Wisconsin stage, and their present attitude in reference to the horizon, suggest a relation of factors that have a bearing on a phase in the drainage history of the St. Lawrence-Susquehanna divide region, and on the question of ice-erosion in the Finger Lake valleys. A reference to the drainage problem was made under the preceding section. The connection with the ice-erosion problem, briefly stated, is this: These old cliffs imply an ice-dammed lake that was not ephemeral; the topography admits such a lake only when the ice-front is nearby. With such a position for the ice west of the Seneca valley, both it and the Cayuga valley were occupied by lobes from the main body of ice. Such lobes, it has been suggested,§ would be competent to accomplish erosion; the non-existence of such lobes has been hypothecated on the absence of moraine belts, hence it is claimed that there was no erosion.‖ But since the stage of glaciation concerned antedated the Late Wisconsin which extended into Pennsylvania, the normal imbrication arrangement of drift sheets may explain the absence of the recessional moraine correlating with the ice-halt that was contemporaneous with the cliff-cutting and the over-steepening of

* R. S. Tarr, Journal Geology, vol. xii, pp. 79–80, 1904.

† Bulletin Geol. Soc. Am., vol. x, p. 68, 1899.

‡ In the Journal of Geology, vol. xiv, 1907, the writer explains this method of working aneroids in pairs.

§ H. L. Fairchild, Ice Erosion Theory a Fallacy. Bull. Geol. Soc. Am., vol. xvi, p. 58.

‖ Ibid., pp. 59–60.

the lower contours in the Seneca and Cayuga valleys by ice-erosion.

Summary.

The cliffs described in this paper are the product of wave-work since they show no connection with such variation in stratigraphical structure as often produce benches, and since it has been found impossible to account for them in any other manner; furthermore, the presence of a cliff-cutting body of water is attested indirectly by other phases in the drainage and ice-erosion history of the region. That these shore lines are older than the recession stage of the Wisconsin (Late) ice sheet, follows from their being overlain by intersecting bands of Wisconsin drift.

Art. XXXI.—*A Form of Outwash Drift;* by Frank Carney.

The triangular area indicated in fig. 1 encloses a formation of outwash drift in an association undescribed in the literature so far as the writer is aware. This drift forms a terrace in the gradual slope to the north, the decline being about 500 feet in three and one-half miles. Approaching the area along the highway from Bluff Point postoffice (v. Penn Yan Quadrangle, N. Y.), one notes the closeness of rock to the surface and the general absence of glacial drift. The slope, though gradual, is presumably the resultant of stream work, being the south wall of an old valley, and of ice-corrasion; but the marked change as one nears this triangle is due to an unusual accumulation of drift which is somewhat interlobate in origin; but the further differences between this and the typical outwash plain are so marked as to warrant a more definite description, and possibly a distinct designation.

Topography of the Region.

The drift under consideration lies on the north slope of Hall's peninsula,* designated on the Penn Yan quadrangle as Bluff Point, which attains an elevation of 700 feet above lake level. A nine-mile cross section, having a general east-west direction through the highest part of Bluff Point, resembles the letter "W", the inner legs being steepest but symmetrical to a vertical axis, while the left or west of the outer legs is the longer and has a gentler slope. The general relation of the two arms of Lake Keuka is strikingly suggestive of an originally south-flowing stream, the valley of which has been blocked by a great mass of glacial drift southwest of Hammondsport, a village at the southern end of this body of water, thus giving rise to the lake, which now has an outlet past Penn Yan into the Seneca valley. Obviously this cross-section, W-like in shape, is made at the junction of the old south-flowing river and a tributary.

The general topography of the Finger Lake region, so frequently alluded to in geological articles, is a systematic assemblage of trough-like valleys opening into the Ontario lowland. Presumably the bed rock of these troughs slopes northward, as do also the divides between them. The Penn Yan quadrangle extends almost to the edge of this Ontario lowland. The Drumlin region reaches its maximum southern extension north

*James Hall, Geology of the Fourth District, Natural History of N. Y., Part IV, p. 459, 1843.

of the Penn Yan sheet, and a few miles southwest of Geneva, which lies within the flaring walls of the Seneca valley.

Ice-Front and Drift as Affected by Topography.

The Ontario lobe, as the ice which occupied this lowland is designated, maintained along its southern margin, during the

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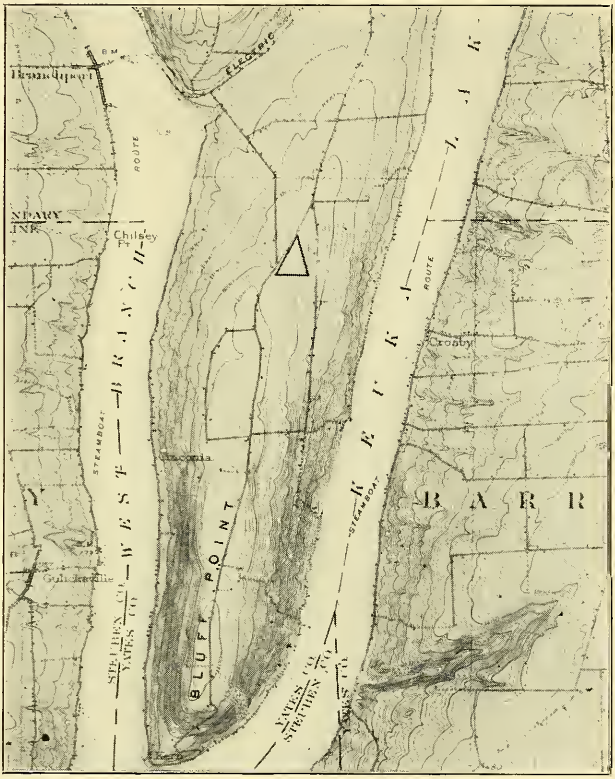


FIG. 1. A part of the Penn Yan (N. Y.) Quadrangle.

advance and retreat of the ice sheet, valley dependencies, the development of which was directly in proportion to the depth of the troughs above alluded to. Of these troughs those of the Seneca and Cayuga valleys are the deepest and therefore probably were occupied longest by tongue-like projections of ice. Contiguous to these troughs are upland valleys which were also occupied by ice showing more or less dependence upon the lobes lying in the Seneca and Cayuga valleys. But as the general border of the ice retreated, the divide ridges separating these trough-like valleys were revealed farther and farther to the north between the converging lines of ice; and in an analogous manner the lesser divides marking and forming the valleys contiguous to the Cayuga and Seneca troughs became reëntrant angles between converging walls of ice. It is the work of two such lesser valley dependencies that is supposed to have given rise to the peculiar drift accumulation with which we are concerned.

A study of the drift about Penn Yan reveals a massive accumulation of debris which begins southward a mile or so from Milo Center and continues a mile or more north of Penn Yan. This moraine, approximately three miles wide, suggests a very slow retreat of the ice in this region. It is evident also that this wide band of moraine represents more than the decay of the ice reaching out from the Ontario lobe into Seneca valley. It more likely is an indication of the general northwest trend of the ice-front crossing Flint, Naples, and Canandaigua valleys. When the ice stood with a reëntrant angle approximately at Milo Center, the Seneca tongue reached many miles southward towards Watkins, while the lesser lobe in the Keuka valley was shorter. A detail of this lesser lobe evidently would give two tongues of ice, one occupying each arm of Keuka lake, with the reëntrant angle along the north-south axis of Bluff Point, and the drift of our triangular area (fig. 1) in process of construction.

Along the margin of these valley lobes drift ridges, often widening into morainic areas, were being formed. The uniformity of such ridges as traced by Tarr on the Watkins quadrangle has suggested the characterization, "almost diagrammatic in their simplicity."* Each such moraine is indicative of stability in the reach of a valley lobe. Two contiguous valleys as those of Keuka and Seneca lakes would give us contemporaneously formed contouring moraines. The particular form assumed by the glacial debris at the angle of two such contiguous moraines will depend in the first place upon the northward slope of the divide; in the second place, upon the debris melted out of the ice at this particular point; and, in the third place, upon the amount of glacial drainage diverging at this point, carrying the material thus melted along the margin of the valley lobes.

From a study of these intertrough divides of the Finger Lake region, it is noted that their northward slope is gradual. The

*Bull. Geol. Soc. Am., vol. xvi, p. 218, 1905.

normal condition then of drift where the lateral moraines of two adjacent lobes unite reveals no special thickening. Where, however, the slope of the divide in question is steepened, and the ice immediately northward is perhaps more stagnant, or where it contains less debris, then we would anticipate a tendency toward the general removal of such debris, and the axis of the slope or divide would have less than the normal veneer of drift. On the other hand, when the axis of the northward slope is more in line with the general deployment of the ice, the chances for the accumulation of drift will certainly be enhanced. It should be noted that the northern part of the longitudinal axis of Bluff Point does trend to the east quite in unison with the direct deployment of ice from the Seneca lake lobe. This being the case then, we have the hypothetical conditions favorable to an assemblage of debris in the triangular area.

There is, however, still a further factor that favors accumulation of the drift, which is operative when the divide flattens immediately to the north, a topographic relationship due to the drainage history of the uplands or divide areas between these northward opening troughs. This fact taken in conjunction with the one just mentioned, that is, when the topography favors free movement from the major lobe, thus directing thitherward more active ice with this load of debris, will give us the conditions that account for the peculiar localization of the drift of the area under discussion.

Description of the Drift in Question.

A detailed study of this particular interlobate outwash material reveals the following facts: (1) the ice-contact face is not accentuated, that is, there is no cliff or terrace to suggest the speedy withdrawal of the ice from a position of long halt; (2) the northern part of the accumulation presents a subdued morainic surface; (3) rather numerous bowlders may be seen, some of which are the largest noted in the region. To the southward, however, this morainic topography gradually blends into a normal outwash slope. The control exercised by the falling contours of the rock slopes both east and west, is manifest in the expanding outwash when considered in connection with the moraine to which it belongs, and in the gradual falling contours of the outwash, i. e., this development of drift has something of a saddle form. Judged from the surface appearance—there is an absence of sections—the outwash material is entirely normal; there is a blending distally from coarser to finer sediments, with a few bumps suggestive of kame topography.

Proceeding southward from this area along the east slope of Bluff Point, one traces a very sharp lateral moraine marking the position of the valley tongue which occupied the Penn Yan arm of the lake contemporaneously with the building up of the outwash. This band of lateral moraine may be traced without a break until it disappears beneath the surface of the lake at a point a little south of Ogoyago. The counterpart of this band of drift on the eastern wall of the Penn Yan branch has not been traced continuously. It has been picked up, however, along the highway directly west of Warsaw, also to a point northeast of Crosby, and continuously traced where it makes the angle around the divide west of Himrods, blending then into marginal drift of the Seneca valley lobe.

But the moraine which marks the position of the valley dependency occupying the west branch of Keuka lake, at the time the outwash was developing, attained only faint expression. Its most pronounced development exists through the first mile and one-half southwest of the drift in question. From that point one cannot be certain of the outline of this valley dependency. Its form, as suggested by drift flanking the west wall of this branch of the lake, has not been investigated.

The Normal Outwash Plain.

Chamberlin cites* references to descriptions of the general type of "glacio-fluvial aprons," variously named by geologists from 1874-1893. But a precise summary of the terminology of the deposits made by glacial waters, together with accurate distinctions on genetic and topographic principles,† appeared in 1902 in Salisbury's Glacial Geology of New Jersey, from which we quote: "Where the subglacial streams did not occupy subglacial valleys, they did not always find valleys at hand when they issued from the ice. Under such circumstances, each heavily loaded stream coming out from beneath the ice tended to develop a plain of stratified material (a sort of alluvial fan), near its point of issue. Where several such streams came out from beneath the ice near one another for a considerable period of time, their several plains, or fans, were likely to become continuous by lateral growth. . . . . Thus arose the type of stratified drift variously known as overwash plains, outwash plains, morainic plains, and morainic aprons."‡

This definition of an outwash plain leaves no uncertainty: genetically it results where there is a lack of alignment between

*Glacial Phenomena of North America, in Geikie's "The Great Ice Age," footnote p. 751, 1894.

†Brief descriptions are also given in Chamberlin and Salisbury, Geology, vol. i, p. 306; vol. iii, p. 372, 1906.

‡Geological Survey of New Jersey, vol. v, pp. 128-9, 1902.

subglacial valleys and subglacial loaded streams; topographically these streams should flow out upon a plain where their individual fans may coalesce. It is also evident, as Salisbury states elsewhere, that the degree of development of this drift-form varies with the time the ice stands at a given halt.

Woodworth alludes* to a washed drift which confronts the terminal moraine on Long Island; this formation, as described, is a normal outwash plain.

In his description of the drift in southern Wisconsin, Alden† describes an "outwash apron" which constitutes a portion of the deposits in the interlobate angle between the Lake Michigan Glacier and the Delavan lobe; his usage of the term outwash elsewhere in the paper is also in accord with the standard of definition.

In applying this definition to the localization of drift referred to on the north slope of Bluff Point, we note the following facts: (1) the absence of an initial plain, (2) the probable absence of a strong subglacial stream, (3) a constancy in the position of adjacent ice-lobes which built up lateral moraines, (4) a synchronous accumulation of debris at the reëntrant ice-angle, (5) diverging slopes to the south that insured rather active drainage away from this angle, and (6) a single alluvial fan-like body of washed drift blending northward into moraine.

The normal outwash plain is an assemblage of such alluvial fan-like units. The drift in question is quite identical with an outwash plain in structure, but different from it in degree of development and in topographic environment; ignoring the latter discrepancy, we may say it is a very subdued form of outwash plain that represents a constant position of the ice at the junction of two rather small valley dependencies.

Since Bluff Point is a not uncommon type of topography in the Finger Lake region, and since the writer has mapped on the Moravia quadrangle similar deposits of drift, he suggests, as a designation for such deposits, the term *inter-lobule* (or inter-tongue) *fan*.

* N. Y. State Mus., Bulletin 84, p. 90, 1905.
† Professional Paper, No. 34, U. S. Geol. Surv., pp. 31-2, 1904.

Art. XXXII.—*Vapor Nucleation in the Lapse of Time*; by C. Barus.

1. *Nucleations depending upon $\delta p/p$.*—As contemplated in my last article,* I have since computed the nucleation of dust-free wet air in the lapse of time in terms of the relative drop $\delta p/p$, where $\delta p = p - p_1$, the difference between the atmospheric and the adiabatic pressure in the fog chamber after exhaustion. I have also taken advantage of new tables for the expression of nuclei per cubic centimeter in terms of the apertures of corresponding coronas, based on data since investigated. The nucleations to be compared in the lapse of time were all reduced to the fiducial values of the relative drop $\delta p/p = \cdot 345$, which is sufficiently near the region of ions for practice, and sufficiently large to insure moderate-sized coronas.

Omitting the tables, I will give the data for the vapor nucleation of the dust-free wet air in the fog chamber and the corresponding temperature in the accompanying graphs, the abscissas showing the running dates. The ordinates are averaged in groups of from two to four successive days, as in the last paper. It is in this presentation that the issue of greatest moment will appear, for the nucleations in their narrower variations (from hour to hour) are similar to those already shown (l. c.). The data for $n_{\cdot 345}$ have been corrected for the effect of temperature, t, on the amount of water precipitated, by taking from the recent results referred to, the temperature coefficients $\delta n/n\delta t$, an example of the values for different relative drops being:

$\delta p/p =$	·1	·2	·3	·4	·5
$10^3 \times \delta n/n\delta t =$	14	18	23	27	30

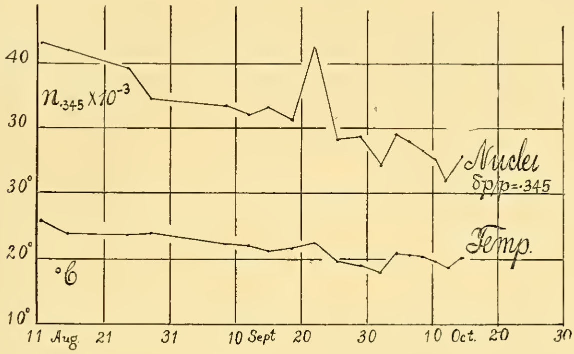
These data would not, however, seriously modify the trend of the curves.

The graph shows that the effect of temperature in the lapse of time has not been eliminated by replacing the extreme variable $(\delta p - (\pi - \pi_1))/(p - \pi)$ by the other extreme variable $\delta p/p$. In other words, if the nucleation corresponding to a fixed exhaustion $\delta p/p = \cdot 345$ is studied in the lapse of time, the successive nucleations show a dependence on the temperature of the fog chamber which can no longer be explained away. Both the details and the general character of the graphs for $n_{\cdot 345}$ follow the fluctuations of temperature to an extent which may be estimated from the figure as an increment of about 2000 nuclei per rise of temperature of 1° C.

* This Journal, xxiii, 1907, § 10, p. 209.

at about 20° C. and for $\delta p/p = \cdot 345$. Finally there is no adequate reason why the effect of cooling below a higher surrounding temperature should be more efficient than the corresponding effect below a slightly lower temperature; for the rate of reheating would depend on the difference of temperatures.

2. *Possible suggestions as to the temperature effects.*—To obtain a suggestion as to the reason of the apparent increase of the size of colloidal nuclei with rise of temperature (caet. par.),



effectively therefore of their apparent increase in number at a given supersaturation, it is expedient to recall the form of Helmholtz's modification of Kelvin's vapor pressure equation. If the ratio of pressures at a convex surface, r, and at a plane surface be p_r/p_∞, R the gas constant of water vapor, θ its absolute temperature, s the density, and T the surface tension of the liquid,

$$p_r/p_\infty = \epsilon^{2T/Rs\theta r}$$

whence it appears that the increments of θ and R may reciprocally replace each other. A small radius at a high temperature is as effective as a larger radius at a low temperature, θ; and that is about what the above data have brought out. Naturally the equation has been pushed beyond its limits for the meaning of T, for particles not large as compared with molecular dimensions is obscure; but it appears in other cases and is probably true here that the suggestions of the equation are trustworthy in a general way. Computing p_r/p_∞ by the aid of the adiabatic equation, we may write $10^6 r = 19 \cdot 5/\theta_1 \log_{10} (p_r/p_\infty)$, where $\log_{10} p_r/p_\infty = \cdot 8$, and $\theta_1 r = 2/10^5$, nearly. But $\theta_1 = 262°$ if the gas is originally at temperature $t = 20°$, whence $r = 75/10^9$. Since $dr/r = -d\theta_1/\theta_1$, an increment of the radius of but ·038 under the given conditions, is equivalent to a rise of temperature of 1° C. of the air within the fog chamber or to 2000 more available nuclei according to the above figure.

3. *Another suggestion.*—The increment of about 2000 nuclei per degree of temperature under the conditions given may also be looked on as a parallel to what occurs in case of a radiant field like that produced by the X-rays. One may regard ionization as a state of dissociation sufficiently advanced to set free electrons and from this point of view equivalent to a very high degree of temperature. One may thus expect a passage of the vapor nuclei of wet dust-free air into the ions through a continuous gradation of nuclei, and in fact they always occur together.

Brown University, Providence, R. I.

Art. XXXIII. — *Types of Permian Insects;* by E. H. Sellards.

[Continued from vol. xxii, p. 258, Sept. 1906.]

Part II.—Plectoptera.

Ephemerids have been until very recently unknown from Permian deposits. The group is scantily represented in the Russian Permian, according to Handlirsch, by one imperfectly preserved wing and three larval forms.* That Ephemerids were present in considerable numbers during Permian time is, however, clearly indicated by the collections made from the Kansas Permian. True Ephemerids make up a conspicuous element in the insect fauna of these deposits.

Protereismephemeridæ, new family.

The insects of this new family are true Ephemerids. In the general shape of the wings and the body, as well as in the manner of holding the body, they very much resemble many of the modern large Ephemerids. The prothorax and head are of medium size; the thorax is large and arched; the mesothorax and metathorax are equal in size or nearly so; the abdomen is long and slender and terminates in streamers. The wings are elongate with rounded inner border; the two pairs are equally developed, or nearly so. The venation of the wing is of a fixed and characteristic type, indicating a well established family. The subcosta, as is usual with Ephemerids, lies close to the border and extends to the apex of the wing. The radius is strong at the base and extends parallel to the subcosta to the apex. The radial sector is very uniform throughout the family. Its divisions, as is true also of other veins of the wing, are by sets of threes, the typical number being three sets of three veins each, or nine branches to the sector in all. The first division of the sector is commonly

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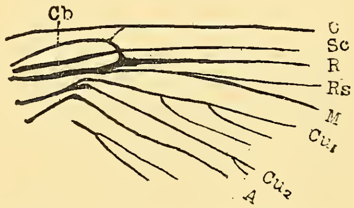

Fig. 1. Arrangement of veins at the base of the wing as seen in the type genus of the family Protereismephemeridæ. Veins drawn to scale from nature. C, costa; Sc, subcosta; R, radius; Rs, radial sector; M, media; Cu_1, first division of the cubitus; Cu_2 second division of cubitus; A, first anal; Cb, costal brace. Enlarged 6 times.

*Über einige Insektenreste aus der Permformation Russlands. Mémoires de L'Académie Impériale des Sciences de St.-Pétersbourg, (ser. 8) vol. xvi, No. 5, 1904, pp. 6–7; Die Fossilen Insekten, Lieferung III, pp. 386–387, 1906.

somewhat in front of the middle line of the wing. The two lower branches resulting from this division are simple; the upper division, after continuing simple a distance of four or five millimeters, breaks into a second set of three veins, of which the two upper are simple; the lower, continuing simple a variable distance, ultimately breaks into a third set of three veins. The middle vein of these sets of three lies on the fold, is usually weaker, and has the appearance of an interpolated vein. Its attachment is variable, sometimes with the upper

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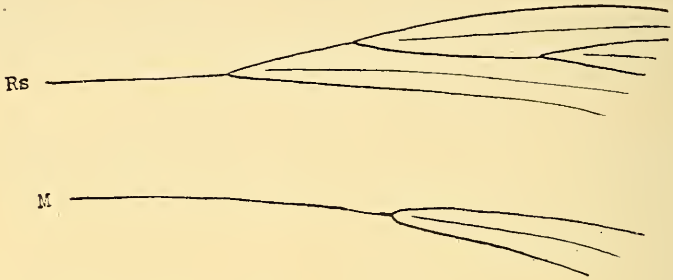

Fig. 2. The radial sector (Rs) and the media (M), as typically developed in the family Protereismephemeridæ. The attachment of the middle vein of the sets of three is variable.

division, sometimes with the lower, or, rarely, directly between the two. In all genera and species thus far made known the radius conforms to this general type. The attachment of the sector is usually with the media. The media is equally constant and characteristic. This vein continues simple to or beyond the middle of the wing, where it breaks into a set of three veins, all of which remain simple. The interpolated vein lies in the furrow, the outer branches and the media itself lying on a fold. The attachment of the interpolated vein is variable with the different genera. The media, usually carrying the sector, is fused at the base with the radius. Cubitus$_1$ and cubitus$_2$ separate just at their basal origin. Each is typically three branches, but in some species additional branches appear at the border. The first anal is a strong, simple, deeply impressed vein, with an abrupt characteristic downward curve at the base.

A strong brace occurs at the base of the wing. The vein forming the brace is without doubt the costa combined with a strong cross vein. This vein arises at the base of the wing between the border and the subcosta. It extends, following an arched course, between the subcosta and the border, a distance of two to four millimeters (variable with the different genera), where it divides. The stronger division turns with a uniform curve across the subcosta and ends on the radius, thus forming the brace. The weaker division turns upward, reaching to and quickly joining the costal border. This structure is also seen in the wings of many modern Ephemerid genera, where it is apparently a disappearing character. As a convenience of reference I suggest for this structure the term *Costal brace.*

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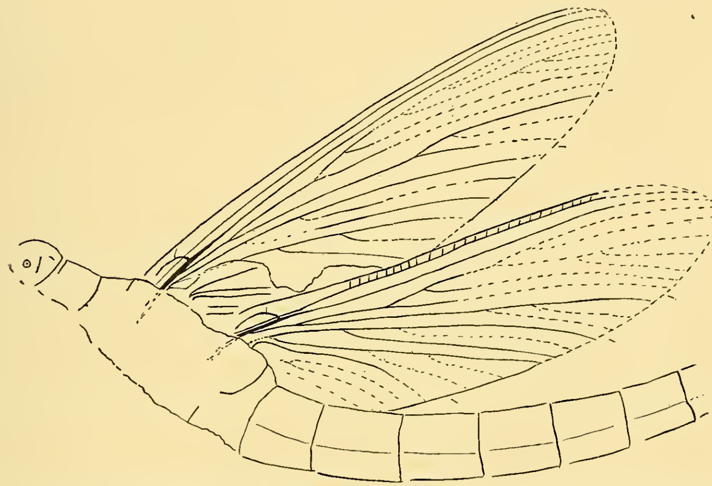

Fig. 3. Type specimen of the genus *Protereisma*. Head, thorax, and first seven segments of the abdomen preserved. The wings are preserved complete except at the tips. The wings are thin and flat. The venation is made more indistinct by the fact that the four wings lie together. The dotted veins and the tips of the wings restored from a second specimen of the same species. Enlarged 4 times.

Protereisma gen. n.

The genus *Protereisma** is regarded as the type genus of the family. The wings are thin, elongate, and but slightly corrugated. The costal border is straight, the inner border rounded. The greatest width is near the middle line of the wing. The venation conforms to the type described for the family. The middle vein of the sets of three arises from the upper division. This feature together with the but slightly corrugated membrane gives a more lax appearance to the wing

* Protos, first ; Ereisma, brace.

than is the case with most other genera of the family. The radius is thickened at the base. The costal brace is strong. Cross veins are numerous, but weak. The abdomen is long, being fully twice the length of the thorax.

Protereisma permianum n. sp. Text figure 3.

This, the type species of the genus, is large, and is to be recognized by the long cubitus, reaching beyond the middle of

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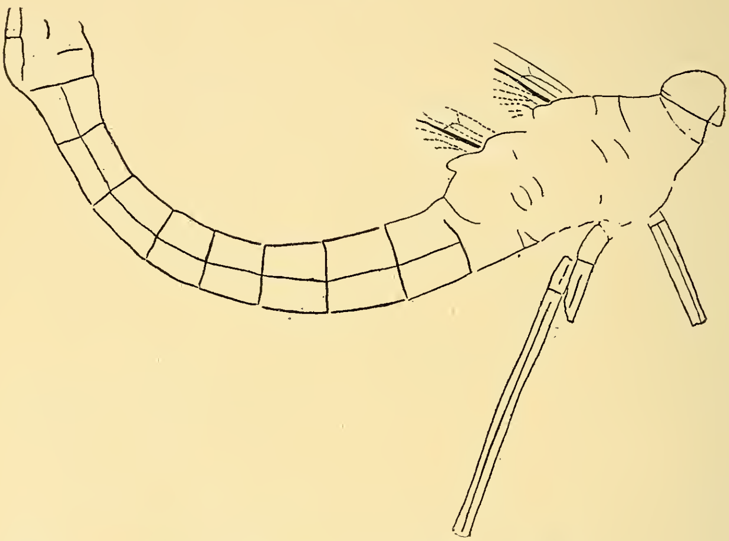

FIG. 4. A male specimen of the genus *Protereisma*, probably *P. permianum*, or the related *P. latum*. Head, thorax and abdomen preserved; also the bases of the wings and parts of the legs. The forceps are thick and strong. Enlarged 4 times.

the wing. The cross veins are numerous, but so weak as to be but indistinctly preserved.

Length of the front wing, 20^{mm}; width, at the middle, 6^{mm}.
Length of hind wing, 18 to 19^{mm}; breadth, 5 $3/4^{mm}$.
Length of abdomen, 20^{mm}; total length of body, 28 to 30^{mm}.

Protereisma minus n. sp. Text figure 9.

This is a small species. The wing is thin and flat, the veins thin; the cross veins numerous, but weak. The cubitus is short, not reaching beyond the middle of the wing.

Length of wing, 16^{mm}; width, 4 $2/3^{mm}$.

Protereisma latum n. sp.

A third species of this genus is present in the collection. The front and hind wings in the type specimen lie together. The wing membrane is of a brownish color. The wings of this, as of the other species of the genus, are but slightly corrugated, the cross veins weak.

Length of front wing, 25^{mm}; width, $7\ 1/2^{mm}$.
Length of hind wing, 22^{mm}; width, 6^{mm}.

Protechma acuminatum gen. et sp. n. Text figure 8.

The shape of the wing of this genus is characteristic, the apex being much more slender and pointed than in any other genus of the family. The wing membrane is corrugated, although not strongly so. The media joins the radius well in front of the costal brace. The interpolated veins of the sector arise from the lower branches. The middle division of the sector forks well toward the apex. The cross veins are of medium strength.

Length of the wing, 20^{mm}; width, $5\ 1/2^{mm}$.

Prodromus rectus gen. et sp. n. Text figure 10.

The wings of this genus are corrugated, but not strongly so. The costal border is straight, the apex rounded; the inner border slightly rounded. The cross veins of the wing are comparatively strong. The forking of the middle division of the sector is shallow. The interpolated veins of the sector arise from the lower divisions. $Cubitus_2$ is five branched at the border. $Cubitus_1$ is partly obscured in the specimen illustrated. A second specimen of the species, however, has this area of the wing preserved. $Cubitus_1$ is seen in this second specimen to give off two branches early, as is usual for the family.

Length of wing, 18^{mm}; width, 5^{mm}.

Bantiska elongata gen. et sp. n. Text figure 7.

Wings corrugated, costal and inner borders straight, costal brace thin. The interpolated veins of the sector arise from the superior divisions; the middle radial sector branch is deeply forked. The interpolated vein of the media arises from directly between the two outer branches. The cross veins of the wing are numerous, regularly placed and of medium strength.

Length of wing, 16 to 17^{mm}; width, 5^{mm}.

Rekter arcuatus gen. et sp. n. Text figure 6.

The wings of this species are characterized by their unusually arched form. The costal brace is thin and lies close to the

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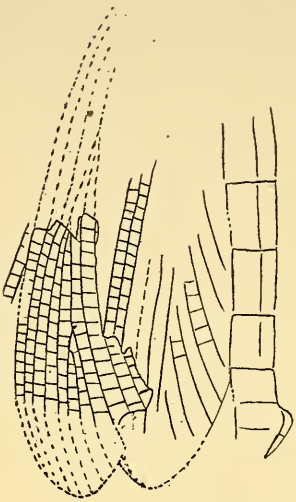

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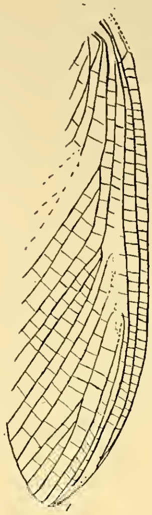

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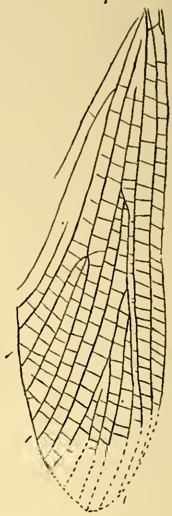

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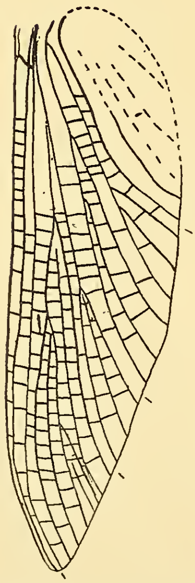

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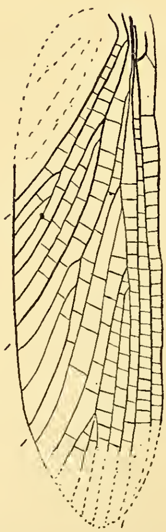

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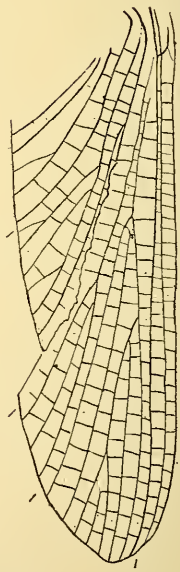

costal border. The forking of the median division of the radial sector is shallow; the interpolated vein arises from the upper branch. The media divides early and turns abruptly toward the inner border at the point of division; the interpolated vein arises from the upper branches very close to the fork. Cubitus branches very tardily as compared with other genera of the family. The wing membrane is not strongly corrugated; the cross veins are uniformly and regularly placed.

Length of wing, 16 1/2^{mm}; width, 4 or 4 1/2^{mm}.

Rekter (?) *extensus* sp. n. Text figure 5.

The species illustrated by text figure 5 is placed doubtfully in the genus Rekter. The part of the front wing seen is strongly arched. The wings are probably longer than are the wings of *R. arcuata*, and the median branch of the sector is much more deeply forked. The terminal seven segments of the abdomen are preserved. The abdomen is very slender, the segments much longer than wide. The cross veins of the wing are somewhat more numerous than those of the type species of the genus. The hind wing of the specimen illustrated has suffered lateral crushing, obscuring the venation in the central part of the wing.

Length of front wing, estimated, 16 or 17^{mm}; width, 4 to 4 1/2^{mm}.

Dromeus obtusus gen. et sp. n.

The genus *Dromeus* is proposed for a small Ephemerid of this family. The wing is corrugated, the cross veins numerous and regularly placed. The middle branch of the sector is deeply forked, the interpolated vein attached to the upper division. The wing of the type species is much smaller than that of any other described species of the family. The genus

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Explanation of Figures.

FIG. 5. *Rekter extensus* sp. n. Apical parts of the wings and the terminal segments of the abdomen preserved. The abdomen is unusually slender. The forceps are slender. Two segments of the forceps are seen. The abdomen is viewed from the side. The wings are but slightly longer than the abdomen. Enlarged 4 times.

FIG. 6. *Rekter arcuatus* gen. et sp. n. The basal attachment of the radial sector is obscured. The second anal is displaced, lying across the first anal. Enlarged 4 times.

FIG. 7. *Bantiska elongata* gen. et sp. n. A genus with wings strongly corrugated and resembling in general form the Odonates. The radial sector is, as a result of lateral crushing, crowded close to R_1, obscuring the cross veins. Enlarged 4 times.

FIG. 8. *Protechma accuminatum* gen. et sp. n. The wing has suffered slight lateral crushing, bringing the middle veins of the radial sector close together. Enlarged 4 times.

FIG. 9. *Protereisma minus* sp. n. Enlarged 4 times.

FIG. 10. *Prodromus rectus* gen. et sp. n. The wing membrane, as indicated by the jagged line, is broken from lateral crushing. Enlarged 4 times.

is easily recognized by the regularly and uniformly rounded apex of the wing.

Length of wing, estimated 12mm; width, 4mm.

Pinctodia curta gen. et sp. n. Text figure 11.

The genus *Pinctodia* is based upon two specimens each preserving the body and parts of the wings. The head is rather large. The thorax is of the arched, humped form common to the family. The abdomen is proportionally short, being somewhat less than twice the length of the thorax.

The segments of the abdomen are broader than long.

Length of front wings probably not less than 15mm.

Length of hind wing not less than 14mm.

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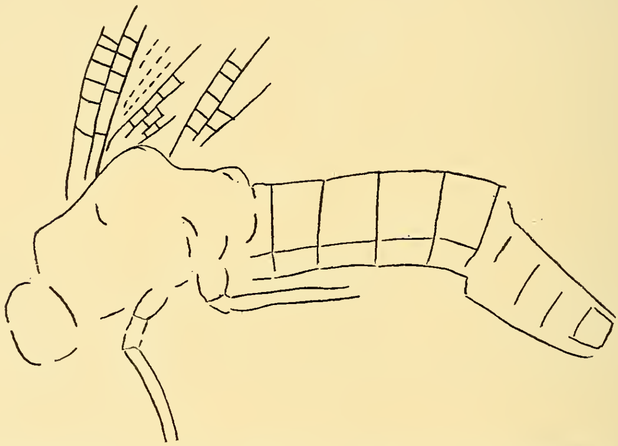

Fig. 11. *Pinctodia curta* gen. et sp. n. Head, thorax, abdomen, base of wings, and two legs preserved. The thorax and first five segments of the abdomen are seen from the side. Between the fifth and sixth segments the abdomen is broken and turned so that the remainder of the abdomen is viewed from above. The abdomen is relatively short and thick as compared with other genera of the family. The cross veins are indistinct. Those shown are in part restored. The wings are much macerated, the impression of the stronger veins only remaining. Enlarged 5 times.

Scopus gracilis gen. et sp. n. Text figure 12.

This genus has a very long, slender abdomen; slender, thin, delicate wings; and apparently rather long legs. The abdomen of the type specimen is preserved complete; the segments are longer than broad. Two segments of the forceps are seen, indicating a male. The caudal setæ are apparently slender. The wings, notwithstanding their thin texture, are strongly corrugated. The cross veins are numerous but weak. The interpolated veins of the sector arise from the upper division. The media is deeply forked; the cubitus is long. The costal brace is rather long. The slender body and wings give to this genus much resemblance to the Zygopterous Odonates.

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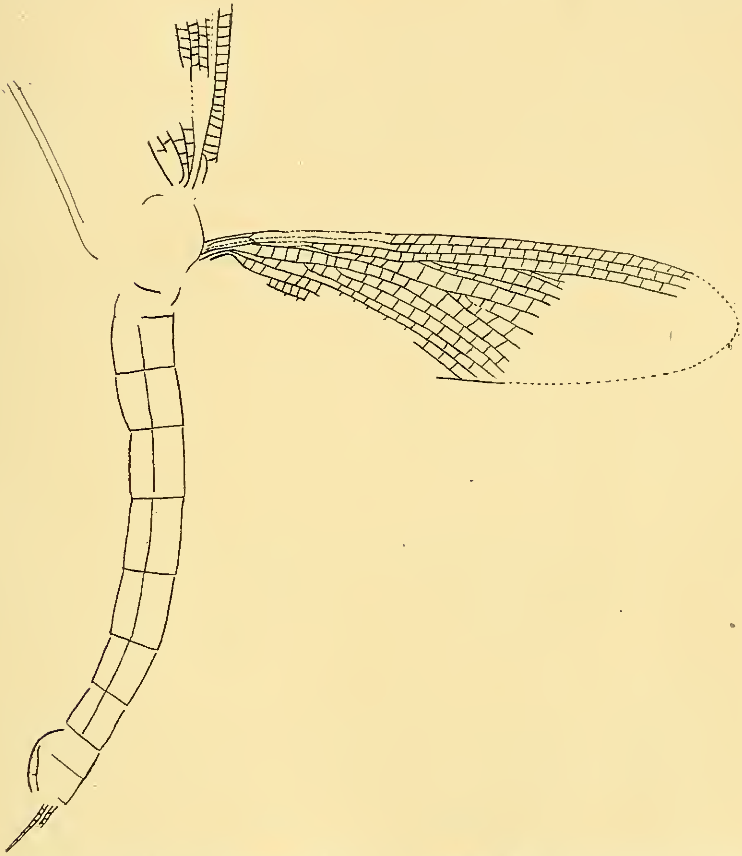

Fig. 12. *Scopus gracilis* gen. et sp. n. A genus with very slender, long abdomen, and with delicate corrugated wings. Male specimen; two segments of the forceps are seen. The caudal setæ are apparently slender. Their preservation, however, is not very distinct. Other specimens, not illustrated, but belonging with the group of genera with slender abdomen, have caudal setæ of the average size and of some considerable length. The segments in the median area of the abdomen of this genus are approximately one and one-half times as long as broad. Enlarged 4 times.

The delicate wings of the type specimen have suffered lateral compression, partly obscuring the radial area at the base of the wings. The subcosta and radius have the appearance of uniting at the base. This is doubtless due to crushing by which the radius is pushed partly over the subcosta. The subcosta is restored in the drawing as seen in other genera of the family.

Length of abdomen, 16^{mm}. Length of wing, 17^{mm}; width, 4 1/2^{mm}.

Therates planus gen. et sp. n.

An aberrant genus probably indicating a subfamily of the Protereismephemeridæ is represented by two specimens, one showing the basal three-fourths, the other the basal one-half of the wing. The wings are slender, thin and but feebly cor-

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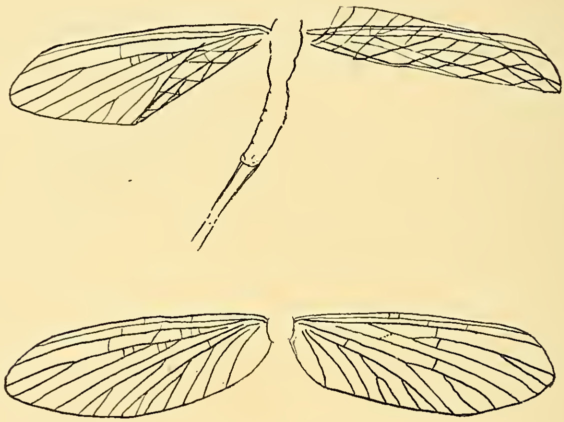

FIG. 13. *Doter minor* gen. et sp. n. Body, caudal setæ, and one pair of wings preserved. The inner half of the right wing is folded across the outer half. In the left wing a small part only of the inner border, including the anal area and a small part of the cubital area, is folded across the rest of the wing. The wings are shown beneath in the figure as they would appear with the folds straightened out. In the counterpart of the specimen the segments of the abdomen are somewhat more distinctly seen. The segments are short, being somewhat wider than long. The dotted vein in the right wing connecting the radial sector with the media is not observed in the specimen, being either lacking or obscured by the folded wing. It is restored as seen in the left wing. Enlarged 5 times.

rugated. The costal brace is strong and reaches 3 to 3 1/2^{mm} from the base. The costal border is straight; the inner border is gradually rounded to the slender basal attachment. The media is strong and fuses with the radius back of the costal brace, not in front of the brace as in other genera described. The cubitus approaches very close to the radius, lying either against or partly under that vein. The first anal is strongly curved at the base as in the case of other genera of the family. Cross veins are numerous but weak. The radius is much thickened at the base.

The special peculiarity of this genus is the late origin of the media, and the close approach of the cubitus to the radius.

Width of the wing, 4 1/2^{mm}; length, partly estimated, 15^{mm}.

Doter minor gen. et sp. n. Text figure 13.

The genus *Doter* is proposed for a small insect the relationship of which has not been fully determined. The genus clearly can not be referred to the Protereismephemeridæ, the venation being altogether different. It is possible that the genus will be found to fall within the Protephemeridæ. The body is small and slender; the abdomen is of equal width throughout or nearly so; the segments are short, being wider than long. The abdomen is terminated by two caudal setæ. Two wings only are preserved on the type specimen. These are proportionally large, longer than the abdomen, and of an ovate shape, the inner border full and rounded. A costal brace such as is seen in the Protereismephemeridæ is lacking. The subcosta and the radius are either united at the base or lie so closely together as to give the appearance of being united. The sector is three branched. The media is simple. Cubitus$_1$ is three branched, cubitus$_2$ five branched. Two anal veins are seen beyond the cubitus. The wing membrane is thin and clear and the veins distinct. Cross veins occur but are not numerous.

Length of the wing, 7^{mm}; width, 2 1/2^{mm}.

Total length of body, (not including setæ), 4^{mm}.

Notwithstanding the presence of fully developed hind wings, the relationship of the Protereismephemeridæ is much closer with the Ephemeridæ than with the earlier and somewhat doubtfully constituted groups of Palephemeridæ and Protephemeridæ. The venation agrees essentially with that of the more generalized of the modern Ephemerids. The wing is similarly, although often not so strongly, corrugated. The main veins are readily identified with the corresponding veins in the wings of modern forms.

The conclusions of Comstock and Needham* regarding the homologies of the main veins of the wings of Plectoptera find support from a study of these earliest known true Ephemerids.

* Amer. Nat., vol. xxxiii, p. 117, 1899.

Art. XXXIV.—*Origin of the Wasatch Deposits*; by F. B. Loomis.

While cataloguing the collection from the Wasatch beds of the Big Basin, secured by the Amherst expedition of 1904, the predominance of terrestrial forms raised the question as to the mode of deposit of these strata. It has been the general impression that they represent an ancient lake bottom,* and this view has been adopted in text-books, except in Chamberlin and Salisbury's Geology, where exposure to the air is suggested. Recent studies of epicontinental modes of deposition have made easy their application to the case in hand. Two means of approach are available: (1) By an analysis of the fauna, and (2) by a study of the section. Both these methods will be employed.

In the following table the fauna is carefully arranged, the groups being given according to their probable terrestrial, arboreal, amphibious and aquatic habits. The collections are from two levels on Tatman Mountain and one level in Buffalo Basin. The upper Tatman Mountain horizon is about 100 feet above the lower, while both Tatman Mountain levels are considerably below the Buffalo Basin level.

	Lower level Tatman Mt.	Higher level Tatman Mt.	Buffalo Basin	Total
Aërial forms:				
Gallinuloides prentici	3	--	--	3
Arboreal forms:				
Pelycodus frugivorus	2	26	3	--
" tutus	--	2	--	--
Anaptomorpha minutus	--	1	--	34
Terrestrial Forms:				
Carnivora:				
Stypolophus whitiae	1	5	--	--
" sp.	1	4	--	--
Viverravus protenus	4	1	--	--
" leptomylus	2	1	--	--
" altidens	--	--	1	--
Oxyaena lupina	2	3	--	--
Uintacyon sp.?	--	3	--	--
Anacodon ursidens	1	4	--	--
" sp.?	1	2	--	36

* Wortman, 1892, Bull. Amer. Mus. Nat. Hist., vol. iv, p. 135.

	Lower level Tatman Mt.	Higher level Tatman Mt.	Buffalo Basin	Total
Ungulata:				
Upland:				
Eohippus borealis	37	59	--	--
" angustidens	6	15	--	--
" resartus	5	9	--	--
" cristonense	--	2	--	--
" montanus	1	1	--	--
" cristatus	9	12	3	159
Lowland:				
Phenacodus wortmani	3	1	2	--
" brachypternus	2	1	--	--
" primaevus	--	--	1	--
Heptodon posticus	--	--	3	--
Ectocion osbornianus	--	1	--	--
Lambdotherium primaevum	--	--	5	--
Systemodon semihians	2	6	--	--
" primaevus	6	26	--	--
" protapirinus	--	2	--	--
Trigonolestes chacensis	--	3	--	--
" metsiacus	--	1	--	--
" etsagicus	--	1	--	66
Amphibious (?) forms:				
Coryphodon armatus	6	10	--	--
" cinctus	--	1	--	--
" elephantopsis	--	2	--	--
" lobatus	2	2	--	--
" testis	5	6	--	--
" cuspidatus	--	2	--	--
" sp.	11	10	3	60
Insectivora:				
Terrestrial:				
Hyopsodus simplex	6	19	2	--
" powellianus	1	1	2	--
" lemoinianus	3	6	--	--
Sarcolemur bicuspis	2	--	--	--
Esthonyx burmeisteri	6	9	--	--
" sp. nov.	--	1	--	--
" "	--	--	2	--
Ictops sp.	--	2	--	60
Rodents:				
Terrestrial:				
Paramys atwateri	--	3	--	--
" primaevus	--	--	2	--
" quadratus	--	--	1	6

	Lower level Tatman Mt.	Higher level Tatman Mt.	Buffalo Basin	Total
Lizards:				
Terrestrial:				
Glyptosaurus obtusidens	--	4	--	4
Crocodiles:				
Aquatic:				
Crocodilus heterodon	4	4	--	--
" wheeleri	6	8	2	--
" liodon	1	2	1	--
Diplocynodus sphenops	1	--	--	29
Turtles:				
Aquatic:				
Trionyx leptomitus	1	4	--	--
" scutumantiquum	1	2	--	--
" sp. ?	--	2	--	--
Plastomenus fractus	1	1	1	--
" communis	1	2	--	--
" corrugatus	--	1	--	--
Emys euthneta	2	2	1	22
Fishes:				
Aquatic:				
Lepidosteus integer	2	4	1	--
Vertebrae indet. ?	1	1	--	9
2 beds of Unio	2	--	--	--
2 beds of Cerithium sp. ?	1	1	--	--
Summary:	151	303	34	488 { individuals

Aëreal, 3.
Terrestrial and arboreal, 375 or 77 per cent
Amphibious, 60 or 12 per cent
Aquatic, 50 or 10 per cent.

In a lake basin land forms would be expected to be washed in, making possibly from ten per cent to fifteen per cent of the total number of individuals. However, strictly aquatic forms should predominate, and where conditions were such as to preserve bones and teeth, invertebrates, also, in the form of shells would be generally distributed. In the Wasatch beds, fish remains were especially sought, but the number of these, including single vertebræ, is far below what would be a fair proportion in a lake basin. While Eohippus, the predominant form, is typical of plains or open country, the remains of this genus alone make up 32 per cent of the total fauna, 77 per cent of the latter being land animals, a proportion so large as to preclude the possibility of attributing it to such a deposit.

1

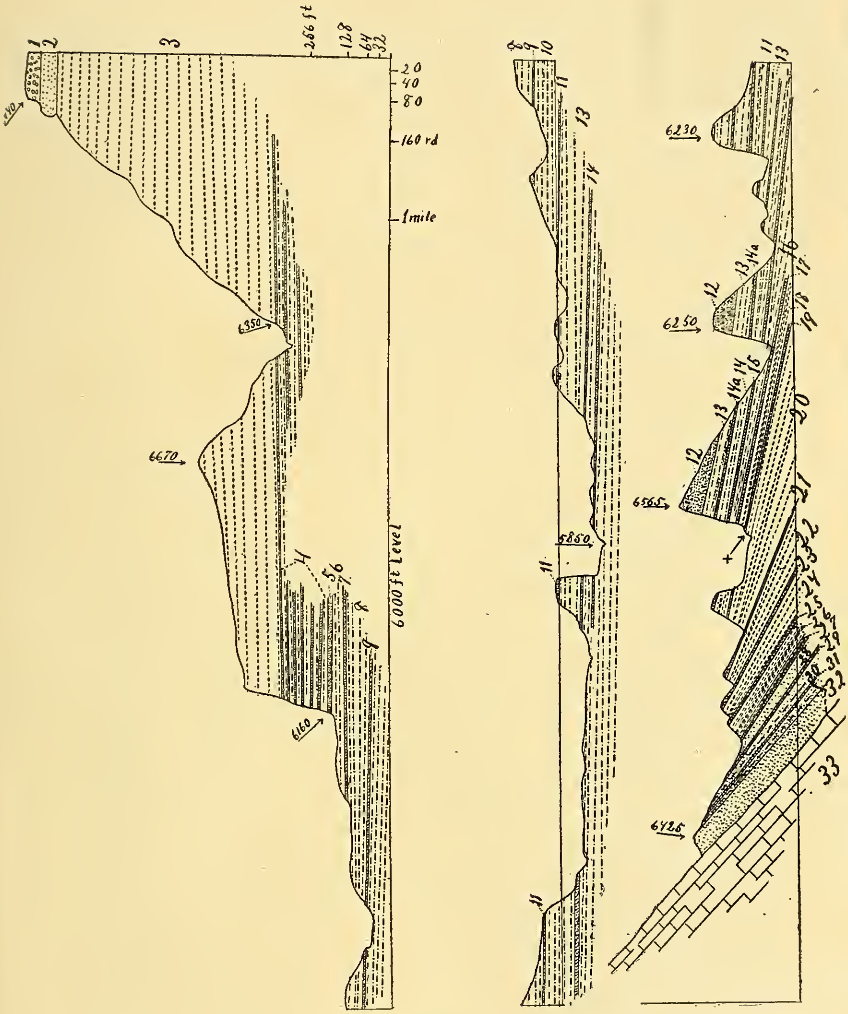

Fig. 1. Section from Owl Creek Mountains across Buffalo Basin, 17 miles to the top of Tatman Mountain, Wyo.; showing the character of the Wasatch deposits.

On the other hand, the presence of crocodiles, aquatic turtles and fishes in numbers sufficient to make up ten per cent of the whole fauna would be very remarkable in a land deposit (æolian for example). More or less water is necessary to account for the appearance of these animals. The mode of deposition, therefore, which would account for their presence, together with large numbers of terrestrial forms, would be that of flood plains. Further, just such deposits might be expected where the streams debouch from recently formed and forming mountains surrounding the basin; namely, the Big Horn Mountains to the east, the Rocky Mountain chain to the west and the Owl Creek Mountains to the south. The mingling of remains of fishes, turtles and crocodiles with those of Eohippus, Hyopsodus and Systemodon would occur when the flooded areas dried off, leaving water animals stranded here and there.

Approaching the present problem from a stratigraphic point of view, a section of the Owl Creek Mountains near Meeteetse, Wyo., across Buffalo Basin, seventeen miles to the top of Tatman Mountain, gives the following, reading from the top of the series downward:

		Feet
1.	Coarse gravel, pebbles all trap and up to a foot and more in diameter	30
2.	Coarse sandstone	30
3.	Clayey shales, brown and gray	730
4.	Sandy clays, red, with bands of cream-colored sandstone every 10 feet or thereabouts	150
5.	Sandstone, dirty cream color	15
6.	Clay shales, gray and brown	45
7.	Sandstone, cream colored	5
8.	Clay shales, banded red and gray	30
9.	Sandstone, cream colored	5
10.	Gray shales, brown	60
11.	Coarse sandstone, pebbles up to 10 inches	15
12.	Sandstone, varying from fine to gravel	185
13.	Clays, variegated, mostly gray and brown	75
14.	Sandstone, cream colored	2
14a.	Clay shales, variegated, blue, brown, and red	75
15.	Sandstone, cream colored	3
16.	Shales, gray and slate color	32
17.	Shales, dirty cream color	6
18.	Shales, slate colored	25
19.	Sandstone	1
20.	Shales, slate colored, with frequent thin bituminous layers	100
21.	Sandstone, cream colored	12
22.	Shales, slate colored	33
23.	Sandstone, cream colored	20
24.	Shales, slate color and brown	38
25.	Sandstone	2
26.	Shale, dark grayish black	90
27.	Sandstone	1
28.	Sandy shale, grayish black	50
29.	Soft sandstone, cream colored	141
30.	Hard sandstone	2
31.	Soft sandstone, gray	22
32.	Sandstone, dirty gray and cream colored	360
	Total	2391
33.	Carboniferous limy sandstone.	

Certain general features should be especially noted: There is a lack of sharp cleavage planes between the stratification layers; the sorting is irregular, so that the clays are a mixture of variable sands and clays, and the sandstones partake of the nature of gravels in that pebbles and grains of various sizes occur; beds change their character or run out, making levels hard to follow for considerable distances. These are all flood-plain characteristics, the sorting in a lake being much more uniform.

On analyzing the section, it is noticeable that the upper part is composed chiefly of brown and gray clays, the middle portion has the red beds, while the basal portion tends to blackish and dark shales. These colors are largely due to the content of iron, which in the presence of considerable bituminous material makes carbonates and gives the black and slate colors. Where little vegetable matter is present, the hydrated oxid, limonite, makes the sandstone and shales cream and brown in color; however, when exposed to air, if under dry and hot conditions, the limonite is reduced to hematite, the color then changing to red.

With these points in mind, it would appear on consulting the section that the lower sandstones were deposited rather rapidly, the dark shales representing the alluvium spread over a country covered with vegetation. This opinion is further confirmed by finding in level 21, at the point marked *x*, a rich bed of plant remains. Above this red beds soon begin to appear, and are apparently due to the alluvial deposits being exposed to the sun, the vegetation cover being scantier and the effect of the heat greater. Above level 12, red beds with bands of sandstone predominate. In the Buffalo Basin, the fossiliferous layer is just below level 11, and very little was found in any other horizon. On the opposite side of Tatman Mountain, however, such layers are considerably lower, the uppermost being a full 100 feet below the Buffalo Basin level and the lower level 100 feet below the upper one. The deposits on the north side of the mountain are more predominatingly red. These red beds seem to have been exposed some time to the air and presumably, in the natural course of events, the bones of terrestrial animals were left on these flats and were subsequently covered by an alluvial deposit; at the same time, occasional crocodiles, fishes, or turtles, becoming stranded far from the river, mixed their remains with those of the land forms. The coryphodons seem to have been amphibious, somewhat like the hippopotamus, and would be either in the stream or would follow the flooded country.

The uppermost 900 feet are non-fossiliferous, mostly clays brown to greenish in color, as though not exposed to the complete drying postulated for the red beds. The top of Tatman Mountain is flat and on a level with several adjoining buttes north of the Grey Bull River. It probably marks about the end of these deposits.

To the north and in the center of the basin, the Wasatch beds are very nearly horizontal, but approaching the Owl Creek Mountains there is a constantly increasing dip rising to 23 degrees immediately adjoining these mountains, so that they would seem to have become greatly elevated since the Wasatch was laid down.

As to correlation, the Tatman Mountain fossil levels are the typical and classical locality for Wasatch fossils, and these have furnished the standard. I find little difference between the two levels. The Buffalo Basin level, however, is a distinct horizon, and while the fossils are scarce they show a material approach to the typical Wind River series. There is (1) a noticeable paucity of horses, especially of the species most abundant in the Wasatch, *Eohippus cristatus* alone being represented; (2) Systemodon is entirely lacking, as in the Wind River; (3) Heptodon, a good Wind River genus, is present, and Phenacodus is unexpectedly abundant; (4) Lambdotherium, another Wind River type, is common, while Coryphodon is rare. The two species of rodents found were typical of that locality. Paramys was not obtained in the lower level on Tatman Mountain, but increases in abundance as one goes upward. This Buffalo Basin fossil level is, I believe, very close to, or represents the base of the Wind River, which would make the uppermost 1000 feet of the Wasatch beds belong to the same period as the Wind River in the basin south of Owl Creek Mountains. My former opinion is thus reversed, yet taking the presence of Lambdotherium, Heptodon and Paramys into consideration, together with the lack of Systemodon and the typical species of Eohippus, it seems a necessary conclusion. A comparison of the above summary with that of Wortman* in 1891 shows little agreement between them, his list being typically that of Wasatch species. However, from the description of the camp in Buffalo Basin,† I am convinced that his locality represents a lower level than that explored by the Amherst expedition, since it lies much further to the southeast. The Amherst party worked from a spring in the western border of the basin, at the very head of Fifteen Mile Creek; Wortman's list is similar to that of the upper level on Tatman Mountain.

In summarizing the foregoing statements, it is seen by an analysis of the fauna that the Wasatch beds seem to be the result of flood-plain deposits; a study of the lithological nature

* Bull. Amer. Mus. Nat. Hist., vol. iv, p. 83. † Loc. cit., p. 146.

of the material likewise furnishes the same result. The upper 1000 feet of the Wasatch appear to overlap in time the base of the Wind River, as shown by the fauna of the upper Buffalo Basin beds.

Appended are the descriptions of two new species from these beds:

Lambdotherium primaevum sp. nov.

Type No. 254, consisting of upper molars 1 and 2 of the right side and lower molars 1, 2 and 3 from the same side, the specimen being from the Buffalo Basin, near Meeteetse, Wyo. This species is fairly abundant at this horizon and is intermediate in size between *L. brownianum* and *L. popoagicum.*

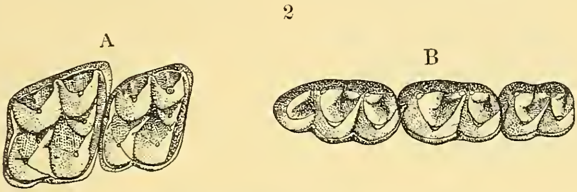

FIG. 2. *Lambdotherium primaevum.* A, upper molars 1 and 2; B, lower molars 1–3. Natural size.

On the upper molars the parastyle, though strong, is not so well developed as in the foregoing forms; the paraconule is well developed, but the metaconule is so annexed to the metacone as to appear like a buttress of this cusp. The second molar measures 12^{mm} transversely by 17^{mm} lengthwise. The robust lower molars have the protoconid markedly bifid, while the paraconid and hypoconid are each high crescents. The heel of the last molar is a high shallow basin completely surrounded by an outer rim. The three molars occupy 41^{mm}.

Glyptosaurus obtusidens sp. nov.

Type No. 133, a lower jaw of the left side, with five teeth; from Tatman Mountain, Wyo. Cotype No. 106, a ventral shield from the same locality.

The genus is characteristic of the Bridger beds, from which eight species have been described, mostly larger than the present one. The genus is characterized by pleurodont teeth on the jaws, the presence of a surface of tiny teeth on the pterygoids, and by osteoderms on the head and body, especially the belly, these osteoderms being characteristically ornamented. Cope* described some of the latter and attributed

* Geog. Surv. West of 100th Mer., vol. iv, p. 42, 1877.

them to the Placosauridæ, without giving them any name. It seems to me, however, that the presence of teeth on the pterygoids, the shape of the teeth on the jaws, and the osteoderms would indicate rather affinity with the Lacertidæ.

The species from the Bridger are, with one exception, much larger. In the present form the cylindrical teeth are attached in a pleurodont manner, with about one-third of the tooth above the outer margin of the jaw. The crown of each tooth is slightly compressed, making a blunt edge front and back.

3

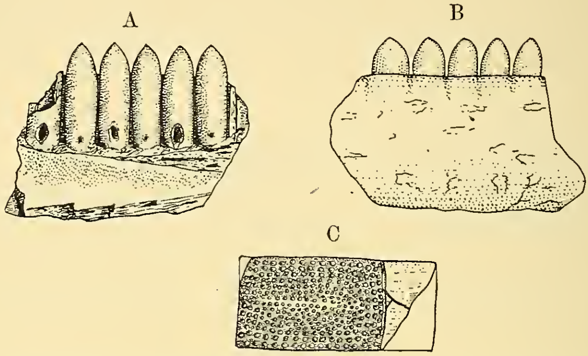

FIG. 3. *Glyptosaurus obtusidens.* A, lower jaw, inner view; B, the same, outer view; C, ventral shield. ×3.

Near the base is a small opening for the blood vessels into the pulp cavity, and on each alternate tooth this is enlarged by the absorption which has taken place near the successional new tooth. The five teeth occupy $6\frac{1}{2}^{mm}$. An ornamented shield characteristic of the genus was found near by, and probably belongs to this species. It has a slight ridge along the middle, but is otherwise flat. The tubercles along the margin are somewhat larger than those near the center. This shield measures $8 \cdot 7^{mm}$ long by 4^{mm} wide. Beside the above specimens, a second jaw and some vertebræ were found.

Art. XXXV.—*A Method for the Estimation of Iron in presence of Titanium;* by F. A. Gooch and H. D. Newton.

[Contributions from the Kent Chemical Laboratory of Yale Univ.—clvi.]

For analytical purposes, a ferric salt in solution is most easily and conveniently reduced to the ferrous condition by the action of zinc; and where many determinations of iron are to be made, the use of the well known reductor, first proposed by Jones* and described in simple form by Blair,† yields accurate results very rapidly. The use of zinc, whether in the flask or in the reductor, has, however, been precluded when the ferric salt is accompanied by titanic acid, for this substance is reduced with the iron and subsequently oxidized by the permanganate in the titration process. When, therefore, titanium is present with the iron, it has been customary to have recourse to other methods of reduction. In this event, either hydrogen sulphide or sulphur dioxide is substituted for the zinc to bring about the reduction of the ferric salt, while titanic acid is not reduced by these reagents; but the removal of the excess of hydrogen sulphide or of sulphur dioxide from solution without oxidation of the ferrous salt is not an easy or rapid process.

The present investigation was undertaken for the purpose of adapting the ordinary convenient process of reducing the ferric salt by zinc to the estimation of iron in presence of titanium. It is obvious that to solve this problem it is only necessary to find and employ some reagent which shall be neutral toward the ferrous salt but capable of reoxidizing the titanium compounds formed by the reducing action of the zinc and without action on the permanganate. Compounds of silver, copper, or bismuth oxidize very easily the reduced titanium salt; but the use of a compound of silver is precluded by the fact that it oxidizes also the ferrous salt to some extent as well as the titanium salt. Cupric salts and pure bismuth oxide prove, however, to be without action upon the ferrous salt.

For the work to be described, ferric oxide was prepared from pure ferrous oxalate and converted to ferric sulphate, and a solution of this salt was made up of convenient strength and standardized by reducing the iron with zinc in a small flask, as recommended by Blair,‡ and titrating with potassium permanganate. Titanium sulphate was prepared in solution by digesting pure titanic acid in concentrated sulphuric acid and diluting the filtered solution to known volume.

* The Chemical Analysis of Iron, Blair, 2d edition, p. 203.
† Ibid., 6th edition, p. 94.
‡ The Chemical Analysis of Iron, Blair, 6th ed., p. 225.

In preliminary experiments it was found that the violet color of the solution containing the titanium compound produced by the action of zinc upon the titanium sulphate was discharged by adding a little cupric sulphate to the solution and heating, and, after filtering, a drop of potassium permanganate gave its characteristic rose tint to the solution. It was found also that when cupric oxide was added to a similarly reduced solution of the titanium salt the characteristic color vanished on shaking the solution. The following table contains the results obtained in titrating with potassium permanganate the ferrous salt left after reducing by zinc in small flasks carefully measured amounts of ferric sulphate and titanium sulphate, treating the mixture thus obtained with cupric sulphate or with cupric oxide, and filtering off the reduced copper and cuprous salt.

TABLE I.

Fe_2O_3 taken grm.	TiO_2 taken grm.	Fe_2O_3 found grm.	Error	
0·1375	0·1	0·1378	+0·0003	Treated with $CuSO_4$
0·1375	0·1	0·1374	−0·0001	
0·1375	0·1	0·1377	+0·0002	
0·1375	0·1	0·1378	+0·0003	Treated with CuO
0·1375	0·1	0·1378	+0·0003	
0·1375	0·2	0·1382	+0·0007	

So it appears that either cupric sulphate or cupric oxide may be used to reoxidize the salt of titanium reduced by zinc, without affecting appreciably the ferrous salt in solution.

Similar experiments in which bismuth oxide was substituted for the copper oxide are recorded in Table II. To the measured amount of ferric sulphate and titanium sulphate contained in a small flask, provided as usual with the funnel valve, zinc was added and the reduction effected in the ordinary manner. The titanium salt appears to act catalytically in this process, so that reduction goes on more easily and with less expenditure of zinc than in the similar reduction of the ferric salt taken by itself. After the zinc had disappeared, the solution, of characteristic violet color, was cooled in the flask, treated with a little bismuth oxide, gently shaken, filtered from the excess of bismuth oxide and the precipitated bismuth into about a liter of cold water, and titrated with standard potassium permanganate.

In Table III are given the results obtained when reduction was effected by passing the ferric sulphate solution through a column of amalgamated zinc, 20–30 mesh, used in the simple

TABLE II.

Ferric Sulphate cm^3	TiO_2 grm.	$KMnO_4$ cm^3	Fe_2O_3 Taken	Fe_2O_3 Found	Error
10	0·04	12·84	0·0993	0·0992	−0·0001
10	0·06	12·85	0·0993	0·0993	±0·0000
10	0·08	12 90	0·0993	0·0997	+0·0004
10	0·1	12·90	0·0993	0·0997	+0·0004
10	0·1	12·89	0·0993	0·0996	+0·0003
10	0·1	12·85	0·0993	0·0993	±0·0000
10	0·1	12·80	0·0993	0·0989	−0·0004
10	0·1	12 90	0·0993	0·0997	+0·0004
10	0·2	12·90	0·0993	0·0997	+0·0004
10	0·2	12·89	0·0993	0·0996	+0·0003
10	0·2	12 90	0·0993	0·0997	+0·0004
20	0·1	25·70	0·1986	0·1986	±0·0000

form of reductor recommended by Blair.* The receiving flask was kept cool in running water, a small amount of bismuth oxide added, the flask shaken and allowed to stand a few minutes, and filtration made with the aid of the suction pump. In the cold solution free from dissolved oxygen there is little danger of reoxidation of ferrous sulphate, as has been shown by Peters and Moody.†

TABLE III.

Ferric Sulphate cm^3	TiO_2 grm.	$KMnO_4$ cm3.	Fe_2O_3 Taken	Fe_2O_3 Found	Error
40	0·01	46·80	0·3943	0·3943	±0·0000
40	0·02	46·79	0·3943	0·3942	−0·0001
40	0·04	46·80	0·3943	0·3943	±0·0000
40	0·06	46·83	0·3943	0·3946	+0·0003
40	0·1	46·75	0·3943	0·3939	−0·0004
40	0·1	46·82	0·3943	0 3945	+0·0002
40	0·1	46·78	0·3943	0·3941	−0·0002
40	0·1	46·80	0·3943	0·3943	±0·0000
40	0·1	46·75	0·3943	0·3939	−0·0004
40	0·1	46·80	0·3943	0·3943	±0·0000
40	0·2	46·77	0·3943	0·3940	−0·0003
40	0·2	46·81	0·3943	0·3944	+0·0001
40	0·2	46·85	0·3943	0·3947	+0·0004

These results show plainly that the ordinary process of reducing ferric salts by means of zinc, either in the flask or in the reductor, may be made applicable in presence of titanium compounds by adding copper oxide or preferably bismuth oxide to the reduced solution and filtering before titrating with potassium permanganate.

* Loc. cit. † This Journal, xii, 367.

Art. XXXVI.—*On the Esterification of Succinic Acid;* by I. K. Phelps and J. L. Hubbard.

[Contributions from the Kent Chemical Laboratory of Yale Univ.—clvii.]

In a former paper* from this laboratory it has been shown that succinic acid analytically pure may be prepared from succinic ester by hydrolysis in presence of a small amount of nitric acid; and, further, that the acid prepared in this way is of a decidedly higher degree of purity than that of the socalled chemically pure acid of commerce. This paper concerns the study of certain conditions under which the preparation of the pure diethyl ester, $C_2H_4(COOC_2H_5)_2$, is readily made and, also, certain conditions under which the esterification of the acid seems to be almost quantitatively complete.

The reaction for the formation of an ester from an alcohol and an acid with the elimination of water is a common example of what is termed a reversible reaction. In order to avoid reversion of the reaction various methods of dehydration have been made use of in the processes brought out for the formation of esters. This seems to have been accomplished most successfully by Fischer† and Speier, although as early as 1864 Carey Lea‡ showed that in the esterification of oxalic acid there in an advantage in acting upon the acid in a tube with gaseous alcohol, in comparison with the usual method of esterification by heating oxalic acid with alcohol. Fischer and Speier have shown that when one part by weight of acid and three, four, or five parts of absolute alcohol containing one or three per cent of hydrochloric acid are boiled on a return condenser for four hours, the product poured into cold water after distilling off half to three quarters of the excess of alcohol, the aqueous mixture shaken out with ether, the ethereal extract dried, and fractioned, gives of the ester a yield which is considered good when compared with the amount obtainable by other methods. While this procedure generally gives good yields when used for the esterification of organic acids, the esterification of each individual acid must, nevertheless, be studied by itself in detail; for, as Fischer has stated, the best yields in given cases are obtained by varying the general procedure.

In Fischer's procedure for the preparation of the ethyl ester of succinic acid the absolute alcohol is a solvent for succinic acid and its esters. It is, also, a dehydrating agent. But inasmuch as the water remains with the alcohol and the esters, it

* This Journal, xxiii, p. 211.
† Berichte der Chem. Ges., xxviii, 3252, 1895.
‡ This Journal [2], xxxix, 210.

may still be active in holding back the completion of the reaction in which the normal ester is formed. Fischer's best yield was 73·9 per cent of that theoretically possible.

In the work here described the attempt has been made to reduce the proportion of water, the presence of which may retard the completion of the action, by introducing the vapor of alcohol charged with dry hydrochloric acid into the solution of succinic acid in alcohol also charged with hydrochloric acid, and allowing the alcohol, water, and hydrochloric acid to pass out from the hot solution to a condenser.

In every experiment recorded in the table, alcohol charged with dry hydrochloric acid was boiled in a 500^{cm^3} flask fitted with a separating funnel and an outlet tube, and passed in vapor to the bottom of a 250^{cm^3} sideneck flask containing a definite weight of succinic acid and a definite volume of alcohol charged with a definite weight of dry hydrochloric acid. The temperature of the mixture in the sideneck flask was kept between 100° and 110° by heating the flask in a bath of sulphuric acid* and potassium sulphate, and this temperature was indicated by a thermometer dipping in the mixture and held in a two-bored stopper fitted to the sideneck flask and carrying also the glass tube for the introduction of the vapor. The vapor liberated in the sideneck flask passed through the sideneck to a condenser and was collected as the liquid distillate. This distillate contained whatever ester may have passed along with the hydrochloric acid, alcohol and water mixture. As succinic ester boils at 213°·3 and as the temperature in the sideneck flask was maintained between 100° and 110°, the amount of succinic ester in the distillate was necessarily a small part of the total ester produced in the reaction.

The mass of ester with its impurities from the sideneck flask was poured into a separating funnel containing a little ice, the last traces of the liquid being transferred from the flask to the funnel by successive rinsings with ether. The impure ester in the funnel was treated with an excess of dissolved sodium carbonate, and the water solution was drained off from the supernatant mixture. This mixture was washed free from sodium carbonate with a water solution of sodium chloride of sufficient density to separate it easily from the mixture. To recover any portion of the ester carried along in the water solution of sodium carbonate and the washwater containing sodium chloride, each solution was shaken out separately three times with fresh portions of ether which were added to the main portion of the mixture. These mixtures of ester in the etherial solutions were gathered in a 250^{cm^3} sideneck flask connected with a 100^{cm^3} side-

*H. Scudder, Jour. Am. Chem. Soc., xxv, 161, 1903.

neck flask as a receiver in the usual way for a vacuum distillation. The lower boiling point impurities in the succinic ester, presumably composed chiefly of ether, alcohol and water, were removed by allowing a gentle current of air to pass through the apparatus while the flask containing the ester solution was heated in a waterbath raised finally to 60° until the pressure registered on the manometer—15^{mm}—indicated that only succinic ester remained in the flask to be distilled. The ester was then distilled over by heating the 250^{cm^3} flask in a bath of sulphuric acid and potassium sulphate at 140°–150°, and collected in the second flask, which was cooled by allowing a current of cold water to strike it constantly during distillation. The last traces of ester left on the distilling flask were removed by flaming suitably the sidewalls of the flask and at the same time increasing the current of air that was passing through the apparatus. The increase in weight of the receiver gave the weight of the succinic ester left in the sideneck flask when the acid was esterified as completely as possible under the conditions imposed in each experiment.

To recover whatever succinic ester might have been carried to the condenser with the alcohol and other vapors during esterification, the acid alcoholic distillate was chilled with ice, diluted with three or four times its volume of water, and shaken out three times in a separating funnel with fresh portions of ether. The ethereal solution thus obtained was treated with an excess of sodium carbonate in solution, washed with distilled water, and distilled in vacuo, in the manner described above, to separate the low boiling point materials present, largely ether, alcohol, and water, and finally to distil the succinic ester, which was weighed.

The sources of loss inherent in this method for the preparation of pure succinic ester were carefully studied. It was found, first, that if a known weight of pure succinic ester—75 grms—was taken in a separating funnel, shaken with sodium carbonate solution containing ice, separated from the sodium carbonate solution, washed with distilled water containing common salt, and united with the portions of ester carried on mechanically and recovered from the water solutions by shaking out three times with fresh portions of ether, that the weight of the ester recovered on distilling in vacuo the ethereal solution containing some water was less than the amount taken by only 0·60 grm.

It was found, further, that when a portion of 5 grms. of succinic ester was put with 300^{cm^3} of the alcoholic hydrochloric acid mixture used in esterification and treated exactly in the manner described for the recovery of the ester from the acid alcoholic distillate, the mass of succinic ester recovered showed a loss of only 0·50 grm.

TABLE I.

				Succinic Ester				Reaction time	
No.	Succinic acid grm.	Alcohol cm³	with HCl %	Theory grm.	Found grm.	Found in distillate grm.	Total yield in %	hr.	min.
				A					
(1)	50	100	1·25	73·7	50·07	0·60	68·0		30
(2)	50	100	1·25	73·7	55·06	0·00	74·9	1	25
(3)	50	150	1·25	73·7	62·26	0·47	85·1		45
(4)	50	200	1·25	73·7	66·30	0·90	91·2	1	55
(5)	50	200	1·25	73·7	66·27	1·40	91·8	1	50
(6)	50	250	1·25	73·7	65·60	2·15	91·9	2	25
(7)	50	250	1·25	73·7	69·05	1·65	95·9	3	
(8)	50	300	1·25	73·7	67·10	3·25	95·5	4	
(9)	50	300	1·25	73·7	69·85	1·65	97·0	5	20
(10)	50	350	1·25	73·7	63·80	4·70	92·9	2	15
(11)	50	350	1·25	73·7	67·31	2·65	94·9	5	
				B					
(12)	50	200	1·25	73·7	66·26	1·82	92.9	2	20
(13)	50	200	1·25	73·7	65·30	5·27	95·8	3	
(14)	50	350	1·25	73·7	66·05	2·90	93·6	3	45
(15)	50	350	1·25	73·7	68·75	1·57	95·4	4	30
(16)	50	200	10	73·7	59·10	5·43	87·4		20
(17)	50	200	10	73·7	67·90	1·50	94·2	2	25
(18)	50	200	10 and Gaseous	73·7	68·32	3·30	95·8	1	45
				C					
(19)	50	200	1·25					2	10
		150	10	73·7	67·60	1·80	94·2	1	
(20)	100	300	1·25					2	
		200	10	147·4	132·80	6·32	94·4	1	15
(21)	50	200	1·25					1	25
		100	10	73·7	69·50	2·50	97·7	1	
(22)	100	300	1·25					2	
		200	1·25	147·4	135·25	4·81	97·5	1	

It was found, also, that when 75 grms. of succinic ester held in a flask fitted with a receiver and capillary tube for a vacuum distillation were heated for an hour in a waterbath at 60° under a pressure of 15^{mm}, that the weight of the ester was diminished by less than 0·05 grm.

From these experiments it appears that the losses in the preparation of pure succinic ester should not exceed two grams.

While the general process of treatment described above was applied in all the experiments recorded in the table, some experiments differed from others in respect to the proportions of the reagents and to supplementary treatment.

In the experiments of series A of the table the alcohol used was 99·5 per cent pure and this was charged with dry gaseous hydrochloric acid to the amount of 10 grams to the liter. The succinic acid was the pure acid of commerce.

In the experiments of series B, the alcohol used was made more nearly absolute than that used in series A by heating 99·5 per cent alcohol for an hour over fresh calcium oxide with a return condenser, and distilling to a protected receiver open to the air through a calcium oxide tube. In experiments (12), (13), (14), and (15) succinic acid prepared pure by hydrolysis of the ester in the presence of nitric acid was used, in the others, the acid of commerce. The alcohol was charged with dry hydrochloric acid to the amount of 10 grams to the liter. In (16) and (17) the alcohol was charged with dry hydrochloric acid to the amount of 80 grams to the liter, and in experiment (18) the alcohol originally charged with 80 grams to the liter was reinforced by passing into the sideneck flask a rapid current of hydrochloric acid gas, dried by passing through concentrated sulphuric acid in a bead tower of thirty centimeters length, simultaneously with the charged alcohol vapor.

An inspection of the yields obtained in the experiments of series B, in which the more nearly absolute alcohol was employed with experiments otherwise nearly similar of series A in which alcohol of 99·5 per cent purity was used, show perhaps a trifling advantage in favor of the slightly stronger alcohol. Thus (12) of B gave 1 per cent more yield than (6) of A though in the latter 25 per cent more of the charged alcohol was used under conditions otherwise closely similar; (13) of B gave about the same yield as (7) of A, though in the latter 25 per cent more of the charged alcohol was used; but the yield in (15) of B with an increase of 16·6 per cent in the amount of charged alcohol and 12·5 per cent in the reaction time was a trifle less than that of (8) of series A.

Upon examining the yields of experiments in which equal amounts of the alcohol similarly charged were brought into action with a given amount of succinic acid, it appears, as is natural, that the amount of succinic ester produced increased with the time of reaction. This inference becomes evident in a comparison of experiments (1) and (2), (6) and (7), (8) and (9), (10) and (11), (12) and (13), and (14) and (15).

It appears also that the proportion of similarly charged alcohol, for a given weight of succinic acid, affects the yield of ester—very markedly at first, but that the effect of increasing beyond a moderate limit the amount of alcohol passed through the apparatus in a given time is not so important. This effect is not surprising when it is remembered that the larger part of the water liberated is found early in the reaction and that the effect of the continued distillation would be naturally more in evidence at that time. Thus the yield of experiment (3), in which 150$^{cm^3}$ of the charged alcohol were used, is 8 per cent greater in half the reaction time than that of experiment (1), in which 100$^{cm^3}$ of the same mixture were employed; while the difference between the yield of (6) from 250$^{cm^3}$ of the charged alcohol and that of (10) from 350$^{cm^3}$ of the similarly charged alcohol is 1·1 per cent. In (12) of B with purer acid and alcohol of greater concentration the process gives the same yield as in (10).

Increase in the amount of dry hydrochloric acid with which the alcohol is charged is effective in increasing the yield. From (18) it appears that a current of dry hydrochloric acid has such an effect. This appears when (18) is compared with (17), and, more strikingly when compared with (5), where the differences are largely the concentration of the hydrochloric acid with a gain of 4 per cent in the yield of (18).

In the experiments of series C the process of forming the ester was conducted in two stages in an attempt to cause the esterification of the final portions of the succinic acid more advantageously. It is obvious from the work recorded in series A and series B that it is comparatively easy to cause the esterification of a little more than 90 per cent of the acid. In experiment (19), after the first portion of alcohol—200$^{cm^3}$—of highest purity charged with dry gaseous hydrochloric acid in the proportion of 10 grams to the liter had acted upon the commercial succinic acid in the manner described above, a fresh portion of alcohol—150$^{cm^3}$—containing 10 per cent of dry hydrochloric acid gas was put with the ester solution and the whole was heated at the boiling point for an hour with a return condenser in an attempt to learn whether a fresh mass of the absolute alcohol hydrochloric acid mixture containing 10 per cent of hydrochloric acid could serve sufficiently as a dehydrating agent to allow the completion of the reaction. It does not seem evident that the second treatment is markedly advantageous in completing the reaction. Its effect, if anything, is slight. In case of experiment (20), after completing esterification of the pure acid so far as possible with 200$^{cm^3}$ of the purest alcohol with hydrochloric acid in the usual way, 200$^{cm^3}$ more of the same alcohol with 10 per cent of hydrochloric acid was driven through the ester as in the first half of the procedure. The effect of this second treatment is not apparently of marked advantage in esterifying the final portions of the acid. In experiments (21) and (22) after the treatment for esterification, as given earlier, was completed, all low boiling point material, chiefly alcohol, water, and hydrochloric acid, was removed from the ester in the sideneck flask by a vacuum fractionation, carried out by heating the flask in a waterbath finally at 60° with the pressure on the manometer registering 15^{mm}, this pressure and temperature being maintained fifteen minutes. The material in the flask was then treated with fresh alcohol and hydrochloric acid in amounts given in the table in gaseous form as in the first half of the experiment. Pure succinic acid was used in case of (21), and commercial acid in case of (22). This process of removing traces of water by the intermediate vacuum distillation from the mixture containing the ester is obviously very effective, and the yield of experiment (21) is the best of the entire suite. Indeed if it be recalled that the losses inherent in the processes of obtaining the pure ester are a fraction more than a gram, it is seen that all of the acid taken appears as ester except a portion as small as 0·30 of a gram.

So it appears that while high purity of the succinic acid and the alcohol, the proportion of the hydrochloric acid, the time of the reaction, are all influential factors in the process of forming the ethyl ester, the thing most important in obtaining a high yield is the removal of the water as it is formed in the reaction; and we have found that this may be done most easily and very effectively by passing the vapor of alcohol charged with a small proportion of hydrochloric acid into a continuously distilling mixture of succinic acid and alcohol also charged with hydrochloric acid. By thus acting with a total volume of 300^{cm^3} of the alcohol charged with 1·25 per cent of hydrochloric acid upon 50 grms. of succinic acid, the yield in action of five hours reached 97 per cent of the theory, while this time of action was cut in two and the yield at the same time slightly increased to 97·7 per cent by interpolating in the process a vacuum distillation to remove water more effectively from the reacting mixture.

Even if the usually small amounts of ester which pass to the distillate are disregarded in the process of recovery, the yield of the process in its simpler form is still 20 per cent higher than that of any other described procedure known to us for making the ethyl ester of succinic acid by the interaction of the acid and alcohol.

Art. XXXVII.—*The Transmission of Röntgen Rays through Metallic Sheets*;* by John Mead Adams.

This subject presented itself in connection with an investigation of the energy of Röntgen rays as measured by a radiomicrometer. In that investigation the rays were allowed to fall upon a thin sheet of platinum at one junction of a thermoelectric circuit suspended in a magnetic field; the heat developed by the absorption of the rays in the platinum was measured by the deflections of the instrument. The necessity of making correction for the incomplete absorption of the rays in the platinum, together with the well known fact that the character of Röntgen rays is changed by passage through substances, made it seem desirable to investigate the phenomena of the transmission of the rays through metallic sheets.

The general law of the absorption of the rays in a metal, viz., that each successive equal increment of thickness is less effective as an absorbing medium than the one preceding it, was confirmed by experiments with the radiomicrometer; and curves showing the relation between the thickness of a metallic sheet and its absorbing power were plotted and were found to have the same general characteristics as similar curves which other investigators had obtained by means of the fluoroscope, the photographic plate, or the ionization electroscope.

The dependence of the absorbing power of a given metallic sheet upon the intensity of the rays incident upon it was examined for sheets of silver, platinum, copper, tin, and aluminium, and in every case it was found that the effectiveness of a sheet as an absorbing medium is independent of the intensity of the incident rays; in other words, the deflection of the radiomicrometer suffered an equal percentage reduction upon the interposition of a metallic sheet in the path of the rays, whether the latter were strong or weak. The rays were weakened by moving the tube away from the rest of the apparatus.

It was found that the effect of the *surfaces* of metallic sheets upon transmission is small, in the case of copper and of aluminium, the only metals examined. To show this, a laminated plate of the metal in question was prepared, equal in total thickness to another solid plate of the metal. These two plates were interposed in turn in the path of the rays, and produced equal reductions in the deflection of the radiomicrometer.

The transmission of a beam of Röntgen rays through a metallic sheet has generally been supposed to render the beam

* Abstract of a paper published (April, 1907) in the Proceedings of the American Academy of Arts and Sciences.

more penetrating toward a second sheet of any other metal than the original beam was. Experiments with the radiomicrometer have confirmed this view in most cases; but the effect of transmission through silver on penetrating power for aluminium was found to be very small, while transmission through aluminium appeared to decrease the penetrating power of the rays for silver, so far as the deflections of the instrument are an indication. This last result is contrary to a conclusion reached by Walter* by a fluoroscopic method, and throws some doubt upon the necessity of the transformation theory which he proposes. In view of this doubt, direct experimental evidence of transformation of one sort of ray into another sort of ray in transmission through a metallic sheet, was sought, with a negative result. The experiment was performed by interposing in the path of the rays a plate made of two sheets of different metals placed face to face. It is to be expected that if transformation occurs in the metals, the effect of the second metal upon rays transformed by the first will not be quantitatively the same as the effect of the first metal upon rays transformed by the second, when the order of the two sheets in the plate is reversed. In other words, the transformation theory leads us to expect that the effect of a two-piece plate upon the deflection of the radiomicrometer will depend upon the order of the pieces. The absence of such dependence was shown by experiment, and is evidence of the absence of transformation.

With the probability of transformation in transmission thus removed, and with experimental evidence showing that any effect of the surfaces of the metal upon transmission is small, the only conceivable action produced upon a beam of rays by transmission through a metallic sheet is an absorbing action. To explain the phenomenon observed with different thicknesses of the same metal, we must suppose, as Röntgen† has suggested, that the rays from a tube are heterogeneous, and that different kinds of rays are differently absorbed in any one metal. To explain the apparent reduction of penetrating power by transmission in certain cases, we must suppose that rays which are more penetrating for some metals are less penetrating for others,—that is, that metals show relatively selective absorption,‡ and that the apparent reduction of penetrating power by transmission through silver, etc., is a real reduction of penetrating power with respect to aluminium. In judging of the significance of Walter's fluoroscopic work, as in fact of all work on Röntgen rays, it must be borne in mind that the

* B. Walter, Ann. d. Phys., xvii, p. 561, 1905.
† W. C. Röntgen, Ann. d. Phys., lxiv, p. 18, 1898.
‡ J. M. Adams, this Journal, xxiii, p. 91, 1907.

selectivity of the absorbing media of the instruments themselves must greatly affect the magnitude of their indications, and that an exact interpretation of those indications is beyond our knowledge at present. This consideration will explain many disagreements in the results obtained by observers using different instruments.

It is simplest to suppose that the effect of transmission through a metallic sheet upon any one component of a heterogeneous beam is independent of the presence or absence of the other components. In other words, the effect of a given sheet upon the transmission of a particular sort of ray is measured by an absorption coefficient which may change with the conditions of the experiment only in so far as those conditions affect the ray in question. An attempt has been made to test the constancy of these coefficients under changing intensity of the rays, by the experiments where the dependence of the percentage reduction of deflection upon the distance between the tube and the sheet was investigated.

It seems very probable that in experiments so conducted the variation in the intensity of the rays incident on the sheet, involved in moving the tube, very nearly fulfills the condition that the changes in the intensities of all the components of the beam shall be in one ratio. Except for the absorption by the air, this ratio is doubtless fixed for all the different sorts of rays by some function of the distances involved; and from numerous experiments with various instruments* it appears that the absorption by air of Röntgen rays in general is negligible for such short distances as these. Of course a real disturbing factor is the changing behavior of the tube, for which correction is made, as well as possible, by alternating and checking readings. Granting that these sources of error have had no appreciable effect, we learn from the observations that the percentage reductions of deflections, due to the metallic screens examined, are independent of the total intensity of the incident radiation, when that intensity changes in such a way that the intensities of all the components change in the same ratio.

If we examine this result in the light of the conclusions already reached in this paper, its practical importance will appear. It is plain that if we knew in advance that all of the absorption coefficients for the metallic sheet and the beam in question are constant so far as intensity is concerned, the constancy of the percentage reduction of deflection would necessarily follow, provided we grant that all of the absorption coefficients of platinum are independent of the intensity. But

* J. Trowbridge and J. E. Burbank, this Journal, vii, p. 396, 1899; A. M. Mayer, ibid., i, p. 467, 1896; C. G. Barkla, Phil. Mag. vii, p. 555, 1904.

to draw conclusions as to the constancy of any or all of the separate coefficients from the constancy of the percentage reduction is not in strictness possible ; it might be that two or more of the coefficients changed together in such a way as to keep the percentage reduction constant. The repetition of this coincidence, however, in experiments with different metals and with rays from tubes in very different conditions is exceedingly unlikely, and the constancy of the percentage reduction of deflection with varying intensity is at least very good presumptive evidence that the coefficients characteristic of the absorption of Röntgen rays in metallic sheets are all constant with varying intensity of the rays.

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Art. XXXVIII.—*The Elm Creek Aërolite;* by Kenneth S. Howard.

Another aërolite from Kansas has just been obtained by Ward's Natural Science Establishment, of Rochester, N. Y. It is of especial interest as having been found near Admire, Lyon County, where the Admire pallasite was found in 1902.

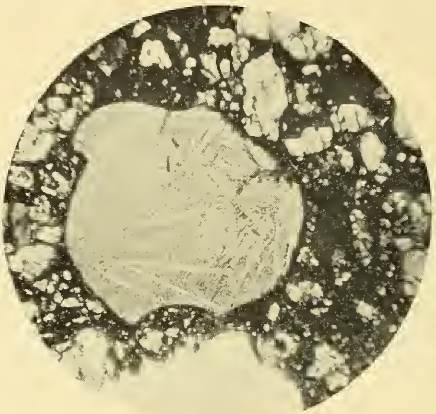
1

The Elm Creek Aërolite.

About May 10, 1906, J. R. Waters ploughed up the meteorite some three miles N.N.E. of Admire. It was buried about eight inches deep in a field that up to that time had never been cultivated to any depth. Mr. Waters also says that "it was on a slope where the soil would wash off of it instead of burying it up deeper." The exterior of the stone exhibits considerable oxidation, so that it has evidently lain in the ground for a number of years. There have been so many aërolites found in Kansas that at first there was a question as to whether this one constituted a distinct fall or if it were merely one of a shower. An examination of a polished surface, however, showed that it is entirely different from other Kansas stones.

Elm Creek, a branch of the Marais des Cygnes river, flows about three-fourths of a mile from where the stone was found, and as one meteorite has already been named after Admire this one will be called the Elm Creek aërolite.

2



Micro-section. × 45
By W. Harold Tomlinson, Germantown, Pa.

Its weight is 7075 grams. It measures approximately $22^{cm} \times 19^{cm} \times 12^{cm}$, its general shape being shown in the accompanying photograph. As will be seen the stone is highly oriented, the pittings radiating from a point shown in the photograph as being a little below the center. Any markings that may have been on the reverse side have been obliterated by oxidation. The stone is very firm and excepting where a few small chips have scaled off shows no signs of fracture.

Dr. Geo. P. Merrill of the National Museum has made a microscopic examination of the aërolite and describes it as follows: "The stone on a polished surface is of a dark gray, nearly black color, thickly studded with metallic iron and with numerous indistinct chondrules which break in large part with the groundmass. Under the microscope the silicate portion is found to consist essentially of olivine and enstatite with a twinned monoclinic pyroxene. The olivine occurs in the usual clear, colorless forms quite free from enclosures; in minute fragments and splinters and in chondrules of the barred and porphyritic type common to meteorites. A part of the porphyritic forms show a base of yellowish glass, while others seem holocrystalline. Occasional forms are met with in which the entire chondrule is composed of a single individual, in which case the central portion is clear and colorless, while the borders are of a light smoky-brown color and show a fibrous structure. All portions are, however, optically a unit.

"The enstatites like the olivines occur in scattered fragmental particles and in chondrules, the latter of the common cryptocrystalline and radiate type, and in porphyritic forms. In the latter the crystal outlines are at times very well developed. The cryptocrystalline forms are often remarkably spherical, or at least circular in outline in the section. As such they rarely polarize as a single individual, but as is commonly the case the field breaks up into sectors, as the stage is revolved between crossed Nicols. It is of course possible that not all of these cryptocrystalline forms are of enstatite; some may be of augite or possibly olivine. An optical determination is impossible, and the determination is based on their resemblance to others which have been tested chemically.

"The monoclinic pyroxene is of interest on account of the beautifully developed polysynthetic twinning which it presents when either in chondrules or in fragments in the groundmass. In this respect it would seem to be fully comparable with the meteorite of Renazzo, Italy, as figured by Tschermak on Plate 15 of his *Mikroskopische Beschaffenheit der Meteoriten.* Crystal outlines are rare and the mineral is a trifle less limpid than the enstatite. A prismatic cleavage is fairly well developed. No feldspars or other silicates than those mentioned were detected.

"The most striking feature of the stone is the spherical perfection of many of the chondrules and the perfection of the twinning in the pyroxene. As a whole the stone is plainly fragmental—is composed of a moderately firm mass of angular fragments in which are imbedded the chondrules. I am disposed to class it with those of Allegan, Michigan, San Emigdio, California, and Warrenton, Missouri. This, following Brezina, would throw it in the group of Ornansite (CcO), from which it differs only in its firm character. I confess, however, that I fail to see the necessity of attempting to name rocks according to their degree of compactness or friability."

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Oxysulphides of Zirconium and Thorium.*—In attempting to prepare sulphides of these metals by heating the sulphates in a stream of hydrogen sulphide, Otto Hauser has found that sulphides could not be prepared in this way, but that well characterized, perfectly pure oxysulphides corresponding to the formulas ZrOS and ThOS were readily produced. The preparation of the compounds succeeds well only when the sulphides are thoroughly dry. For this purpose they were heated in a stream of dry air at 380–400°. Then they were heated in a combustion tube to a moderate red heat in a rapid stream of hydrogen sulphide. A change of color from pure white to yellowish brown indicated a chemical action, while the weights of the resulting products, and analyses of them, corresponded closely to the compositions required by the formulas. The oxysulphides, particularly the zirconium compound, are inclined to ignite spontaneously when exposed to the air, unless they are allowed to remain in the hydrogen sulphide for some time after cooling. The formation of these compounds is of considerable theoretical interest on account of the existence also of COS, with carbon, the typical element of their group. Their formation indicates also that one of the SO_4 groups in the sulphates, $Zr(SO_4)_2$ and $Th(SO_4)_2$ is more firmly combined than the others, at least at high temperatures.—*Zeitschr. f. anorgan. Chem.*, liii, 74. H. L. W.

2. *New Method of Preparing Titanium Tetrachloride.*—A convenient method for preparing titanium tetrachloride on a rather large scale is described by Vigouroux and Arrivant. They make use of commercial ferro-titanium, which is now manufactured with a contents of above 55 per cent of titanium. The direct treatment of this material with chlorine gas in a heated porcelain tube gives ferric and titanium chlorides, which may be separated to a great extent by their different volatility, but in this procedure the apparatus soon becomes clogged by the condensation of the iron compound. They recommend, therefore, the elimination of the greater part of the iron as a preliminary step by treating the powdered ferro-titanium with dilute hydrochloric acid as long as it reacts. A heavy residue very rich in titanium is thus obtained, which is used as before in the preparation of the tetrachloride. The product is collected in a cooled glass condenser. It is always colored by ferric chloride, but the latter being very insoluble in the liquid can be almost completely removed by simple filtration. Fractional distillation then gives a completely pure product, boiling at 136°, free from chlorides of iron and silicon, entirely colorless, and not fuming in the air.—*Comptes Rendus*, cxliv, 485. H. L. W.

3. *Separation and Estimation of Beryllium.*—PARSONS and BARNES have devised an analytical method for the heretofore very troublesome separation of beryllium from iron and aluminum. The principle is simple and the execution of the process has given excellent results in the hands of the authors. The separation is effected by the action of a 10 per cent solution of acid sodium carbonate upon the hydroxides. The liquid is heated rapidly and is just brought to boiling for not over a minute. Beryllium hydroxide dissolves, while the other hydroxides remain undissolved. A double application of the operation appears to be necessary with large quantities. In the filtrate, or united filtrates, the beryllium may be precipitated, after acidifying and boiling off the carbon dioxide, by means of ammonia. The washing of the beryllium hydroxide with ammonium acetate is recommended, as in the absence of an electrolyte it tends to pass through the filter in a colloidal condition.—*Jour. Am. Chem. Soc.*, xxviii, 1589.
H. L. W.

4. *Atomic Weights of Manganese and Cobalt.*—BAXTER and HINES have made an elaborate series of determinations of the atomic weight of manganese by analyzing the chloride and bromide, obtaining in both cases the number 54·96. Hence no change is recommended at present in the number 55·0 now accepted. BAXTER and COFFIN have made a new determination of the atomic weight of cobalt by means of an extensive series of analyses of the chloride and have obtained 58·997, which is the same as the result of Richards and Baxter upon the bromide. Both of the investigations here mentioned are good examples of the refined work on atomic weights that are being carried on under the leadership of Professor T. W. Richards.—*Jour. Am. Chem. Soc.*, xxviii, 1560 and 1580. H. L. W.

5. *Introduction to Metallurgical Chemistry;* by J. H. STANSBIE. 12mo, pp. 252. New York, 1907 (Longmans, Green & Co.).—Although purported to be published in New York, this is an English book. The author has prepared it for technical students in connection with his work with night classes in the Birmingham Municipal Technical School. Its object is to give such students the chemistry needed for the subsequent study of metallurgy. While the book is admitted to be mainly practical in its character, and to deal particularly with the metals, it treats the subject much more broadly than might be expected, and shows so much originality, and so many good experiments, that it is well worth the attention of teachers of chemistry as a book that may furnish many useful suggestions. H. L. W.

6. *A Text-Book of Electro-Chemistry;* by MAX LE BLANC. Translated by W. R. Whitney and J. W. Brown. 8vo, pp. 338. New York, 1907 (The Macmillan Company).—This is a translation of the fourth German edition of a well known and valuable work. The earlier translation of the first edition by one of the collaborators in the present work has been mostly rewritten, and extensive additions and changes have been made in it. For the

benefit of those who may be unfamiliar with the work, it may be added that it is a theoretical treatment of the subject, with many references to practical applications. H. L. W.

7. *Exercises in Chemistry;* by W. McPherson and W. E. Henderson. 12mo, pp. 69. New York, 1906 (The Ginn Company).—This little book comprises directions for 49 laboratory exercises in elementary chemistry. It is designed to be used in conjunction with the authors' text-book, "An Elementary Study of Chemistry." The experiments are well chosen for simplicity and for imparting knowledge of the subject, while the directions are clear and the illustrations showing the arrangements of apparatus are excellent. The book appears to be an excellent one for the use of younger students. H. L. W.

8. *Specific Charge and Velocity of Cathode Rays excited by Röntgen Rays.*—A. Bestelmeyer employs in his investigation a magnetic field with lines of force at right angles to the lines of force of an electric field so arranged that they exercise opposite effects upon the moving electrons. He concludes that:

(1) The velocity of the excited cathode rays is independent of the intensity of the exciting Röntgen rays and increases with the hardness of the latter rays.

(2) The value of $\frac{\epsilon}{\mu} = 1{\cdot}72 \times 10^7$ obtained is much smaller than Simon's number.

(3) This value changes with the velocity.

(4) Although this value is nearer Lorentz's value than those of Abraham and Bucherer, the conditions are not sufficiently exact to form a conclusion.

(5) The method of crossed magnetic and electric fields is much to be preferred to the method of parallel fields.—*Ann. der Physik.*, No. 3, pp. 429–447. J. T.

9. *Wave Length of Röntgen Rays.*—J. D. Van der Waals, Jr. points out that the value of wave length obtained by various observers, notably Haga and Wind, Sommerfeld and Wien, depends upon the manner of impact of the electrons. Wien had assumed that the cathode ray particles gave up their great velocity to the anticathode in a straight line impact. If, however, there is a scattering effect, collisions not in a straight line, zigzag effects, another value of wave length might be anticipated.—*Ann. der Physik.*, No. 3, p. 603, 1907. J. T.

10. *Chemical Effects of the Electric Discharge in Rarified Hydrogen and Oxygen.*—Rev. P. J. Kirby calls attention to a previous paper by him, Phil. Mag., Jan. 1905, which showed that the chemical effects were most intense within the region of the cathode fall of potential. He has taken up the subject with modified apparatus and has confirmed his previous results. He estimates that 5×10^{-12} ergs is the superior limit of the work involved in separating the atoms of oxygen. Very little ozone is formed during the discharge in rarified oxygen. The quanti-

ties of water vapor formed in the positive column and in the cathode fall were in the ratio of 4·5 to 6.—*Phil. Mag.*, March, 1907. J. T.

11. *Radio-active Matter in the Earth and the Atmosphere.*—Observers differ in regard to the amount of this matter. A. S. Eve, Phil. Mag., September, 1903, came to the conclusion that a proportion of $1·8 \times 10^{-11}$ gr. of radium bromide per c.cm. uniformly distributed in the earth's crust is necessary for the penetrating radiation observed in the atmosphere. This is about four times the average amount found by Strutt in rocks. G. A. Blanc, Ph.D., of Rome, desirous of obtaining the relative amounts of radium and radio-thorium excited activity in atmospheric air in Rome and its surroundings, exposed an insulated brass wire about twelve meters long electrified to 500 volts for three days. It was found that the excited activity of the radio-thorium type represents generally a large part of the total amount exhibited by the wire, precisely from 50 to 70 per cent. Experiments were made on the terrace of the Physical Institute in Rome, in a garden at a certain distance from the city, and in the Catacombs of Saint Agnes near Rome, which are dug in the volcanic formation pozzolana.—*Phil. Mag.*, March, 1907. J. T.

II. Geology and Mineralogy.

1. *Manual of the Geology of Connecticut;* by William North Rice and Herbert Ernest Gregory. Bulletin No. 6, Connecticut State Geological and Natural History Survey. Hartford, 1906. 273 pp., 31 pls., 22 figs. (10 maps).—This is the first complete presentation of Connecticut geology since the report of Percival in 1842. While thoroughly scientific in its method of treatment, it is yet divested as far as possible of technicalities and contains introductory portions on the cycles of erosion, principles of metamorphism and the origin of the rock types, enabling readers with only a slight knowledge of geology to read the volume intelligently. This method of treatment is in conformity with the purpose of the work, which is not only to record the present progress in the geological knowledge of the state for the use of other geologists, but to make a volume useful for general educational purposes within the state. This last object cannot be too highly commended. The present volume, written by men who have spent years in studying Connecticut geology at first hand, and designed for the intelligent layman as well as the professional geologist, is doubly valuable.

The information contained in this volume is in large part derived from field studies by the authors themselves supplemented by the observations and writings of others, to whom proper acknowledgment is made. Among these other names may be singled out those of J. G. Percival, J. D. Dana, W. M.

Davis, and W. H. Hobbs as the chief contributors. A considerable part of the information on which this manual is based has been obtained from field work done for the U. S. Geological Survey and much of which is still unpublished.

The geology of Connecticut is as intricate and obscure as that of any region of like area in New England and the geology of the New England province is rated as difficult, if not more difficult to unravel than that of any other region in the United States. Consequently in spite of the prolonged labors of three generations of geologists there are many large problems which still await definite solution. The writers, appreciating this fact, state in the preface :

"To geologists it is unnecessary to say, but to the general reader it is important to say emphatically, that this Bulletin does not aim to set forth a complete and final statement of the geology of Connecticut. In spite of all the earnest study that has been given to this field, there are many questions still unanswered ; and the knowledge which we possess seems small in comparison with the territory of the unknown. The problems presented by the Triassic are simpler than those presented by the crystalline rocks, and have been much more nearly solved ; but, even in regard to the Triassic, important questions still remain without any answer conclusively established or unanimously accepted.

"Obviously, then, the present paper is in large degree provisional. It is a report of progress ; not a final report. It may be hoped that future investigation will correct some of its errors and answer some of its questions ; but, however many interrogation points may be changed to periods in the progress of knowledge, it seems not unlikely that for generations to come the new questions which will be started may be more numerous than the old questions which will be answered. The problem of our crystalline rocks seems, in the present state of our knowledge, to be analogous to mathematical problems in which the number of unknown quantities exceeds the number of equations."

These difficulties account for the lapse of sixty-five years without the publication of a single comprehensive report on the geology of the state, and the need of it for teaching local geology had become extreme.

An outline of the work and a summary of Connecticut geology, dwelling especially upon the earlier events and the less known metamorphic regions, may be given by quoting from the volume as follows :

"The relation of the successive changes of geological history to the present geography and topography of Connecticut may be briefly summed up in the following statements :—The rocks of the Highlands acquired their present crystalline character in connection with the orogenic movements of Archæan and Paleozoic time. The sedimentary rocks of the Central Lowland were deposited in Triassic time, and were derived from the waste of the mountain ranges which may then have existed in the regions of the present Highlands. The draining of the Connecticut estuary occurred at the close of Triassic time. The whole area of Connecticut was reduced to a peneplain in later Mesozoic time. A general elevation of the country in Tertiary time led to the development of the broad features of the present topography. While the action of erosion on the soft rocks of the Central Lowland was able to reduce that part of the state again to a condition approaching a peneplain, in the same lapse of time the streams working on the hard rocks of the Highlands could only carve narrow, gorge-like valleys. While the broad features of the topography were shaped in Tertiary time, many minor details, such as drumlins, river terraces, waterfalls, lakes, and harbors, were due to the changes of Quaternary time."

In regard to the geological history of the Connecticut crystallines the junior author states as follows :

"Fossils are the most readily applicable means of determining the age of rocks, and the only fossils found within the state are those of the Triassic sandstones—chiefly fishes, reptiles and plants. There is, therefore, no formation within Connecticut older than the Triassic, whose age has been definitely determined by the examination of the rocks themselves. Their position in the time scale can be determined only by comparison with other regions where similar rocks are present in known relations. By combining such comparison with the study of the structure of the rocks themselves, it is found that the crystallines within the state have had a long and complicated geological history, beginning before the earliest fossiliferous strata were deposited.

"Rocks older than the Cambrian exist in Connecticut, but we are ignorant of their origin and exact age. They may have been sediments containing fossils, or they may have been igneous masses. Whether they represent the Archæan or the Algonkian system, or both, is unknown. Their position and structure and texture are so altered by metamorphism that all evidences which might be used in determining their age have been destroyed. There is, however, little warrant for assuming in general that the gneisses and granites in Connecticut represent parts of the 'original earth's crust.' The Becket gneiss and certain other formations in Connecticut are believed to be pre-Cambrian, although without conclusive evidence.

"A study of the Cambrian rocks of North America shows the distribution of land and water to have been very different from the present. There are some facts that suggest that Connecticut was under water, and that a land mass existed to the eastward beyond the present shore line. It has been fairly well demonstrated that a sea or bay of salt water stretched across New England and up to the St. Lawrence. The extent of this Cambrian sea is unknown ; but part of the marble of the Housatonic valley is believed to have been made from calcareous mud deposited at that time; and the quartzite at Poughquag, just west of the

Connecticut border, is believed to be the metamorphic representative of a Cambrian sandstone.

"During the Ordovician period the conditions for the deposition of sediments continued, and sandstone and shales and calcareous deposits were formed. The calcareous material is now represented by the upper part of the limestone of western Connecticut and Massachusetts, and the shales and sandstones are believed to have been the originals from which certain schists were developed by metamorphism. The accumulation of these sediments implies the wearing down of the adjacent lands, perhaps to a plain.

"In western Connecticut no definite record is left of the long interval of time between the Ordovician and the Triassic. The absence of known Devonian and Carboniferous strata, and the facts which are known in regard to the geological history of eastern North America in general, suggest the belief that the state during these ages was part of a land mass bounded on the west by a salt-water sea and on the east by the ocean. Moreover, it is believed that Devonian time saw western New England molded into mountain ranges, and witnessed their disappearance into land of less relief. The inference that an area of dry land existed in western New England during Devonian time, rests upon the fact that the fossils found in Maine are unlike those of corresponding age found in New York, thus indicating the presence of an isthmus separating two water bodies in the northeastern United States. Then again, the sediments of Devonian age both east and west of Central New England show a retreating shore line, as if the land were rising along a northeast-southwest axis. The great thickness of Devonian sediments in the region to the west—5,000 to 10,000 feet—indicates that the land area of New England constituted a mountain range comparable in height to the southern Appalachians and perhaps rivaling the Alps.

"Between the Ordovician and the Triassic occurred the universal metamorphism of the sedimentary deposits, with the intrusions of igneous rock and the formation of the numerous veins of quartz which form such characteristic features of the metamorphic crystallines. The portions of the intrusive masses now exposed to view cooled and crystallized beneath the earth's surface; but it is reasonable to assume that part of the molten rock reached the surface, and gave rise to volcanic phenomena, all traces of which have now disappeared. The date of these intrusions and details of their character are unknown. All that can safely be said is that they represent different periods of igneous activity and occurred between the Ordovician and the Triassic. Metamorphism of the pre-Triassic rocks occurred at some date or at several different dates later than the original deposition of the rocks. The exact time when these great changes took place cannot be stated, but the metamorphism in large part seems to have been associated with the mountain-making movements which were so marked near the close of the Carboniferous. A wide extent of territory in the eastern part of the United States was affected at this time, extending from the St. Lawrence to Alabama. Sediments which had been accumulating for ages were forced into smaller compass. Along the present Appalachians the rocks were folded into arches; and the more severe compression in New England resulted in profound alteration of the rocks and the production of slates, schists, and gneisses. The result is that no unchanged sediments of pre-Triassic age exist in Connecticut, but their metamorphosed equivalents are present everywhere. The igneous intrusions have likewise been forced in many places to develop schistosity and to take on gneissoid structure."

The geological formations of the metamorphic areas which have resulted from this geologic history include those of the Western and Eastern Highlands. In regard to the former it is stated that—

"With the exception of a small area of Triassic rocks in Woodbury and Southbury, the entire western part of Connecticut, bounded by a line extending from New Haven to North Granby, is composed of ancient crystalline rocks. The distinct formations here represented are—the Becket gneiss, which is regarded as a pre-Cambrian complex equivalent to the Fordham gneiss in the vicinity of New York City; the Poughquag quartzite, of Cambrian age; the Stockbridge limestone of Cambro-Ordovician age; the Berkshire (Hudson) schist, of Upper Ordovician age; and the Hartland (Hoosac) schist, probably of Silurian age. The Waterbury gneiss is Hartland schist modified by igneous injections. In addition to these there are igneous masses; namely, the Danbury granodiorite-gneiss, Brookfield diorite, Thomaston granite-gneiss, Collinsville granite-gneiss, Bristol granite-gneiss, Prospect porphyritic gneiss, Litchfield norite, areas of peridotite, and numerous amphibolite dikes and pegmatite veins. In the southeastern part of the district are found the Orange phyllite and the Milford chlorite schist."

The relations as regards the Eastern Highlands are summarized as follows:

"All of the state of Connecticut east of a line extending from Lighthouse Point, New Haven, to Somers, is made up of ancient crystalline rocks, nearly all of which have been affected by intense regional metamorphism. The formations in this section of the state have not been so carefully studied as those west of the Triassic area, and many of the statements regarding them are to be considered preliminary and subject to radical revision. In some cases the boundaries of the formations have been of necessity arbitrarily drawn, because the rocks seem to grade into one another, and yet to present such differences as to make it worth while to give them separate names.

"The geological formations occurring in the Eastern Highland may be summarized as follows:—The Monson and Branford granite-gneisses, and the Mamacoke gneiss are probably igneous in origin and of very great age, and may represent pre-Cambrian masses. The Glastonbury granite-gneiss is of uncertain origin. The Bolton, Brimfield, and Woodstock schists, Pomfret phyllite, Plainfield and Scotland schists, and Putnam gneiss are doubtless the metamorphic equivalents of sedimentary strata of varying composition. The relation of these sediments to the igneous gneisses has not been made out, and there is practically no evidence in the field which determines the position of these formations in the time scale. The discovery of fossils of the Carboniferous period in the Worcester phyllite, which is probably the equivalent of the Pomfret phyllite, suggests a late Paleozoic age for most of the schists east of the Connecticut River. This view is strengthened by the evidence presented by the geological formations of central Massachusetts, where they have been studied by Professors Emerson and Perry. However, there is great similarity between the Bolton schist and the Hartland (Hoosac) schist; between the Woodstock and Plainfield quartz schists and the Poughquag quartzite; and between the Brimfield and the Berkshire schist. It is not at all impossible that more extended investigations may reveal evidence that the metamorphic rocks of the Western Highland are related to those of the Eastern Highland in time as well as in lithologic character. No organic remains have been found in the crystalline rocks of eastern Connecticut, and so long as fossil evidence is lacking no definite statements can be made regarding the stratigraphic position of the different formations. The Eastford, Sterling, Canterbury, Maromas, Haddam, Stony Creek, Lyme, and New London granite-gneisses, and the Preston gabbro-diorite, are intrusions in earlier strata; but were intruded before the time of the metamorphism that reconstructed the rocks of the entire state, and are accordingly much modified by the development of gneissoid and schistose features. The Hebron gneiss and the Middletown gneiss are of uncertain origin; the Willimantic gneiss is merely a more injected phase of the Hebron. Pegmatite and amphibolite are found cutting all of the formations mentioned above, and occasionally small lenses of limestone are found. The Westerly granite with its various types in the southeastern part of the state is later than the pegmatite, and is therefore the latest of all the formations, with the exception of dikes of diabase, probably of Triassic age, which extend in broken lines from the Sound to the Massachusetts border."

The chapter on the Triassic by the senior author comprises a clearly written and well illustrated summary of sixty-three pages on the stratigraphy, fossils, igneous intrusions and extrusions, and deformations of that system of rocks. A characteristic of the volume as a whole is the judicial attitude toward unsolved problems, the possibility of more than one opinion being repeatedly pointed out. In regard to the "conditions of deposition" of the Triassic, however (pp. 166–170), the discussion is wholly based upon the hypothesis that the sediments were accumulated in a fresh or brackish water estuary, or possibly a lake in close connection with the sea, entirely overlooking the suggestion of Davis, put forth in 1897, that,—"The pre-Triassic peneplain might have been warped so as to alter the action of the quiescent old rivers that had before flowed across it, yet not to drown or to pond them. Such a change would set the streams to eroding in their steepened courses, and to depositing where their load increased above their ability of transportation. As with marine or lacustrine deposits, the thickness of the strata thus produced would depend upon the duration of the opportunity for their deposition. A progressive warping, always raising the eroded districts and depressing the area of deposition, would in any of these cases afford the condition for accumulating strata of great total thickness. The heavy accumulations of river-borne waste on the broad plains of California, of the Po, or of the Indo-Gangetic depression all agree in testifying that rivers may form extensive stratified deposits, and that the deposits may be fine as well as coarse. They are characteristically cross-bedded and variable, and they may frequently contain rain-pitted or sun-cracked layers."

"In contrast to marine deposits, Penck has suggested the name 'continental' for deposits formed on land areas, whether in lakes, by rivers, by winds, under the creeping action of waste slopes, or under all these conditions combined. This term seems more applicable than any other to the Triassic deposits of Connecticut. It withdraws them from necessary association with a marine origin, for which there is no sufficient evidence, and at the same time it avoids what to-day is an impossible task—that of assigning a particular origin to one or another member of the formation. A continental origin of the formation would accord with Dana's conclusion that the Triassic beds 'are either fresh-water or brackish-water deposits.' There may possibly be included an occasional marine deposit along the axis of the depressed trough, for at one time or another a faster movement of depression than usual may have outstripped deposition and thus caused submergence ; but, in the absence of marine fossils, the burden of proof must lie on those who directly maintain the occurrence of marine deposits."*

The suggestion of Davis as to the possible fluviatile and subærial origin, taken in connection with the foot-prints, rain-prints and mud-cracks which characterize so much of the formation, is raised to the level of the only probable view for such portions of the Triassic if the conclusions in an article by the reviewer on "Mud-Cracks as a Criterion of Continental Sedimentation"† be

*W. M. Davis, The Triassic Formation of Connecticut. 18th Ann. Rept. U. S. Geol. Surv., 1897, Pt. II, pp. 32, 33.

† Joseph Barrell, Studies for Students. Relative Geological Importance of Continental, Littoral, and Marine Sedimentation. Journal of Geology, vol. xiv, 1906, Pt. III, pp. 524–568.

accepted. As yet the writer has heard no dissent from these conclusions.

If the hypothesis of fluviatile origin be accepted, it may be further stated that the character of the sediments indicates an origin in down-sinking basins with no necessary connection with the sea, and in those north of Virginia, under a sub-arid climate.

The last chapter in the volume, on the glacial geology, by the junior author, gives a clear presentation of the problem presented by the surface features of the state and how the solution, step by step, has led to one of the most astounding conceptions in geology,—that of a continental ice sheet which in very recent geological times spread from Canada over the northern portion of the United States, incidentally burying the entire land surface of Connecticut.

In conclusion it is not too much to say that this volume will do more toward the dissemination of first hand geological knowledge through the state than all papers previously published, and in all geological instruction will be found by the teacher within the state an invaluable adjunct to the text-book. J. B.

2. *Preliminary Geological Map of Connecticut ;* by Herbert Ernest Gregory and Henry Hollister Robinson. Accompanied by Bulletin No. 7, explanatory of the map. Connecticut State Geological and Natural History Survey. Hartford, 1907.—Since Percival's map of 1842, no geological map of Connecticut has been published until the present. As a consequence, to all except specialists in Connecticut geology the districts outside of the Connecticut valley have formed a terra incognita. This map is, therefore, a most welcome addition to geological literature and will be of great value for educational purposes, especially within the state. On account of the lack of detailed surveys over much of the area, it is stated by the authors in the accompanying bulletin to be a preliminary map only, and to be open to correction upon the completion of such detailed surveys. Nevertheless it will take its place as an important contribution to Connecticut geology.

The difficulties of the region are such as those geologists working in more favored regions can with difficulty appreciate, and account for the interval of sixty-five years between the first and second geological maps of the state. These are due in general, first, to the high degree of metamorphism of all but the Triassic of the valley of the Connecticut, which has destroyed all fossils and obscured the original nature and relations of the formations. As a result the age of the greater number of formations is unknown and such as are known have been determined by tracing them into the state. A second difficulty arises from the complex and repeated deformations to which the region was subjected in Paleozoic times and the faulting of the Mesozoic. Again, the tangle of granitic injections, more or less gneissoid, which on their margins are sometimes interfingered and infiltrated with the surrounding schists for miles ; and lastly the covering of glacial drift which largely mantles the state. It is to be expected, therefore, that detailed study may result in minor shiftings of such granite boundaries as are of a transitional character, and possibly further determinations of age.

As noteworthy features indicated on the present map and different from the earlier conceptions of the geology may be noted the large areas of granite-gneiss which are regarded as mostly intrusive of Paleozoic age and the reduced areas of gneiss which are regarded as of pre-Cambrian age.

In the accompanying bulletin a sketch is given of the history of Connecticut geology and also credit for the sources of information. Especially to be noted is the following tribute to the work of Percival done from 1835 to 1842:

"The more the modern geologist becomes familiar with the involved structures and exasperating variations found within the metamorphic rocks of the state, the more respect and admiration he has for Percival's discrimination and skill in delineation. It is doubtful if a more accurate discrimination of the various members of a complicated series of crystalline rocks on field evidence alone was ever accomplished" (p. 16).

The latter part of the bulletin contains brief lithological descriptions of the forty-two rock formations which are mapped.

J. B.

3. *Second Biennial Report of the Commissioners of the State Geological and Natural History Survey of Connecticut.* Bulletin No. 9, State Geological and Natural History Survey. Pp. 23. Hartford, Conn., 1906.—This report states the scope and plan of the Survey, gives a synopsis of the bulletins already published, of those accepted, and of the work still in progress. Plans for future work in geology, botany and zoology are also outlined.

In connection with the tabulation of expenses of the Survey the Superintendent remarks: "The fact will be noted that the compensation is in all cases very small in relation to the amount of work done and the grade of ability and attainment of the scientific men employed. The work has been indeed on the part of all who have engaged in it a labor of love" J. B.

4. *Iowa Geological Survey, Volume XVI. Annual Report, 1905, with Accompanying Papers.* FRANK A. WILDER, State Geologist. T. E. SAVAGE, Assistant State Geologist. Pp. viii + 673, pls. viii, figs. 78, maps 14. Des Moines, 1906.—In this well bound, well printed and well illustrated volume, besides the administrative reports and recommendations and statistics of mineral production for 1905, there are the detailed reports of the geology of eight counties, viz: Winneshiek, Clayton, Bremer, Black Hawk, Franklin, Sac, Ida, and Jackson; also a report on the plants of Winneshiek County. The greater part of the state has now been covered in detail. J. B.

5. *Limeless Ocean of Pre-Cambrian Time* (A correction).—Through a mistake of the author the conditions of an experiment, cited by R. A. Daly on page 102 of this volume, were wrongly

stated. In justice to the experimenters, Messrs. Irvine and Woodhead, to whom also sincere apology is due, and at Mr. Daly's request, the following correction is here made. On page 102, line 19, the words "lime salts" should read "calcium carbonate." In the second line following, the expression "calcium sulphate" should be inserted before the word "and." The proper meaning of the context will be discerned after this correction is made.

6. *Samples of the Sea-floor along the Coast of East Greenland*, 74½–70 *N. L.*; by O. B. BÖGGILD. Mineralogical and Geological Museum of the University, Copenhagen. Contributions to Mineralogy, No. 3. Pp. 95, pls. 9.—This paper is a study of the character of 41 samples taken approximately along the 100 fathom line off the east coast of Greenland above latitude 70° N. A geological map of the coast from Nathorst is given between these latitude limits showing areas of Archean, sedimentary and volcanic rocks but without giving any ages for the latter two groups. These sea-floor deposits give a clue as to the lithological nature of the land formations. J. B.

7. *Mikroscopische Physiographie der Massigen Gesteine*; von H. ROSENBUSCH. Erste Hälfte, Tiefengesteine, Ganggesteine, 4te Aufl. 1907, pp. 716; 8°.—In this, the fourth edition of this well-known handbook, whose first edition dates back to 1877, the old material has been thoroughly worked over and a vast amount of new added. The use of a somewhat larger page and a thin, tough paper will make the completed volume presumably no more bulky than before, in spite of probably fifty per cent of added matter. In essence, so far as the development of classification and the treatment of the subject from the theoretical standpoint is concerned, there is little that is new, the work agreeing with the ideas enunciated in the last edition. A constant tendency, however, may be noticed to treat the classification of rocks more strongly from the genetic point of view. An instance of this may be seen in the charnockite-mangerite-anorthosite series, which is, so to speak, rather suggested than actually installed.

The author states, in reference to the series, that it parallels the lime-alkali-granite, syenite, gabbro and the alkali-granite, alkali-syenite, nephelite-syenite, essexite-shonkite, etc., series; that it is chemically characterized by the striking retreat of iron and magnesia (leaving, of course, lime and alkalies), and mineralogically by the predominance of a peculiar microperthite, of pyroxenes rather than hornblende or mica, as well as by the extension of orthoclase and quartz into the very basic forms. Charnockite, it may be recalled, is the hypersthene granite from India of HOLLAND, while mangerite is the name given by the author to rocks composed chiefly of microperthite associated with the anorthosites of Norway and termed monzonite, etc., by KOLDERUP.

If the idea involved in the erection of this new series takes root and flourishes, it will be of interest in the future to see the growth of the new clan of dike rocks that will inevitably arise. Here will be a new source of difficulty for the unlucky field-geologist who is striving to carry all the details of petrographic classifications into field practice.

In regard to the femic differentiates of the new series, Rosenbusch says that to separate, in the gabbro family, those which belong to the new series from those of the old, mentioned above, is at present impossible.

Whether the reader agrees with the ideas of classification which characterize the author's work or not, the volume still remains as before, the indispensable handbook, the best digested treatise of the literature, the needed work of reference that every working petrographer must have. The added matter covers what has appeared during the last ten years and brings the work down to date. Perhaps the most notable feature which the survey of it reveals is the very great amount of work, during this time, which has been done upon the alkali rocks and the great extension which our knowledge of them has received.

The appearance of the second half of the work will be awaited with great interest. L. V. P.

8. *Hendersonville Meteorite.*—An account of the new meteorite from Hendersonville, North Carolina, was given in this Journal by L. C. Glenn in 1904 (vol. xvii, p. 215). Dr. G. P. Merrill now gives a detailed account of its mineralogical composition and micro-structure, with a series of analyses by Wirt Tassin. It is characterized by the presence of numerous spherulitic chrondules of radiating and cryptocrystalline enstatite, with also others of the ordinary porphyritic type of enstatite and olivine. Certain peculiarities of structure are similar to these of the Kernouvé meteorite which have been ascribed to mechanical trituration and resintering from a subsequent elevation of temperature.—*Proc. U. S. Nat. Mus.*, xxxii, pp. 79–82.

9. *Reproduction Artificielle de Mineraux au xix*e *siècle;* par Pierre Tchiruwinsky. Pp. 637, lxxxiii, with 22 plates. Kieff: 1903–1906.—This very important volume contains a complete and careful summary of the work accomplished during the nineteenth century on the artificial reproduction of mineral species. How exhaustively the author has accomplished his work can be seen from the survey of the list of chemists and mineralogists whose results have been cited. The work is published in the Russian language but includes a brief résumé in French.

IV. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The annual spring meeting of the National Academy was held in Washington on April 16–18; forty members were in attendance. The following officers were elected: President, Ira Remsen; Vice President, Chas. D. Walcott; Home Secretary, Arnold Hague. The new members elected are as follows: Joseph P. Iddings, Chicago; F. P. Mall, Baltimore; Harmon N. Morse, Baltimore; Elihu Thomson, Institute

of Technology, Boston, Mass. Prof. Dr. David Hilbert of Göttingen, Sir James Dewar, of London, Prof. A. R. Forsythe, of Cambridge, and Prof. John C. Kapteyn, of Gröningen, were elected foreign associates. The next meeting of the Academy will be held at Columbia University, New York City, on Nov. 19.

The following is a list of the papers presented at the meeting :

W. T. Swingle and Lyman J. Briggs : Utilization of ultra violet rays in microscopy, and demonstration of the apparatus employed.

Karl F. Kellerman : On the purification of the Isthmian potable water supply.

J. W. Gidley : A new horned rodent from the Miocene of Kansas.

F. H. Knowlton : The Laramie problem.

David White : Permo-Carboniferous climatic changes in South America.

F. W. True : On the occurrence of European genera of fossil Cetacea in America.

J. M. Crafts : A new and more accurate form of normal barometer. The catalysis of sulphonic acids in concentrated solutions.

F. H. Bigelow : A solution of the vortices in the atmospheres of the earth and the sun.

L. A. Bauer : Results thus far obtained by the oceanic magnetic survey of the Carnegie Institution of Washington, and their bearing.

Richard B. Moore : The relation of radium to hot spring and geyser action.

Henry F. Osborn : Exploration in the Upper Eocene of the Fayum Desert.

Lewis Boss : Remarks on the solar motion.

A. L. Day : Some new measurements with the gas thermometer.

Simon Newcomb : On the optical principles involved in the interpretation of the canals of Mars. Methods of detecting correlations between the variations of fluctuating quantities with an application to the question of the variability of the Sun's radiation.

W. W. Campbell : The D. D. Mills Expedition to the Southern Hemisphere.

C. D. Perrine : Results of the Intramercurial planet search.

Alexander Agassiz : The eggs of flying fishes. The elevated reefs of the Windward Islands.

Bailey Willis : Continental structure of Asia.

Wirt Tassin : The occurrence of elemental silicon in a meteoric iron.

R. von Lendenfeld : Description of Zeiss' microscopic apparatus for ultra violet rays as applied to the study of sponges.

Horace L. Wells : Biographical notice of Samuel L. Penfield.

E. W. Hilgard : Biographical notice of Joseph Le Conte.

2. *Commemoration of the Two Hundredth Anniversary of the birth of Linnæus.*—The two hundredth anniversary of the birth of the Swedish naturalist Linnæus, on May 23, 1907, will be commemorated at New York City under the auspices of the New York Academy of Sciences. The exercises will begin in the morning at the American Museum of Natural History, with addresses and an exhibition of the animals, minerals and rocks first classified by Linnæus. They continue in the afternoon at the Botanical Garden and Zoological Park in Bronx Park, with addresses and suitable exhibits of plants and animals and the dedication of the "Linnæan Bridge." This bridge, recently completed, over the Bronx river connects the Botanical Garden and the Zoological Park and is to be named in honor of Linnæus ; a bronze tablet with suitable inscription will commemorate his work

in Natural History. The exercises will be concluded in the evening with simultaneous exercises at the Museum of the Brooklyn Institute, Eastern Parkway, and at the New York Aquarium in Battery Park.

3. *Director United States Geological Survey.*—On May first Dr. George Otis Smith assumes the Directorship of the United States Geological Survey, made vacant by the appointment of Dr. Charles D. Walcott as Secretary of the Smithsonian Institution. Dr. Smith was born in Hodgdon, Maine, Feb. 22, 1871, graduated at Colby College and Johns Hopkins University, entered the government service as assistant geologist in 1896, was appointed geologist in 1901 and later made chief of the section of petrology. The publications of Dr. Smith relate chiefly to the areal geology and petrography of Washington, Utah and Maine.

4. *Ricerche Lagunari:* in charge of G. P. Magrini, L. de Marchi, and T. Gnesotto, under the auspices of the Reale Instituto Veneto di Scienze, Lettere ed Arti.—The commission appointed by the Venetian Institute to make a study of the waters of the northern Adriatic (this Journal, xxi, 407) has issued three bulletins: 1. *Relazione Preliminare,* 12 pp., 2. *Mareometro Normale Lagunare*, 17 pp., 2 pls., and 3. *Mareografo Normale Lagunare,* 22 pp., 5 figs. Bulletin No. 1 explains the commercial importance of a systematic study of the waters of the Venetian coast, and gives an historical sketch of work previously carried out for the improvement of the local water ways. The present plan is to make a study of the tides, waves, and currents of the upper Adriatic, with especial reference to the Gulf of Venice. Bulletins Numbers 2 and 3 describe the type of instruments installed as tide gauges and give accounts of tests made. The investigation has been carried far enough to indicate satisfactory methods of collecting and interpreting data, but no detailed results are as yet available.

5. *The River Pilcomayo;* by Gunnar Lange. Pp. 123, with 22 illustrations and portfolio of detailed map in 7 sheets. Buenos Aires, 1906 (Argentine Meteorological Office). — The exploration of the Pilcomayo River from parallel 22° S. to the Paraguay River was undertaken for the purpose of finding a feasible commercial route from Asuncion to the Argentine colony of Buena Ventura in the Gran Chaco. Observations in latitude, variations in compass and, especially, hydrographic measurements, were made in detail. Notes of types of forest trees were also made. The river was found to be aggraded throughout the entire extent and no bed-rock was seen. At the rapids, and elsewhere in the bed of the river, there is seen a "somewhat undulating surface of a layer of impermeable hard 'tosca,' which probably in remote times formed the bed of a great lake of little depth which gradually was filled up by the slime brought down by the upper rivers." At the Arroyo Dorado the tributary streams are cutting back rapidly, perhaps indicating a recent elevation at this point, and rafts ("raigones")

of hard-wood block the stream in a number of places. The Pilcomayo was found to be navigable for boats of light draft, with the exception of the marshes at Estero Patino, where canals and locks would be necessary. H. E. G.

6. *The British Tunicata;* by the late JOSHUA ALDER and the late ALBANY HANCOCK, edited by JOHN HOPKINSON. Vol. II, pp. xxviii+164, plates 21–50. London, 1907 (The Ray Society).—This is the second volume of an unfinished monograph which for more than thirty years after the death of both of the authors had remained unpublished. This portion completes the work on the solitary and social ascidians. The thirty plates, most of which are colored, furnish excellent illustrations of the appearance and anatomy of the 58 species discussed. The first volume was noticed in vol. xx, p. 469, of this Journal. W. R. C.

7. *Die Insektenfamilie der Phasmiden;* bearbeitet von K. BRUNNER V. WATTENWYL, und JOS. REDTENBACHER. Mit Unterstützung der Hohen k.k. Akademie der Wissenschaften in Wien aus der Treil-Stiftung. I. Lieferung: Bogen 1–23 und Tafel I–VI. Phasmidae Areolatae; bearbeitet von J. REDTENBACHER. Pp. 180, 4to. Leipzig, 1906 (Wilhelm Engelmann).—This is the first installment of an extensive systematic monograph of all the species of Phasmids of the world. The senior author is a recognized authority on this group of the Orthoptera. W. R. C.

8. *Trades and Anti-Trades.*—The long-accepted theory of the existence of anti-trades blowing southwest and northwest above the northeast and southeast trade winds, and formed by the ascending currents above the thermal equator, has rested mainly upon the observations upon the Peak of Teneriffe. Here the southwest wind can be observed through the year, though it is lower in winter than in summer. The truth of this theory, however, has been questioned, and in the summer of 1905 the steam yacht Otaria was purchased and equipped by M. Teisserenc de Bort, and an expedition was made, the expenses of which were borne by him and by Mr. A. Lawrence Rotch of the Blue Hill Observatory, Hyde Park, Mass. The observers were Messrs. Maurice and Clayton, and observations were carried on chiefly in the neighborhood of the Azores, Madeira, the Canaries and Cape Verde Islands. Kites were used up to an altitude of 3000 meters and balloons above this level; the latter could be followed by the telescope to a height of 11,000 or 12,000 meters. The facts observed, given in detail in the original article, contain various points of considerable interest.

The conclusion reached is stated as follows: "that the upper anti-trade is shown both by the balloons and by the drift of the clouds, the stratified conditions giving place to the southerly wind between 3000 and 4000 meters. Therefore, the classic observations of the return-trade, which were long ago made on the Peak of Teneriffe, indicate a general phenomenon and agree with those obtained over the open ocean by the present expedition."—*Proc. Amer. Acad.*, xlii, 263–272.

9. *The Museum of the Brooklyn Institute of Art and Sciences. Science Bulletin, Volume I, No. 10.*—This bulletin contains a

paper by Charles Schaeffer on New Bruchidae, with notes on known species and list of species known to occur at Brownsville, Texas, and in the Huachuca Mts., Arizona. Pp. 291–396.

10. *University of Illinois Bulletin. Volume IV, No. 3.* Pp. 30, 5 figs. Urbana.—This bulletin contains a report by Edward Bartow, for the year ending Aug. 31, 1906, entitled: Chemical and Biological Survey of the Waters of Illinois.

11. *Bulletin, No. 1, of the Carnegie Foundation for the Advancement of Teaching.* Pp. 45. March, 1907.—The important question as to whether universities which are technically state institutions should profit by the Carnegie Fund for retiring allowances is discussed in the present Bulletin from the standpoint of these institutions. The following papers are included: Memorandum from the Officers of the National Association of State Universities; another from Dr. Maurice Hutton, Acting President of the University of Toronto; and a third from Professor Henry T. Eddy, of the University of Minnesota. Dr. Henry S. Pritchett, President of the Carnegie Foundation, presents the subject fully and impartially in a paper prepared expressly for the benefit of the Trustees. Although no final decision of the question has thus far been reached, it is stated in the introduction that an unofficial expression of opinion indicated that a large majority of the Trustees were opposed to placing retiring officers of state institutions upon the Carnegie foundation.

12. *Dictionnaire-Manuel-Illustré de Géographie;* par Albert Demangeon. Pp. 860. Paris, 1907 (Librairie Armand Colin).—This Dictionary is one of a series dealing with different subjects in science, letters, and the arts. It gives more than 850 closely printed pages, the vocabulary including not only names of prominent places, with statements in regard to them, but also definitions of general terms more or less closely related to the different branches of geography. In the case of important geographical divisions, the definitions are much extended and are often accompanied by illustrations and maps. The variety and fullness of the information contained in this compact manual should give it a wide sphere of usefulness.

13. *Self-Propelled Vehicles;* by James E. Homans. Pp. vii, 598. New York, 1907 (Theo. Audel & Co.).—The sixth edition of a practical treatise on the theory, construction, operation, care and management of automobiles, covers the subject from tire to steering-wheel. About four hundred illustrations and diagrams aid in making the fundamental principles of the machine and its management intelligible even to those who are less mechanically inclined. The chapter on "care and operation" is a short cut to a valuable fund of information that is usually obtainable only by long and varied experience. There can be no question but that a study of this book would bring to many owners increased pleasure in the use of an automobile, and a corresponding diminution of business to the repair men. A complete index makes the contents readily available. D. A. K.

14. *Ostwald's Klassiker der Exakten Wissenschaften.* Leipzig, 1906 (Wilhelm Engelmann).—The following list includes the titles of recent additions to this valuable series of scientific classics (cf. p. 188, Feb. 1906).

Nr. 151. Abhandlungen über die regelmässigen Sternkörper. Abhandlungen von L. POINSOT, J. BERTRAND, A. L. CAUCHY, A. CAYLEY. Übersetzt und herausgegeben von ROBERT HAUSSNER. Pp. 127, mit 2 Tafeln.

Nr. 152. Abhandlungen über Elektrizität und Licht; von Theodor von Grotthuss. Herausgegeben von R. LUTHER und A. V. OETTINGEN. Pp. 198, mit einem Bildnis und 5 Figuren in text.

Nr. 153. Rein analytischer Beweis des Lehrsatzes, dass zwischen je zwey Werthen, die ein entgegengesetztes Resultat gewähren, wenigstens eine reelle Wurzel der Gleichung liege; von BERNARD BOLZANO. Untersuchen über die unendlich oft oszillierenden und unstetigen Funktionen; von HERMANN HANKEL. Herausgegeben von PHILIP E. B. JOURDAIN. Pp. 115.

Nr. 154. Physiologische Untersuchungen über die Beweglichkeit der Pflanzen und der Tiere; von HENRI DUTROCHET (1824). Übersetzt und herausgegeben; von ALEXANDER NATHANSOHN. Pp. 148, mit 29 text figuren.

Nr. 155. Abhandlungen zur Kristallographie; von QUINTINO SELLA. Herausgegeben von F. ZAMBONINI. Pp. 44, mit 8 figuren in text.

Nr. 156. Neue Methode zur Integration partieller Differentialgleichungen erster Ordnung zwischen irgend einer Anzahl von Veränderlichen; von C. G. J. JACOBI. Herausgegeben von G. KOWALEWSKI. Pp. 227.

Nr. 157. Beobachtungen nach einer neuen optischen Methode. Ein Beitrage zur Experimentalphysik; von AUGUST TOEPLER. Herausgegeben von A. WITTING. Pp. 61, mit einem Bildnis von Toepler und 4 Tafeln.

Nr. 158. Beobachtungen nach der Schlierenmethode; von AUGUST TOEPLER. Herausgegeben von A. WITTING. Pp. 102, mit 4 Tafeln and 1 Textfigur.

14. *Frequency Curves and Correlation;* by W. PALIN ELDERTON. Pp. xiii, 172. London, 1906 (Published for the Institute of Actuaries by Charles and Edward Layton).—The science of Statistical Mathematics and its applications has been developed and made of practical value both in replacing empirical methods and in opening new fields of research,—as for example in economics,—largely within a decade or two, and chiefly by the investigations of Professor Karl Pierson of Oxford University.

The present volume is an interpretation of his work for the benefit of actuaries in preparing mortality tables and the other statistical results of life insurance, the pioneer field of statistical investigation. The volume was prepared at the request of the Institute of Actuaries in order to put before the members of the profession generally a connected and practical exposition of Professor Pierson's methods of dealing with statistics and the means of judging of their degree of usefulness,—as yet unproved —in this field. W. B.

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VOL. XXIII. JUNE, 1907.

Established by BENJAMIN SILLIMAN in 1818.

THE AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

FOURTH SERIES

VOL. XXIII—[WHOLE NUMBER, CLXXIII.]

No. 138—JUNE, 1907.

WITH 1 PLATE.

NEW HAVEN, CONNECTICUT.

1907

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

Published monthly. Six dollars per year, in advance. $6.40 to countries in the Postal Union; $6.25 to Canada. Remittances should be made either by money orders, registered letters, or bank checks (preferably on New York banks).

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXXIX.—*The Mesozoic Sediments of Southwestern Oregon*; by J. S. DILLER.

The Mesozoic Sediments of Southwest Oregon.

Introduction.

The Klamath Mountains of southwest Oregon and the adjacent portion of California, like the Sierra Nevada, are composed in large part of Paleozoic sediments associated with masses of intrusive and effusive rocks of various ages. Mesozoic sediments are of less amount than the Paleozoic and have their most extensive development along the mountain borders, from which they overlap and by deformation are so involved with the older rocks as to form an important structural element of the Klamath mountain mass.

The peripheral portion of the Klamath Mountains has been surveyed in the Lassen Peak and Redding quadrangles of California and the Roseburg, Coos Bay and Port Orford quadrangles of Oregon. The remaining peripheral portion, as well as the mountains themselves, has been covered by reconnaissance, and the general results in areal distribution are shown upon the geological map of North America, published by the International Geological Congress for the meeting in Mexico, 1906.

The study of the Mesozoic in southwest Oregon is far from complete, but the publication of the map referred to above and the general interest in the region, as shown by Mr. Louderback's article in the Journal of Geology for September, 1905, p. 514, call for additional data, which this paper is intended to partly supply. It will, however, be limited to the consideration of the sedimentary rocks only, since they alone contain the records of geologic age to which the others must be referred.

Subdivisions Discriminated.

The Mesozoic, as far as known in southwest Oregon, belongs to the Cretaceous and Late Jurassic. The bottom of the latter has not yet been determined, and what may lie between it and the Paleozoic rocks of the same region is a matter for further investigation. The bodies of strata thus far discriminated are as follows:

Cretaceous
- Chico formation
- Myrtle "

Jurassic
- Dothan formation
- Galice "

Galice Formation (Jurassic).

Definition.—The Galice formation is composed chiefly of fine dark to black sediments with a well-marked slaty cleavage. Subordinate amounts of sandstone and conglomerate occur and the whole is characterized by an upper Jurassic fauna. It is named from Galice Creek, where the rocks are well exposed.

Lithology.—The slates are generally black and weather gray. A well-developed slaty cleavage prevails, but locally they may be shaly or on the other hand so sheared as to break up into small slickensided fragments. Where massive, their stratification is shown only by occasional thin beds of sandstone.

The sandstones are light-gray, hard and siliceous, and though much less abundant than slate form occasional heavy beds, but more commonly are not a foot in thickness.

The conglomerates, much less abundant than sandstone, are composed chiefly of cherty quartz pebbles with some fragments of sandstone or rarely of limestone. Igneous material is for the most part absent, though sometimes abundant in tufaceous rocks interstratified with the others. One bed of moderately fine conglomerate is 30 feet in thickness. The others were all less than ten feet, with pebbles smaller than marbles.

Quartz veinlets are locally abundant in the slates parallel to their cleavage and may fill numerous small irregular fractures in the sandstone, but they are neither a conspicuous nor a regular feature.

The stratification of the Galice formation is in most places plainly marked. The strata have been greatly compressed and folded but not crushed to small fragments. Incipient schistose structure occurs locally with very little recrystallization along lines of special disturbance, but it is neither a prominent nor common feature.

Distribution and thickness.—The Galice formation is distributed at intervals along a line running northeast from the boundary of California to the South Fork of the Umpqua River, a direct distance of nearly 100 miles. The most important area extends from Galice on Rogue River in a slightly irregular course northeast for 20 miles across Grave Creek to Cow Creek, 2 miles below Glendale. This belt is from 2 to 3 miles in width, and continuous throughout, but is completely surrounded by igneous rocks. It is the small Jurassic area noted along Rogue River on the map of North America. The strata, with but little variation, dip S.E. at an angle ranging from 30° to 50°, and have a thickness of not less than 2,000 feet. Grave Creek affords an excellent section across the belt, distributed approximately as follows :

30 feet.	Conglomerate locally overlain by a few feet of black slates greatly sheared.
300 "	Dark sandstones with some heavy layers and a small proportion of interbedded slates.
1000 "	Black slates.
500 "	Sandstones and conglomerates with a smaller proportion of slates.
200 "	Slates, black and gray.

Within the Galice area to the northeast of Grave Creek the proportion of dark sandy slates increases and to the southwest along Galice Creek and Rogue River it is slightly diminished. Along the eastern border tufaceous rocks play a considerable part.

Sixteen miles northeast of Glendale the Galice slates reappear on the slope of Canyon Creek and form a narrow belt extending northeast between volcanic rocks to the forks of Beal Creek and beyond, where it merges into a great thickness of black slates exposed along the South Fork of the Umpqua.

To the southwest of Galice the slates are interrupted by igneous rocks but reappear 35 miles beyond in California, where the conglomerates and slates cover a large area. They are well exposed near the Oregon line about the head of Shelly and Monkey creeks, which are tributaries of Smith River.

Fossils and age.—The first fossils discovered in this formation were obtained on Galice Creek by Prof. J. N. Hyde, of the State University of Oregon, who through Chester W. Washburne kindly loaned his collection for determination. Dr. T. W. Stanton, who has examined all the fossils, reports the following forms:

Along Galice Creek and Rogue River, *Aucella erringtoni* occurs at many points. Is well preserved at Almeda mine, where *Perisphinctes* was obtained through the superintendent, H. B. Perks. In a conglomerate at the mouth of Anderson Gulch, *Trigonia*, *Amberleya*, and *Belemnites* were found with *Aucella*, and Dr. Stanton remarks that "the state of preservation of this lot is too poor for specific determination. Many of the Aucellae cannot be distinguished in form from *A. piochi*, but a few fragmentary imprints of the surface indicate that they were striated like *A. erringtoni*."

Along Grave Creek, *Aucella erringtoni* was found at numerous horizons throughout the section. Belemnites is common, and at one point Pecten ? was found.

On Cow Creek, near the mouth of Rattlesnake, one-fourth mile below Reuben Spur, the largest collection was obtained, and Dr. Stanton recognizes "Aucella erringtoni, Ctenostreon ? sp., Pecten ? sp.—may be a Lima, Turbo ? sp., Perisphinctes ? sp.—same as that from Anderson's ditch on Galice Creek."

On O'Shea Creek only *Aucella erringtoni* was found. The same form occurs with Belemnites by the stage road from Grant's Pass to Crescent City, on Shelly and Monkey Creeks.

In the field, the three areas of the Galice formation noted above were regarded as Jurassic, and Dr. Stanton remarks that "the examination of the fossils has confirmed this view, although the evidence is not as strong as might be desired. In most cases the determination is based on the occurrence of a form of Aucella with numerous distinct radiating striae which I have identified with *Aucella erringtoni*, a common species of the Mariposa slates in California. The Aucellae of the Lower Cretaceous Knoxville beds often have nearly the same outlines, but they never show the distinctive surface sculpture above mentioned. So far as our present knowledge goes, therefore, we are justified in assigning all beds containing Aucellae with numerous fine radiating striae to the Jurassic. In two of the lots, 6682 (Anderson's ditch) and 6687 (Almeda mine), this reference is strengthened by the presence of Ammonites of Jurassic type. This is especially true of 6687, which contains a Perisphinctes very closely related to or possibly identical with the Mariposa species doubtfully referred by Hyatt to *P. filiplex*. The Perisphinctes (?) in lot 6682 is of a different group which also resembles European Jurassic forms."

Four lots from Galice, Grave and Rattlesnake creeks "all contain poorly preserved specimens of Aucella that do not show the surface features well enough for specific identification, though from the character of the matrix and from their relations with the lots containing *Aucella erringtoni*, it is probable they are Jurassic.

Four lots from Shelly and Monkey creeks "are probably also Jurassic as the Aucellae though not very well preserved seem to have the striated surface in most of the lots."

Structure of Galice area.—Notwithstanding the fact that there are three good sections of the Galice area afforded by Rattlesnake Creek, Grave Creek and Rogue River, its structure and relation to the associated volcanic rocks are not clearly understood. Along the main stream and East Fork of Rattlesnake the position of the strata suggests a synclinal structure for the belt, with the western arm well marked but the eastern one less regular and indefinite. This is due at least in some measure to the fact that in the eastern arm the slaty cleavage makes a large angle with the stratification and tends to obscure it. Where the strata strike N. 45° W. and dip 50° S.W., the slaty cleavage strikes N. 55° E. and dips 50° S.E. The slaty cleavage throughout the area with but few doubtful exceptions dips to the S.E. more or less steeply, and is generally much more distinctly marked than the stratification.

The section so well exposed along Grave Creek dips, with rare exceptions, to the S.E., and it is evident that if the general structure of the Galice area is synclinal the southeast arm must have been overturned towards the northwest so as to give the strata a monoclinal attitude. Strong evidence against the synclinal view is afforded by a comparison of the two halves of the Grave Creek section, for they are not repetitive but supplemental.

The narrow V-shaped valley of Rogue River affords a good section of the Galice area. Just above the mouth of Galice Creek the beds are much twisted and sometimes vertical, but farther up the river the dip is from 25° to 50° S.E., and this agrees with their position on Galice and Taylor creeks. The slaty structure has the same position, and approaching the eastern border of the area the fine sediments become so decidedly slickensided as to suggest displacement. Below the mouth of Galice Creek the strata with few exceptions dip to the N.W. at a high angle ranging from 65° to 80°, and at the Almeda mine along the northwest limit of the area the slates are practically vertical.

Though the section of the Galice area along Rattlesnake Creek suggests a synclinal structure, the view is not supported by the Grave Creek and Rogue River sections, and overlooking minor displacements within the mass it appears to be essentially monoclinal and a continuous series with general dip to the S.E.

Limits of Galice formation.—The limits of the Galice formation are not fully determined. In the Galice area the outlines are marked by the adjoining igneous rocks, but it is believed that the full development of the Galice series is not represented in that area. On the South Fork of the Umpqua a greater thickness of vertical black slate occurs. They closely resemble those of the Galice series but are not yet known to be fossiliferous.

Relation to the igneous rocks bordering the Galice area.—The igneous rocks bordering the Galice area northeast of Rogue River are chiefly if not wholly volcanic, and the general dip of the flows is to the S.E., approximately parallel to the general position of the stratification in the enclosed Galice area. This accordance would be expected if the Galice beds of the Galice area are interstratified with the volcanics, a view which may be favored also by the following consideration: On Rogue River, east of the mouth of Galice Creek, some tufaceous sediments and sheets of basic igneous rocks appear interstratified with the fossiliferous sediments of the Galice series, suggesting contemporaneous volcanic activity; others appear to be intrusive, but the contacts are obscure and the exact relations a matter of doubt.

The borders of the Galice area are generally lines of displacement. Along the eastern border of the area, on Rogue River, a short distance below Massie's ferry, the slates are so greatly sheared in the plane of general slaty cleavage dipping to the southeast as to indicate decided displacement.

On Grave Creek, near Anderson's, 5 miles below Leland, the eastern border is an irregular fault which is locally exposed and at least in part vertical. The general dip of the Galice strata of that vicinity is to the southeast, and the topmost slates are greatly sheared in the same direction as if volcanics were overthrust from the southeast.

On Cow Creek, near the mouth of Rattlesnake, the contact of the Galice slates and the volcanics is exposed within a few square rods on three lines, all of which run approximately northeast and southwest parallel to the strike of the slaty cleavage. Two of the contacts are clearly fault planes, straight and smooth with slickensides and local polish. These two lines of evident displacement can be traced only about a score of feet and run out into the volcanics. The third line of contact which lies between the other two is much less regular. Though the projecting portions of the volcanics along the line are rounded as if by some form of attrition, it is not so clearly a line of faulting. Wherever the contact of the Galice formation and the volcanics is exposed about the Galice area it shows displacement, but the amount of the displacement and its full meaning are not yet fully comprehended. It seems certain, however, that the Galice formation in its present position stratigraphically overlies a great portion of the associated volcanics.

Dothan Formation (Jurassic).

Definition.—The Dothan formation is an extensive succession of conformable Jurassic sandstones and shales in which the strata though often thin-bedded frequently range from 10 to over 100 feet in thickness. The sandstones predominate and locally there are thin beds of fine conglomerate and small lentils of radiolarian chert. The name is adopted from Dothan post-office on Cow Creek, in the midst of one of the best sections of the formation.

Lithological features. The shales are gray, dark within, rarely black. For the most part they are not slaty. At other places they may be slickensided parallel to cleavage. The sandstones are gray, weathering yellowish brown. They are in the main firmly lithified with silica, and in some places so squeezed as to give rise to a schistose structure with numerous veinlets of quartz. Many of the sandstones, however, are less firmly lithified and break with a rough surface due to the fact that the grains are stronger than the cement and the fracture passes between them instead of through them. The thin beds of conglomerate are made up largely of siliceous pebbles. The chert is of various colors, gray to red. It is sometimes massive but more frequently banded with thin films of brown shale.

Occurrence.—The Dothan formation occupies a broad belt running southwest from Cow Creek across Rogue River and the Illinois, reaching the coast near the southern border of the state. The larger area of Jurassic in southwest Oregon, as outlined on the Geological Map of North America, is chiefly Dothan. It lies northwest of the Galice area, from which it is separated generally by a belt of volcanic rocks. The most accessible and the best cross section of the series is on Cow Creek and West Fork, where it may be seen along the railroad in continuous exposures for nearly a dozen miles.

The section begins nearly 4 miles southeast of Dothan, where the rocks are mainly sandstone with less shale and a few thin beds of siliceous conglomerate. Sandstones occasionally massive attain a thickness of 100 feet, but most of the beds are much thinner and with the shales clearly mark the position of the strata dipping to the southeast beneath the sheets of lava which limit their outcrop in that direction. Near the border lava flows and tuffs occasional masses of chert are found interbedded with the other sedimentary rocks.

Farther down Cow Creek about Dothan and beyond on the main stream to the limit of the Dothan formation near Nichols Station, the proportion of shales is somewhat increased so that in some places shale is more abundant than sandstone. In the same portion of the section on West Fork, sandstones are decidedly the most abundant. The beds range from 2 to 30 feet in thickness and the stratification is conspicuous. As the northwest side of the area is approached, the attitude of the strata becomes more variable. Dips to the northwest become more frequent though the general dip may remain to the southeast. Quartz veinlets are abundant anywhere in cross fractures but are never conspicuous. Those of calcite become more abundant to the northwest near the Cretaceous, and lie mainly in the plane of slaty cleavage as well as in the fault planes which cut the earlier veins of quartz.

Rogue River between Howard and Mule Creek, for a distance of over a dozen miles, has cut a rugged canyon directly across the Dothan series and exposed an almost continuous section. The principal difference between the Cow Creek and Rogue River sections of the series is the presence of a large mass of conglomerate in the latter near the middle, forming prominent outcrops for several miles along Rogue River between Ditch and Kelsey creeks. The conglomerate is made up in part of limestone fragments and is so crushed as to obscure its folding. The rest of the section is made up of alternating sandstone and shales in variable but on the whole nearly equal proportions. They are greatly compressed and often sheared so that the sandstones appear as small lenses in the shales. Their dip is variable but generally southeast at a high angle.

Southwest of Rogue River the belt of Dothan is narrowed by the advance of the overlapping Cretaceous and Eocene formations. Beyond the Illinois, although traversed at a number of points to the coast, the country has not been sufficiently studied for mapping.

The thickness of the Dothan formation is difficult to determine owing to its disturbed condition, but it is certainly more than a mile and perhaps more nearly 2 miles. The belt is about a dozen miles wide where greatest, and no definite evidence could be obtained tending to show a repetition of any horizon. The faulting, as will be noted presently, tends to decrease rather than increase the apparent thickness.

Fossils and age.—Fossils have been looked for with care at many places on the Dothan formation and their general scarcity or absence contrasts this series with the Galice (Jurassic) on the one hand and the Myrtle (Cretaceous) on the other. Excepting the radiolaria of the chert and problematical wormtracks and leaf fragments which have been found at various horizons, definite fossils are known to occur only near the northwestern border of the main area in the vicinity of Nichols Station or in a small area on Doe Creek and Thompson Creek, 11 miles farther northeast.

The Nichols Station localities are in the sandstone and fine conglomerate of a small gulch about half a mile northwest of the post-office and on Table Creek near Logsden's place. A collection made by Mr. Will Q. Brown last summer at the last-named locality contains forms which are distinctly striated and leave no doubt concerning their specific determination as *Aucella erringtoni.* The rocks containing them are twisted and crushed but not silicified, and contain only veins of calcite.

On Doe Creek and Thompson Creek, Aucella have been found at a number of points but chiefly near Lost Prairie, a mile and a half northwest of Nickel Mountain, where they occur in a sandstone which is decidedly sheared and shows incipient schistosity cut by veins of quartz.

Associated with the fossiliferous silicified sandstone on Doe Creek is a considerable thickness of black slate. These rocks are cut off by a mass of greenstone about the head of Thompson and Judd creeks but reappear on the Umpqua River by the fording 3 miles northwest of Myrtle Creek post-office, where an example of *Aucella* was found. This is apparently the same horizon that occurs on Johnson Creek in the Port Orford quadrangle, where striated Aucella have been found in loose fragments but not in place.

It thus appears that the only characteristic fossil yet found in the Dothan formation is *Aucella erringtoni*, but that is so well marked and so distinctive as to leave scarcely a doubt concerning the Jurassic age of the formation. This reference is strongly supported when we come to consider its relations to adjacent terranes.

Relation to adjacent volcanic rocks.—The relation of the Dothan formation to the volcanic rocks which bound it for many miles upon the southeast has already been indicated in considering the Cow Creek section whose contemporaneous lavas and tuffs are found interbedded with the marginal portion of the Dothan strata. The general dip of the Dothan formation near the border is to the southeast beneath the great mass of lavas.

The contact of the Dothan formation with the overlying volcanics along the eastern border of the main area is everywhere a zone of decided shearing, affecting both the sediments and volcanics and producing not only slaty structure and slickensides but entailing the local development of talcose and chloritic schist-like material and considerable ore deposits. The displacement, however, has not changed the apparent stratigraphic succession, and the facts observed clearly indicate that the Dothan formation at present is stratigraphically beneath the mass of volcanics.

Relation to adjacent Galice formation.—The mass of volcanics which overlies the Dothan series is the same that has been shown to lie beneath the Galice series, and there seems no doubt that the two series in their regular order of succession are for the most part separated by an interval of volcanic rocks. This succession illustrates their order of age unless they have been overturned, a condition which is suggested by the planes of displacement.

At a number of points along Cow Creek and elsewhere striated fault planes were found rising to the northwest, generally at a high angle but sometimes horizontal as though there was an overthrust from the southeast.

A suggestion that the Galice is older than the Dothan may be found in the fact that the area occupied by the Galice lies between that of the Dothan and the nearest Paleozoic on the southeast. The most common dip among all the rocks is to the southeast, as if the Jurassic passed beneath the Paleozoic as a result of an overturn. However, the structure has not yet been resolved and the faunal differences between the Dothan and the Galice are not sufficiently great for age distinction.

Myrtle Formation (*Cretaceous*).

Characterization.—The Myrtle formation is a succession of shales, sandstones and conglomerates in which the alternating shales and sandstones, often thin-bedded, are of approximately the same volume but the conglomerates, generally fine, are of much smaller mass. Lentils of chert and limestone occur locally and the whole assemblage of beds is characterized by such a lower Cretaceous fauna as demonstrates its essential equivalence to the Shasta series of California.

Lithification.—The greater portion of the rocks of this formation are somewhat less firmly lithified than the majority of those belonging to the Galice and Dothan formations, but this is not the case everywhere. In the Myrtle, carbonate of lime as cementing material and in veinlets is widely distributed though siliceous cement and quartz veinlets are common in some areas. In the two Jurassic formations silica is the more common and widely distributed cementing material and quartz veinlets are locally abundant. Carbonate of lime is often present in them, but in both cement and veinlets it plays a much less extensive rôle than silica.

On lithological grounds, therefore, the Myrtle and Dothan are not always easily distinguished. The higher degree and more extensive silicification of the Dothan affords presumptive evidence, but it is only by means of fossils or definite stratigraphic data having reference to fossiliferous horizons that affords a satisfactory basis for separating the Dothan and Myrtle in the field.

Distribution.—The Myrtle formation lies north and northwest of the Dothan. Its largest area is along the coast about the mouth of Rogue River and as far north as the Sixes, where it passes beneath Eocene. This area mapped in the Port Orford folio as Myrtle certainly contains some Jurassic rocks for they have locally yielded *Aucella erringtoni* in the stream gravel of Johnson Creek, but as the fossils could not be found in place, and the rocks thus distinguished from similar rocks containing Knoxville fossils in the same region, they could not be mapped separately.

East of the Coast Range beyond the Eocene the Myrtle formation reappears along Myrtle Creek from which the formation was named and also a short distance farther northwest about the post-office of Dillard. All three areas are indicated upon the Geological Map of North America and are shown in detail in the Roseburg, Coos Bay and Port Orford folios, where a more extended account of the Myrtle formation may be found.

Relation of the Myrtle formation to the Dothan.—The actual contact of the Knoxville (Cretaceous) and the Dothan (Jurassic) has not been observed though it has been followed throughout the greater part of a distance of 50 miles and mapped in detail for nearly 30 miles. From Rogue River below the mouth of Mule Creek northeast to West Fork the Knoxville follows the border of the Dothan series, but near that point it turns abruptly east by way of Nichols Station to Canyonville, unconformably overlapping the broad belt of Dothan. Although the contact could not be found exposed, the strike of the Dothan carries it directly beneath the Knoxville ; it is for the most part more disturbed and more firmly lithified than the Knoxville and there can be no reasonable doubt that the unconformity is generally great. The Dothan and Knoxville where exposed within a few rods of each other are generally in strong contrast, the Knoxville strata having calcareous veins and cement while those of the Dothan are siliceous bespeaking a decided discordance, but this is not always true, for the Dothan, as near Nichols, well characterized by *Aucella erringtoni*, is locally calcareous and the Knoxville, in places equally well characterized, is locally siliceous.

Plant beds.—Plant beds containing a flora which according to Ward,* Fontaine and Knowlton has a decidedly Jurassic facies, occur in southwestern Oregon and northern California. In Oregon and more especially at Big Bar, Cal., some of the plants of Jurassic facies are clearly associated with shells which are regarded as characteristic of the Knoxville, but near Oroville, Cal., the plant beds contain an assemblage of shells which Dr. Stanton reports as having "a decided Jurassic aspect," in his opinion "older than the aucella-bearing Mariposa formation." The plant beds with "Jurassic flora" will be considered in a separate paper.

The Dillard Series of Louderback.

Introduction.

Louderback's general results.—"The Mesozoic of Southwestern Oregon" is the title of a paper† in which Prof. G. D. Louderback considers particularly the Myrtle formation of the Roseburg, Coos Bay and Port Orford folios. The results of his studies, to use his own language (p. 521), "are to the effect

* 20th Ann. Rept., pt. 2, pp. 368–377, and Monograph LVIII.
† Journal of Geology, vol. xiii, No. 6, pp. 514–555, Sept.–Oct., 1905.

that the formations mapped as Myrtle *senso stricto* may be separated into two chief groups or series (upper and lower), each representing quite an extent of geological history, and separated from each other by a distinct interval during which there were intrusions of igneous rocks and a period of considerable erosion."

Lower series.—The lower series, according to Louderback, is composed principally of gray sandstone so firmly lithified by siliceous cement that when the rock is broken the fresh fracture surface is smooth, traversing the grains. Besides this characteristic sandstone the lower series contains some shale, occasionally slaty, as well as foraminiferal limestone and radiolarian chert, the last being very characteristic. For the lower series Louderback proposes the name "Dillard", after a village situated on the railroad and south fork of the Umpqua River in the midst of the largest area of this series in the Roseburg quadrangle.

Upper group.—Louderback states that in the upper group the most abundant and characteristic rock type is shale, then sandstone and conglomerate. No trace of radiolarian cherts or cherts of any type occurs in this group, nor do foraminiferal limestones corresponding to the Whitsett lenses, although there are calcareous shales. For this division Louderback proposes to retain the name *Myrtle group.*

Comparison.—Comparing his Dillard series and the Myrtle group, Louderback remarks that their most striking general difference is the markedly inferior lithification of the Myrtle group, in which the sandstones (p. 525) "are commonly brown, sometimes buff or greenish, and never show the peculiar gray compact facies so often seen in the sandstones of the lower series." In describing (p. 343) the strong contrast between the close-lying areas of Myrtle and Dillard he points out that the change from one to the other is abrupt and not gradational. The only locality referred to where this contrast may be seen is a few miles southwest of Dodson Mountain, but unfortunately for that locality the two contrasted series are separated by a belt of serpentine. The general impression conveyed in Mr. Louderback's lengthy paper is that the two series are "well defined and distinctly separable" lithologically and readily discriminated in the field, epecially by one who is familar with the Franciscan of California.

Dillard Area of Dillard Series.

Defined.—The largest area of the Myrtle formation outlined on the map of the Roseburg quadrangle centers about the village of Dillard, where it crosses the Umpqua River and is conveniently referred to by both Louderback and the writer as the Dillard area. The lentils of limestone (Whitsett) and the larger masses of radiolarian chert, amphibole schist, and igneous rocks within the area are separately outlined and the great predominance of the other sediments is apparent at a glance.

Rocks considered.—Igneous rocks play a very important rôle in the geologic records of southwestern Oregon. Many of the rocks are of types found elsewhere in the Klamath Mountains at various horizons in the Paleozoic and Mesozoic. Since their ages are determined by reference to associated sedimentary rocks they will not be considered in this paper, which will be devoted to the consideration of the sedimentary rocks only.

Different views.—The Myrtle formation of the Dillard area was described in the Roseburg folio as Cretaceous and regarded as having its equivalence in the Knoxville and Horsetown of the Shasta group in California. Mr. Louderback designated the rocks of the same area as the "Dillard series," and regarded them as stratigraphically below and older than the Knoxville and equivalent to the Franciscan of California.

Locality of Louderback's observations.—Mr. Louderback states (p. 540) that "a large part of the Dillard area was studied by the writer, with the result that everywhere formations characteristic of the Dillard series were found, while no representative of the Myrtle group was recognized. It is probable that this whole area belongs to the lower series, although a more complete study may show subordinate patches or infoldings of the lower members of the Myrtle group. All of the members of the sedimentary series, all of the main types of igneous rocks, and the peculiar schists, described as characteristic of the Dillard series, occur within this area. The Whitsett foraminiferal limestone lentils crop out at intervals from about four miles directly east of Dillard to the northeast extremity of the area."

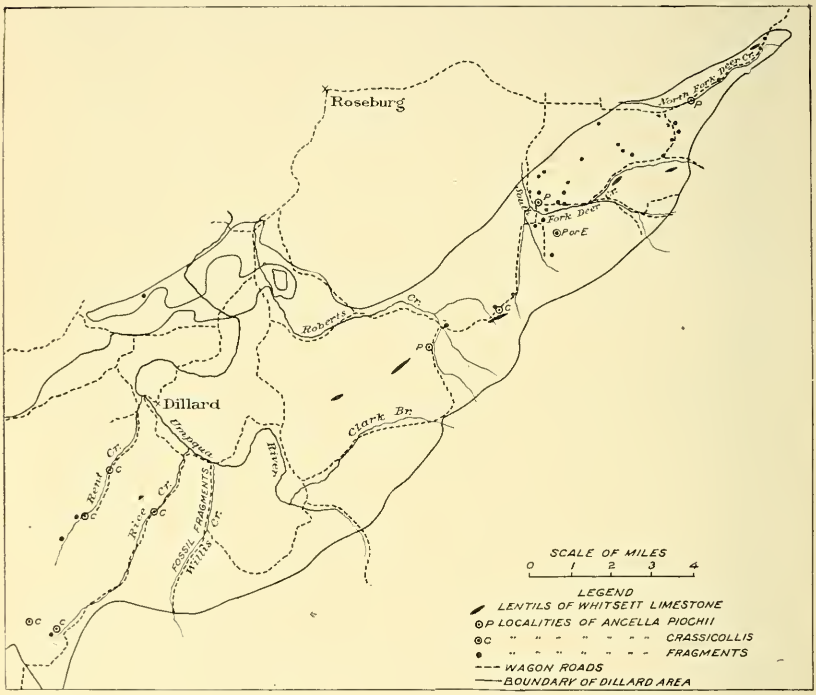
Expecting to have an opportunity to re-examine the "Dillard area" in connection with the survey of the Riddles quadrangle, which adjoins the Roseburg upon the south, I wrote to Mr. Louderback, enclosing a geological map of the Roseburg quadrangle and asked him to indicate by shading or otherwise "the large part of the Dillard area" he had studied, so that in the field I would have a lithological standard of comparison in endeavoring to discriminate between his "Dillard series" and "Myrtle group." In reply he stated: "I examined the country along *all* of the roads of that area northeast of the Umpqua River, and furthermore I visited those areas mapped as amphibole schist and as limestone which lie off the roads. To the southwest of the river I went over the area north of Winston and Brockway where cherts and schists are shown and also made a trip into the hills across from Dillard, but not far from the river road. I also went the full length of the three disconnected areas between the Dillard and the Myrtle Creek areas and believe them to be entirely Franciscan (Dillard)."

Points of agreement.—Before considering the differences of opinion attention should be called to points of agreement. Mr. Louderback and the writer agree in regarding the conglomerates, sandstones, shales and limestones of the Dillard area as forming but one series. Along *all* the roads east of the river and over whatever routes he traveled to examine the various small areas outlined within the Myrtle area, Mr. Louderback reports "everywhere formations characteristic of the Dillard (Franciscan) series were found." The writer, reviewing his own work in that portion of the Roseburg quadrangle last September, re-examined many and perhaps most of the localities studied by Louderback and found, as did Louderback, no sufficient reason for considering the sedimentary rocks in question as belonging definitely to more than one series.

The writer's views.—While surveying the Dillard area for the Roseburg folio in 1895–6 Knoxville fossils were found at four widely separated localities in the sandstones, and this furnished the reason for including this area in the Myrtle formation. When I read Mr. Louderback's paper his confident statements greatly surprised me that I should have overlooked so important an unconformity or break in the series in relegating the whole to the Knoxville. My surprise was lessened, however, when I remembered the Dothan that lies unconformably beneath the Knoxville in the Riddles quadrangle. Upon returning to the Dillard area I was expecting to find it composed in large part of the Dothan, containing Jurassic fossils, but in this I was disappointed, for all the determinable fossils found at over forty localities are Knoxville.

Knoxville fossils in the Dillard area.—The general distribution of Knoxville fossils collected in the Dillard area is shown upon the accompanying outline sketch (fig. 1), which indicates their position with reference to the roads, principal lines of drainage and the lentils of limestone, outlined within the area. The search for fossils was made chiefly in the northeast and southwest portions. In the former because it contains all the lenses of limestone and some of other rocks examined most particularly by Mr. Louderback, and in the latter because sedimentary rocks known to belong at the bottom of the Knoxville (plant beds), and next beneath it (Dothan) lie in that direction.

Northeast portion: From the head of Roberts Creek northeast along the road for over a dozen miles fossils occur at frequent intervals. In some places the fossils are well preserved but in others they are small fragments of aucellae, and it is only by careful search that specimens can be found complete enough to permit specific determination. Such specimens have been found, however, at a number of places and Dr.



Stanton has determined without question *Aucella piochii* and *Aucella crassicollis*, both of which are characteristic Knoxville forms. From one locality he reports a form that "may be either *A. piochii* or *A. erringtoni*," but from its field relation I have no hesitation in calling it *A. piochii*.

Fossils were not found at every outcrop nor could this reasonably be expected, for where best exposed in California the Knoxville strata are not all fossiliferous. There is no doubt, however, that further search would greatly extend the localities. The fossils were found most common along the central and northwest side of this portion of the Dillard area but some were found upon the southeast side, and lithologically the strata upon that side are the same as those containing fossils.

In the sandstone within 300 feet of the type area of Whitsett limestone, $1\frac{1}{4}$ miles northwest of Dodson Mountain, well preserved specimens of *Aucella crassicollis* were found. The sandstone very near or in contact with the limestone upon both sides appears to be identical with that which is fossiliferous.

Aucella occurs in the sandstone adjoining the northeastern lentil of limestone in Section 14, as well as near the mass of basic eruptive in Section 21 as shown in the Redding folio and near both of the border areas of amphibole schists a few miles farther southwest.

Southwest portion:—Some years ago *Aucella* was found in a conglomerate several miles north of Brockway in the immediate vicinity of the outcrops of chert and amphibole schist of that region, but the greater number of observed localities are about Kent, Rice, and Willis creeks.

On Kent Creek, fragments of shale, sandstone and conglomerate containing *Aucella crassicollis* occur throughout its course. Those in calcareous shale are in place within two miles of its mouth; the others come from higher up, where they occur more frequently in rocks that are locally well-veined with quartz.

Rice Creek has a gentle grade and a few rock outcrops in its bed as compared with Kent Creek. *Aucella crassicollis* was sought for at only two points and found at both. At Rice's Ranch, nearly 2 miles above the mouth of the creek, Aucella was found in fragments like those of Kent Creek. Near the head of the creek in Sec. 25, T. 29, R. 7, Mr. Storrs, to whose skill as a collector I have so often testified, recently found *Aucella crassicollis* in conglomerate shale and sandstone that is in part traversed by distinct veins of quartz. This locality is within a short distance of the intrusive which forms Big Baldy and occupies so large an area on the southern border of the Roseburg quadrangle.

On Willis Creek fossiliferous fragments of sandstone and conglomerate are common, especially above the forks in the neighborhood of a mass of red chert. Sufficient time was not devoted to this locality to find them in place, but the rocks are of the same character as those on Kent and Rice creeks. They must occur in place before reaching the limit of the area within a mile south of the mass of red chert.

Dr. Stanton's report on the fossils.—The fossils collected in the Dillard area were not made the subject of a special report by Dr. Stanton but included in his general report upon all the

Mesozoic fossils collected during the season in Douglas County. He says:

"In the Douglas County area the discrimination between the Jurassic and Cretaceous rests on the same slender basis as in the case of previous collections from the same region, that is, most of the localities in question contain no determinable fossils except Aucella, and when these are marked with numerous, distinct, radiating striae they are referred to the Jurassic species *Aucella erringtoni*. The Cretaceous species *Aucella piochii* has very nearly the same form, but lacsk the radiating striae.

It is evident, therefore, that the paleontologic separation of Jurassic and Cretaceous cannot be very positively made, especially when the surface features of the fossils are not very well preserved. It is true, however, that all of the specimens in this collection that can be referred to *A. erringtoni* came from the area that had previously been determined as Jurassic, and was so classified in Mr. Diller's list. This species was recognized in the lots from Thompson Creek, Table Creek, O' Shea Creek, and doubtfully in those from the South Fork of Beal Creek. The other lots from the supposed Jurassic area usually contain only fragmentary specimens of Aucella that cannot be specifically determined, or, in a few cases, some other fossil which is not diagnostic."

"The lots that were classified in the field as Cretaceous (including those of the Dillard area) apparently all belong to that system, although a few of them do not contain enough to distinguish between Jurassic and Cretaceous."

Quartz veining.—A considerable portion of the rocks of the Dillard area contain veinlets of quartz and in some cases the veinlets are abundant, though their distribution is very irregular. They occur most frequently in compact gray sandstone and are mere films, a small fraction of an inch in thickness and but a few inches in extent. Some irregular masses occur of a few feet in length.

A good exposure of this siliceous sandstone occurs in the immediate vicinity of the limestone lentil at the Marble Works in the eastern part of Sec. 19, T. 27, R. 4, and in the hills within 2 miles to the westward, where some of the beds containing quartz veins have calcareous cement and in others such veins are entirely absent.

Southwest of the Umpqua River among the rocks of the Dillard area a somewhat larger proportion is veined with quartz generally associated with those of calcite. Where quartz veinlets are most abundant calcite is often wanting. Towards the heads of Kent and Rice creeks, such rocks contain *Aucella crassicollis*, affording definite evidence of their Knoxville age, and yet it should be noted that specifically determinable fossils were not found in the ledges richest in quartz veins.

Limestone.—There are six lentils of Whitsett limestone scattered at intervals along the axis of the northeast portion of the Dillard area. They all contain the same foraminiferal remains, lie approximately in line, and are interstratified with the same series of sediments throughout so that there is good reason to suppose they represent but one geological horizon and that they belong to the same horizon as the strata with which they are associated. The limestone lentil near Whitsetts at the northwest base of Dodson Mountain has yielded a few fossils concerning which Dr. Stanton reports as follows:

"The collection from the Whitsett limestone is not as satisfactory as those previously obtained at the same place. When all of these are put together the evidence is not conclusive for the Cretaceous age of the bed, through there is nothing definitely opposed to this reference. The lot No. 6939 which was collected only 100 yards from the Whitsett limestone is certainly of Knoxville age."

The occurrence of limestone in the upper part of the Knoxville of the Dillard area is now holly exceptional, for it occurs at that horizon in several places along the western side of the Sacramento Valley in California.

Chert.—Lenses and irregular masses of radiolarian chert are mentioned by Louderback as very characteristic of the Dillard (Franciscan) as though the mere occurrence of chert were sufficiently distinctive. It is well to remember that in the Klamath Mountains radiolarian chert is widely distributed in some of the Paleozoic formations and occurs at intervals in later formations. In the Shasta group of Tehama County, Cal., where it attains perhaps its greatest known thickness, no cherts were observed as far as the writer is aware, but this cannot be considered a valid reason for excluding them from its equivalent series in Oregon. Nor, on the other hand, can it be reasonably claimed that because some of the chert belong to the Dothan formation of Oregon and is Jurassic, all of it in that region belongs to the same horizon.

In the Roseburg folio radiolarian chert is mapped as "Juratrias?" The intimate association of the chert with the Myrtle formation was recognized as tending to show that the chert is Cretaceous, but greater weight was given to the fact "that the sandstones and conglomerates of the Myrtle formation contain veined fragments of chert, suggesting an age for much of the chert clearly earlier than the Myrtle formation, which was itself probably laid down during the early portion of the Cretaceous period."

While still holding to the view that much of the chert is earlier than the Knoxville, I see no sufficient reason for concluding that it is *all* older. As pointed out elsewhere, the intimate association of chert with Knoxville strata furnishes strong evidence of its Knoxville age. At this time I shall refer to but one of the cherts in the Dillard area and that is the one at several points associated with the Whitsett limestone. It is distinctly radiolarial and so involved with the limestone that both must belong to the same horizon.

Nomenclature.—Primarily upon lithological evidence the name "Dillard series" was proposed for the sediments of the Dillard area under the impression that they were older than the Knoxville. The presence of Knoxville fossils at so many points throughout the area demonstrates conclusively that the great part if not the whole mass of sediments within the Dillard area are really Knoxville and were properly included in the Myrtle formation as originally defined and since unchanged. The Myrtle formation has always been regarded as practically equivalent to the Shasta group of California.

As stated in this paper, the writer is of the opinion that the equivalent of what is called "Franciscan" in California is most likely in the Dothan and not the prevailing rocks of the Dillard area. The fossils clearly show that the bulk of the rocks in the Dillard area are Knoxville. No definite trace of Dothan fossils or of the plant beds with "Jurassic flora" were found in the Dillard area, as might reasonably be expected if they occur there, for their nearest outcrops a few miles to the southwest have distinctive fossils.

It is possible that rocks of the Dothan series may yet be identified in the Dillard area, but as it now stands our failure to find within the area any fossils definitely older than the Knoxville leaves a decided objection to adopting Louderback's term Dillard for the strata here included under the Dothan. If striated Aucellae are yet discovered in the strata at Dillard station proving it a type locality for strata older than the Knoxville, the name Dillard should supplant Dothan as a formation name.

Résumé.

The Mesozoic sediments of southwestern Oregon may be, for the present, most conveniently considered under four heads as follows: Galice formation, Dothan formation, Myrtle formation, and Chico formation.

The Galice formation is composed mainly of dark slates and is characterized by a late Jurassic fauna.

In the Dothan formation sandstone predominates though there is much interbedded shale. Its Jurassic age is indicated by the presence of *Aucella erringtoni.*

Both formations where best developed dip to the southeast and the Galice beds overlie the Dothan. They are generally separated by a belt of volcanics. Both series and the associated volcanics are locally sheared by thrust from the southeast.

The prevalence of shearing from the direction of the dip suggests that the strata are overturned and that the Galice is really older than the Dothan.

From its lithology and fauna the Galice may be correlated to the Mariposa.

The Dothan lies unconformably beneath the Knoxville and with its occasional beds of chart may be the equivalent in part of the Franciscan in California, which is said to occupy a corresponding position. If so, the Franciscan is Jurassic.

The Dillard of the type area of Louderback is characterized in large part by the presence of Knoxville fossils and therefore belongs chiefly if not wholly to the Myrtle formation.

Art. XL.—*Studies in the Cyperaceæ;* by Theo. Holm. XXV. Notes on *Carex*. (With 13 figures drawn from nature by the author.)

Carex capitata L.

It seems very difficult to place this species in a natural way among the other *Carices*, even if it must be considered as a true *Vignea*. The small roundish, androgynous spike with the greenish, wingless, membranous perigynia spreading at maturity, and the straight beak with hyaline orifice are characters that are seldom met with among the other *Vigneæ*. And although it naturally stands as a "*forma hebetata*," we have failed to detect any analogies in structure by which it might be associated with some of the more evolute types. For this reason the writer has preferred to place it in a grex of its own: *Microcephalæ*,* thus preceding the *Cephalostachyæ* (*C. foetida* cet.) and the *Sphærostachyæ* (*C. incurva*).

The geographical distribution of the species is extremely wide, extending throughout the northern hemisphere. We find it in Alaska and Yukon, in the Rocky Mountains (Wyoming, in the White Mountains (New Hampshire), in the Hudson Bay Region, on the coasts of Greenland, in Iceland, Scandinavia; Tyrol, arctic Russia and in the mountains of Bajkal and Davuria; it occurs, moreover, in South America and has been collected in Argentina and in Tierra del Fuego. And in spite of this enormous distribution the species does not show any tendency to vary, but remains constantly the same. Variation among the "*formæ hebetatæ*" is, as we remember, not very pronounced, especially not among the *Vigneæ*, but there are some species, nevertheless, which do vary in certain regions, for instance: *C. nardina* and *C. gynocrates*. Among the *Carices genuinæ* variation has been noticed in *C. Geyeri*, *C. nigricans*, *C. lejocarpa*, *C. scirpoidea*, etc.

In regard to the external characters *C. capitata* is well known, but it does not seem as if the internal structure has been studied so far. A comparative study of the "*formæ hebetatæ*" might give some interesting results inasmuch as they are looked upon as representing, at least to some extent, the habit of ancestral types of the genus. Being in possession of a very rich material of this species, the writer has examined the anatomy of specimens from very remote localities, and does not hesitate to present the results as a contribution to the knowledge of these "*formæ hebetatæ*."

* "Greges Caricum." (This Journal, vol. xvi, p. 456, 1903.)

The root-structure shows nothing of particular interest, but we might mention that a hypoderm is developed, and that the cortical parenchyma is divided into two distinct zones, a peripheral of three to five layers, which are thick-walled, and an inner of about ten strata, thin-walled and tangentially collapsed. Furthermore that the pericambium is interrupted by all (six) the proto-hadrome vessels.

The flower-bearing stem is cylindric, furrowed, but glabrous. Very peculiar is the structure of epidermis.* The outer, and partially also the lateral, cell-walls show an enormous thickening and are extended into large, club-shaped papillæ around the stomata, which are sunk below the adjoining epidermis (fig. 1). Where epidermis covers the stereome, the cell-walls are, also, very thick but not extended into papillæ. The cortical parenchyma is developed as palisades radiating towards the center of the stem, except those that border on the mestome-strands, which radiate toward the center of these. The mestome-strands are located in one circular band, large and small in regular alternation with each other. Of these the former, the larger ones, have a support of stereome extending to the epidermis. A thin-walled parenchyma- and a thick-walled mestome-sheath surrounds each mestome-bundle. The pith is thin-walled and hollow; thus we have in this species of *Carex* a cylindric and hollow stem; we remember that a triangular and solid stem is the most frequent in the *Cyperaceæ.*

The leaves are very narrow, but flat, at least toward the base; near the apex they are hemicylindric with a groove in the middle. We find here the same thick-walled epidermis as observed in the stem, and the stomata are, also, here surrounded by protuberances of the outer cell-walls. These protuberances (fig. 2) show a very peculiar shape, being branched at the summit, a structure which we have not, so far, observed in any other "forma hebetata" of *Carex.* The lumen of the epidermis is somewhat wider on the ventral face than on the lower, but bulliform cells in the stricter sense of the word are not developed. The chlorenchyma consists of palisades arranged in the same way as in the stem, but is interrupted by wide lacunes. The stereome is very thick-walled and accompanies the larger mestome-bundles as hypodermal strands. There are about nine mestome-bundles, of which the three are much larger than the others; each is surrounded by a thin-walled parenchyma- and a thick-walled mestome-sheath.

The perigynium.

The very thin perigynium is glabrous except near the apex, where a few prickle-like projections are to be observed. The

*Compare this Journal, vol. x, p. 282, 1900.

outer epidermis is quite thick-walled and covers a few, one or two, layers of chlorenchyma. There are only two mestome-strands, both with a support of stereome on the leptome- and hadrome-side, while no isolated strands of stereome were observed between the veins.

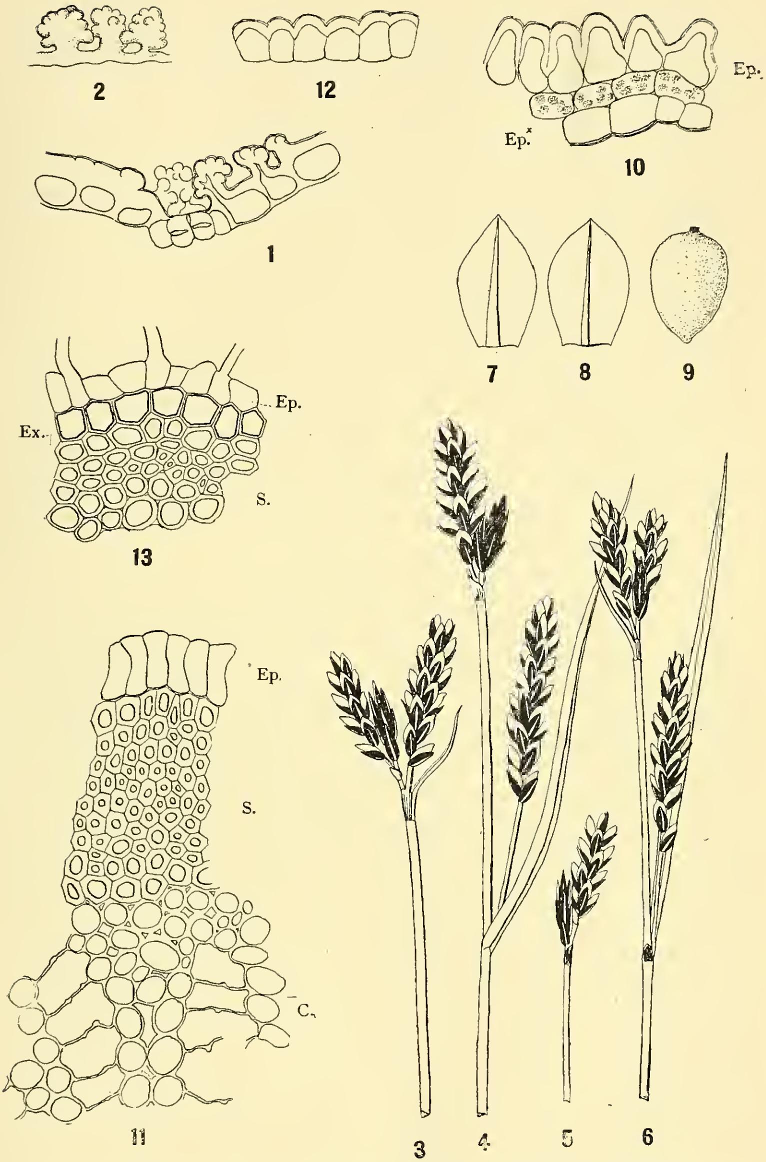
Characteristic of *Carex capitata* is, thus, the very conspicuous epidermal protuberances which protect the stomata*; moreover the relative strong development of stereome in stem and leaf, but accompanied by a hollow pith and a chlorenchyma traversed by broad lacunes. The specimen, described above, was collected by the writer on dry rocks at Egedesminde in Greenland, and we noticed exactly the same structure in other specimens from wet soil at Sukkertoppen (Greenland), from swamps in the mountains of Sweden and Tyrol, besides from Yukon.

If we compare now the structure of our *Carex* with that of other "*formæ hebetatæ*" we notice that a cylindric and hollow stem is not so seldom met with among these. This stem-structure is characteristic of the following species from dry rocks: *C. elynoides*, *C. Oreocharis*, *C. nardina* and *pyrenaica*. On the other hand, the stem is cylindric and solid in *C. circinita*, but triangular and hollow in *C. rupestris*.

A cylindric and hollow stem is, furthermore, to be observed in the following species from bogs: *C. dioica*, *C. gynocrates* and *C. paralela*, while a triangular, hollow stem occurs in *C. lejocarpa*, *C. exilis* and *C. nigricans*; in the last of these, however, the stem varies from triangular to cylindric A triangular and solid stem was found in *C. polytrichoides*, and a pentagonal, solid in *C. pulicaris*. The chlorenchyma of the leaves is very open from wide lacunes in all these species, and the cortex of the stem shows, also, lacunes in these with the only exception of *C. elynoides* and *C. exilis*. But in regard to the position of the stomata, *C. capitata* is the only one in which these are sunk and protected by papillæ; in all the other species the stomata are superficial.

In considering the "*formæ hebetatæ*" of *Vigneæ* and *Carices genuinæ* it appears as if the anatomical structure is not influenced by the nature of the surroundings, since we have observed an open chlorenchyma and cortex in species from dry rocks as well as from bogs; moreover the position of the stomata is the same in these except *C. capitata*. From this comparison it would appear as if our *Carex* represents a peculiar typeof *Vignea*, and at the same time a remarkable "*forma hebetata*" on account of the protected stomata.

* Similar epidermal projections have been observed in some of the more evolute types of *Vigneæ* and *C. genuinæ*, for instance: *C. paniculata*, *tereti-uscula*, *vesicaria*, *ampullacea* (Schwendener), *riparia* and *provincialis* (Mazel).



Let us, however, extend our comparison still further, and consider the structure of the 38 species of *Carex* examined by Mazel.* All of these are evolute types, and nearly all "*formæ*

* Etudes d'anatomie compareé sur les organes de végétation dans le genre Carex. Thesis, Genève, 1891.

centrales" of *Vignea* and of *Carices genuinæ.* Mazel observed in these that the stomata were superficial in 21 species from woods and hills and in 4 from bogs; moreover that the stomata were sunk or protected by papillæ in 5 species from woods and hills, in 8 from bogs.

The species treated by Mazel belonged to many different greges, thus illustrating the same fact as observed in the lower types, described above, that the position of stomata indicates no special environment, at least not in the present genus.

If the question be asked, whether it may be possible to detect some certain degree of relationship among the *Carices* by means of the anatomical structure, we must answer in the negative. But we must state, at the same time, that the number of species examined is yet too small to enable us to reach any decisive conclusion. In the material which we have examined, comprising types of the various greges and including lesser and higher developed forms, it has appeared to us, so far, that the structure is too uniform in general for connecting the species in greges by means of their internal structure. In some greges such classification may seem possible, but in others we have met with very serious difficulties.

Carex holostoma Drej.

This peculiar and rare species was discovered by Vahl on the west coast of Greenland, and described by Drejer.* The original diagnosis reads as follows: Spicis binis ternisve, terminali mascula reliquis breviore vel deficiente, femineis duabus elongatis laxifloris subæquialtis, perigyniis subgloboso-ovalibus lævibus rostro brevissimo integerrimo, squamis ovatis obtusis perigynio brevioribus, stigmatibus ternis." By Drejer the species was considered a near ally of *C. alpina* Sw. and identical with Wahlenberg's variety *inferalpina*; Blytt, however, retained *inferalpina* as a variety of *C. alpina* and as being very distinct from *C. holostoma.* As stated above, *C. holostoma* occurs in Greenland, and has, so far, only been found in a few localities between 68° 21′ and 72° 20′ N. L. on the west coast. Since then it has, also, been found in Finmark: "Gakkovarre, convallis Reisendal in regione Salicina" by Arnell and Blytt (Aug. 1891). It grows in wet places, and was found, for instance, by the writer near Christianshaab (Greenland) in a *Polytrichum*-bog associated with *C. alpina*, *capillaris*, *rariflora* and *stans.*

A similar view was held by Lange,† who placed the species between *C. alpina* and *atrata* in a section with: spicæ invicem

* Revisio Caricum borealium in terris sub imperio Danico jacentibus inventarum (Naturhist. Tidsskr. Kjöbenhaven, 1841, vol. 3).

† Conspectus Floræ Groenlandicæ (Medd. om Grönland. Part 3. Kjöbenhavn, 1880, p. 139).

approximatæ, terminalis androgyna, basi mascula, reliquæ fœmineæ. The terminal spike in *C. holostoma*, however, is at least in typical specimens purely staminate, and the species does not seem to be so very closely related to any of these species. In *C. alpina* the terminal spike is gynæcandrous, and the two or three lateral pistillate spikes are very short and closely sessile forming an almost globular head, while in *C. holostoma* the pistillate spikes are cylindric, lax-flowered and frequently remote. Figs. 3–6 illustrate the inflorescence of the Greenland plant, and in all of these the staminate spike is very small and partly hidden by the much larger pistillate ones. The number of pistillate spikes varies somewhat, but two seem to be the most common (fig. 3), and the lower one is often remote; three pistillate spikes (fig. 6) is rather seldom met with, and a single pistillate with or without the terminal staminate may be observed in depauperate specimens (fig. 5). The perigynium (fig. 9) is much broader than that of *C. alpina* and lacks the distinct, emarginate beak. As already suggested by Drejer, *C. holostoma* is a member of the *Melananthæ*, but we have preferred to place it among the more evolute types, next to *C. Raynoldsii* Dew., instead of near *C. alpina* and *atrata*, on account of the structure of the terminal spike and the perigynium.

In the Norwegian specimens of *C. holostoma* we observed exactly the same disposition of the spikes and structure of the perigynium as described above as being characteristic of the Greenland plant.

So far the species is only known from West Greenland and Finmark, but we should not feel surprised if the geographical range might be extended to the northeastern shores of our continent, for instance along Baffin Bay and Davis Strait.

In regard to the anatomical structure *C. holostoma* does not show but a very few points of interest when compared with the other species examined so far; but taking into consideration the fact that the species is very rare and has not so far been studied from this point of view, we have thought that a brief description might be of some interest to students of the genus. The internal structure of the vegetative organs may, thus, be described as follows:

The roots.

All the roots are long, amply ramified and hairy. Inside the thin-walled epidermis is a moderately thickened exodermis of a brownish color. The cortex consists of about ten strata, of which the peripheral three are somewhat thick-walled, but contain starch like all the others. The inner layers are collapsed tangentially; thus this portion of the cortical parenchyma represents a very open tissue. We find in the stele a thick-walled endodermis of the U-type, and a thin-walled pericambium, which is broken by all the proto-hadrome vessels. The hadrome consists of several (about eleven) rays of vessels, in which the oldest are mostly single or, but seldom, two side by side. Alternating with these rays are strands of leptome of the usual structure, while the center of the stele is occupied by a broad cylinder of thick-walled conjunctive tissue. In regard to the interruption of the pericambium we noticed in some cases that this is not constant. In the same roots, for instance, a few of the proto-hadrome vessels were located inside this tissue instead of bordering directly on endodermis. Similar variations we have observed and described as characteristic of several other Carices.

The rhizome.

The stolons have a moderately thickened epidermis and a broad cortical parenchyma of about twenty layers, containing deposits of starch. Of these the peripheral (six) strata are slightly thick-walled in contrast to the inner ones, which are broken down into wide lacunes. Endodermis shows the same structure as observed in the roots. A pericycle of two to three layers of rather thin-walled stereome surrounds three almost concentric bands of mestome-bundles, of which the peripheral are collateral, the others mostly leptocentric. A thick-walled, starch-bearing pith occupies the center of the stele.

The culm.

The flower-bearing stem is sharply triangular, scabrous and solid. The cuticle is smooth and the epidermis shows the outer walls heavily thickened and extended into obtuse papillæ; the characteristic cones in the cells of the epidermis were observed outside the stereomatic strands. The cortex contains chlorophyll and consists of six layers of roundish cells (in cross-sections) with rather narrow lacunes but of no palisades. A thick-walled stereome occurs as broad strands on the leptome- and hadrome-side of the mestome-bundles, extending to epidermis, besides that an isolated group of this tissue, the stereome, occurs in each of the three angles of the stem. The mestome-strands are arranged in one band, and represent two sizes, smaller and larger ones in regular alternation with each other. They are collateral and possess a thin-walled parenchyma, and a moderately thickened mestome-sheath. The pith is thin-walled, but solid.

The green leaves.

The leaves are flat and scabrous, especially on the dorsal face, where the thick-walled epidermis is extended into numerous short and obtuse papillæ around the stomata. The ventral epidermis is rather thin-walled and shows only a few papillæ; above the midrib is a band of bulliform cells in a single stratum. In regard to the stomata, these occur on both faces of the blade, but are most numerous, however, on the dorsal; they are sunk below the surrounding epidermis, and the air-chamber is deep and quite wide.

The stereome is well developed and distributed as hypodermal groups accompanying the veins, on both the leptome- and hadrome-side of the larger ones, but only on the leptome-side of the smaller; a small isolated group of stereome is to be observed in the leaf-margins. The chlorenchyma represents a homogenous tissue of roundish cells (in cross-section), and no palisade-cells were observed; it is broken down into wide lacunes, one between each two mestome-strands. All the mestome-bundles are collateral and possess a thin-walled, green parenchyma-sheath and a mestome-sheath with the inner cell-walls thickened.

The perigynium.

The perigynium is generally described as being glabrous, but the surface is, nevertheless, distinctly granular from numerous papillæ like those observed in the green leaves. The cuticle is thick and smooth, and the outer epidermis is quite thick-walled (fig. 10) in contrast to the inner one (Ep.* in fig. 10). A thick-walled stereome occurs as hypodermal strands on both faces of the two mestome-bundles, besides as three isolated strands on the flat, narrow side of the perigynium and as nine on the much broader, convex one. The chlorenchyma is poorly developed as a single layer between the veins, and as two to three layers around these. The mestome-strands are very thin and consist mostly of leptome; no parenchyma or mestome-sheath was observed, at least not as continuous sheaths.

We have, as stated above, placed *C. holostoma* among the "*formæ centrales*"* as an ally of *C. stylosa* C. A. Mey. and *C. Raynoldsii* Dew., and we might now add a few remarks upon the structure of these species. The difference in structure is relatively slight, inasmuch as they all show the principal anatomical features exhibited by the genus *Carex* in general.

Carex stylosa C. A. Mey.

The roots.

Our figure 11 shows a transverse section of one of the strong, secondary roots, and we notice here nine strata of very thick-

* "Greges *Caricum*." This Journal, vol. xvi, p. 457, Dec. 1903.

walled cells inside epidermis; they are stereïds, but are rather short and with the cross-walls horizontal, not oblique as in typical cells of this tissue. Inside the stereïds are about twelve layers of cortex, which are collapsed tangentially; the cells are moderately thickened and contain starch. Endodermis is heavily thickened as a U-endodermis; the thin-walled pericambium is interrupted by all the protohadrome-vessels, ten in all. The hadromatic rays are very short, each consisting only of two vessels, alternating with very small strands of leptome. The center of the stele is occupied by a large mass of thick-walled conjunctive tissue.

Characteristic of the root is, thus, the strong development of the stereïds, which extend to epidermis; thus no hypoderm, in the stricter sense of the word, is observable.

The culm.

The sharply triangular culm is scabrous from numerous, obtuse papillæ, and solid. The structure agrees well with that of the former species, but the cortex is more open on account of the larger lacunes, and the stereome is better developed, forming broad arches on the hadrome-side bordering on the pith, while it is not represented as isolated strands in the three angles of the stem as observed in *C. holostoma.*

The leaf.

The green leaves are flat, scabrous on the dorsal face, but glabrous on the ventral. The bulliform cells occur here in two strata above the midrib, but otherwise the epidermis shows the same structure as described above. The chlorenchyma consists of more oblong cells and those on the ventral face represent almost typical palisades; wide lacunes traverse the chlorenchyma between the veins. In regard to the stereome this tissue is better developed in this species than in *C. holostoma*, and especially on the hadrome-side.

The perigynium.

The perigynium differs from that of the former species by being stipitate, ovate-elliptical and provided with a short beak, which is more or less distinctly emarginate. The outer epidermis (fig. 12) is thick-walled, but not papillose. The chlorenchyma agrees with that of *C. holostoma* and contains only two mestome-strands, surrounded by a parenchyma- and a mestome-sheath, both of which are clearly differentiated. Thin strands of stereome accompany the veins, besides that there are a few, about two, isolated strands between these.

Carex Raynoldsii Dew.

The structure of this species agrees in most respects with that of *C. stylosa*, but the following distinctions may be mentioned. The culm is sharply triangular, but glabrous, and very robust; the homogenous cortical parenchyma is traversed by very wide lacunes, and the stereome is much stronger developed than in the former species. The thin-walled pith is hollow. The very broad leaves are glabrous and flat; epidermis is thin-walled on both faces and the outer cell-walls are extended so as to form low papillæ, especially on the dorsal face; the stomata are sunk, and the air chamber is shallow, but wide. No palisades are developed in the chlorenchyma, and the stereome is well represented on both faces of the mestome-strands besides in the leaf-margins.

The perigynium is very thin and perfectly glabrous; the dorsal epidermis is moderately thick-walled in contrast to the ventral, and the chlorenchyma is very sparingly represented. There are only two mestome-strands, but about twenty narrow strands of stereome between these.

In comparing the structure of these species: *C. holostoma*, *stylosa* and *Raynoldsii*, we notice the very prominent development of papillæ in *C. holostoma*, to some extent also in *C. stylosa*, but not at all in *C. Raynoldsii*. Furthermore the presence of almost typical palisades in the leaf of *C. stylosa* in contrast to the homogenous chlorenchyma in the other species. The bulliform cells occur only as one band above the midrib, of two strata in *C. stylosa*, but of only one in the other species.

The perigynium is glabrous in *C. Raynoldsii*, but granular in the others, and the presence of many isolated stereome-strands is characteristic of this same species.

If we extend the comparison to *C. alpina* Sw., which represents a lower type of the *Melananthæ*, we do not observe any character in anatomical respect by which this species may be distinguished from the more evolute *C. holostoma* or its nearest allies. The roots (fig. 13) possess an exodermis, and four strata of stereïds, while the cortex consists of eight layers of thin-walled cells, tangentially collapsed. The endodermis is heavily thickened, and the pericambium is interrupted by all the protohadrome-vessels. The culm is obtusely triangular and glabrous, with the cortex traversed by wide lacunes. The mestome-bundles are arranged in one band and supported by thick-walled stereome. The leaves are scabrous from obtuse papillæ, and the stomata are raised a little above the adjoining epidermis; on the ventral face the chlorenchyma shows one stratum of almost typical palisades; thus the leaf-structure resembles that of *C. stylosa*, and more so than that of *C. holostoma*.

Finally the perigynium is granular, but not papillose, and possesses three stereomatic strands between the two mestome-bundles; the external shape of this organ is, as stated above, very different from that of *C. holostoma*.

The affinity of *C. holostoma*, thus, seems to be with *C. stylosa* and *C. Raynoldsii* instead of with *C. alpina*, when we compare the external structure of the spikes, and especially of the perigynium. But from an anatomical point of view the distinction is barely noticeable, and we have, thus, in *C. alpina* a type that exhibits the same internal structure as the higher developed within the same grex. It must not be forgotten, however, that *C. alpina* being pleiostachyous represents a higher type than the monostachyous "formæ hebetatæ" of the other greges.

Brookland, D.C., April, 1907.

EXPLANATION OF FIGURES.

FIG. 1. Epidermis of the culm of *C. capitata* showing the branched papillæ; × 560.

FIG. 2. Epidermis of the leaf of same species. × 560.

FIGS. 3–6. Inflorescences of *C. holostoma*; $1\frac{3}{8}$ × natural size.

FIG. 7. Scale of staminate spike of *C. holostoma*; magnified.

FIG. 8. Scale of pistillate spike of same; magnified.

FIG. 9. Perigynium of same; magnified.

FIG. 10. Same, transverse section; Ep.=dorsal, Ep.*=ventral epidermis; × 320.

FIG. 11. Transverse section of the root of *C. stylosa*: Ep.=epidermis; S.=stereïds; C.=cortex. × 320.

FIG. 12. Epidermis of perigynium of *C. stylosa*. × 240.

FIG. 13. Transverse section of the root of *C. alpina*; Ex.=exodermis; the other letters as above. × 320.

ART. XLI.—*Contributions to the Geology of New Hampshire: No. III, On Red Hill, Moultonboro;* by L. V. PIRSSON; with Analyses by H. S. WASHINGTON.

[Continued from p. 276.]

Petrography of the Dikes.

THE previous part of this paper deals with the geology of Red Hill and the petrography of the main mass of nephelite-syenite composing it. The petrography of the rocks occurring in dikes in and about it will next be considered and in conclusion some general considerations regarding the origin of the rocks is given.

Trachiphyro-miaskose (*Nephelite-syenite-porphyry*).

This rock was not found in place but occurs in blocks in the central western valley. The best place to find them is in the stone walls of the Horne farm; they are very uncommon, indicating a restricted amount of the rock. A similar type is also seen in small scattered fragments on the north peak but was also not found in place; it is denser and more felsitic than that in the valley below and the pieces observed are deeply weathered to a red-brown color and too much altered for investigation. Although not found in place the characters of the rock, combined with the facts mentioned, point quite clearly to its occurrence in dikes whose exposures in the main rock mass are hidden under the soil and vegetation covering it. As few porphyries of Brögger's aschistic class of the lenfelic rocks have been described it is of interest to add a new occurrence.

Megascopic characters.—Holocrystalline; medium dark gray; very fine but still megagranular; of a porphyritic texture, rather thickly dotted with phenocrysts of feldspar of a grayish white and very thin tabular on 010 and columnar on $\dot{a}$, presenting lath sections averaging 5–10^{mm} long by 1^{mm} broad. Occasional specks of a ferromagnesian mineral. Quite fresh; of a rough hackly fracture and weathering on exposed surfaces to a yellow brown clay.

Microscopic characters.—The following minerals are found in the section; iron ore, apatite, zircon, rosenbuschite, biotite, aegirite-augite, alkalic feldspars, nephelite, sodalite and cancrinite.

The iron ore is very rare, a few grains 0·03–0·05^{mm} diameter were observed. Zircon is not uncommon as an accessory in minute grains. Apatite is seen in small occasional prismoids. The biotite is of a greenish variety, $\mathfrak{a}$ and $\mathfrak{b}$ strong olive-green, 𝔞, pale brownish yellow and carries inclusions of zircon surrounded by pleochroic halos. It forms occasional tablets 1^{mm} long by 0·5 broad which might rank as phenocrysts but the greater part of it is scattered through the groundmass in minute shreds, flakes and tablets varying from $0·05–0·10^{mm}$ in diameter.

The aegirite-augite is in shapeless pieces which now and then tend to elongated sections; it has the following pleochroism: 𝔞 and 𝔟, clear grass-green, 𝔠 yellow. The angle of $\dot{c}$ on 𝔞 is variable, about 10° and less toward the border in some cases; this shows it to be between pure aegirite and aegirite-augite.

Rosenbuschite.—Attached to aegirite there was observed a bunch of radially divergent, colorless needles, whose refractive index is about 1·6, birefringence rather high. They have a negative optical extension in all cases. Are in nephelite. A few other needles of the same mineral were observed with these characters. They are not sillimanite, wollastonite or pectolite and the optical and other characters combined with the place of occurrence make it practically certain that the mineral is rosenbuschite or an allied one.

The feldspar phenocrysts whose size and shape has been mentioned are of microperthite, the amount of albite and orthoclase being about equal; the albite lamellae commonly show albite twinning.

The groundmass is made of laths of alkalic feldspars which average about 0·20 by $0·03^{mm}$. Sometimes these are of albite as shown by the twinning, sometimes they are of orthoclase. In the angular interspaces between them is the nephelite and sodalite, the last products of crystallization. The sodalite was in somewhat larger areas than the nephelite and at times a little cancrinite is with it.

Mode.—The actual quantitative mineral composition was determined by the Rosiwal method. With a moderately high power the minerals were well individualized and could be measured fairly accurately. There was of course some uncertainty at times in discriminating between the feldspathoid components and their borders, but these errors, provided a sufficiently large number of measurements be made, tend to balance one another. The average size of grain was $0·08^{mm}$ and 150 sections of the grains were measured in a total distance of $12·00^{mm}$ with the results given in the table.

The amount of zircon is probably too high; a single large grain was encountered in the traverse; there is too little both of it and of magnetite to determine it accurately, but the amount is too small to be of practical importance.

Chemical Composition.—The approximate chemical com-

Minerals	mm.	Vol. %	Sp. G.	Wt. %
Orthoclase	4·20	35·00	2·55	33·5
Albite	3·70	30·83	2·62	30·4
Nephelite	1·80	15·00	2·55	14·4
Sodalite	·60	5·00	2·30	4·3
Aegirite	·55	4·58	3·50	6·0
Biotite	1·05	8·75	3·00	9·9
Magnetite	·05	·41	5·00	0·8
Zircon	·05	·41	4·70	0·7
Total	12·00	99·98		100·0

position of the rock may now be deduced from the mode given above. For this purpose the following mineral compositions are assumed:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	TiO_2
Nephelite	45·1	33·3	---	---	---	---	16·4	5·1	---	--
Aegirite	50·0	5·0	16·0	5·5	4·0	9·5	8·5	0·5	---	1·0
Biotite	32·0	17·0	19·0	14·0	1·0	---	1·5	8·0	4·5	2·0

The biotite is that of the green lepidomelane from the nephelite syenite of Litchfield, Maine* with correction for TiO_2; that of the aegirite-augite one from nephelite-syenite of Särna, Dalecarlia, Sweden† and the nephelite the average of a number of closely agreeing analyses of nephelites. The presence of the potash in this mineral is to be noted; it is wrong in such calculations to consider it as pure $NaAlSiO_4$, as in the norm, the modal nephelite contains considerable potash. The results of the calculation are as seen in No. I of the table.

	I	II	III	IV
SiO_2	57·08	58·30	59·01	·951
Al_2O_3	20·20	21·38	18·18	·198
Fe_2O_3	3·39	1·05	1·63	·021
FeO	1·97	2·04	3·65	·028
MgO	·34	0·22	1·05	·008
CaO	·57	0·95	2·40	·011
Na_2O	7·70	8·66	7·03	·124
K_2O	7·21	6·06	5·34	·077
H_2O	·45	·80	·65	---
TiO_2	·36	·10	·81	·005
ZrO_2	·47	·02	tr.	·004
P_2O_5	tr.	·04	tr.	---
CO_2	tr.	none	---	---
Cl	·31	·35	·12	·009
	100·05	100·05	99·98	
O=Cl	·07	·08	·03	
Total	99·98	99·97	99·95	

* Bull. 168 U. S. Geol. Surv., p. 21. † Rosenbusch, El. Gesteinslehre, p. 122.

I. Microscopical analysis of phyro-miaskose, Red Hill, N. H., by L. V. Pirsson.
II. Chemical analysis of grano-miaskose, Horne Quarry, Red Hill, by H. S. Washington. Includes SO_3, 0·08.
III. Chemical analysis of tracho-umptekose, Red Hill, by W. F. Hillebrand, includes MnO, 0·03, BaO, 0·08.

The composition thus calculated is very similar to the other ones already given, especially to that of the grano-miaskose, as may be seen in the table. The water is all from the biotite; ZrO_2 is probably too high.

Texture.—The texture of the groundmass is a purely trachytic one, caused by the slender lath-like feldspars. These are scattered, pointing in all directions, but groups of albites tend to be subparallel or divergent in places; no fluidal texture was seen.

Classification.—In the quantitative system the place of this rock is shown by its norm, calculated from the microscopic analysis, to be as follows:

	Norm
Or	42·81
Ab	29·34
An	0·56
Ne	14·20
So	4·30
Di	1·97
Ol	0·10
Mt	4·87
Il	·80
Zr	·70
H_2O	·45
Total	100·10

Sal = 91·21

Fem = 7·74

$$\frac{Sal}{Fem} = \frac{91·21}{7·74} = 11+, \text{ I, Persalane}$$

$$\frac{L}{F} = \frac{18·50}{72·71} = 0·25, \text{ 6, Russare}$$

$$\frac{K_2O' + Na_2O'}{CaO'} = \frac{201}{9} = 22, \text{ 1, Miaskase}$$

$$\frac{K_2O'}{Na_2O'} = \frac{77}{124} = 0·62, \text{ 3–4 } \begin{cases} \text{Miaskose-} \\ \text{Beemerose} \end{cases}$$

Comparing the norm with the mode, it may be noted that the biotite and aegirite have disappeared, while orthoclase and magnetite have much increased. The potash of the modal nephelite has increased the normative orthoclase and has been replaced by the soda of the aegirite, the amount thus remaining the same. The lepidomelane has split up into orthoclase and magnetite, the iron of the aegirite aiding. The biotite and aegirite-augite of the mode form about 16 per cent and are not present in the norm; the mode is therefore an abnormative one. The texture is porphyritic and microscopically trachytic and the rock may therefore be termed biotitic-trachiphyro-miaskose. In the older systems it would be a nephelite-syenite-porphyry.

Its especial interest lies in the fact that it is the same magma as that which forms the main mass of the mountain, producing the same minerals but with an entirely different texture, which can only be the result of its crystallization under quite different physical conditions, such as would obtain, for instance, at the contact with colder rocks or in a dike. It represents therefore, as stated above, an excellent example of the aschistic dikes of Brögger, or the granitic porphyritic ones of Rosenbusch's classification.

Grano-alaskose (*Aplite*).

The presence on the eastern side of the mountain of aplitic dikes associated with trap-like ones in the contact zone of gneiss has been already mentioned. They are all of them very clearly persalic rocks; some indeed are quite devoid of any femic or alferric minerals. They are fine-grained, and composed essentially of feldspars and quartz. The relative amounts of these two and the character of the feldspar are the only features of especial interest concerning them, and a specimen from a six-inch dike in the gneiss outcrops above the highroad at the east foot of the north peak was selected as a typical one for study and measurement to determine these relations.

Megascopic.—Holocrystalline; grayish white; speckled with minute dark points of a black mineral. Fine-grained; average diameter about $0{\cdot}25^{mm}$. Of a sugar granular habit. Weathers light brown.

Microscopic.—Mostly alkalic feldspar and quartz granules. A small amount of oligoclase is present and the mass is dotted with shreds of biotite, largely altered. A few minute zircons were seen. The feldspar is quite fresh; the alkalic variety shows considerable albite in microperthite intergrowths. The average character of it is estimated to be Or_3Ab_2, but this, of course, is only a rough approximation.

Mode.—The rock is well adapted for measurement by the Rosiwal method, which gives the following mineral composition:

	Vol. per cent.	Wt. per cent.
Quartz	37·5	37·9
Alkalic feldspar	55·0	54·3
Oligoclase	4·7	4·7
Biotite	2·8	3·1
Zircon	trace	trace
Total	100·0	100·0

Chemical Composition.—From the mode just given, if we assume, as mentioned above, that the alkalic feldspar has the average composition Or_3Ab_2 and the oligoclase, as shown by its optical properties, is Ab_4An_1 we can reckon the mass composition of the rock to be as follows:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Total
77·9	11·6	0·2	0·4	0·3	0·2	2·9	5·9	0·5 =	99·9

The small amount of biotite is assumed to be like that of an average granite rock. The composition thus reckoned must be rather close to the actual one, the only important uncertainty being in the relations of soda to potash.

Classification.—In the quantitative system the rock has practically a normative mode, the biotite being negligible. It is persalic, quarfelic and peralkalic, and is therefore alaskase.

If we accept the relations of soda to potash as given in the analysis, the molecular ratios are $K_2O : Na_2O :: 0·063 : 0·047$; it is sodipotassic and considering the texture is grano-alaskose. In Rosenbusch's classification it is a typical granite aplite; in ordinary usage a fine-grained biotite granite.

Paisanal Liparose (*Paisanite*).

This rock occurs in a narrow dike cutting the grano-miaskose or nephelite-syenite of the Horne quarry. The quarry is a large shallow pit from which the crumbling gravelly debris has been carried away for road-making or other purposes. leaving bowlders and exposures of fresh massive rock in place. It is in these that fragments of the dike occur, and it is also seen in place on the edges of the excavation cutting the altered rock, but it cannot be traced in the grass-covered pasture field beyond.

Megascopic characters.—Holocrystalline; fine-grained; light-gray; sparsely flecked with minute black dots; full of concealed joint planes or contraction cracks along which it readily splits, making good specimens difficult to obtain. Tough; hard and very fresh; weathers brown in color.

Microscopic characters.—The minerals seen in thin section are riebeckite, epidote, biotite, alkalic feldspar and quartz. The riebeckite occurs in irregular poikilitic patches from $0·2^{mm}$ down to minute microscopic specks; it is somewhat intergrown with quartz and feldspar: it sometimes shows a tendency to elongation parallel to the vertical axis; crystal boundaries are entirely wanting. The refractive index is high; the birefringence very low indeed. It is strongly pleochroic and $\mathfrak{c}$ and $\mathfrak{b}$ are a deep bluish green sometimes passing into a greenish blue, while $\mathfrak{a}$ is a light gray-brown sometimes almost colorless: the absorption $\mathfrak{c}$ and $\mathfrak{b} > \mathfrak{a}$ is therefore very strong and combined with the low birefringence makes it impossible to deal further with the arrangement of the optic system. The angle c on c is about 14°; this is different from most amphiboles of this group where $\mathfrak{a}$ is nearer c. The plane of the optic axes, so far as one may safely judge, lies in the symmetry plane.

Since the only minerals in the rock outside of the quartz and alkalic feldspar which is present in any amount, beyond mere traces, is this hornblende, its composition can be pretty closely calculated from Washington's chemical analysis of the rock given beyond. This shows it to be as follows:

	I	II	III	IV	V	VI
SiO_2 ...	45·4	49·65	45·53	34·18	0·756	0·827
TiO_2 ...	4·0	——	——	1·52	·050	——
Al_2O_3 ..	——	1·34	4·10	11·52	——	0·013
Fe_2O_3 ..	16·8	17·66	9·35	12·62	·105	·110
FeO ...	22·0	19·55	23·72	21·98	·306	·271
MgO ...	0·6	——	2·46	1.35	·015	——
CaO ...	4·2	3·16	4·89	9·87	·075	·056
Na_2O ..	6·7	7·61	6·07	3·29	·108	·122
Rest ...	——	1·67	0·88	3·26		
Total	99·7	100·64	99·96	99·59		

I. Amphibole from Red Hill.
II. Riebeckite from granite, Quan. Class. Ign. Rocks, 1903, Table xiii.
III. Cataphorite, San Miguel, Azores. Rosenb., El. Gest., p. 266, 1898.
IV. Hastingsite, Hastings, Ontario. Adams, this Jour. vol. i, 1896, p. 213.
V. Molecular ratios of No. 1.
VI. Molcular ratios of No. 2.

It is therefore very close in composition to the riebeckite from the Quincy granite described by Washington,* and as may be seen by reference to the other analyses, is similar to alkalic hornblendes in general. Both Nos. I and II have the general composition $m\ \mathrm{Na\overset{III}{Fe}Si_2O_6}.\ n\ \mathrm{FeSiO_3}$, as may be readily shown from the molecular ratios in the following manner:

	No. I.			No. II.		
SiO_2	0·756	·806	·420 = 4·00	.827	·827	492 = 4·02
TiO_2	·050		·386 = 0·97			335 = 1·02
Al_2O_3	——			·013	·123	·123 = 1·00
Fe_2O_3 ...	·105	·105	·105 = 1·00	·110		
FeO	·306	·396	·396 = 1·00	·271	·327	·327 = 1·00
Mg	·015			—		
CaO	·075			·056		
Na_2O	·108	·108	·108 = 1·03	·122	·122	·122 = 0·99

* This Journal, vol. vi, p. 181, 1898.

In No. I the ratio of $Na_2O : Fe_2O_3 : SiO_2 = 1{\cdot}03 : 1{\cdot}00 : 4{\cdot}00$ and of $(FeO,MgO,CaO) : (SiO,TiO_2) = 1{\cdot}00 : 0{\cdot}97$. In No. II $Na_2O : Fe_2O_3 : SiO_2 = 0{\cdot}99 : 1{\cdot}00 : 4{\cdot}00$ and $(FeO,CaO) : SiO_2 = 1{\cdot}00 : 1{\cdot}02$. These calculations are worth giving thus in detail because the feldspars having been calculated out of the rock exactly, all of the errors of the analyses fall on the oxides in the amphiboles except silica, and the exactness of these ratios is a proof of the correct composition of these amphiboles, and is also a striking tribute to the remarkable accuracy of Washington's analysis.

In the first the ratio of $NaFeSi_2O_6 : FeSiO_3 = 1 : 3$ and in the second 1 : 2.5.

Washington states for the Quincy mineral that c on $\dot{c}$ = 4°–7° and in paisanal liparose from Magnolia, Essex Co., Mass.,* he mentions the same arrangement of the axes of elasticity. Thus the present instance makes the third occurrence in the Novanglian province of alkalic hornblende in which c lies nearest to $\dot{c}$. White† on this account calls it a glaucophane, and Washington to some extent follows him. Rosenbusch‡ has shown, however, that the arrangement of the optical system in the alkalic hornblendes is variable and it is best to make the distinction between the glaucophanes and the arfvedsonite-riebeckite series a purely chemical one, as he does. The present mineral then, determined by its chemical composition, would be a riebeckite with bluish-green colors and abnormal axial position.

In connection with the greenish blue or bluish green color of riebeckite it is of interest to note that it resembles Prussian blue; the latter is a ferrous ferricyanide, riebeckite is a ferrous ferri-silicate. Vivianite, the hydrous ferrous phosphate, is colorless when fresh, but on exposure and oxidation of a part of the iron to the ferric condition it becomes a Prussian blue color. There is evidently a connection in these substances between this particular blue color and an arrangement of ferrous-ferric molecules.

In places it is bleaching and altering to epidote.

Of biotite only a few flakes were seen. Also a number of small grains of zircon occur and minute grains of an unknown mineral of high single and low double refraction. Titanite was not observed.

The feldspars are microperthites and the albite lamellae frequently show the albite twinning. They are developed in the larger crystals as short, thick, tabular on the $\grave{a}$ axis and attain a length of 2·0^{mm}. Further description of them is deferred

* Jour. of Geol., vol. vii, p. 113, 1899.
† Petrog. Boston Basin, Proc. Bos. Soc. Nat. Hist., vol. xxviii, p. 130, 1897.
‡ Micro. Phys. Min., vol. i, pt. 2, p. 247, 1905.

until the subject of texture is considered. The quartz is in minute grains averaging 0·02–0·05^mm^.

Texture.—Megascopically the rock has a somewhat fine, sugar granular texture which gives it an aplitic habit. It there appears even granular, but in the section it is seen to be microporphyritic. The feldspars which form the great bulk of the rock are present as phenocrysts and as groundmass. The amount of phenocrysts however is very large, as much, if not more, than of groundmass, and they range in size from the largest mentioned above down to those of the groundmass, which may be only 0·05^mm^ in diameter. The pattern then of the fabric is given by these very numerous, square to short rectangular microperthites of variable size lying in a very fine microgranular groundmass of quartz and feldspar, in which the quartz predominates.

Mode.—The actual mineral composition is readily told from the chemical composition, since the amphibole, feldspars and quartz are the only minerals present in more than mere traces. It is as follows:

Riebeckite	7
Quartz	13
Orthoclase	33
Albite	47
Total	100

Chemical Composition.—This is shown in the following table:

	I	II	III	IV	V	VI
SiO_2	69·51	76·49	73·35	76·01	73·93	1·159
Al_2O_3	15·06	11·89	14·38	11·96	12·29	·148
Fe_2O_3	1·25	1·16	1·96	2·06	2·91	·008
FeO	1·63	1·56	0·34	n.d.	1·55	·022
MgO	0·05	tr.	0·09	tr.	0·04	·001
CaO	0·31	0·14	0·26	0·26	0·31	·005
Na_2O	6·02	4·03	4·33	4·46	4·66	·097
K_2O	5·48	5·00	5·66	4·73	4.63	·059
H_2O+	0·23	0·38	?	0·28	0·41	---
H_2O-	0·11	0·12	?	---	---	---
CO_2	none	---	---	---	---	---
TiO_2	0·29	tr	?	---	0·18	.004
ZrO_2	0·01	---	---	---	---	---
P_2O_5	tr.	---	---	---	---	---
MnO	?	tr.	---	tr.	tr.	---
BaO	none	---	---	---	---	- -
Total	99·95	100·77	100·37	99·76	100·91	---

I. Paisanal liparose, Horne Farm Quarry, Red Hill. H. S. Washington anal.

II. Paisanal liparose, Magnolia, Essex Co., Mass. (loc. cit). H. S. Washington anal.

III. Paisanal liparose, Mosquez Cañon, Apache Mts., Texas (A. Osann. Tsch. Mitth. xv, p. 439, 1895). Osann anal.

IV. Paisanal liparose, Mt. Scholoda, Abyssinia (G. T. Prior, Min. Mag. xii, p. 264, 1900). Prior anal.

V. Riebeckite granite, Quincy, Mass. (H. S. Washington, this Journal, vi, p. 181 (1898). Washington anal.

VI. Molecular ratios of No. I.

The rock has somewhat lower silica and more alkalies and alumina than the other members of this group; it therefore contains a little more feldspar and a little less quartz. It is also a somewhat more sodic rock than they are.

Classification.—The position of the rock in the quantitative scheme of classification is shown by its norm and calculation as follows:

	Norm		
Qz	12·90		
Or	32·80		$\frac{Sal}{Fem} = \frac{92·33}{6·92} = 13+ =$ I, Persalane
Ab	46·63	Sal = 92·33	
Ac	3·70		$\frac{Q}{F} = \frac{12·90}{79·43} = 0·16 = 4$, Britannare
Di	1·21		
Hy	1·40		
Il	·61	Fem = 6·92	$\frac{Na_2O' + K_2O'}{CaO'} = \frac{148}{0} = 1$, Liparase
Rest	·35		
Total	99·60		$\frac{K_2O'}{Na_2O} = \frac{59}{89} = 0·64$, 3, Liparose

Its coördinates are I, 4, 1, 3; it is persalic, quardofelic, peralkalic and sodipotassic. Its texture is granular and microporphyritic; it is therefore graniphyri-liparose and has riebeckitic amphibole as a varietal mineral. Since this is not present in notable amount, the mode is normative within the limits of the subrang but a small amount of a critical mineral is present, thus constituting a modal variety. The rocks thus known as paisanites which fall within the limits of this rang, as most of them do, are riebeckitic liparose. The rock under discussion may be thus taken as constituting a type with a given mode, norm and texture to which the adjective *paisanal* may be given, and it thus becomes paisanal liparose.

In conclusion it is of interest to note that this new occurence sustains Murgoci's* contention that the riebeckitic rocks are accompanied by zircon and not by titanite, while the main syenite, which it cuts and whose hornblende is cataphorite as

* This Journal, xx, p. 137, 1905.

described elsewhere, has some zircon; it also has considerable titanite.

Phyro-nordmarkase (*Syenite-porphyry*).

It has been stated in the geological part of this work that a dike of feldspar porphyry occurs on Fore Point, and that fragments of a similar rock are found on the north peak of Red Hill. They are too much weathered for detailed study and analysis, but from the material and the section of the Fore Point rock the following has been determined:

Megascopic.—Holocrystalline; dense and porphyritic; brown-gray weathering to red-brown; thickly sowed with white to flesh-colored feldspar phenocrysts, thick tabular in form and $2–5^{mm}$ across and with scarce, dull, greenish black, altered ferromagnesian phenocrysts averaging $2–3^{mm}$ long by $0{\cdot}5^{mm}$ broad. Rough, hackly fracture, much jointed.

Microscopic.—The rock consists for much the greater part of alkalic feldspar which is turbid and brown with kaolin granules. The phenocrysts are of microperthite, and the small feldspars of the groundmass are also mixtures of orthoclase and albite. Scattered through the rock are small shreds, leaves and strips of chlorite and serpentine which are occasionally lumped together and are remains of the larger phenocrysts. They may have been mica or hornblende or both; it cannot now be told. The feldspars of the groundmass average about $0{\cdot}06 \times 0{\cdot}02^{mm}$ and are short broad laths. A little quartz occurs now and then in their interstices. In texture the pattern of the fabric from these feldspars is trachytoid with a tendency to the granular.

Classification.—The rock is clearly persalic, perfelic and peralkalic; its coördinates are I, 5, 1, and it is therefore nordmarkase. If we assume that there is about an equal amount of orthoclase and albite present as indicated by the section and in analogy with the other rocks of the district, it would be sodipotassic and in subrang 3. Taking the texture into account it would then be trachiphyro-phlegrose.

In the system of Rosenbusch the rock is a syenite-porphyry; its mode of occurrence and character of groundmass would make it a bostonite, especially if one considers its genetic relations. It would then be a bostonite porphyry.

Trachi-nordmarkase (*Bostonite*).

On the south point of Hoag's Island, which forms the north bank of the narrow strait in Lake Asquam which leads into Bear Cove, the gneiss is cut by a narrow dike of feldspar rock, three feet wide, with trend to Red Hill. The outcrop lies at the edge of the water and is somewhat altered in consequence. From the inside of a good-sized piece fairly fresh material was obtained for study.

Megascopic.—Holocrystalline; dense, and very sparingly porphyritic; medium gray with a brown tinge and weathering brown; has a faint, dull, silky luster. Has a few phenocrysts of feldspar which tend to be roughly arranged along one plane in the rock but lie without the individual orientation seen in flow structures. Phenocrysts average about 4^{mm} by 2^{mm} by $0{\cdot}5^{mm}$; tabular; dull, opaque white. The rock has a rather pronounced schistose fracture.

Microscopic.—The section shows an interwoven mass of minute feldspar laths with occasional scattered shreds of brown biotite. A considerable amount of alteration of both constituents is present, and this, combined with the small size, the laths being about $0{\cdot}1^{mm}$ in length, and the general presence of repeated Carlsbad twinning, makes it impossible to say with certainty whether they may not be in part a soda-lime feldspar. It is judged that this is wanting or nearly so, but only a chemical analysis can definitely decide the point, and neither the condition of the material nor the results to be gained would warrant undertaking this. The few phenocrysts are of unstriated alkalic feldspar. The rock is penetrated by tiny veinlets of secondary quartz mingled with occasional areas of fluorite. No original quartz could be detected, and a gelatinization test for nephelite gave negative results. The laths, which often tend to thin plates, lie interwoven without orientation in a typical trachytic texture, except that around the few phenocrysts they are arranged in expansion structure.*

Classification.—The rock is evidently persalic and perfelic; it is almost without doubt peralkalic. This would make it nordmarkase. The only question is whether it is sodipotassic or dosodic, whether phlegrose or nordmarkose. Judging by analogy with the other rocks of the region, it is probably the latter. The texture is micro-trachytic; the few rare phenocrysts are not sufficient to justify one in calling it a porphyry. It is therefore a trachi-nordmarkase. In the system of Rosenbusch it is a typical bostonite.

Camptonase (*Camptonite*).

As previously mentioned, there are a considerable number of dark trap-like dikes in and about Red Hill. The microscopical study of these has shown that they should all be referred to the rang of camptonase, or in other words, they are camptonites. Unfortunately, out of some fourteen different dikes from

* This Journal, vol. vii, p. 277, 1899.

which specimens were collected, not one afforded good fresh material for chemical analysis and detailed study, all being to a greater or lesser extent altered. Moreover, they are so similar to the dikes of camptonase occurring in the Belknap Mountains at the other end of Lake Winnepesaukee which have been minutely studied and described in a recent publication by Dr. Washington and the writer,* that it hardly seemed worth while to repeat again for these rocks what is there given. A brief summary of their more important characters may be of service in case the former paper is not at hand.

They are very dark gray to black rocks, often speckled with small areas or amygdules of calcite. In one or two cases they contain visible phenocrysts of labradorite. They never show abundant, large, well-developed crystals of hornblende and hence they are not of the modal habit of camptonose of the original locality at Livermore Falls, a habit frequently seen elsewhere and which we have called the hampshiral habit. Large hornblendes occasionally occur in them but the characteristic mode of occurrence of this mineral is in very small and needle-like crystals, just perceptible to the eye or lens and frequently giving a somewhat silky appearance to the rock.

The microscope shows them to be composed of iron ore, apatite, brown alkalic hornblende, labradorite and usually more or less indeterminable matter of a feldspathic character, usually doubly refracting. These minerals are all more or less altered; sometimes it is the hornblende and iron ore, sometimes the feldspathic minerals, generally both. The study of all the sections gives a good composite idea of the original fresh rocks but no single occurrence corresponds. Like those found in the Belknap Mountains, some of the dikes contain also augite in addition to the hornblende.

In summation it may be said that they represent typical rocks complementary to the persalic dikes (paisanite, aplite and bostonite) previously described and parallel similar occurrences of alkalic rock complexes found in other regions.

Intrusion Breccia.—It has been mentioned that at the Horne farm house the nephelite-syenite encloses a mass of dark colored rock filled with fragments of the syenite itself. The microscopical study of this material reveals the minerals of which it is composed, but throws no additional light upon its origin above what may be seen by its study in the field and on hand specimens.

The finely granular dark rock which serves as a cement to the inclusions under the lens is seen to be formed of an equal mixture of white feldspathic and black ferro-magnesian granules, the latter in part biotite. It is crowded with small frag-

* Petrography of the Belknap Mts., this Journal, vol. xxii, p. 498, 1906

ments and larger irregular crystals of the nephelite-syenite as well as the actual pieces of the rock previously alluded to.

Under the microscope this dark cement is found to consist of olivine-brown hornblende and alkalic feldspar with occasional tablets of biotite, rare prismoids of a pale gray-green diopside or scattered crystals of sphene. It is interesting to note that it contains little or no iron ore, the iron being all in the hornblende. The fabric tends to be equi-granular, the grains equiform and roughly rounded. The enclosed feldspars of the syenite have extremely irregular, ragged boundaries, otherwise they show no change. A significant circumstance is that between some of the included rock fragments, the minerals of the cementing rock are arranged in such a manner as to indicate flowage structure, from which they are more or less orientated.

Summary and Conclusions.

The study of Red Hill shows it to be a mass of nephelite-syenite intruded into granite-gneiss. Its intrusion was followed by smaller upthrusts of magmas more salic and more femic, which appeared in fissures in the syenite and in the zone of cracked and shattered gneisses about it, forming a series of complementary dikes. Since the dikes were not found cutting one another their relative sequence cannot be given. Their general characters are such as to point clearly to their magmatic relationship to the main mass of syenite which they accompany. This is shown by their mineralogical and chemical nature and is the same relation which has been repeatedly observed in other regions. Thus, while the study of the area affords the weight of additional evidence to the genetic connection which in recent years has been seen to exist in complexes of igneous rocks, it offers nothing new or especially striking in this regard. One feature however deserves further attention. It has been shown that the outer portion of the mass is decidedly more siliceous than the inner one, the latter being a nephelite-syenite with SiO_2, 58·3 per cent, while the outer one is slightly quartzose-syenite in which the SiO_2 cannot be less than 66 per cent.

It has also been shown that there is probably some vertical difference of the same kind, the top being more siliceous than the inner portion. While this does not appear to be the case ordinarily seen in intruded masses, which usually have the outer zone more basic or femic than the interior, yet a number of such instances are known, one of the latest which has been described being in the massif of the neighboring Belknap Mountains as shown by Dr. Washington and the writer.*

* This Journal, vol. xxii, p. 509, 1906.

In most cases this has been ascribed to differentiation within the mass itself and various agencies have been appealed to as causes deemed sufficient to explain such differentiation. Others have viewed these changes in a mass of igneous rock as caused by the melting up and absorption of the enveloping rocks with which it has come in contact.

Unfortunately in the present instance the place where the evidence usually lies, the contact between the two, is practically everywhere covered up and the evidence, if there is any, concealed. The fact that the country rock is a granite-gneiss and much more acid than the average of the syenite, seems to point clearly in favor of the latter view, and so do the very acid dikes of aplitic alaskose found in the granite-gneiss on the east side and departing radially outward from it. But if we seek this origin for these dikes, how then shall we explain the complementary very basic ones of camptonose which accompany them side by side? For these are much more basic than any rock of the mass or its surroundings, and their origin must be ascribed to processes of magmatic differentiation. But in this case they must have acid complementary forms which we can readily see in the aplitic alaskose. Again, the presence of the acid paisanal liparose dikes in the very center of the nephelite-syenite cannot be explained by digestion of the bordering rocks and again points to magmatic differentiation.

But if differentiation has occurred, as these cases seem to prove, it may well have caused the changes observed in the main mass itself without the necessity of seeking some other agency, though it is possible to conceive as suggested by Daly,* for the origin of certain granites, that the effect is the combined one of assimilation and differentiation. Since the evidence the contact might afford is hidden, this must however remain a purely speculative hypothesis.

Sheffield Scientific School of Yale University,
New Haven, Conn., Feb. 1907.

* This Journal, xx, p. 185, 1905.

ART. XLII.—*A Method for the Qualitative Separation and Detection of Ferrocyanides, Ferricyanides and Sulphocyanides;* by PHILIP E. BROWNING and HOWARD E. PALMER.

[Contributions from the Kent Chemical Laboratory of Yale Univ.—clviii.]

THE ordinary method for the detection of ferrocyanides, ferricyanides and sulphocyanides by means of ferric and ferrous salts leaves little to be desired in point of delicacy when these substances are not present together. When mixtures are to be examined, however, the colors tend to mask one another and various methods to obviate the difficulty have been suggested, such as the bleaching of the red ferric sulphocyanide by mercuric chloride in testing for ferrocyanide, and the distillation of sulphocyanic acid before testing for that acid. In testing for a ferrocyanide in the presence of a ferricyanide the formation of the deep blue color with the ferric salt or ferrous salt has generally been considered of sufficient delicacy for all practical purposes.

The work to be described is the result of an attempt to effect a separation of these substances one from another as well as to accomplish their detection.

Potassium ferrocyanide has long been mentioned as a precipitant of the ferrocyanides of the rare earth elements, cerium, thorium, yttrium, zirconium, etc., while it is also known that ferricyanides of these elements are soluble. These facts suggested the use of a member of the above mentioned group as a precipitant of the ferrocyanogen ion and selection was made of a soluble salt of thorium as perhaps the most satisfactory and available.

A solution of potassium ferrocyanide was made by dissolving one gram of the salt in a liter of water, and measured portions of this solution were used when amounts of five milligrams or less were required. This solution was neutral to litmus and remained so throughout the investigation, as shown by frequent tests.

The delicacy of the reaction was tested by adding to portions of the solution enough water to make the total volume between 5^{cm^3} and 10^{cm^3}, acidifying faintly with acetic acid or hydrochloric acid and adding a few drops of a 10 per cent solution of thorium nitrate. Amounts of the ferrocyanide as small as 0·0001 grm. gave a distinct cloudiness to the solution. Similar experiments made in the presence of 0·1 grm. of potassium ferrocyanide and 0·1 grm. of potassium sulphocyanide showed that these salts did not interfere with the delicacy of the test. In order to test the effect of dilution and the highest delicacy of the reaction, some precipitations were made in 100^{cm^3} and 500^{cm^3} of water, and it was found possible to detect 0·0005 grm. in 100^{cm^3} of water and 0·0010 gms. in 500^{cm^3} of water, or one part of the ferrocyanide in 500,000 parts of water.

The presence of considerable amounts of alkali acetates have a tendency to decompose the thorium ferrocyanide into soluble products, but this tendency may be overcome by further addition of thorium salt or hydrochloric acid.

Some difficulty was found in filtering the thorium ferrocyanide on paper alone, on account of its finely divided condition, but this difficulty was removed by agitating the liquid and suspended precipitate with some finely shredded asbestos before filtration.

In making the choice of a precipitant for the ferricyanogen ion with a view to subsequent testing for the sulphocyanogen ion by the ferric salt, some reagent giving a colorless solution was preferable. Salts of the elements zinc and cadmium meet this condition and cadmium salts proved to be the more delicate. Following the general method already mentioned, it was found that 0·0001 grm. of the ferricyanide could be readily detected in from 5^{cm^3} to 10^{cm^3} of water acidified with acetic acid even when 0·1 grm. of potassium sulphocyanide was present. The cadmium ferricyanide presented the same difficulty in filtration that has been described in the case of the thorium ferrocyanide, and the difficulty was overcome in the same manner.

The method as recommended is as follows: The solution to be tested, preferably dilute and about 5^{cm^3} to 10^{cm^3} in volume, is acidified faintly with acetic acid or hydrochloric acid and treated with a soluble thorium salt to complete precipitation. To the liquid and suspended thorium ferrocyanide some finely shredded asbestos is added, the whole is agitated and thrown on a filter and the precipitate washed with a little water.

The presence of the ferrocyanide may be confirmed by decomposing the washed precipitate with strong sodium hydroxide on the filter, acidifying the clear filtrate with hydrochloric acid and testing with ferric chloride.

The filtrate from the thorium ferrocyanide is treated with a soluble cadmium salt to complete precipitation of the cadmium ferricyanide, which after the addition of the asbestos is filtered and washed as previously described. The presence of the ferricyanide may be confirmed by treating the cadmium ferricyanide with sodium or potassium hydroxide, acidifying the filtered solution and testing with a ferrous salt.

The filtrate from the cadmium ferricyanide is acidified with hydrochloric acid and treated with ferric chloride, which gives the red ferric sulphocyanide.

The method is especially recommended for the detection of small amounts of ferrocyanides and ferricyanides in the presence of each other. The following table gives some results obtained :

$K_4FeC_6N_6$ present grm.	$K_3FeC_6N_6$ present grm.	KSCN present grm.	Indication
		Tests for $K_4FeC_6N_6$ only	
0·0010	0·1	0·1	Distinct
0·0005	0·1	0·1	Distinct
0·0002	0·1	0·1	Distinct
0·0001	0·1	0·1	Distinct
		Tests for $K_3FeC_6N_6$ only*	
0·1	0·0010	0·1	Distinct
0·1	0·0005	0·1	Fairly distinct
0·1	0·0002	0·1	Faint
0·1	0·0001	0·1	Very faint
		Tests for KSCN only	
0·1	0·1	0·0010	Distinct
0·1	0·1	0·0005	Distinct
0·1	0·1	0·0002	Distinct
0·1	0·1	0·0001	Distinct
		Tests for $K_4FeC_6N_6$, $K_3FeC_6N_6$ and KSCN	
0·0100	0·0100	0·0100	Good tests for $K_4FeC_6N_6$, $K_3FeC_6N_6$, KSCN
0·0050	0·0050	0·0050	Good tests for $K_4FeC_6N_6$, $K_3FeC_6N_6$, KSCN
0·0010	0·0010	0·0010	Good tests for $K_4FeC_6N_6$, $K_3FeC_6N_6$, KSCN
		Tests of mixtures unknown to analyst	
0·0010	0·0010	——	Found $K_4FeC_6N_6$, $K_3FeC_6N_6$
0·0010	——	0·0010	Found $K_4FeC_6N_6$, KSCN
0·0010	0·0010	0·0010	Found $K_4FeC_6N_6$, $K_3FeC_6N_6$, KSCN

* These tests were made without waiting to wash the ferrocyanide precipitate thoroughly.

Art. XLIII.—*Irvingite*,* *a New Variety of Lithia-mica*; by S. Weidman.

Among the minerals of the pegmatite veins which form abundant large dike-like masses in the quartz-syenite and nepheline-syenite near Wausau, Wisconsin, was observed a nearly colorless mica, the analysis of which shows it to be, apparently, a new variety of lithia-mica. This mica was found in the quartz-bearing pegmatite in the N.W. $\frac{1}{4}$ of section 22, T. 29 N. Range 6 E., the same locality in which the new variety of pyrochlore, marignacite,† was discovered.

The most abundant minerals‡ occurring in the pegmatite of this locality are quartz, alkali-feldspar, crocidolite, riebeckite, acmite containing an appreciable quantity of Al_2O_3 and K_2O, a pyroxene higher in Al_2O_3 and Na_2O than jadeite, and lepidomelane. Some of the less abundant minerals are rutile, fluorite, the pyrochlore, marignacite, and zircon containing much alumina.

Physical Characters.—The lithia-mica was observed in the pegmatite in crystals varying from a fraction of an inch to over an inch in diameter. Many of the larger crystals have, besides the well-developed basal cleavage of mica, a very prominent prismatic parting. This parting enables it to separate into laths and needles of variable width. The color varies from grayish white to yellowish and pinkish white. It is extremely tough and elastic and possesses easy fusibility. The interference figure in convergent light appears to indicate an axial angle somewhat larger than that of the lithia-micas lepidolite and zinnwaldite.

Chemical Composition.—The analysis made by Prof. Victor Lenher and the molecular ratio are shown in the accompanying table

There was no difficulty in obtaining sufficient pure material for analysis. The analysis shows the mica to contain a considerable amount of lithia and fluorine and a relatively large amount of silica and soda.

* Published by permission of the Director of the Wisconsin Geological and Natural History Survey.

† This Journal, vol. xxiii, p. 287, 1907.

‡ For a general description of the minerals of the pegmatite veins see "The Geology of North Central Wisconsin," Bulletin 16, Wis. Geol. and Nat. History Survey, pp. 275–331, 1907.

Analysis of the lithia-mica, Irvingite.

	Analysis	Molecular ratios
SiO_2	57·22	954
TiO_2	0·14	2
Al_2O_3	18·38	180
Fe_2O_3	0·32	2
FeO	0·53	8
MgO	0·09	
CaO	0·20	3
K_2O	9·12	96
Na_2O	5·14	83
Li_2O	4·46	149
F	4·58	120
H_2O at 110° −	0·42	
H_2O at red heat	1·24	69
	101·84	
Less O=F	1·93	
	99·91	

In the following table the analysis of this lithia-mica is compared with that of a representive analysis of lepidolite from Rumford, Me., and of zinnwaldite from Zinnwald, Bohemia, and with that of cryophyllite and polylithionite.

Analyses of varieties of lithia-mica.

	1	2	2*a*	3	4	5
SiO_2	57·22	59·25	58·68	51·52	51·96	46·44
Al_2O_3	18·38	12·57	10·24	25·96	16·89	21·84
Fe_2O_3	0·32		4·02	0·31	2·63	1·41
FeO	0·53	0·93			6·32	10·06
MnO	trace		0·31	0·20	0·24	1·89
MgO	0·09					
CaO	0·20			0·18	0·15	
K_2O	9·12	5·37	11·05	11·01	10·70	10·58
Na_2O	5·14	7·63	1·61	1·06	0·87	0·54
Li_2O	4·46	9·04	8·24	4·90	4·87	3·36
H_2O at 110° −	0·42				1·31	
H_2O at 110° +	1·24			0·95		
F	4·58	7·32	8·16	5·80	6·78	7·62
TiO_2	0·14					
Total	101·84	102·11		101·89	102·73	103·74
Less O=F	1·93			2·44	2·86	
	99·91		98·87	99·45	99·87	

1. Irvingite from Wausau, Wis., anal. by V. Lenher.

2. Polylithionite from Kangerdlaursuk, Greenland (quoted by Dana's Min., 6th ed. p. 627).

2*a*. Polylithionite from Narsarsuk, Greenland, anal. by Flink (cited Jour. Chem. Soc. (London), vol. lvii, p. 412, 1900).

3. Lepidolite from Rumford, Me., anal. by Riggs (quoted by Clarke, U. S. Geol. Survey, Bulletin 220, p. 73).

4. Cryophyllite from Auburn, Me., anal. by Riggs (quoted by Clarke op. cit., p. 74).

5. Zinnwaldite, from Zinnwald, Bohemia (quoted by Dana's Min., 6th ed. p. 626).

It will be observed upon comparing the analysis of the lithia mica from this locality with the analyses of other varieties of lithia-mica, that each has characteristic chemical features not possessed by the others. The cryophyllite, 4, and zinnwaldite, 5, are characterized by high content of iron and low sodium, while the lithia-mica, 1, and polylithionite, 2, are essentially free from iron and are high in sodium, and lepidolite, 3, is low in sodium and free from iron. The lithia-mica from this region, 1, differs essentially from polylithionite 2 and 2a in containing a higher content of alumina and lower fluorine, as well as possessing different proportions of the alkalies: it differs from cryophyllite, zinnwaldite and lepidolite in its higher content of silica and soda.

On the whole, this mica 1 differs essentially from the other varieties of lithia-fluorine micas, apparently being a new variety of this interesting group of minerals, and the name "*Irvingite*," after R. D. Irving, is proposed for it. Prof. R. D. Irving's principal geological work was done in Wisconsin, and hence it seems appropriate that this new mineral from Wisconsin be named after him.

Theoretical Composition of Irvingite.—The percentage composition and the molecular ratios of the constituents of this lithia-mica have already been stated. Prof. F. W. Clarke has pointed out that the trisilicate molecule dominates in all the lithia-micas. Not one of them approaches a full orthosilicate, and in nearly all the SiO_2 ratios fall below the metasilicate proportions.

The late Prof. S. L. Penfield, who examined this mineral and analysis, pointed out that the analysis yields a ratio of $SiO_2 : Al_2O_3 : R_2O : (F.OH)$ approximately as 6 : 1 : 2 : 1. According to Penfield, the ratio corresponds to a formula of a trisilicate, $3Si_2O(Al.(FOH))''O.R'_2O$. The alkalies in R_2O approximate the following ratios: $K_2O : Na_2O : Li_2O$ as 1 : 1 : 2 and in (F.OH) F : OH as 3 : 1. Assuming these proportions, the calculated approximation to the theory to the above ratios is shown in the following table:—

Molecular ratios			Per cent
6—	SiO_2	360	60·00
1—	Al_2O_3	102·00	17·00
2	$\frac{1}{2}K_2O$	47·1	7·83
	$\frac{1}{2}Na_2O$	31·00	5·17
	$1Li_2O$	30·00	5·00
1	$\frac{1}{3}H_2O$	6·00	1·00
	$\frac{2}{3}F$	24·00	4·00
		600·00	100·00

Prof. Clarke has pointed out that the ratios in this lithia-mica are very near $R'_2AlX(F.OH)$, in which X represents the acid radicals Si_3O_8 and SiO_4, in the ratios of 4 : 1. According to the view of Clarke, regarding all the OH as F, it could be written thus: $4R'_2Al.Si_3O_8F+1R'_2Al.SiO_4F$. The true formula is probably some multiple of this expression as previously stated by Clarke.*

* F. W. Clarke, U. S. Geol. Survey, Bulletin 125, p. 48.

Art. XLIV.—*The Composition of Molybdite from Arizona;* by F. N. Guild.

Mr. W. T. Schaller has recently shown* that the rare mineral known as molybdic ocher, or molybdite, from at least four different localities, does not possess the chemical composition of the trioxide which for over fifty years has been attributed to it, but is in reality a hydrated ferric molybdate. These investigations suggest the probability of the non-occurrence of the uncombined trioxide in nature, all samples hitherto so described being an iron molybdate instead of mixtures of the pure oxide with limonite. The matter cannot be definitely settled, however, until a large number of analyses from various localities have been reported. Owing to the extreme rarity of the mineral and its usual mode of occurrence as a dusty incrustation associated with limonite, chances for good analytical results are not many.

The Museum of the University of Arizona contains some excellent specimens collected from the Santa Rita mountains about thirty miles south of the city of Tucson. The mineral occurs in milky quartz with the usual associations of molybdenite and limonite. Occasionally small cavities are found in the pure quartz filled with pure molybdite not mingled with an appreciable amount of the oxide of iron. Here the mineral consists of tufts of fine fibers and acicular crystals sometimes two millimeters in length. They possess the usual silky luster and bright yellow color.

Sufficient amount of this material for analysis was collected by means of a pair of sharp-pointed pincers and the following results obtained:—

	No. 1	No. 2
Insoluble residue	4·86	2·66
Water	16·83	16·61
Ferric oxide, Fe_2O_3	20·88	21·18
Molybdic trioxide, MoO_3	57·38	59·79
Total	99·95	100·24

These two samples were collected independently from two different cavities in the same hand specimen. The insoluble residue was examined under a microscope and found to consist of small crystals of quartz.

* This Journal, vol. xxiii, p. 297, April, 1907.

Deducting the insoluble residue and recalculating the analyses, we have

	No. 1	No. 2	Average	Ratio
H_2O	17·69	17·02	17·355	7·06
Fe_2O_3	21·97	21·70	21·835	1·
MoO_3	60·34	61·27	60·805	3·09

The empirical formula calculated from the above figures is $Fe_2O_3.3MoO_3.7H_2O$, or, $Fe_2(MoO_4)_3 7H_2O$. With the exception of the water of crystallization, these results are identical with those obtained by Mr. Schaller on samples from New Hampshire, Ontario, Colorado and California.

Art. XLV.—*On Climatic Conditions at Nome, Alaska, during the Pliocene, and on a new Species of Pecten from the Nome Gold-bearing Gravels;* by William Healey Dall,* Paleontologist U. S. Geol. Survey.

The conditions indicated by the faunas of the Post-Eocene Tertiary on the Pacific Coast from Oregon northward are a cool temperate climate in the early and middle Miocene, a warming up toward the end of the Miocene culminating in a decidedly more warm-water fauna in the Pliocene, and a return to cold if not practically Arctic temperatures in the Pleistocene. In these particulars the climatic variations are not unlike those of the southeastern Atlantic Coast of the United States.

On the north side of Norton Sound, Alaska, where the town of Nome is situated, the conditions are practically Arctic at the present time, as the sound is covered with heavy ice during a third of the year or even more.

This gives a particular interest to a small collection of marine shells from the gravels near Nome, recently received through Dr. A. H. Brooks, U. S. G. S., from Messrs. Moffit and Beaver of Nome.

These prove to contain, not only species inhabiting at present only a more southern habitat, but also a conspicuous large scallop at present living only in northern Japan, the *Pecten swifti* Bernhardi, a most unexpected find.

Several species occur, like *Monia macroschisma* Desh., and *Macoma middendorffi* Dall, which are now known in the living state only south of the line of floating ice in winter, in Bering Sea and the Aleutian Islands.

Nine determinable species were found, of which four extend from the Arctic to Puget Sound at the present time; three are known only from south of the winter line of floating ice; one occurs at Hakodadi, Japan, and the following, probably extinct species, appears to be new.

Under the circumstances the gravels in question are identifiable as Pliocene in age, but that there are both later and earlier gravels on the northern coast of Norton Sound is quite probable.

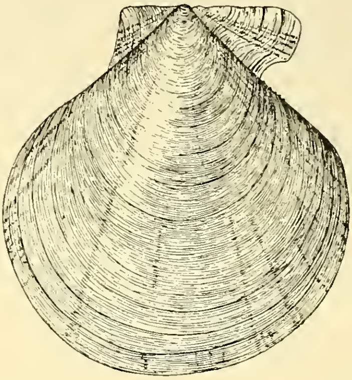
Pecten (*Chlamys*) *lioicus* Dall, n. sp.

Shell of the general form of *P. islandicus* Müller, but externally smooth, or sculptured only with incremental lines and, near the posterior basal margin, with extremely faint indica-

* By permission of the Director of the U. S. Geological Survey.

tions of obsolete radial threads, flattish and about a millimeter in width; submargins showing minute traces of vermicular, scaly, minor sculpture; byssal ear large, concentrically rugose, with a broad, concavely striated byssal fasciole, above which are four or five shallow radial grooves; ctenolium short with

1



six denticles; posterior ear small, with about four faint radial grooves; hinge line straight; internally with a rather large ligamentary pit and muscular scar; interior of the disk smooth; color of the shell apparently yellowish-red originally. Alt. of shell, 61; lat. of shell, 55; do. at ctenolium, 25; do. at hinge line, 30^{mm}. (Fig. 1, seven-ninths natural size.)

Fifty feet below the surface in marine gravels near Nome, Norton Sound, Alaska, Moffit, U. S. N. Mus. 110480.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *A Peculiarity of Platinum Amalgam.*—When mercury is shaken up with water, it is well known that the two liquids separate as soon as the agitation is stopped. Moissan has observed that it is otherwise when the mercury contains platinum in solution. After a few seconds of agitation the platinum amalgam forms a semi-solid mass of buttery consistency with a volume about five times as great as that of the original amalgam. The emulsion thus formed is so permanent that it does not appear to have changed its volume after standing at rest for a year. It resists the action of heat, for it may be heated to 100° without apparently changing its volume, and without any disengagement of gas. It resists the action of cold, and when an emulsion made with water containing fuchsine was cooled to −80° and a section was made of the frozen mass, this showed a cellular structure under the microscope due to globules of water. When the emulsion is subjected to a vacuum it diminishes in volume, a little water separates, and bubbles of gas are given off.

Amalgams of copper, silver, and gold do not produce such an emulsion, but platinum amalgam forms the emulsion not only with water, but with sulphuric acid, solutions of ammonia, ammonium chloride, and sodium chloride ; with glycerine, acetone, absolute alcohol, ether, essence of turpentine, carbon tetrachloride and chloroform. It appears to have no effect with dry benzene. All the emulsions thus produced are stable.

The emulsion may be made by shaking 2^{cc} of pure mercury with 12^{cc} of distilled water to which has been added a few drops of 10 per cent solution of platinic chloride.—*Comptes Rendus*, cxliv, 593. H. L. W.

2. *The Explosion-Limits of Certain Gas Mixtures.* — By means of a special piece of apparatus, which will not be described here, N. Teclu has determined the lower and upper limits at which mixtures of several combustible gases with air are explosive. These results are given in the following table :

Kind of gas	Lower explosion-limit in per cents.	Upper explosion-limit in per cents.
Hydrogen	9·73–9·96	62·75–63·58
Illuminating gas	4·36–4·82	23·35–23·63
Marsh gas	3·20–3·67	7·46– 7·88
Acetylene	1·53–1·77	57·95–58·65

The results show marked differences in the percentages required to form explosive mixtures, marsh gas showing the narrowest range and acetylene the widest one.—*Jour. prakt. Chem.*, lxxv, 223. H. L. W.

3. (*A New Method of Forming Organic Compounds of Phosphorus.*)—It has been found by Berthaud that when white

phosphorus is heated in a sealed tube with methyl alcohol at a temperature not below 250°, for several hours, the phosphorus disappears completely. The products are phosphoreted hydrogen and phosphines as gases, and as a residue phosphoric and phosphinic acids to some extent, but principally tetramethyl-phosphonium hydrate $(CH_3)_4POH$. Ethyl alcohol gives similar results with tetrathylphosphonium hydrate as the principal product.—*Bull. Soc. Chim.*, IV, i, 146. H. L. W.

4. *Oeuvres Complètes de J.-C. Galissard de Marignac*, par E. Ador. Two volumes 4to, pp. lv+701, and 839. Société de Physique et d'Histoire Naturelle de Genève (1907).—These magnificent volumes are a worthy memorial to the celebrated Swiss chemist, and the bringing together of all his published work is a valuable contribution to the history of modern chemistry. The work includes an excellent biographical notice and a portrait. Marignac's scientific work extended from 1840 to 1887. It is characterized by its quantity, as well as by its variety and importance. His researches were chiefly in the domain of inorganic chemistry; he made many important contributions to chemical theory., but probably his most important investigations were in connection with the determinations of atomic weights, as he was the pioneer in the application of the most refined and painstaking methods in this line of work. H. L. W.

5. *Outlines of Industrial Chemistry;* by Frank Hall Thorp. Second edition, revised and enlarged, and including a chapter on Metallurgy by Charles D. Demond. 8vo, pp. 618. New York, 1907 (The Macmillan Company).—The applications of chemistry in manufacturing operations are of much importance and interest to students of chemistry. The text-book under consideration gives an excellent outline of this subject. The descriptions are clear and concise, matters of detail properly belonging to special hand-books being omitted. The illustrations are numerous and well adapted for their purpose. The new edition brings the subject well up to the present time, and includes a chapter on elementary metallurgy. H. L. W.

6. *Note on the Decay of Ions in the Fog Chamber;* by C. Barus (communicated).—The following results are chosen at random from a large number of similar data for all ranges of nucleation up to 10^6 per cubic centimeter. They were obtained in the endeavor to standardize the coronas of cloudy condensation by aid of the decay curves, in case of ions produced in dust-free wet air, by radium or by the X-rays acting from without.

Table: $-dn/dt = cn + bn^2$

$10^3 b = \cdot 001 \quad c = \cdot 0356$

Time, t, elapsed since $a = 0$	Nuclei per cm^3 $10^{-3}\,n$, observed	Successive $10^6(-dn/dt)/n^2$	$10^{-3}n$ computed
0 sec.	310	1·5	310
5	107	—	107
10	55	1·6	60
20	29	2·4	28
30	17	5·2	16
40	9	—	10
50	7	—	6

A method of accounting for these results was suggested by the writer in connection with his work with phosphorus nuclei (Smithsonian Contributions, 1901, No. 1309). There may be either generation or destruction of ions proportional to the number n present per cubic cm., in addition to the mutual destruction on combination of opposite charges. In other words $-dn/dt = a+cn+bn^2$, where a is the number generated per second by the radiation, cn the number independently absorbed per second, and bn^2 the decay per second by mutual destruction. If a is zero (radiation removed) $1/n-1/n_0=(1/n_0+b/c)\,(\epsilon^{c(t-t_0)}-1)$ where the nucleations n and n_0 occur at t and t_0 seconds.

The fog chamber hardly admits of a sharp distinction between b and c; but if the provisional values of the table be accepted, since $-(dn/dt)/n^2 = c/n+b$, c will become rapidly more important as n falls below the order of 10^4. All my data show this conclusively. Again the c here obtained is of the same order as the value found for phosphorus nuclei. Finally in case of equilibrium in the presence of radiation, $dn/dt = 0$, the rate of production becomes $a = cn+bn^2$, where a measures the intensity of the radiation. It no longer varies as n^2.

7. *Electric Conductivity.*—K. Bädeker has determined this conductivity for a number of oxides and sulphides of metals, and also the thermoelectric force of these preparations. In general the oxides and sulphides are of higher resistance than the metals. This is shown in the following table :

Cu	0·0000017	CuI	0·045
Pt	0·000014	30 per cent H_2SO_4	1·35
Bi	0·00012		
CuS	0·000125		
PbO_2	0·00023 (?)		
CdO	0·0012		
Ag_2S (at 200°)	0·0017		
Graphite	0·0028		
Cu_2O	0·0028		
Cu_2O	40·		
CuO	400 ?		

The first three numbers give for comparison the resistance of Cu, Pt, Bi.—*Ann. der Physik*, No. 4, 1907, pp. 749–766. J. T.

8. *Interference of Wireless Telegraph Waves.*—F. Kiebitz reaches the conclusion that it is possible to set many rectilinear Hertz exciters in oscillation with determined phase differences, if one connects them in a suitable manner with a system of standing waves. Moreover differences of direction were observed which corresponded with phenomena expected from interferences. —*Ann. der Phys.*, No. 4, 1907, pp. 943–972. J. T.

9. *Rays of Positive Electricity.*—Prof. J. J. Thomson has studied the canal rays by means of phosphorescence. The end of the canal ray tube was sprinkled with powdered willemite, and the deflections of the phosphorescent spot under the com-

bined action of a magnetic and an electric field were observed. The results obtained by Wien for $\frac{e}{m}$, viz.: 10^4, was confirmed for the more deflected rays, while 5×10^3 was obtained for the lesser deflected ones. The apparatus resembled that employed by Wien, except that one very fine hole was made in the cathode through which the canal rays passed. This fine column of rays was deflected by a very powerful magnet of the Du Bois type; and great care was taken to screen the discharge tube from the magnetic field. The tube was enclosed in a soft iron vessel, which, however, allowed the canal-ray tube to project from the vessel. The author discusses reasons for the existence of a continuous band of phosphorescence produced by the united action of the magnetic and electric fields. The value obtained for $\frac{e}{m}$ are mean values: for the positive particles in their passage through the canal-ray tube may lose a part of their charge by collision or otherwise. The positive rays were investigated for hydrogen, helium and argon, and also in gases at very low pressures.—*Phil. Mag.*, May, 1907, pp. 561–575. J. T.

10. *Electrons;* by Sir OLIVER LODGE. Pp. xv + 230. London, 1906 (George Bell & Sons).—The author has succeeded admirably in fulfilling the requirements suggested by the last sentence of his preface, namely: "The present book is intended throughout for students of general physics, and in places for specialists, but most of it may be taken as an exposition of a subject of inevitable interest to all educated men." Merely as a parenthetical remark, the reviewer cannot refrain from quoting a sentence from page 203 which seems to be framed for "specialists" and not for more general readers. It is as follows: "Especially must the inner ethereal meaning both of positive and negative charges be explained: whether on the notion of a right-and-left-handed self-locked intrinsic wrench-strain in a Kelvin gyrostatically stable ether elaborated by Larmor, or on some hitherto unimagined plan." The fundamental conceptions and problems associated with the theory of electrons are developed clearly and logically. One attractive feature of the book is the confidence which the manner of presentation inspires in the reader. Quite a number of the more or less popular books on the nature of electricity, of matter, and of radio-activity which have been published in the last five years give the impression of unpreparedness, in the sense that the authors seem to have read the texts of J. J. Thomson, Rutherford and others in a somewhat superficial manner and then to have presented the most important facts in their own language, but without possessing such real convictions as can alone come from long experience in a given subject. It is just the reverse with the book under consideration. Not only does the author write in an authoritative manner but he is thorough in details. For example, he places stress both on the retention of κ and μ in

equations expressing electro-magnetic conditions, and on the verification of such equations by the aid of the dimensions of the physical quantities involved in the several terms. On the whole, the book will probably appeal most to students who already have a fair knowledge of the subject and who desire to review the ground under the guidance of a reliable author. H. S. U.

11. *La Moderna Teoria dei Fenomeni Fisici:* Radioattivita. Ioni, Elettroni; by AUGUSTO RIGHI. Terza Edizione. Pp. x, 290. Bologna, 1907 (Nicola Zanichelli).—This third edition of Professor Righi's admirable popular work follows the first edition in less than two years after its appearance, a success which is due to its remarkably clear style and logical treatment of the important phenomena which are, as yet, hardly familiar to students not possessed of a technical training in physics. The very limited use of mathematical language in the book is confined to foot-notes and it is not essential to a good understanding of the topics discussed. C. S. H.

12. *La Ionizzazione e la Convezione Elettrica nei Gas;* by LAVORO AMADUZZI. Pp. 386. Bologna, 1907 (Nicola Zanichelli). —The aim of this interesting volume can perhaps be most speedily defined by naming the titles of the chapters. Chapter I, The Electron: II, Canal Rays: III, Röntgen Rays: IV, Ionization by means of Röntgen Rays: V, Characteristics of Ions: VI, Other Means of Ionization: VII, The Electric Discharge.

The chapters are followed by about fifty pages of appendices and twelve pages of useful, and apparently exhaustive, bibliography. The treatment of the subjects named is such as to adapt the work for a reader with an ordinary training in the philosophy of physics, and it is difficult to imagine how the author's part could have been better done. The clear typography and liberal margins which the publisher has provided make the volume a model of what such scientific summaries should be. C. S. H.

II. GEOLOGY AND NATURAL HISTORY.

1. *Geological Survey of Western Australia. Third Report on the Geological Features and Mineral Resources of the Pilbara Goldfield;* by A. GIBB MAITLAND. Bulletin No. 23, pp. 87, with 7 geological maps and 13 figures. Perth, 1906 (Fred. W. Simpson, Government Printer).—Taken in connection with bulletins Nos. 15 and 20, the present report furnishes a general summary of the geological as well as the mining prospects of a large area in northern West Australia. The formations recognized are arranged as follows, beginning with the oldest: 1. Warrawoona, gold-bearing metamorphic quartzites, conglomerates and greenstone schists, probably Archean. The tin-bearing granite and gneiss which occupies the larger portion of the Pilbara district is intrusive into the Warrawoona. 2. Mosquito Creek, grits, shales,

conglomerates. 3. Nullagine, sandstones, thin beds of limestones and volcanic rocks. 4. Oakover, sandstones, limestones and charts separated by a marked unconformity from the Nullagine. The absence of fossils renders the age of the beds unknown. There is some evidence for considering the Nullagine of Cambrian age. In addition to gold, the Pilbara field bids fair to continue as a producer of tin and tantalum. In the granite of the Cooglegong tin field occurs the rare mineral gadolinite, the following analysis of which has been made by B. F. Davis :

Silica, SiO_2	23·33
Iron protoxide, FeO	10·38
Beryllium oxide, BeO	12·28
Cerium sesquioxide, Ce_2O_3	2·50
Lanthanum sesquioxide, La_2O_3 } Didymium sesquioxide, Di_2O_3 }	18·30
Yttrium sesquioxide, Y_2O_3	33·40
Magnesia, MgO	·69
Ignition, loss, He,H,N,CO_2	·32
	101·20

Specific gravity, 4·14.

2. *Geological Survey of Western Australia. The Prospects of Obtaining Artesian Water in the Kimberley District;* by R. Logan Jack. Bulletin No. 25, pp. 35, with a geological map. Perth, 1906 (Fred. Wm. Simpson, Government Printer).—The geological formations represented in Kimberley are Silurian or Cambrian metamorphic rocks ; Devonian sandstone, grit, and limestone ; Lower Carboniferous limestone ; and Upper Carboniferous sandstone. Granite is present, which „evidently represents the ultimate stage of metamorphism of the sedimentary rocks," and large areas of Tertiary basalts are mapped. Nine small areas were found to offer favorable conditions for artesian wells. The geological map accompanying this report, on a scale of 12 miles to the inch, includes the work of previous observers and brings the geological information down to date. H. E. G.

3. *New Zealand Geological Survey;* J. M. Bell, *Director. The Geology of the Area Covered by the Alexandra Sheet, Central Otago Division* (including the survey districts of Leaning Rock, Tiger Hill, and Poolburn) ; by James Park. Bulletin No. 2, pp. 49, with 23 illustrations, 17 photographs and 8 maps.—The second volume issued by the newly organized Geological Survey of New Zealand fulfills the promise of continued high grade work set by the first bulletin (this Journal, xxii, 542). Central Otago seems to be an unusually good field for the study of mountain building and physiography. A peneplain is well developed upon which Mount St. Bathans and Mount Ida stand as monadnocks. "This peneplain can still be clearly traced throughout eastern Otago from the main divide to the eastern shore. . . . It is tilted and slants gently from the alpine ranges to the southwest."

Plateau-like mountains with a height of 5,000 to 5,500 feet form dominant topographic features and are described as "conspicuous examples" of block mountains with intervening graben. The mountains are described as possessing "no great descending spurs or ridges and no foot-hills," and the streams in the intervening basins have experienced an interesting life history. The Manuherikia basin, in particular, is marked out by faults, one on each side of the valley, and the drag on the country rock adjoining the faults is marked and furnishes criteria for determining the date of the fault as later than Pliocene. Definite fault rifts which have controlled the courses of streams are described. The region exhibits also great thicknesses of glacial and alluvial deposits. Bedrock is made up of two series: one, Manuherikia, Pliocene, consists of "cement stone," sandstone, sands; the other, Maniototo, Paleozoic, consists of schists of various types. The unusual "cement stone" consists of quartz sands and gravels cemented into a stone by siliceous waters "which probably had some genetic relation to the great lines of fault structure." Petrography is well represented in this report, microscopic descriptions with excellent photographs being given of most of the rock types. Chemical analyses have been made of mica schist, chlorite schist and quartz schist. In the discussion of economic geology of the region the theories of ore deposition receive considerable attention. H. E. G.

4. *Cape of Good Hope Geological Commission.*—Three sheets of the new geological map of the Cape of Good Hope have been received. Sheet 2 covers an area east of Cape Town, including the coast line from Struis Bay to Cape Barracouta. Sheet 4 includes the valley of the Great Berg River and extends from the coast at Saldanha Bay eastward to longitude 16°. Sheet 45 includes an area between parallels 27° 40′ and 28° 40′ and longitude 22° 40′ and 24°. The maps are printed in color on a scale of 1 to 238,000. These maps embody the work of A. W. Rogers, E. H. L. Schwartz and A. L. DuToit, and are published by the Geological Commission.

5. *The Stone Implements of South Africa;* by J. P. Johnson. Pp. 53, with 258 illustrations. London, 1907 (Longmans, Green and Co.).—During the past four years Mr. Johnson has made numerous discoveries relating to the Stone Age of South Africa. Descriptions and illustrations of the "finds" are now given. Primitive, Paleolithic and Advanced groups are recognized and their relationship in time is indicated by numerous specimens of stone implements of various types. The Paleolithic groups are shown to be of "great antiquity." A gradual evolution of implements from the Eoliths to the weapons and implements of the present native races is indicated and the suggestion is made that the Bushmen may have been the makers of the stone implements. "If so, they belong to a more backward epoch of the Stone Age than the contemporary aborigines of either America or Australia."

In this book, Mr. Johnson has made an important addition to our limited knowledge of prehistoric South Africa. H. E. G.

6. *Ore Deposits of the Silver Peak Quadrangle, Nevada;* by JOSIAH EDWARD SPURR. U. S. Geol. Survey, Professional Paper No. 55. Pp. 174, 24 pls., 40 figs. in text.—The sedimentary rocks of the Silver Peak quadrangle include a thick series of limestones, slates and quartzites, of Paleozoic age, with shales, sandstones, tuffs and interbedded lava flows of Tertiary time. There are abundant intrusions of granitic rocks which pass into alaskites and by diminution of feldspar into pure quartz veins. The various phases of the granitic intrusions are regarded as derived from a single granitic magma, and represent a single period of intrusion.

An intimate interrelation has been recognized for all the metalliferous ores of the quadrangle, and all have been traced to the consequence of the intrusion of granitic rocks into Paleozoic sediments. The ore deposits may be divided into two chief groups, (1) bodies of auriferous quartz which separated out from alaskite during the process of cooling; (2) quartz veins due to replacement or impregnation of original material along fracture zones by siliceous solutions more attenuated than those which deposited the ores of the first type and probably residual from the crystallization of the magmatic quartz of the first type. These deposits contain relatively more gold when they occur in the granite and more silver and lead when they occur in the sedimentary rocks. Their different character under these conditions is believed to be due largely to the difference in the wall rocks. W. E. F.

7. *Geology and Gold Deposits of the Cripple Creek District, Colorado;* by WALDEMAR LINDGREN and FREDERICK LESLIE RANSOME. U. S. Geol. Survey, Professional Paper No. 54. Pp. 496, 29 pls., 64 figs. in text.—The Cripple Creek gold deposits, discovered in 1891, were investigated by Cross and Penrose in 1894. The extensive developments in the district since that time rendered a resurvey of the district desirable. New maps have been prepared and a detailed study of the rocks and ore deposits of the district is presented in this paper. The following are the most important modifications of the views presented in the original paper:

The various volcanic rocks of the district are proven to have very close genetic relations with each other, and in many cases are found to be so closely connected by intermediate types as to be practically inseparable. None of the massive rocks can be properly called andesites, and the volcanic breccia, usually spoken of as "andesitic breccia," is rather composed chiefly of fragments of phonolitic rocks accompanied locally by much granite, gneiss, or schist detritus.

None of the massive rocks erupted from the Cripple Creek volcanic center show any evidence of being surface flows. They are for the most part intrusive porphyries, ranging from nepheline-syenite to the aphanitic phonolite of the dikes. The breccia in the main fills a steep walled chasm extending to unknown depth and constitutes a typical volcanic neck.

The second part of the report consists of a detailed description of the geology and vein systems of the various mines of the district. W. E. F.

8. *The Genus Encrinurus;* by A. W. VOGDES. Trans. San Diego Soc. Nat. Hist., i, 1907, pp. 61–77, pls. i–iii.—In this paper the author brings together all the species of this genus, but does not attempt a final revision of them. C. S.

9. *On some Pelmatozoa from the Chazy Limestone of New York;* by G. H. HUDSON. Bull. 107, N. Y. State Mus., 1907, pp. 97–131, pls. 1–10.—Here is described in great detail combined with much speculation, a peculiar echinoderm long imperfectly known as *Blastoidocrinus carchariaedens.* The author has secured a wonderfully perfect individual, and as its structure is neither that of crinoids nor blastoids he erects for it a new order, Parablastoidea. This genus is included by Bather in his grade Protoblastoidea. The other forms described are: *Pachyocrinus crassibasalis*, *Deocrinus* (new) *asperatus*, *Hercocrinus* (new) with the following new species: *H. elegans*, *H. ornatus*, and *Archaeocrinus ? delicatus* (new). C. S.

10. *Remarks on and Descriptions of Jurassic Fossils from the Black Hills;* by R. P. WHITFIELD and E. O. HOVEY. Bull. Amer. Mus. Nat. Hist., xxii, 1906, pp. 389–402, pls. xlii–lxii.—In this paper are described 18 (16 new) species of marine invertebrate fossils from the Upper Jurassic of the Black Hills of South Dakota. C. S.

11. *Some New Devonic Fossils;* by JOHN M. CLARKE. Bull. 107, N. Y. State Mus., Geol. Papers, 1907, pp. 153–291.—For a number of years the New York State Geologist has been at work on a study of the Lower and Middle Devonic faunas of Maine, New Brunswick and Gaspé, Canada. "To insure some part of the results" of his labors, preliminary descriptions of new species are here presented, as follows: 18 trilobites, 2 *Tentaculites*, 4 cephalopods, 4 pteropods, 24 gastropods, 53 pelecypods, 50 brachiopods, 1 bryozoan, 1 coral, and 1 graptolite. This is the largest addition to the Lower Devonic faunas since Hall's Palaeontology of New York, vol. iii, published in 1861. Of new genera there are *Gaspelichas* (for a most remarkable spinose genus of trilobite "equipped with cerements of mortality"), and *Gaspesia* (for a supposed brachiopod described by Billings as *Orthis aurelia*).

Of particular interest is the large addition of pelecypods heretofore almost unknown in the American Lower Devonic. These remind one strongly of the Coblenzian of Germany and of the American Middle Devonic as well. Among the brachiopods of special interest are several species of coarsely plicated *Rensselaeria*, a development rarely seen in America, together with an *Amphigenia* and a large *Athyris*. C. S.

12. *The Eurypterus Shales of the Shawangunk Mountains in Eastern New York;* by JOHN M. CLARKE. Bull. 107, N. Y. State Mus., Geol. Papers, 1907, pp. 295–310, pls. 1–8.—Until very

recently the Shawangunk formation was regarded as the same as Medina, but now on the basis of both statigraphy and paleontology it is shown to be an eastern facies of the Salina. Near Otisville the grits alternate with thin beds of black shale, many of which have remains of *Eurypterus* of the same general development as in the Pittsford shale (Lower Salina) of western New York. In the grits are found burrows resembling *Arthrophycus*.

The fauna consists of 4 new species of *Eurypterus*, 1 *Hughmilleria*, 1 *Pterygotus*, 1 *Stylonurus?*, and fragments of Phyllocarida. Of particular paleontologic interest is the presence of very small individuals of *Eurypterus* indicating the following ontogenetic changes :

"(1) Very early change from the scorpioid to the gently tapering abdomen ; (2) gradual but irregular increase in segmentation ; (3) gradual but irregular elongation of the head ; (4) highly irregular variation in position of the eyes, but gradual travel from the margins inward to their normal locus." C. S.

13. *Ueber "Organbildende Substanzen" und ihre Bedeutung für die Vererbung.* (*Nach seiner am 21, Juni 1906 in der Aula der Universität Leipzig gehaltenen Antrittsvorlesung*) ; von Prof. Dr. CARL RABL. Pp. 80. Leipzig, 1906 (Wilhelm Engelmann).—This address is a scholarly discussion of the discoveries regarding the nature and localization of those substances in the germ cells which have recently been shown to give rise to definite portions of the adult organism, together with a critical examination of the evidences as to the actual physical mechanism concerned in inheritance.

The conclusion from the evidence is that there exists in the germ cells no one particular substance concerned in inheritance, but that every one of the fundamental organs of the cell is necessary in order that inheritance may be accomplished. The author accepts the view that the development of the organism is but a continual chain of chemical processes, all connected and regulated by a definite anatomical substratum. In an appendix is placed a brief discussion of the more important recent publications bearing on the subject.

This address may be looked upon not only as a most able presentation of a subject of profound interest, but also as an indication of the advanced position reached by the most recent biological work in cytology. W. R. C.

14. *Ueber die Vererbung erworbener Eigenschaften ; Hypothese einer Zentroepigenese ;* by EUGENIO RIGNANO. Pp. 399. Leipzig, 1907 (Wilhelm Engelmann).—There is probably no question in biology of more general interest than that as to whether characters acquired or accentuated during the lifetime of the individual can under any circumstances be transmitted to descendants. The author assumes that such characters can be thus transmitted and produces such documentary evidence in support of the doctrine as can be found in the writings of a number of well-known biologists of the last quarter century. He furthermore proposes

an elaborate hypothesis with which to explain such a supposed inheritance, and which will at the same time supply the inadequacy of the older theory of epigenesis. This hypothesis of centroepigenesis, as it is called, supposes, briefly, (1) that ontogeny is a recapitulation of phylogeny, with the immediate or indirect results of all influences ; and (2) that each specific nervous impulse sets aside (in the germ cells) a certain definite substance, which is able exclusively to give rise again to the identical kind of impulse which caused its formation.

Another, purely speculative, hypothesis suggests that all vital processes consist essentially of an intranuclear oscillating nervous discharge or series of impulses.

The need of such a speculative hypothesis regarding the inheritance of acquired characters in the higher animals will not be felt by the great mass of biologists of the present day who find no real evidence that such characters ever are inherited.

The present book is a translation and revision of the original French edition. W. R. C.

15. *A Guide for Laboratory and Field Work in Zoology ;* by HENRY R. LINVILLE and HENRY A. KELLY. Pp. 104. New York and Boston, 1907 (Ginn & Company).—This excellent little manual aims to direct young pupils in making intelligent observations on the common representatives of each group of animals. As is the case with the Text-book of Zoology by the same authors, especial emphasis is laid on those features of the subject which are naturally more interesting to the pupil or which have a direct bearing on the important problems in biology.

W. R. C.

16. *Les Débuts d'un Savant Naturaliste, le Prince de l'Entomologie, Pierre-André Latreille, à Brive, de 1762 à 1798 ;* par LOUIS DE NUSSAC. Pp. 264. Paris, 1907 (G. Steinheil).—This work consists of an interesting account of the first thirty-six years of the life of the French naturalist, Latreille, together with extracts from his correspondence and a discussion of his earlier published investigations. W. R. C.

17. *Der Einfluss des Klimas auf den Bau der Pflanzengewebe. Anatomisch-physiologische Untersuchungen in den Tropen;* by DR. CARL HOLTERMANN. Pp. 259, 16 pl. Leipzig, 1907 (W. Engelmann).—In this quarto volume the author describes a large number of observations which he has made on tropical plants. Much of the work was done in the botanical garden of Perideniya, Ceylon, and the remainder on preserved material collected in the vicinity of the garden. Although the majority of the observations are of an anatomical nature, the physiological point of view is continually kept in mind. The work is divided into five sections. In the first, which deals with the transpiration of plants in the tropics, the conclusion is reached that this process is on the whole no less vigorous than in temperate regions, although it is perhaps more subject to prolonged interruptions. The second section describes a number of tropical vegetation zones, with

special reference to the histological structure of their representative species. The author finds, among other points of interest, that certain plants which have been regarded as more or less xerophytic are not actually so in the strict sense of the word. The mangroves, for example, and some of the species found on moist sandy beaches show no peculiarities which tend to reduce transpiration. They develop, however, a water tissue, capable of direct absorption, and by this means are enabled to undergo a prolonged transpiration without injury. In the three remaining sections the author discusses the fall of leaves in the tropics, the effect of climate on the formation of annual rings in wood, and the subject of direct adaptation in tropical plants. Many of his conclusions seem influenced by the theory that acquired characters are transmitted, and it is hardly probable that all will be accepted without reserve. In spite of this fact the work will always be of value on account of the many and careful observations which it records. A. W. E.

III. Miscellaneous Scientific Intelligence.

1. *Carl Friedrich Gauss Werke.* Band VII. Theoria Motus Corporum Coelestium in Sectionibus Conicis Solem Ambientium. Pp. 650. Herausgegeben von der Königlichen Gesellschaft der Wissenschaften zu Göttingen. Leipzig, 1906 (B. G. Teubner).— It was within two or three years of a century ago that Gauss's famous *Theoria motus* first appeared. Now it comes out as the first 290 pages of the seventh volume of his complete works. The remaining 360 pages of the volume are made up of various notes and letters, in small type, which have been culled from the huge *Nachlass.* To rank all this matter as notes would, however, be extreme minimization; for there are two extensive investigations on the perturbations of Ceres and Pallas filling respectively 35 and 200 pages. Of these the latter for a long time seemed destined to receive the large prize offered by the French Academy for a treatment of the perturbations of the asteroid Pallas; but like so much of the work of this *Princeps mathematicorum,* it never came to publication during his life, which lasted some 20 years after this investigation was practically completed. Nothing shows more clearly the great assiduity and rapidity of Gauss's researches than the way he carried through his computations on Pallas to the extent of over 340,000 figures in the time of about three months.

With this Volume VII the edition of Gauss's works, which has occupied nearly 40 years, is complete except for one miscellaneous volume, the tenth, which will probably soon be given to the public. The scientific world owes a deep debt of gratitude to those who have so cheerfully spent a large amount of their time and energy on this great and highly valuable undertaking.

E. B. W.

2. *The Temperature of Mars: a Determination of the Solar Heat recorded;* by PERCIVAL LOWELL, Proc. Amer. Acad., xlii, 651–667.—The author discusses the temperature of Mars, taking into account not simply the question of distance from the sun, but also the other factors which may be supposed to affect the problem. The results reached are as follows: The mean temperature is 48° F. (9° C.); the boiling point of water 111° F. (44° C); the amount of air per unit surface 2/9 of the earth's, involving a pressure of 7 inches (177^{mm}); the density of the air at the surface 1/12 of the earth's, or 2·5 inches (63^{mm}).

3. *The Evolution of Matter, Life, and Mind;* by W. STEWART DUNCAN. Pp. 250. Philadelphia, 1907 (Index Publishing Co.).—In an earlier volume entitled "Conscious Matter," published some twenty-five years ago, the author, as he now states, "attempted to lay the foundation of a clearer method of explaining mental activity or psycho-physical phenomena. . . . In that little volume reasonable means were taken to bridge the chasm between the mental and physical, by claiming for all Energy in Receipt a new name, that of Subjectivity; the elementary unit of which is Feeling. Feeling and Energy were contended to be alternate states of matter everywhere. Feeling was given out as Energy. Energy was experienced as Feeling. . . . ." The scope of the work now issued will be inferred from this quotation, as also from the following: "The same mode of view is maintained in the present volume with an endeavor to show how it works out in detail throughout the whole history of evolutional creation."

4. *Esperanto in Twenty Lessons;* by C. S. GRIFFIN. With Vocabulary. Pp. 100. New York, 1907 (A. S. Barnes & Co.).—The new universal language invented by Dr. Zamenhoff has had remarkable success thus far. It is claimed, for example, "that with a speaking knowledge of Esperanto a person can travel all over the European continent and be understood everywhere. Nearly one hundred papers are published in the language . . ." Whether the prediction that in the course of a few years scientific works, among others, will be published in Esperanto, as well as in the original language, is to be verified remains to be seen; but in any case this excellently prepared handbook will be highly valued by many who wish to inform themselves on this interesting subject.

5. *Wellcome's Photographic Exposure Record and Diary.* United States Edition, 1907. Pp. 260. London (Burroughs, Wellcome & Co.) and New York (45 Lafayette St.).—Photographers will find in this little handbook and diary many important suggestions for their work, dealing particularly with the question of exposure. The Wellcome Exposure Calculator is a simple device by which a rotating disc serves to connect the light-value determined by the month of the year with that due to the special conditions existing at the time and with the plate-speed, yielding at once the correct exposure in seconds, or fractions of a second, for the usual stops. The usefulness of the "tabloid" developers is also clearly brought out.

INDEX TO VOLUME XXIII.*

* This Index contains the general heads, BOTANY, CHEMISTRY (incl. chem. physics), GEOLOGY MINERALS, OBITUARY, ROCKS, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

CHEMISTRY.

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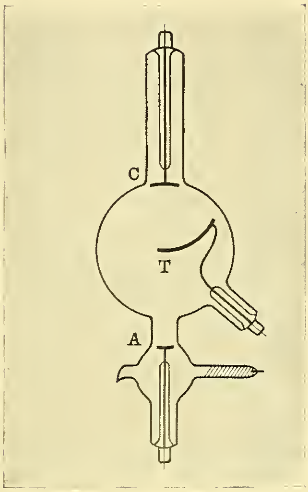

Fig. 1

Fig. 2

Fig. 3

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