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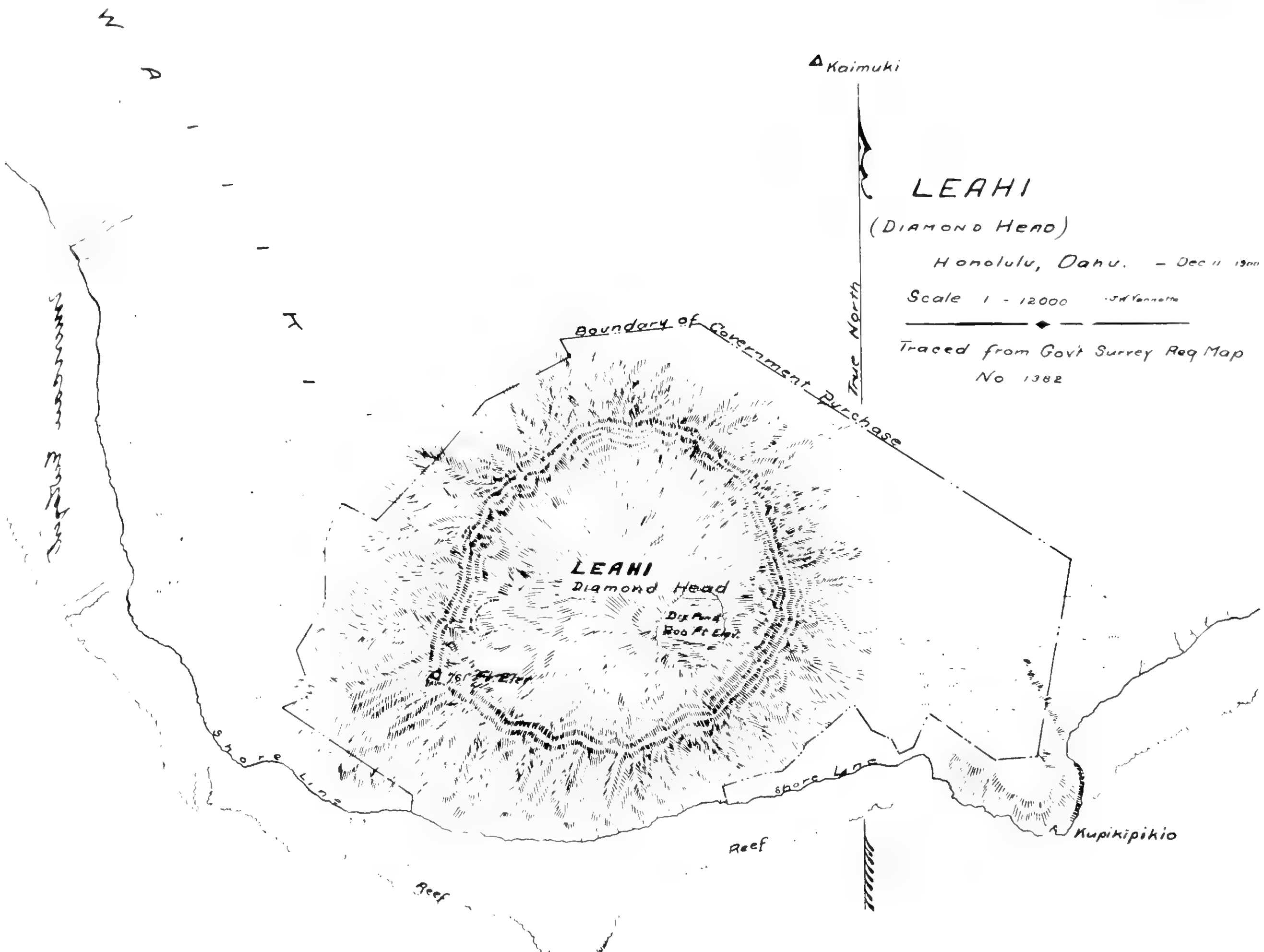

LEAHI
(DIAMOND HEAD)
Honolulu, Oahu. – Dec 11 1900
Scale 1 - 12000
Traced from Gov't Survey Reg Map
No 1382
Kaimuki
True North
Boundary of Government Purchase
LEAHI
Diamond Head
Shore Line
Shore Line
Reef
Reef
Kupikipikio

THE

AMERICAN GEOLOGIST.

VOL. XXVII. JANUARY, 1901. No. 1.

BREVITY OF TUFF-CONE ERUPTIONS

By S. E. BISHOP, Honolulu.

PLATE I.

Tuff-cones, of which a number have been formed on the eastern coasts of the island of Oahu, are produced by the class of eruptions distinguished as " explosive." The semi-liquid tuff has been projected in a jet or fountain to a considerable distance and having been driven laterally by the expansion of the steam and other gases contained, has fallen at some distance from the vent, building up a cone with a more or less regular rim enclosing a concave bowl. All the explosive eruptions actually observed seem to have occupied a very brief time. The greatest one, that of Krakatoa, was probably less than one hour in actual emission, although the fall of its lighter ejecta continued for several hours.

It therefore seems remarkable that an opposite opinion should have been expressed respecting the eruption which produced Diamond Head. This typical tuff-cone, lying in the suburbs of Honolulu, bounds our ocean view to the eastward. It was recently examined by Doctor W. H. Dall of the Smithsonian Institution with especial regard to the age of the fossil shells found in its debris. In the "Bulletin of the Geological Society of America," Volume 11, pp. 57-60, Dr. Dall expressed conclusions respecting the age of the crater, which I feel obliged to controvert. He says:

"The conclusion to which I came was that the whole mass of Diamond Head had been slowly deposited in comparatively shallow water and gradually elevated without being subjected to notable flexure The ejection of material at first must have been intermittent with long quiescent periods to enable the shore to have become repopulated with mollusks and corals." A good picture of Diamond Head appears opposite page 40 preceding.

It is necessary here to remark upon two serious errors of observation committed by Dr. Dall. It is true that Diamond Head was deposited in shallow water, its center being about one mile outside of the previously existing shore line. I undertake, however, to question the idea that it has since been "gradually elevated." Such elevation if it occurred must have been some 200 feet to have exposed what he calls a marine formation on its seaward base. Dr. Dall should have observed the total absence of marine erosion around the sides of the cone, upon the soft material of which the action of the waves would have been extremely destructive There is also no trace of such erosion around the evidently older tuff-cone of Punchbowl, four miles away, nor any elevated beach marks along the neighboring mountains.

Dr. Dall's second error of observation was in attributing a marine origin to the mass of material lying against the seaward base of the crater. That mass is composed of mingled small angular fragments of tuff fallen from the hights above, with large quantities of calcareous beach sand. Pervading the mass are numberless laminated calcareous concretions, which Dr. Dall has mistaken for coral reef. These fragile laminated crusts are identical with those forming the interior structure of our numerous calcareous sand dunes. The layers constantly vary in angles of dip, corresponding to the formerly varying surfaces of the dunes. Had the tuff enclosed ever been exposed to the action of the waves, so far from retaining its angular forms, it would immediately have been ground into soft mud.

The whole mass is of Aeolian formation. It is simply a great sand-dune. The contents have been assorted by the wind, the eastern end being composed mainly of larger fragments of tuff, and the western end, one-third mile away, mainly of sand much triturated, and stained by the brown tuff. The mollusks of Tertiary age enclosed in the mass, as found by Dr. Dall, may be fully accounted for as having fallen from the hights with the tuff. They were torn off from the ancient submerged reefs and beaches traversed by the shaft of the eruption. I have found large shells embedded in the laminated tuff at Koko Head, as well as corals. Farther evidence is found in the fact that fragile land mollusks are enclosed between the crusts in great numbers side by side with the marine shells. Both fell together from the cliffs above.

My main contention, however, is to prove the absolute impossibility that a crater like Diamond Head should be a product of "intermittent ejection" with "quiescent periods," even brief ones, or that it could have been "slowly deposited." I propose to prove that a cone of such peculiar form and structure could have been created only by an extremely rapid projection aloft of its material, completed in a few hours at most, and ceasing suddenly and finally.

My first proof of this conclusion is derived from the extreme regularity of the elevated circular rim of this cone, such as could be the result only of a single, rapid, uniform, unintermitted outthrow of the tuff. Two-thirds of the elevated perimeter is part of an almost perfect circle of about 5,000 feet in diameter, and of a comparatively uniform hight, about 450 feet above sea-level. The tuff is piled up in this regular ridge, originally rounded on its top, in very uniform quaquaversal layers or lamniae, whose steepest dip on the outside is about 35°, and much less on the inside of the broad bowl. The great subaerial erosion discloses the interior structure of the rim, although it has not obliterated the really delicate symmetry of the original form. (See Plate 8, Vol. 11, p. 46.)

The southwest third of the perimeter of the crater is massive, attaining a present hight of 762 feet. It is severely wasted by the impact of storms, and was once probably 1,000 feet high. The original rounded summit must have been considerably to seaward of the present sharp peak. The original form may be best understood by comparison with those of Koko Head and of Lehua island, which are of somewhat similar form and dimensions, but remain substantially unaltered in their rounded summits. The immense enlargement of the southwest portions of these craters, as well as of many others is doubtless correctly attributed by W. L. Green to the action of the strong trade winds deflecting to leeward the lofty jet of tuff, and piling it up disproportionately on that side.

With due allowance for the single disturbing influence of the wind upon the summit of the mighty fountain, it is evident that the very perfect symmetry of the main portion of the rim could have been produced only by an extremely regular fall of the spreading fountain of ejecta at a uniform and unvarying distance from the vent. Any interruption or intermission would have so disturbed that precise uniformity of projection as to have piled the falling tuff in irregular positions. The beautiful symmetry of the crater is a powerful witness of its sudden and rapid formation. It forbids any other conception.

My second evidence of the brevity of the eruption which created the crater-cone is derived from an arithmetical computation of the time required to deposit the actual mass of the cone by a fountain of adequate hight to deliver its ejecta upon the existing rim of the bowl. Data are easily secured for a sufficiently approximate estimate of the time to show that it could have occupied a very few hours at most. Let us first compute the solid contents of the tuff deposited. The average diameter of the bowl is about 5,000 feet. Two-thirds of the perimeter is 450 feet high, to which 50 feet may be added on account of the average depth of sea at the distance from the shore where the eruption occurred. The other third of the perimeter was occupied by a conical mass probably 1,000 feet high, but standing in perhaps 250 feet depth of sea. Estimating this cone as 1,250 feet high, with 5,000 feet diameter of base, its solid content would be about 8,000,000,000 cubic feet. The contents of the other two-thirds of the perimeter would be about 5,000,000,000 feet, making with the cone a mass of 13,000,000,000 cubic feet of tuff in the entire crater.

A similar result is obtained by assuming a base equivalent to 5,000 feet square, and an average hight of 500 feet, which gives a solid content of twelve and a half billions of cubic feet. It is evident that such an estimate is sufficiently large.

Now, to have ejected the whole mass in five hours would have required an emission from the vent of two and a half billions of cubic feet of tuff in an hour, or of 694,444, feet in one second. Supposing the vent to have a sectional area of 2,000 feet, which I believe to be much too small, the velocity of emission would be only 347 feet in a second, which is equivalent to a theoretical hight of only 1,900 feet of projection aloft. It is evident that this is totally inadequate. Assume then only two hours' duration of the eruption. This gives us 875 feet of velocity of emission, equivalent to a hight of projection of 11,925 feet. Such an altitude of the fountain might be adequate to the actual distribution of the ejecta to an average distance of 2,500 feet from the vent. But it must be noted that the hight attained with the assumed velocity could hardly be more than two-thirds of the theoretical one, on account of the resistance from the falling tuff encountered by the ascending jet. It is also evident that the fountain must have been a very lofty one for the tuff to have been driven half a mile to the leeward by even a heavy gale, as so much of it was done in building up the massive cone.

The real area of the vent can be less accurately estimated. The partially exposed vent of the neighboring crater of Punch Bowl is apparently fully a hundred feet in diameter. The only completely open vent of the kind which I have seen is that of Kalaupapa at the leper settlement on Molokai. This is a rocky well with vertical sides reaching down to salt water, which is 800 feet deep. The diameter of this well or shaft was, as I remember it, from 100 to 150 feet. Guided by these data I should consider 5,000 square feet as a very conservative estimate for the sectional area of the shaft from which issued the tuff of Diamond Head, instead of the 2,000 feet assumed above Such increased area would reduce the two hours' duration assumed, to 48 minutes. It would be much less if we allow a greater velocity of ejection, so as to get a hight of the fountain adaquate to allow of its extensive deflection by wind. I incline to the belief that the eruption did not last more than half an hour. It is absolutely impossible that it could have continued many hours.

These explosive eruptions are of gigantic force and brief duration.

Honolulu, November 14th, 1900.

POSSIBLE NEW COAL-PLANTS ETC., IN COAL.

PART III.

By W. S. GRESLEY, Erie, Pa.

Plates II-VIII.

Reference to and Remarks on the Figures in Plate II.

Fig. 1. Portion of a cluster or patch of seed-like bodies, partly in plan and partly in section, embedded in a fragment of ordinary commercial anthracite (Carboniferous) from Pennsylvania. The name or number of the vein or seam, as well as location, is not known.

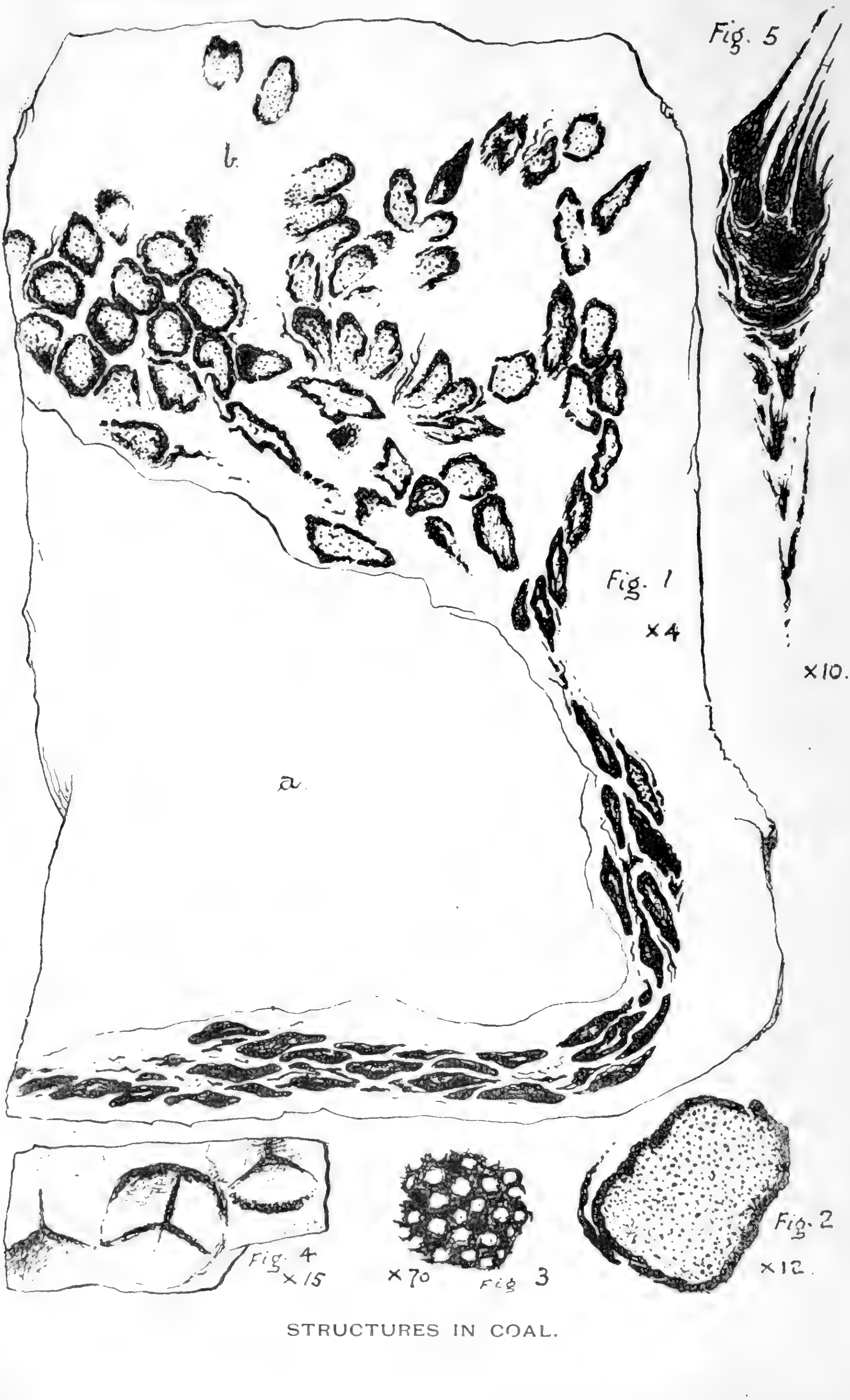
Fig. 2. Horizontal section of one of the objects—pods or seeds (? megaspores) in fig. 1. In reality the spotted aspect of the contents of these black-bordered bodies should be spoken of as clear, black, compact anthracite as a matrix to hundreds if not thousands of minute gray specks.

Fig. 3. Magnified appearance of the ? microspores—seed contents—of these little ? pods.

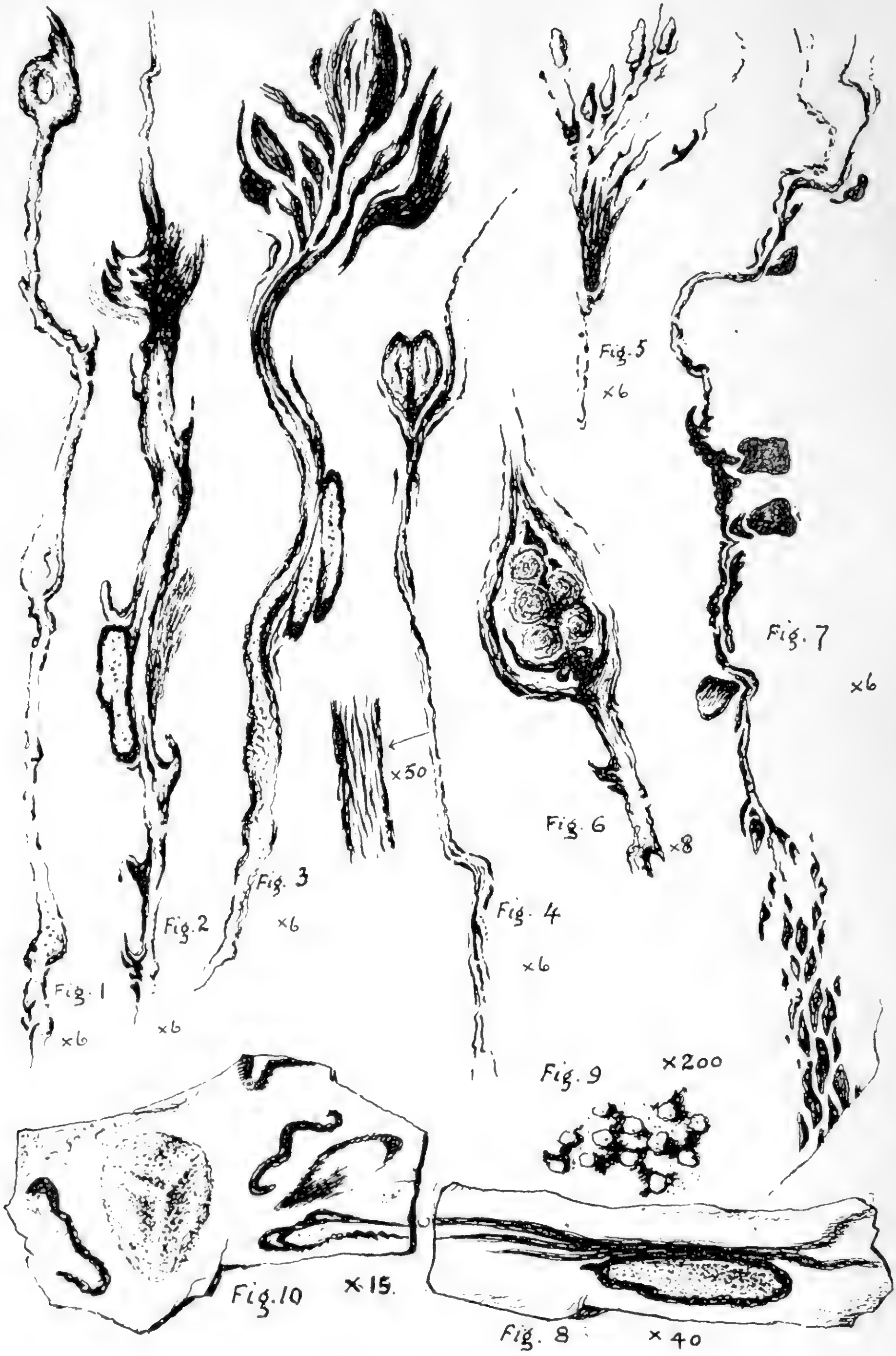
Remarks on the foregoing. Whatever these fructifications represent they appear to be oblong in form rather than circular. Along the lower right and along the bottom of the specimen the pods are seen in oblique section, on account of the breaking of the coal. Since the blank area "a" shows a different horizon in the coal from that in which the fossil reposes, it is quite reasonable to suppose that the seeds lie beneath it, and not less closely packed than seen higher up in the fig. near "b." Is there not in the pose of these bodies a suggestions of symmetry in form or arrangement, as opposed to a disposition resulting from scattering or accidental accumulation. While the various pods are not seen to possess connection by stalks, there is nevertheless among them indication of such in the shape of coaly filamentose appendages or inter-twinings suggesting that the fossil represents seeds syncarpous in form rather than individually scattered or accidentally buried here in a mass together. In this fossil I see nothing to suggest a cone-derivation for these spores. May they not have belonged to a water plant?

Other, but smaller and less preserved specimens of very similar seeds have been met with in the same coal; the exact

*For earlier papers of this series see AMERICAN GEOLOGIST, Feb. 1899, Oct. 1899, and July, 1900.



STRUCTURES IN COAL.



STRUCTURES IN COAL.

character of the enclosing material, being rather dull and gray, or "bony," than black or more glossy coal.

Notice how easily the lower part of the specimen fig. 1 might be mistaken for the form illustrated in fig. 3, plate II, facing p. 50, vol. xxvi, July, 1900.

Fig. 4. Vertical view showing a patch of ? detached or scattered *tri-radiate* spores, ? occurring in coal same as fig. 1.

Fig. 5. Longitudinal section, ? somewhat oblique, apparently exhibiting a small cone or inflorescence belonging to some unknown plant embedded in a dark gray lamina of Pennsylvania anthracite.

Reference to plate III and remarks on the specimens.

Figs. 1 to 7. Horizontal, or for the most part horizontal, sections of various pods, seeds, infloresences etc., of several kinds attached to or in such close contact with parts of stalks, twigs or other extremities of plants that they are probably *in situ*. Observed upon the planes of lamination of various specimens of Pennsylvania anthracite.

Fig. 8. Oblique section of a comparatively small ? macrospore, apparently attached at the junction of ribbon-shaped processes. Pennsylvania anthracite.

Fig. 9. Magnified aspect of some of the ? microspores of the form fig. 8.

Fig. 10. Exterior of macrospore ? (in this case composed of pyrite) embedded in anthracite; associated with several other scattered ones composed of coal. The shape of this fossil seems peculiar.

Note. If we admit that for the most part those fossils are fragmentary all that I care to say concerning them is that we seem to be presented with some five or six different species of seeds and ovules, as the case may be, none of which seem to belong to cones, but rather to meandering, swelling, branching and sinuous plants. However this may be, these drawings may serve to direct the attention of other workers to similar forms, so that eventually their significance may appear. Since some layers or horizons of the anthracite are quite crowded with this kind of forms, the plants to which they belonged were decidedly coal-forming in their nature, or as to their substance.

Reference to Plate IV, and remarks on the specimens.

Fig. 1. Part of a small patch of what may be seeds composed of a milk-white substance surrounded by brittle coal. *Horizon.*

Bedding plane of coal-seam (bituminous). *Loc.* What Cheer, Iowa.

Fig. 2. Tri-radiate macrospores ? with leafy expansions apparently torn and fragmental. Color, pale brown. Same horizon and same locality as specimen fig. 1. (See *"Triletes,"* Kidston, in Trans. Roy. Soc. of Edin.; vol. 35, p. 63.)

Fig. 3. A pear-shaped seed—exterior view; seems to be made of coal. Same horizon and locality as specimens fig. 1 and 2. (Similar or very similar forms had been noticed by me in the "Pittsburg" coal bed, Pa., and in the "Barnsley Thick" coal in Yorkshire, England.)

Fig. 4. A flattened fruit or seed? *Cardiocarpon* consisting of coaly material.

Horizon and locality same as the above.

Fig. 5. A three-cornered seed or pod, fossilized it would seem when about to open along tri-radiate lines. Composed of lime etc., and found in a concretion of that material with pyrites, in the coal bed of What Cheer, Keokuk county, Iowa.

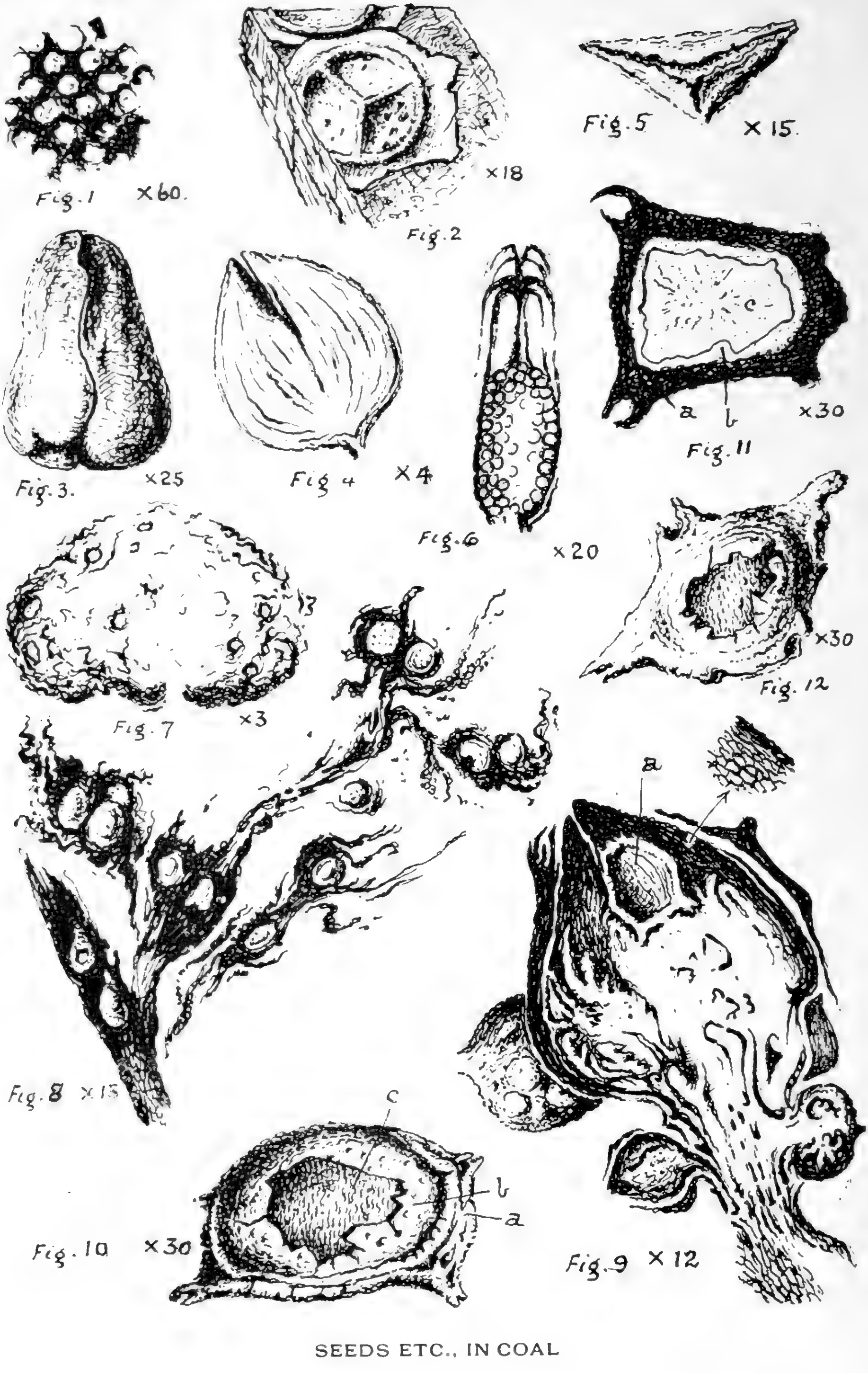
Fig. 6. Nearly horizontal section of what appears to be a pod filled with seeds. Composed of black carbonaceous material and pyrite. *Horizon.* Coal bed. *Loc.* What Cheer, Iowa. (Discovered by grinding and polishing the material.)

Fig. 7. Horizontal view of a little patch of moss-like filaments (blackish in color, and embedded in pyrite), enclosing brown ? seeds. *Locality,* the coal bed at What Cheer, Iowa.

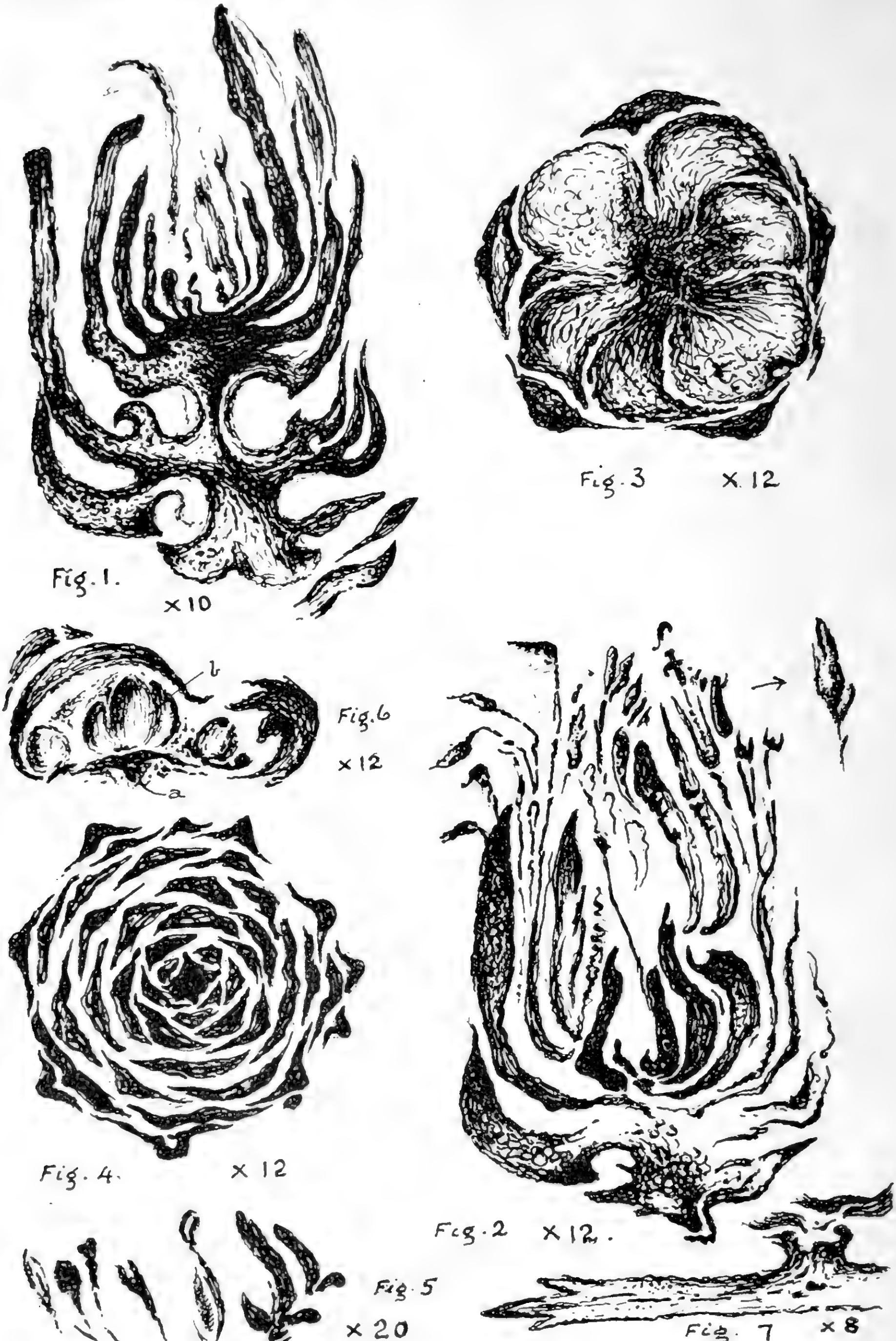
Fig. 8. Horizontal section or view of part of some plant, in or upon the parts of which are seen little, bright, yellowish, red-coated seeds, having pearly white nuclei more or less visible. This and the form illustrated in fig. 7, may be the same plant. Found in a lime and pyrite concretion in the coal at What Cheer, Iowa.

Fig. 9 Horizontal section (developed by grinding and polishing a fragment of a pyrites nodule taken out of the coal at What Cheer, Iowa) of a seed-bearing inflorescence. *a.* shows a seed case or ovule (or epicarp?), to all appearances in place in this fructification. The specimen seems to be bractiform in character. The material of the epicarp? is of a brown color. Other points of interest in this specimen may be noted by examining the drawing.

Fig. 10. Enlarged view, in perspective, of what seems to be a horned or four-cornered seed vessel, perhaps similar to the one seen at *a* in fig. 9. This specimen was not found *in situ* but lying near others, as though scattered, but in the same mineralized concretion as for fig. 9. *a* is the testa or pericarp, brown in color, and broken away around the seed; *b,* membrane, copper colored, with surface showing excrescences, broken and partially removed to show the nucleus or seed; *c,* elegantly crinkled or crimped surface of the seed itself,



SEEDS ETC., IN COAL



INFLORESCENCE IN COAL.

which is, I think, globular in form, peeping through the broken envelope *b*. The substance of *c* is beautifully pearly white, or of a pale resinous hue, and presumably is petrified albumen or endosperm.

Fig. 11. Seed, very similar to that in fig. 10, and in the same or a similar pyritous nodule in the What Cheer coal bed. Developed by grinding and polishing. Shows flocculent, cloudy white, central or nucleal material *c*: golden colored membrane *b;* horned and 4-cornered testa or pericarp *a*.

Fig. 12. External aspect of another seed very like the one in fig. 10, but probably a less perfect specimen as to the outer envelope, one of the 4 corners seems to be broken off. Here again is seen the pearly-looking nucleus where the coverings have been removed.

These seeds are, in the What Cheer coal material, associated with *Lepidodendron, (?) Sphenophyllum, Myclopteris,* and the other forms herein illustrated, e. g. *Cardiocarpus, Pecopteris,* etc.

The horizon of the What Cheer coal bed is, by the state geological survey, considered to be near the base of the coal measures, or in the "Des Moines" *stage* of the Carboniferous. (See Iowa Geological Survey, Vol. IV. Third Annual Report, 1894, pp. 225-311.)

The pyritous concretions in the What Cheer coal furnish us with samples of what may be called the *raw material* of coal saved from coalification by these concentrations of iron, sulphur, lime, etc.

Reference to Plate V. and Remarks on the Specimens.

Fig. 1. Longitudinal section, developed by grinding and polishing a fragment of a pyritous concretion, of a small bractiform inflorescence. *Locality.* What Cheer, Iowa.

Fig. 2. Longitudinal section of another very similar form, possessing stamens *in loco natali.* From same material, same coal-bed, and same locality as specimen fig. 1. Does not this specimen suggest a male flower showing pollen sacs? Attached to the stalk of this fossil were two other very similar flowers (if flowers they can be called), one on each side and about one-eighth of an inch below it. The stalks, however, were very poorly preserved, no structure was observed in them.

Fig. 3. Transverse sectional aspect of one of these cones, very close to its base.

Fig. 4. Transverse section—polished, of one of these cones from the coal in Iowa.

Fig. 5. Illustrations of stamens, or the ? *calyptra* of the same, in another specimen of the same inflorescence.

Fig. 6. Longitudinal section through the central part of a cone showing several barren ? seed-vessels *b* at the top of the stalk *a*.

Fig. 7. Longitudinal section of a fragment of a twig or branch showing indications of the peduncular attachment belonging to one of these inflorescences. The form of one twig seems to have been deeply grooved longitudinally, and was perhaps of hexagonal section.

Reference to Plate VI. and Remarks on the Fossils.

Fig. 1. View of a group of small conical forms, some attached to the stalk and branch, as exposed by fracturing a mineralized nodule (pyrite, lime, etc.) taken from the coal at What Cheer, Iowa. In this specimen the stalk consists of a softish, brownish black material and exhibits no organic structure. In close touch with these cones were several nuts of *Cardiocarpus* (Plate VII).

Fig. 2. Longitudinal section of a cone?, and a cluster of what looks like three seeds within bractiform envelopes; both objects are attached to the badly-preserved twig. From the same pyritous concretions in Iowa coal.

Fig. 3. Longitudinal and rather oblique section of the terminal of a branch or twig, bearing what appears to be a damaged inflorescence at *a*. Brought to light by grinding and polishing the pyritous material out of the coal in Iowa.

Fig. 4. Transverse section through the lower part of the twig fig. 3, showing leaves surrounding the twig or branch, of which there seem to have been about ten to each node.

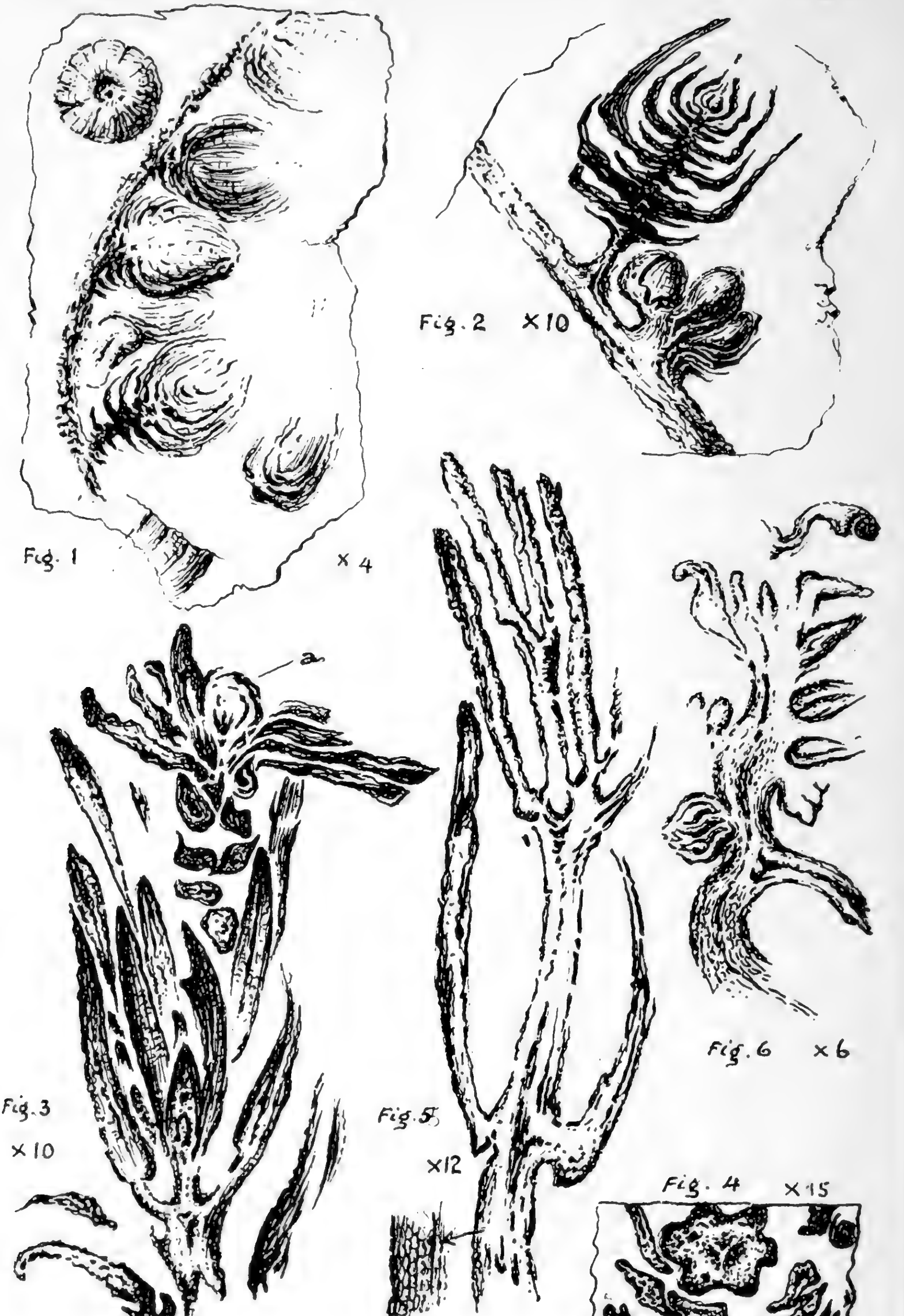
Fig. 5. Longitudinal section of what appears to be a terminal of some twig belonging to still another plant.

Fig. 6. Longitudinal section of part of a seed bearing ? twig of possibly still another species.

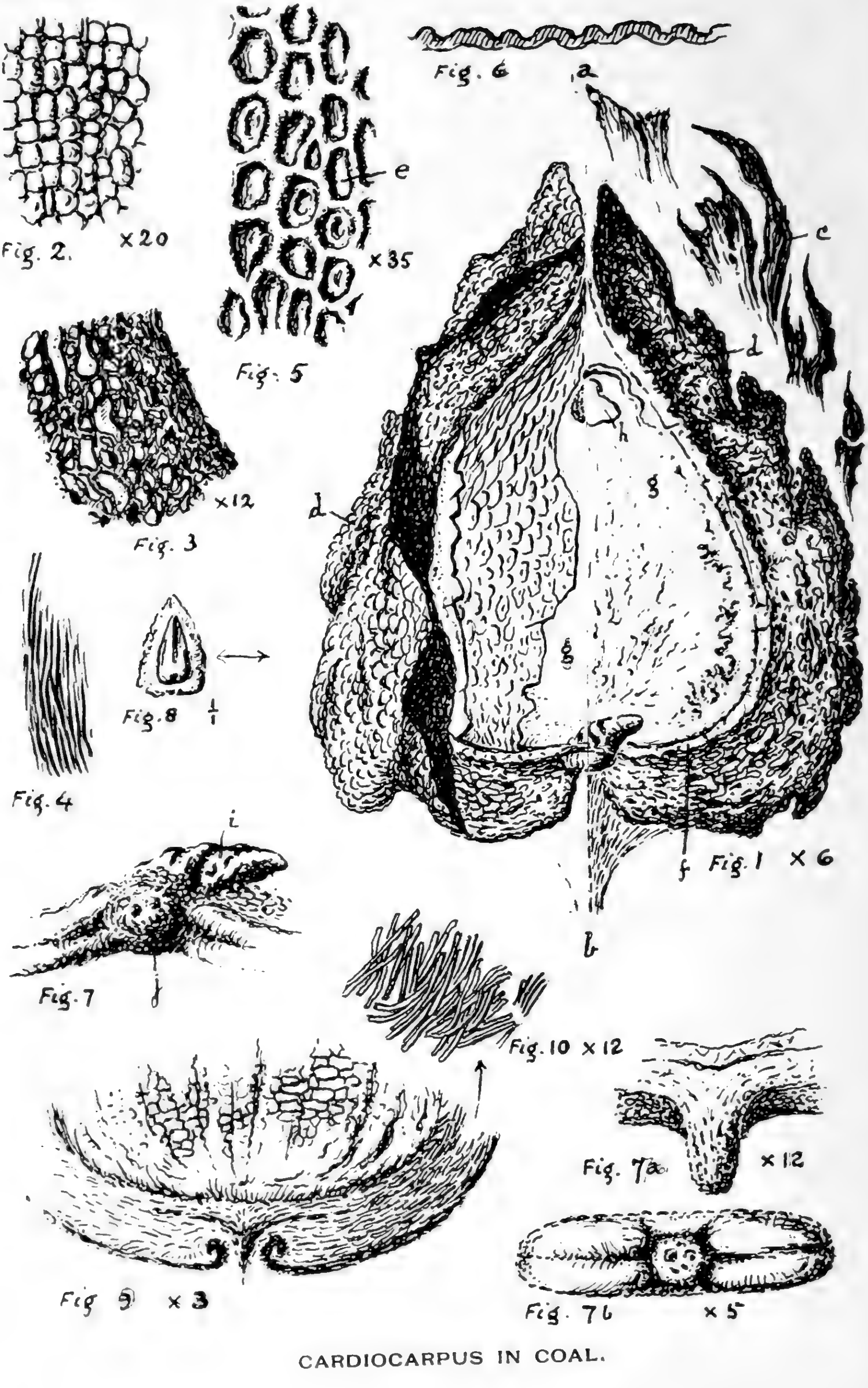
All of the above specimens were discovered in the pyritous nodular concretions out of the coal-bed at What Cheer, Iowa.

Reference to Plate VII. and Remarks on the Specimens.

Fig. 1. Longitudinal sectional view or diagram, compiled from several different specimens, of a *Cardiocarpus*—(cardiocarpon fruit). The right half of this fruit, seed, or nut, from the line *a b* is wholly sectional, and shows indications of bracts or leaves *c* enclosing or partly surrounding the exotesta *d*. Between the latter and the perispermic membrane? is a zone of calc-spar *f*. *g* is the nucleus—the endosperm, consisting of milky white calcareous material, and exhibiting a beautiful radiate flocculent structure by a paler tint per-



CONES ETC. IN COAL.



CARDIOCARPUS IN COAL.

vading the more cloudy one. Near the exterior of the nucleus are beautiful plays of microscopic aborescent pyrite, which wave about and creep inwards or towards the center of the seed. There are near the apex of *g*, certain yellowish brown inclusions or formations *h*, that may suggest an embryo. At the base of the seed may be noticed several interesting structural features pertaining to the peduncle.

The left hand half of the figure shows a portion of the exotesta removed so as to bring into view the aspect of the membrane fig. 5, and beneath this membrane at *g* the surface of the kernel or seed itself appears, which surface is marked or bears the impress of the pattern or formation suggested by the drawing fig. 5—the membrane *e*. Observe the rugged exterior of the outer envelope *d*. In some specimens this is seen to be broken and displaced, suggesting something harder than a fleshy composition.

From mineralized nodules in the coal bed at What Cheer, Iowa.

Fig. 2. Pattern or quasi tessellated appearance of the exotesta *d* fig. 1. The color of it is golden brown to greenish gold—has a bronzy aspect.

Fig. 3. Suggests the character of the substance or structure of the exotesta *d*. In color is grayish, but often mottled or variegated—black, white, gray, brown, yellowish and reddish. Near the sides the cells become smaller.

Fig. 4. Hairy aspect of the inner surface of the exotesta *d*: greatly magnified.

Fig. 5. An attempt to depict the pattern or moulded form of the membrane or thin envelope in contact with the endosperm *g*. In substance this membrane is very brittle, thin, and of a golden brown color. Where the kernel *g* is widest the pattern is best developed; as the micropyle is approached the pattern is elongated, contracted and narrowed down as indicated in fig. 1. In reality this pattern consists of little ovoid knobs within little ovoid depressions.

Fig. 6. Transverse section of the membrane *c*, so far as showing its corrugations.

Fig. 7. Oblique view of part of the base of this *Cardiocarpus*, showing the hilum *j*, and what is perhaps a radicle or caulicle *i* protruding into the nucleus *g* fig. 1. This radicle?, or whatever it is, is colored golden brown outside, and its interior substance is white. Does this feature indicate two cotyledons?

Fig. 7. a. Longitudinal section of another aspect of the base or near to the base of this or another species. I do not understand it.

Fig. 7. b. View of the base of the nucleus g, fig. 1: ? the hilum.

Fig. 8. Longitudinal section, end view, of one of these specimens of *Cardiocarpus*.

Fig. 9. Longitudinal section of part of possibly a different species of *Cardiocarpus*. This specimen, being badly squeezed or preserved, is difficult to understand. It seems to have possessed a fibrous exotesta, the character of whose tissue, being pulled apart, is shown in fig. 10. The pattern on the inner envelope, and some structures near the peduncle are indicated. This fruit was about twice the size of the *Cardiocarpus* fig. 1. Same horizon, locality and material as for specimens figs. 1 to 8.

I am not aware of any *Cardiocarpus* showing more internal organization than do these from the coal of What Cheer in Iowa, and so possibly they may aid in settling the still open question—were *cardiocarpa* seeds?

Though the nodules were quite rich in numbers of the fruits figs. 1 to 8, I failed to detect any of them attached to stalk or twig. They lay in the matrix in all positions and scattered; evidently dropped upon or into the vegetable material enclosing them; in some cases they were in actual contact with the inflorescenses, Plate V, and with forms shown in Plates VI and VIII.

To facilitate reference to authorities on *Cardiocarpus*, the following are given:

Q. J. G S., vol. xxviii, plate 27, fig. 4. (an Australian specimen).

Manual of Palaeontology, by A. Nicholson, vol. 2, p. 450.

Cat. Palae. Plants in the British Museum, by R. Kidston, 1886, p. 207.

Report of the Second Geological Survey of Pennsylvania, vol. P, (Atlas, *Coal Flora*) pp. 561-574, plate lxxxv, figs. 32-50, and plate lxxxvii, fig. 8.

Palaeontological Botany, by J. H. Balfour, 1872, pp. 65, 66.

Fossil Botany, by Solms-Laubach, 1891, p. 118.

Text-book of Geology, by A. Geikie, 1882, p. 731.

Geological History of Plants, by Sir J. W. Dawson (1888), pp. 80, 82, 153.

Acadian Geology (second edition), by Sir J. W. Dawson (1868), pp. 459, 460.

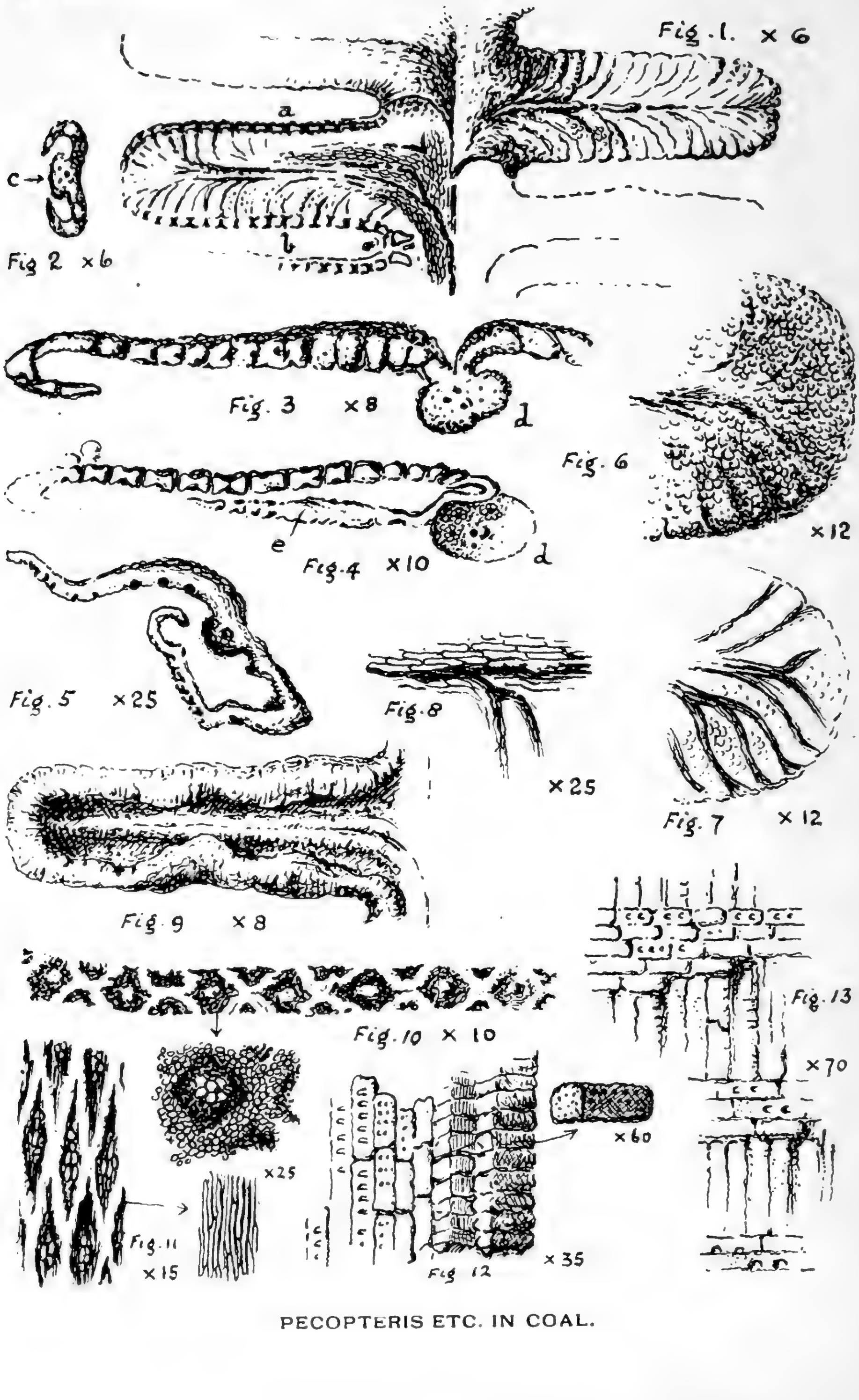
Geological Survey of Ohio (Palæntology, vol. 1), by J. S. Newberry, 1873. Plates xli, xliii.

Geological Mag., 1872, vol. ix, pp. 55, 57.

Phil. Trans. Roy. Soc. Fossil Plants of the coal measures, part viii, by W. C. Williamson, 18 May, 1876, plates xiv, xv, and xvi.

Reference to Plate VIII. and Remarks on the Specimens.

Fig. 1. Fragment of a small *Pecopteris,* shown more or less in diagram, indicating the form, the shape and disposition of the pinnæ, with the exterior venation on the right, and some



PECOPTERIS ETC. IN COAL.

anatomical structures on the left. From pyrites nodule in the coal at What Cheer, Iowa.

Fig. 2. Transverse section of a pinna through *a b* fig. 1, showing curling under of the rim or sides of the pinnæ, and the position, shape and size of the mid-rib *c*.

Fig. 3. Longitudinal section through a pinna, near the curving-under line (*c* fig. 2), showing cross section of the branching venation, the curved-under point of the pinna, and the stalk of the frond at *d*.

Fig. 4. Another long section of a pinna between its mid-rib and the curving-under line, showing frond's mid-rib *d*, and the curved-under edge of the pinna *e*.

Fig. 5. Rather oblique cross section of a pinna, showing curiously curved form.

Fig. 6. The aspect of the exterior or upper surface of a pinna.

Fig. 7. Details of the venation near the tip of a pinna.

Fig. 8. Longitudinal section of part of a mid-rib, with branching or rebranching venation and associated cellular structure.

Fig. 9. View of the underside of a pinna (restored).

Note. In these pyrites concretions in the coal bed at What Cheer in Iowa, this species of *Pecopteris* is rather common. It was by grinding and polishing that the structural details were brought to light, and I am greatly indebted to Dr. David White of the United States Geological survey for suggesting that this fossil be figured, because probably of scientific value paleobotanically. Instances of fossilized anatomical structures in the leaves of ferns are certainly very rare, in fact this is about the only case I can find or know of.

Fig. 10. Transverse section of part of one of the What Cheer nodules, showing a portion of a row of pyrite-colored XXX and dots, separated by or embedded in a blackish substance.

Fig. 11. The aspect of the specimen fig. 10 after grinding and polishing obliquely. The material was evidently vegetable. and the structures seem to suggest the palm or the cane.

Fig. 12. Fragment of mineralized cellular vegetable material (chiefly pyrite), showing pitted and punctate vessels of two or three kinds. From the coal bed at What Cheer, Iowa.

Fig. 13. Coniferous? wood-cells and medullary ray? material, composed of pyrite etc., in the coal of What Cheer, Iowa.

Note. The surfaces of these What Cheer pyritous nodules, while preserving a generally regular outline or contour, are in reality anything but smooth—they are decidedly rough; the pyrites mixed with the coal laminæ of the seam, and the coal on the other hand penetrates the pyrites.

And in regard to the well-preserved condition of the vegetable contents of these concretions. it would be very interesting to know, could the point be determined, whether this vegetable matter passed through the coaly state between that of the wood, leaves, seeds, etc., and the pyritous condition—to stone; or whether the wood, seeds, etc., passed direct into stone *pari passu* with the process which converted the vegetable matter that is now the coal into coal. And this thought leads to another, viz.: Are the same fossils in the coal as we find in the concretions? The ragged surfaces of the concretions and the aspect of the fossils where they terminate on these surfaces (sometimes they grade into coal) suggest an answer in the affirmative. But be this as it may, the phenomenon which these nodules reveal, of so much uncrushed or apparently loose-lying vegetable tissues and structures as they do, shows with what intricate subtle and complex processes and ways the conversion of the vegetable matter of the Carboniferous period into coal, and petrifactions in the coal, was in all probability attended.

Physically and stratigraphically it is interesting to find, as I have done, the following familiar forms either in or upon this particular bed of coal; which indicate accumulation of the vegetal material under marine rather than fresh water conditions: *Discina, Natica?, Pentamerus, Lingula, Terebratula, Pleurotomaria?* and *Orthoceras.*

ON THE PETROGRAPHY OF MOUNT ORFORD.

By John A. Dresser, Richmond, Quebec.

The Green mountains of Vermont enter the province of Quebec in several ranges which run in parallel courses and have a general northeasterly direction, varying in elevation from inconspicuous hills, or ridges, to mountains upwards of 3,000 feet in hight. One of these ranges, which is a continuation of that to which Jay peak belongs in Vermont, forms the Sutton mountains; another, appearing first at some distance on the east side of lake Memphramagog, becomes the Stoke range, and is a more noticeable feature of the landscape farther towards the northeast, where it has a greater elevation;

a third forms the line of hills along the international boundary line between the states of New Hampshire and Maine on the one hand and the "eastern townships" of the province of Quebec on the other.*

A little to the east of the Sutton ridge and parallel to it there is for some distance north of the Vermont boundary line a series of irregular hills, which have a quite different origin from the ranges on either side of them. While the latter have been produced chiefly by the crumpling and folding of sedimentary strata the former are of volcanic origin, being the remains of immense outputs of lava, now greatly altered in character and reduced in amount, which were ejected from a series of volcanoes or fissure eruptions, probably caused by the weakening of the sedimentary strata in the process of the folding which produced the Sutton mountains.

The largest of these igneous masses is that which comprises mount Oxford, the area of which is not less than twenty square miles. If its average hight above the surrounding country be estimated at 1,000 feet,§ the mountain at present represents four cubic miles of lava which have been extruded in this one mass, and it must also be remembered that a considerable portion of the mountain has doubtless been removed by denudation, for besides the action of subaerial agencies, it has also suffered from glaciation, even upon the summit.†

The densely wooded nature of the mountain as well as its precipitous sides in the only practicable direction of approach make the mountain difficult of access and render a detailed field examination at present impossible. Yet well known paths of ascent on the southern side give almost continuous exposures from the Canadian Pacific railway at the base to the summit, while, as has been pointed out by Dr. Ells,‡ a unique

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*Dr. R. W. Ells, *Rep. Geological Survey of Canada*, Vol. II, 1886, Part J. and map, and Vol. VII, 1894, Part J. and map.

§The Canadian Pacific Railway at Miletta Station is 905 feet above mean sea level. P. Alex. Peterson, Chief Engineer, C. P. Ry.

Dr. Ells (op. cit.) found the height of the summit to be 2800 feet above sea level by aneroid measurements which were subsequently corroborated by Mr. Chalmers. (*An. Rep. Geol. Survey of Canada*, Vol. X, Part J.

Messrs. Evans and Leroy (*Can. Rec. Sci.* pp. 225-7, July 1900) find the total elevation somewhat less, viz: 2650 feet.

†*Can. Rec. Sci.*, July 1900, pp. 223-5.

‡*Am. Rep. Geol. Survey of Canada*, 1894, Part J., pp. 59-62.

section is exposed by the cutting of the railway which skirts the base of the mountain between Miletta and Eastman, in a direction normal to the axis of folding as well as to the strike of the adjacent sedimentary rocks. On the whole, however, any observations that can yet be made on the larger petrographical relations of the mountain must still be regarded as of a preliminary nature.

The rocks of Orford mountain comprise two main divisions. The first, which is found on approaching the mountain from the eastern side, i. e., along the railway from Miletta station, and which is intrusive through Cambro-Silurian strata, constitutes much the greater part of the mountain and is an igneous rock of rather uniform character, probably the product of a single eruption

Its extent along the railway track is as nearly as possible a mile and a half and it forms the only rock traversed in the ascent of the mountain by the usual paths from "Orford crossing." The second division comprises several rocks of different varieties both igneous and sedimentary folded together in a comparatively narrow band running along the western base of the mountain. It is about one-third of a mile in width on the railway, and so far as known does not appear in the more elevated portions of the mountain at all. The actual contact between these two divisions of the mountain has not yet been found.

The rock of the first, or greater, mass has a uniformly green coler, showing gray grains on a freshly broken surface. Quartz veins are very abund nt in it and joint planes and seams are often studded with small quartz crytals. Yellowish-green patches, some times as much as a foot in diameter, are numerous. They are harder than the normal rock and stand out in relief on the weathered surface, owing to the more resistant material of which they are composed; of which the mineral epidote appears to be a prominent constituent. The texture of the rock becomes much finer towards the outer edge. and also towards the top of the mountain, where the cooling of the igneous mass would have taken place more rapidly and under less pressure.

In thin sections examined by the aid of a microscope, the rock is found to have had its original characters much obscured by the excessive alteration of its component minerals, the primary constituents that remain being comparatively rare. In specimens from the summit the following minerals were distinguished: plagioclase feldspar, generally quite turbid from decomposition, though retaining its crystal outlines and occasionally plainly showing the distinctive multiple twinning; aggregates of chlorite, epidote and a light green or colorless hornblende (?) which are taken to represent primary pyroxene; an abundance of leucoxene, indicative of the existence of primary iron ore and indicating its titaniferous character; quartz, which is also apparently of secondary origin.

The arrangement of the feldspars in reference to aggregates of pyroxenic decomposition products, and to one another, is that characteristic of the structure of diabase, to which the composition indicated above also allies the rock. It is therefore an altered diabase closely resembling that known to occur at Owl's Head,* sixteen miles to the southward.

But it has been said that the rock is coarser in the central portions, while other variations also appear in it on more detailed examination. In these coarser parts such as are seen for the first one-third or half of the way up the mountain on the south side, the original structure was more granular than that of a diabase. The mineral olivine also appears, either enclosed in or associated with larger masses of fibrous hornblende, while the other mineral constituents are essentially the same as in the preceding specimens. While a rock of this composition and structure would be a dioryte, yet as the hornblende, from its fibrous character, irregular outlines and the probable presence of a little pyroxene in one slide, is likely in a large measure uralitic, it would have been originally a gabbro. It is accordingly best classed as a gabbro-dioryte, in the sense in which the term was used by Prof. G. H. Williams† in connection with an apparently similar phase of the Baltimore gabbros to indicate not only the composition and structure of the rock, but also its origin.

*"Notes on the Microscopic Structure of Some Rocks of the Quebec Group," by Dr. F. D. Adams, *Rep. Geol. Survey of Canada*, 1880-1-2-3, p. 13 A.

†*Bulletin, U. S. Geol. Survey*, No. 28, p. 17, et aliter. The term is similarly used by F. D. Chester, "Gabbro and Associated Rocks of Delaware," *Bulletin U. S. Geol. Sur.* No. 58, pp. 15-19.

This rock cannot be sharply separated from the diabase just described, but passes into it gradually, many intermediate types being found. The two rocks are thus apparently differentiation products of a single magma and any line of separation between them could only be arbitrarily drawn.

The rocks of the smaller division on the western side of the mountain consist, as has been said, of a succession of sedimentary and altered igneous rocks. The following horizontal section obtained by approximate measurements along the railway between Miletta and Eastman, will help to show the relative position and extent of the two main divisions as well as of the subdivisions of the smaller part. The direction of the section is almost due west from Miletta.

Sedimentary strata at contact with diabase near Miletta...

I.	Diabase and gabbro-dioryte, main part of mountain,		7837 feet.
II.	Graywacke,	165 feet.	
	Serpentine, ophicalcyte etc.,	577 "	
	Sandstone,	82 "	
	Serpentine, ophicalcyte etc.,	1567 "	2391 feet.

Sedimentary slates.

The greywacke is a greenish gray rock containing discernible grains, some of which show vitreous lustre, while others do not. In the thin section the latter are found to be feldspar and the former quartz, while the greenish color is due to a micaceous-chloritic cement in which the grains are embedded. It is a clastic rock and a fairly representative specimen of a graywacke, belonging to the chloritic slates of Logan,* which is closely associated with the serpentines in many parts of the eastern townships, now recognized as Cambrian† in age. It agrees in all essential respects with specimens from Potton and Shipton, which have been fully described by Dr. F. D. Adams.‡

The sandstone which occurs in this belt is of a light buff color and consists of grains of feldspar and quartz of uniform size and often angular or subangular in form, which are cemented together by secondary silica, which, though not in large amount, occasionally shows very good examples of the

*Geology of Canada, 1863, p. 245.

†Map to accompany Part J, Vol. VII, *An. Rep. Geol. Survey of Canada*, Ells.

‡Op. cit. pp. 19-22.

enlargement of grains in crystallographic forms. The original grans being comparatively fresh in appearance and without any coating or iron the clastic nature of the rock is not easy to discern in all parts, especially as it is very compact, and hence the secondary silica is in relatively small amounts. Small fragments of a colorless mica are to be seen also, which are unlike any of the micas found in the accompanying igneous rocks. On the whole it is a rock that differs from the greywacke in conditions of deposition rather than in the character of the original fragmental material, and is probably only a phase of it.§

The serpentine is at this place darker in color than is usual in the eastern townships, presumably from the greater amounts of chromic iron which it contains. In the thin sections that have been examined, the alteration of the primary minerals has been so nearly complete that the entire field except for grains of iron ore, consists either of dull polarizing serpentine or of the allied secondary form, probably bastite, which has a fibrous structure with the extinction parallel to the fibres, and polarizes in rather brilliant colors. It agrees in all essential respects with the serpentine of Melbourne, which has been described by Dr. F. D. Adams,* and of which mass it is practically a continuous part.

Associated with the serpentnes are ophicalcytes and talc schists into which they appear to pass by rather sharp transitions.

The ophicalcytes are mottled, light and dark green rock and are often quite schistose. In the thin section as well as in the hand specimen, the only essential constitutens are seen to be serpentine and calcite. The former in some places is in parallel bands separated by calcite, in others it forms an irregular network having the interstices filled with calcite. or it occupies irregular areas in a groundwork of calcite. The calcite is well crystallized and is free from specks of graphite or other dark colored inclusions. But it is often penetrated by small strings or needles or a feebly polarizing mineral also thought to be serpentine. The boundaries be-

§Logan, loc. cit.
*Op. cit. p. 19A..

tween the two minerals are very irregular. A few grains of chromic (?) iron form the only other constituent of the rock.

The talc schists of slate are soft, greenish gray in color, and have the distinctive tlose or greasy feel. They are often finely laminated with a distinct cleaverage. In ordinary light the thin section appears colorless except for the presence of small grans of iron or leucoxene, which are somewhat evenly distributed throughout the field. Between crossed nicols the colorless mineral polarizes faintly in tints of gray. No crystal outlines are surely distinguishable in it.

An earlier origin is assumed for the western than for the much larger eastern division of Orford mountain from a consideration of the following facts, most of which have been already stated.

The serpentine and other metamorphic rocks are in a more advanced stage of alteration than the diabase, and are intricately associated with sedimentary rocks of Cambrian age and may be even older than these. The diabase and gabbro-dioryte mass, which, as has been said, forms the higher and greater portion of the mountain, contains little, if any, serpentine and clearly cuts strata recently determined on fossil evidence* to be of Cambro-Silurian age. Also, the serpentines, which with their associates occur very frequently along the southeastern side of the Sutton mountain anticlinal similarly associated with clastic rocks, without the presence of diabase at all, are here in a few instances cut by dykes, while no dykes have been found in the diabase. These dykes are too far altered to make it possible to determin their precise original characters. In the case of three near Orford pond the minerals augite, or secondary hornblende, are prominent constituents along with larger amounts of epidote, commonly in the form of zoisite, and in one case with a little quartz. They are not very different from the extremely fine, "aphanitic," form of the diabase as seen near its contact with the slates about Miletta and hence very probably belong to that mass.

*Dr. R. W. Ells, *An. Rep. Geol. Survey of Canada*, Part J., p. 38; Dr. H. M. Ami, "Preliminary Lists of Organic Remains," Appendix to the above, Part J., p. 133. Dr. Ells also points out that Serpentine rarely if ever occurs in masses intrusive through strata of Cambro-Silurian age, op. cit. p. 80.

Accordingly, from the evidence thus far available the geological history of mount Orford would be briefly told thus:

1. The parent rock of the serpentine was either intruded in extensive sheets amongst the old stratified rocks, or was extruded as a surface flow and these subsequently deposited upon them.

2. These rocks then became very intricately folded together, and were much worn down by long denudation.

3. An eruption of diabasic material took place along the eastern edge of the serpentine, which gave rise to the present mass of the mountain as well as to whatever part of it has been since removed by denudation. It is probably to this period, too, that the extrusion of the mountains along lake Memphramagog, Owl's Head, Elephantis, Hog's Back, belong, in which "serpentine very rarely, if ever, occurs.*

ON SOME NEWLY DISCOVERED AREAS OF NEPHELINE SYENYTE IN CENTAL CANADA.

By Willet G. Miller, Kingston, Ontario, Canada.

In a recent paper Dr. F. D. Adams refers to the probable occurrence of a large area of nepheline-bearing rocks on the northeast coast of lake Superior, western Ontario.† During the summers of 1897 and 1898 the writer was engaged in tracing out some belts of these rocks in eastern Ontario and showed that they cover a large area in this part of the province.‡ Prior to 1897 nepheline syenyte was known to occur in only one outcrop in the province.§ Late in 1896, however, corundum was found in this part of the province and as the deposit of this mineral appeared to be of economic value, the writer was engaged to make an examination of it and to search for other deposits in the district.

On examining the rocks in which the corundum occurred, it was found that they were generally either nepheline syenyte or of some other variety of syenyte. Outcrops of these rocks were traced along one belt about seventy-five miles in length and along two other belts of less length. In some parts of

*Dr. R. W. Ells, op. cit. p. 80 J.
†Journal of Geology, May-June, 1900.
‡Reports, Bureau of Mines, Toronto, 1897-8.
§Am. Jr. Science, July, 1894.

these belts the rock in which the corundum occurred was found to be not the alkali-bearing varieties, the various syenytes, but the alkaline-earth rocks, anorthosytes.¶

From the character of these belts, at their extremities, it was believed that they could be traced still farther in an east and west direction.

Late in the autumn of 1899 the writer, while spending a few hours in the vicinity of the city of Hull, Quebec, discovered a well-rounded boulder containing grains of nepheline, which confirmed his belief that the belt of these rocks continued eastward from the province of Ontario across the Ottawa river into the adjoining province, and early in the present year he discovered nepheline syenyte in place about twenty miles east of the Ottawa river.

The rock found here was composed essentially of a white feldspar and nepheline in grains, some of which had a diameter of two inches, together with a little black mica. The rock is similar in character to much of that found in the corundum belt of eastern Ontario. Time did not permit of an attempt being made to trace out a belt of these rocks to the east of the Ottawa river, but from what was seen of the outcrops and from his knowledge of the field relations of these rocks in Ontario, the writer believes a belt of considerable length exists in this part of Quebec.

A thin section was made of a fragment of the Hull bounlder. Under the microscope the rock is seen to be composed of orthoclase, microperthite acidic plagioclase and nepheline, together with considerable dark grown mica. The section also showed several grains of calcite with somewhat rounded outlines. This occurrence of calcite in the section is an interesting feature of the rock, as it was also found to be present in the first specimens of the rock examined in Ontario by Dr. F. D. Adams, and has since been found in specimens of the rock from a number of other localities in the province. The fact has been referred to that this carbonate has the appearance of being an original constituent.*

There are several somewhat puzzling features in connection with this whole series of nepheline-bearing rocks. Among

¶Am. Geol., November 1899, with map.
*Am. Jr. Science, July, 1894, p. 14.

these are the great variation in size of grain and mineralogical composition in parts of the same masses, the presence of grains of calcite and scapolite, both of which have the appearance of being original constituents, and the occurrence in some of the masses of crystals of apatite some inches in length. It will be seen that in these features these rocks resemble to some extent certain of the Canadian apatite deposits. In these deposits water, in a highly heated state, has been considered to be the chief agent concerned in the deposition. It would seem then that water may have played a more inportant part in the deposition of the nepheline-bearing series than in the case of other so-called igneous rocks.

A short time ago the writer made a hurried trip into another part of Quebec about 140 miles to the northwest of the locality to which reference has just been made, and was somewhat surprised to find an outcrop of nepheline syenyte and related rocks there. This outcrop is situated on the Kippewa river about twenty miles to the northeast of the southern end of lake Temiscaming, which forms the head waters of the Ottawa river. The breadth of this outcrop, so far as exposed above the surface of the water and drift material, is about 400 yards. The rock in the outcrop shows a well-developed schistose structure and a considerable variety of mineralogical composition, in a direction at right angles to the strike, as do many of the outcrops in Ontario. Much of the material has the composition of mica or hornblende syenyte, while some of it is more basic, holding a high percentage of hornblende. A not inconsiderable portion of the rock has the composition of nepheline syenyte. The nepheline is in grains of different size up to pieces three inches in diameter. Some of the hornblende associated with the nepheline and feldspar is in the form of masses whose diameter is four inches.

It was observed, in tracing out the nepheline rocks in Ontario, that they were nearly always associated with crystalline limestone. No attempt was made, however, to explain this association.

The first outcrop found in Quebec during the past season is also associated with crystalline limestone.

In the district lying immediately to the west and southwest of the Kippewa outcrop which has been geologically surveyed by Dr. A. E. Barlow and which embraces a territory of over 4000 square miles, three quarters of which is Laurentian, crystalline limestone was found in only a few small areas.* Since this rock was of so rare occurrence in the district which has been mapped, it was not expected that it would be found in abundance just outside this area. On discovering the outcrop of nepheline rock, however, the writer stated to those accompanying him that it was very likely they would find crystalline limestone not far off. On proceeding up the river a short distance, the limestone was found in place.

From the discovery of outcrops of nepheline syenyte over such an extensive territory in Ontario and Quebec, it would appear that no Laurentian area of any great size in central Canada, which contains much crystalline limestone or in other words which belongs to the Grenville series, is without the presence of nepheline syenyte and related rocks. This is of economic importance, in addition to any scientific interest it may have, as very promising deposits of corundum have been found at different points, in certain facies of these rocks, some of which are now being worked on a comparatively large scale.

The reason why these rocks have not been discovered in many places in this part of Canada in earlier years are no doubt the non-familiarity of many observers with the appearance of nepheline in the field, owing to its comparative rareness in most countries, and its resemblance under some conditions to other light colored minerals. Two instances can be cited in which rocks containing nepheline were examined megascopically years ago and in which the mineral wsa mistaken for quartz. One of these is the case of the syenyte of Montreal mountain, in which it is said the nepheline was mistaken for quartz for years. The other is the case of centain outcrops along the York (Shawashkong) river in Hastings county, which were examined in 1853 by the late Alex. Murray, and described by him in his reports as "hornblende rock" and mica slates."† These outcrops while they are more or less schistose in character, still contain the nepheline in distinct grains, some of which are of considerable size.

*Report Geol. Surv. Can. I, p. 89, 1897.
†Geol. Surv. Can. 1843-6, Map No. 17.

Boulders of nepheline rocks were found many years ago in the region north of lake Superior.* Dr. A. C. Lawson discovered rocks containing the mineral in the Rainy River district, towards the western boundary of the province, some 800 miles west of the eastern outcrops.† It would thus seem that no really large area of the Archæan in this part of Canada is without the presence of the nepheline-bearing series. These outcrops whether they be considered of Laurentian or Huronian age, may be all looked on as having come originally from the same magma. Many of the districts, however, in which these high alkali-holding rocks occur cannot be said to be characterized by the presence of these alone. Large areas of rocks holding a high percentage of alkaline earth metals are of just as common occurrence. This is especially true of those areas in the extreme eastern and western parts of Ontario and the western part of Quebec. At localities on either side of the boundary between these two provinces, anorthosytes, including among others the well known Morin area, occur in large masses, and from the fact that corundum occurs in some of these as well as in the nepheline-holding rocks, there seems to be little doubt that these rocks whose bases, in addition to alumina, are essentially the alkalis, sodium and potassium, and those whose basic constituent in place of the alkalis is chiefly calcium, are the products of one magma.

PENEPLAINS OF THE OZARK HIGHLAND.

By Oscar H. Hershey, Bragdon, Calif.

The Ozark highland comprises all of the mountain country of Arkansas, the eastern portion of Indian Territory, and most of the hill-country of Missouri south of the Missouri river. On the north and west it is bounded by the long eastward slope of the "great plains" and the Upper Mississippi region; on the east by the Illinois depression and the Mississippi embayment country, and on the south the sloping plains of Cretaceous and Tertiary strata stretch from its borders to the gulf of Mexico. It is separated into two somewhat distinct uplifts, by the long, narrow Arkansas basin, which is a

*Geol. Can. 1863, p. 480, and Reports for 1846-7.

†*Bull. Univ. Cal.*, 1896.

structural and physiographic as well as a topographic depression.

South of the Arkansas valley, the country is characterized by the long, narrow east-west ranges of the Ouachita mountains, surmounting a dome-shaped "uplift" or elevated area of the deformed Tertiary peneplain. These ridges are truly mountains, and bear a marked resemblance, both in stratigraphy and structure, to portions of the Appalachian mountain system. They correspond to the Blue mountains and similar ridges in Pennslyvania, east of the main Alleghany range.

The synclinal trough of the Arkansas valley has no representative in the Appalachian region, but topographically the valley of east Tennessee is its counterpart. The former separates the true mountain portion of the Ozark highland from the northern or plateau division. This latter is what is commonly known as the "Ozark uplift," and many would restrict the name Ozark to it. The plateau is a great dome-shaped, elevated tract of the deformed Tertiary peneplain which attains a maximum altitude of about 1,750 feet A. T. in northwestern Arkansas near Fayetteville, and slopes thence gently to the north and east, and more steeply toward the west and south. It is surmounted, along a line 20 to 30 miles north of the Arkansas river, by an east-west range of mountains commonly referred to collectively as the Boston mountain. This corresponds to the Cumberland and main Alleghany ridges of the Appalachians, and the broad plateau north of it is the counterpart of the Alleghany plateau.

This close resemblance of the physicial features of the Ozark highland and the Appalachian mountain region has frequently been commented on. It is also known that the history of the physiographic development of the two areas has been essentially alike in character, as all orographic and epeirogenic disturbances of the one have affected the other also. However, the geomorphology of the Ozark province is not so well known as that of the Appalachians, and a generalization of its physiographic features may be of interest, if not also instructive, to students of American geology.

The Cretaceous peneplain.—This, as Mr. L. S. Griswold has identified it, emerges from beneath the Cretaceous strata in extreme southwestern Arkansas and southeastern Indian Territory, and rises at quite a perceptible rate toward the north. The plain-like character is soon lost, and the peneplain is represented by long, narrow ridges whose remarkably even crests constitute the remnants of the ancient plain of denudation. Still farther north, in Polk and neighboring counties of Arkansas, and the adjacent portion of Indian Territory, the ridges with even crest-line have disappeared, but the peneplain seems represented in a general way, by the long east-west mountains rising 1,200 to 1,500 feet above the general level of the country, and separated by basins five to twenty miles wide. Of these ridges, some of the most prominent are the Push, Rich, Poteau, Cavanal, Sugar Loaf and the Magazine mountains. There are many low passes through them, and they show a tendency to isolation more than the Appalachian ridges. Indeed, several stand alone, in monadnock-like masses, on the Tertiary peneplain. Only in a few instances are their summits clearly truncated by a plane of erosion base-level. Several of the highest have flats of sufficient extent to afford room for farms on the mountain-tops, notably the Rich and the Magazine mountains. However, there is such a general similarity in hight between contiguous portions of the mountain system (and neighboring peaks) as to leave little doubt that the Cretaceous peneplain is approximtely represented by the summits of the Ouachita mountains at an average elevation between 2,000 and 2,500 feet, reaching a maximum of about 2,750 feet on Rich mountain on the line between Arkansas and Indian Territory, and sloping thence very gently to the west and north, and more steeply to the east and south.

Between Cavanal, Sugar Loaf and the Magazine mountains on the south of the Arkansas valley, and the Boston mountains on the north of that broad basin, the Cretaceous peneplain has been completely destroyed over a width of probably fifty miles, and extending east and west completely across the Ozark highland. But it is undoubtedly again represented in the Boston mountain at an everage elevation of 2,000 feet, reaching a maximum of 2,257 feet near Winslow on the S. L. & S. F. R. R. Unlike the narrow ridges south of the Arkansas river, the Boston mountain is a dissected plateau, ten to fifteen miles wide, trending east to west, bowed slightly along a central line, but otherwise remarkably even in surface. The erosion of valleys 500 to 1,000 feet in depth has pretty thoroughly cut up this plateau into flat-topped ridges, although there are undissected tracts of 300 or 400 acres as level as any plain. The origin of these flats is difficult of explanation except on the theory that they are remnants of an ancient baselevel of erosion, a peneplain. Nearly all the ridges reach this peneplain level.

The Boston mountain is monadnocked upon the Tertiary peneplain to the extent of about 500 feet vertical. Hence, the dissected peneplain to its summit is an oldr one. From the general correspondence in hight between the Ouachita mountains and the Boston mountain, it appears evident that the same peneplain may be represented in both. Hence, I feel safe in identifying the Cretaceous peneplain north of the Arkansas river, at a maximum altitude of about 2,250 feet near Winslow and 500 feet above the main Tertiary peneplain.

Northward from the Boston mountain, the Cretaceous peneplain is represented by isolated outliers of the main plateau—flat-topped peaks, sometimes elongated into ridges—in other words, by a series of monadnocks standing on the Tertiary peneplain. These are mainly of Coal Measure shales and sandstones and some might consider them as due to structural rather than physiographic conditions. However, I am confident that many of them (especially those whose summits are truncated) are remnants of the Cretaceous peneplain, so well represented on the Boston mountain. This gradually descends toward the north and approaches the main Tertiary peneplain; near Hindsville, in Madison county, Ark., there is an interval of only a few hundred feet between them, and near Eureka Springs, several monadnocks forming small groups widely separated from each other and far distant from the main system near Boston mountain, seem to indicate that here the Cretaceous peneplain has descended to within 100 feet of the lower baselevel.

Over the Ozark plateau region of southern Missouri, it is doubtful if any hill can be positively identified as a remnant of the Cretaceous peneplain. There are a few low monadnocks in Stone and Barry counties, which seem to belong to the same system as those of north Arkansas. One in particular near Scholten, in the latter county, is a narrow, flat-topped ridge rising about fifty feet above the surrounding plain. Coal Measure sandstone and Burlington limestone are so combined in its structure as to make its truncated summit difficult of explanation under any other than baseleveling conditions. I am inclined to believe this is a remnant of the Cretaceous peneplain, here only fifty feet above the Tertiary. Northward from here, along the so-called "crest" of the Ozarks they may be completely merged into one.

The main Tertiary peneplain.—Between the narrow Ouachita mountain ridges of south-central and southwestern Arkansas, there are broad basins which, like the inter-montane valleys of Pennsylvania, represent the Tertiary peneplain. In the vicinity of Mena, in Polk Co., Ark., the surface is gently undulating, the streams not having cut much below the originally very flat peneplain. It is here elevated about 1,300 feet above sea-level, but slopes gently in all directions, particularly toward the east and south. Southward from Mena, there are tracts of many square miles, where the surface is a remarkably level plain. But if we go northward from Mena, toward the Arkansas river at Fort Smith, after passing Rich mountain through Eaglegap, we find the floors of the inter-montane basins quite thorougly dissected by narrow valleys separating still narrower ridges. These ridges are long and straight, remarkable for their even crests, and for their equal hights. In other words, the summit-plane of these ridges forms as perfect a dissected peneplain as can anywhere be found on the American continent. This imaginary plain is absolutely indifferent to the stratigraphy and structure. That it represents a base-level of erosion common to the entire Ouachita region is demonstrated by the fact that its slope in each basin is uniform in direction and degree with that of contiguous basins; that is, were the Ouachita mountains removed, and the valleys filled to the level of the long, even-crested ridges of the basins, the whole country would be perfectly even plain, rising toward a central point near Mena to form a dome-shaped elevation of the land—the Ouachita uplift. This is the main Tertiary peneplain of southern Arkansas and Indian Territory. On it stand the Ouachita peaks and ridges like monadnocks and catoctins, and beneath its plane are trenched narrow basins and canyon valleys of systems to be described later.

This Tertiary peneplain emerges from among the mountains to form the very even plain of the Arkansas valley where for a width of fifty miles or more it is not interrupted by any monadnocks. Standing on a slight elevation and looking across the Arkansas valley, the surface appears to be a remarkably even plain, sloping very gently from the prominent mountains on the south toward the Arkansas river, quite perceptibly eastward or down the valley in Indian Territory west of Fort Smith, and very decidedly from the Boston mountain to the river. In short, the deformation of the plain can be very clearly seen from any point of vantage. Along the axis of the trough flows the Arkansas river and in its vicinity at Fort Smith and Van Buren the Tertiary peneplain has no greater altitude than 600 feet above the sea.

I have said the Arkansas valley appears like a very even plain, but in reality it is not. The original plain has been pretty thoroughly dissected, and remains only in narrow ridges. South of the river, there are the long, straight, even-crested east-west ridges as in the inter-montane basins. Many of these ridges are 200 to 300 feet in hight and are locally known as mountains. In places they are separated by considerable basins, and the streams cut through them in narrow gorges like the water-gaps of Pennsylvania. Indeed, the topography is that of the eastern Pennsylvania and northern New Jersey mountain country on a smaller scale.

North of the Arkansas river, the ridges which form the dissected Tertiary peneplain are less regular in crest-line and trend prevailingly in a north-south direction. Now an extremely curious feature of Ozark highland structure comes to light. Generally the slopes of the peneplains in the Ozark region are at a very low angle. But here on the southern slope of the Boston mountain the Tertiary peneplain descends steeply from an altitude of about 1,700 feet A. T. near Winslow to 600 feet A. T. near Van Buren, a distance in an air-line of little more than twenty miles. This gives the peneplain's remnant-ridges on the north of the Arkansas river a very decided slope lengthwise or along their axes. In fact, they soon rise up to form the foot-hills of the Boston mountain, and just where the dissected peneplain leaves off and the mountain spurs begin to be monadnocked on it, is not everywhere easy of determination.

Within the Boston mountain the Tertiary base-level is hardly recognizable. The valleys on the southern slope are cut through the interval between the Cretaceous and Tertiary base-levels and far below the latter. Those north of the divide are not so deep and hardly reach the level of the Tertiary peneplain. But in emerging from the mountain on the north, the newer peneplain is soon encountered, in one of its most typical and unmodified forms, at an average altitude of about 1,700 feet A. T. Standing on a spur of the Boston mountain, one may look northward for many miles over a country distinctly lower and apparently a regular plain upon which rise the outliers of the Coal Measure strata. The plain is pretty thoroughly dissected by narrow basins and still narrower canyon valleys. In places there are long, narrow, even crested ridges as in south Arkansas, but usually the drainage systems are of a perfect dendritic type, and the ridges branch and re-branch like the limbs of a tree. Near the White river, the whole country is cut up into a complex of very narrow ridges and gorge-like, V-shaped valleys, some of which are so deep that the intervening remnants of the strata are called mountains; notably the Eureka mountains in Arkansas, and the Carney mountains in Missouri. The same topography prevails along the Osage river and, indeed, belts of such extremely rough country follow all the main streams in the Ozark plateau region.

That the general upland surface from the northern base of the Boston mountain to the Missouri river represents one and the same dissected peneplain needs no elaborate demonstration. Where the plateau is trenched by deep valleys and even such broad basins as that along the White river in Missouri, the "mountains" on either hand correspond in hight. The most broken portion of the Ozark plateau, when looked at from a distance, appears like a plain of remarkable evenness. Along the main divides, such as that followed by the S. L. & S. F. R. R. from Lebanon to the Boston mountain, erosion has not been active, and the streams have not cut deep valleys into the surface. Here the plain-like character of the country in the Tertiary era has not been destroyed. The land is generally rolling, and the "crest" gently ascends and descends, but it is evident that it is the same plain which is being followed from end to end.

This Tertiary peneplain descends very slowly from its maximum of about 1,700 feet in northwestern Arkansas, to about 1,500 feet on the Pea ridge, where it is crossed by the Missouri line, and thence to 1,300 feet near Springfield and Lebanon. A local uplift of no great extent seems to elevate it to about 1.700 feet at Cedar gap in Missouri. The White River valley in Missouri occupies a kind of depression in the surface of the peneplain. The same Tertiary base-level is represented by the main ridges of the undulating plain about Joplin in extreme southwest Missouri, at about 1,000 feet A. T. It is the same peneplain which forms the general upland surface of eastern Kansas. Thence southward through Indian Territory it may be traced around the Boston mountain to the Tertiary peneplain in the Arkansas valley, thus escaping the complication of the curious monocline on the southern slope of the Boston range.

North of the so-called "crest" of the Ozarks in southern Missonri, the peneplain continues to descend gradually, and has no greater elevation than about 900 feet at Boonville and Jefferson City on the Missouri river. The highest hills in the vicinity of both towns represent it. It is much dissected all along the Missouri river, but there are enough remnants left to demonstrate that it is present on both sides of the comparatively narrow valley.

The Lafayette base-level.—In that portion of the Ozark highland which is south of the Arkansas river, a large part of the surface has been reduced by erosion below the main Tertiary peneplain to a later and relatively lower base-level. This Pliocene or late Tertiary cycle of erosion resulted in the formation of broad, shallow basin valleys whose floors were once quite flat, being composed of the broad alluvial plains of the streams of that period. They are now dissected by the canyon valleys of later age, and may easily escape detection except upon close observation. In approaching the Arkansas river, these basin valleys become quite pronounced, spreading out into undulating plains three to five or more miles in width, and separated by the ridges which constitute the remnants of the main Tertiary peneplain. One of these small peneplains, extending westward from Fort Smith, is of particular interest. for its surface is sheeted with the gravelly alluvium of the Lafayette formation. This fixes the age of the completion of the basin valleys as Lafayette, and the plane of their floor throughout the Ozark region may be designated the Lafayette base-level. In the vicinity of Fort Smith it is about 100 feet lower than the main Tertiary peneplain, and over all of south-central Arkansas and east-central Indian Territory it maintains a level 75 to 100 feet below the earlier base-level.

Between the Arkansas river and the Boston mountain, there are, among the hills, certain depressed areas which seem to represent the Lafayette base-level at a level about seventy-five feet below the main Tertiary peneplain as the latter is fixed by the general upland surface. In this region the physiographic features are obscured because of the abnormal southward slope of the country which has especially favored post-Lafayette erosion. But in northern Arkansas, on the Ozark plateau, we find the basin valleys well defined. All the principal streams flow in valleys which are duplex in character, being composed of a broad upper trough, beneath the floor of which is trenched a narrow canyon valley. Along that portion of the White river which passes through Missouri there is a basin three to five miles in width, trenched through the Lower Carboniferous cherty limestones and well down into the dolomytes of the Ozark series. Its floor is everywhere dissected by the canyon valleys of Ozarkian age. but the main hill-tops seem to represent a base-level of erosion at a level between 200 and 300 feet beneath the main Tertiary peneplain. Passing up the tributary valleys, this base-level is represented by persistent rock-terraces along the valley sides, some of which spread out into benches of sufficient width to be occupied by farms. They are especially noticeable on the War Eagle fork of White river in Arkansas, and the James river and its tributaries in Missouri. In this region, the rock-terrace always occurs at about the same level relative to the main Tertiary peneplain, namely, nearly 300 feet below it.

In the extremely broken and even truly mountainous country of the King's river hydrographic basin in Arkansas, one may stand on one of the ridges of the Eureka mountains and look far to the eastward across a vast complex of hills. Three base-lèvels are distinctly noticeable. The summits of many of the ridges form the dissected floors of basin valleys often several miles in width, and which occupy three-fourths of the entire surface. This is the Lafayette base-level. Several hundred feet higher, the main upland ridges represent the Tertiary peneplain. Looking across their summits the very hilly country in the far distance apparently merges into a plain. The sky-line is even with the exception that a few monadnocks rise above the peneplain. Some of them are cone-shaped, but several are elongated into ridges whose crests are even and summits flat, suggesting the Cretaceous base-level. In all the Ozark region, this is one of the most instructive to the student of physiography.

The existence of the basin valleys, rock-terraces, and depressed areas among the hills of the entire Ozark highland country is a fact which may be verified by anyone who doubts it. It is also a fact that they have their level irrespective of the rocky structure, and that the frequent concurrence of the floor of the basins with the top of centain formations is merely fortuitous. These basin-floors and rock-terraces often bevel the edges of the strata, and they may be observed to pass from one formation to another without deformation. Hence, there is every reason to consider them to represent a base-level of erosion distinct from and considèrably later than the main Tertiary peneplain. In many places from the Arkansas to the Missouri river, this base-level is the site of remnants of an ancient river alluvium containing a peculiar brown gravel which is known to be of Lafayette age. The presence of this river-gravel is corroborative of the Lafayette age of the base-level as drawn from purely geomomphologic evidence.

The vicinity of the White river appears to be the region in which there is the greatest interval between the main Tertiary and the Lafayette base-levels, here reaching a probable maximum of 300 feet northward from the "crest of the Ozarks;" in the Osage basin and along the Missouri river, the difference in level is only about seventy-five feet. In this region the duplex character of the valleys is not so prominent, but is still noticeable. Near Bunceton, in Cooper county, Lafayette remnants occur about two-thirds of the distance from the valley bottoms to the hill-tops. At this level there are frequently distinguishable "shoulders" or benches on the hill-slopes, and sometimes there occur in the valleys ridges whose truncated summits lie no higher than the Lafayette base-level. When one's attention is once called to it, it is not difficult to recognize the "trough within a trough" character of these valleys.

In approaching the Osage river, the country becomes extremely broken. The remnants of the Tertiary peneplain become isolated into widely separated elongated ridges and small flat-topped peaks, none of which approach very closely to the river. The steep, rocky ridges which bound the narrow and very crooked canyon valley represent, in a very imperfect manner, the Lafayette base-level, here also about seventy-five feet below the main Tertiary or "Tennesseean" base-level. That the tops of these "river-hills" actually represent a plane of stream erosion is indicated by a curious depressed area or valley among the hills about four and one-half miles north of Lime creek. Here the canyon valley of the Osage makes a great bend to the southward and encloses a peninsula-shaped tract of upland. A considerable portion of one of the higher ridges (a remnant of the Tertiary peneplain) is cut off by a distinct valley or depression in the hills, having a width of about one mile, a depth of seventy-five feet, and steep slopes like an ordinary river valley, but whose bottom is dissected by transverse ravines just as all the remainder of the upland is. This abandoned valley connects the basin valley above the great bend with that portion below it, and during the Lafayette period undoubtedly was occupied by the Osage river. This valley, the hill-tops along the Osage, and the remnants of Lafayette stream-gravels in Cooper county, unite in fixing the Lafayette base-level of erosion in central Missouri at a level only seventy-five feet below the main Tertiary peneplain, and all that portion of the valleys of greater depth than this is essentially Ozarkian in age.

In southwestern Missouri, in Jasper and neighboring counties, the declivity of the streams is not great, and the valleys are broad and without the canyon form except very locally The Lafayette base-level would be difficult to detect here, were it not that a few remnants of the Lafayette stream-gravels have been found, notably near Duneweg, about six miles due east of Joplin. They indicate that to Pliocene erosion may be charged the upper one-third of the valleys, thus placing the Lafayette base-level at fifty to seventy-five feet beneath the main Tertiary peneplain so well represented by the general upland surface. There are rock-terraces along Shoal creek, south of Joplin, but they seem of later age than the Lafayette. A somewhat similar rock-terrace along the Spring river in Cherokee county, Kansas, is doubtfully referred to the same category as the terraces of James river and Flat creek in Stone and Barry counties, Missouri, known to be of Layfayette age.

In short, that after the completion of the main Tertiary (presumably Tennesseean) peneplain, there ensued another (and vastly shorter) cycle of Tertiary erosion, resulting in the formation of a type of valleys which have been designated "basin valleys," because they are broad and shallow and have gently sloping sides, of supposably Lafayette age in their completion, may be gathered from evidence scattered all over the Ozark highland region. This implies, beyond doubt, an elevation of the province in general of an epeirogenic character, but also to a slight extent orographic, as is indicated by the 250 to 300-foot depth of erosion in the White River basin, in place of the normal seventy-five to one hundred feet of nearly the whole remaining portion of the Ozark region. It is this differential character of the uplift which strengthens the evidence.

Before closing this subject, I desire to remark that the same or a like system of basin valleys trenched beneath the main Tertiary peneplain is a recognized feature of the geomorphology of northwestern Illinois and contiguous areas, and are known to me to exist in the inter-montane valleys of Pennsylvania and New Jersey. May they not be recognized in the southern Appalachian province, whose physiographic history is otherwise so nearly like that of the Ozark province?

The Ozarkian valleys.—The narrow, crooked valleys trenched beneath the Lafayette base-level include the erosion of the Glacial and post-Glacial subdivisions of the Quaternary era, but the major portion of their excavation seems to have been accomplished during that long, early epoch of the Pleistocene period marked by an abnormal elevation of perhaps the whole of the North American continent, and which has come to be known as the Ozarkian epoch or sub-period; hence, for convenience in discussion, I shall refer to the lower troughs of the Ozark highland as the Ozarkian valleys. The canyon-like form is a characteristic of them which seems to be persistent throughout the Mississippi basin, particularly on the limestone areas. It reaches its most typical development in south-central Missouri, along such streams as the Osage and Gasconade rivers and their tributaries. The canyon valleys of this region have been so often described that I will merely mention the facts that they are steep-sided troughs winding about in the bottoms of the basin valleys, have frequently a mural precipice on one side and a steep slope, strewn with river-gravel, on the other, and are rarely more than several times as wide as the streams flowing into them. The canyon valley of the lower Osage averages one-half mile in width and about 150 feet in depth. Nowhere else in the Ozark highland are the Ozarkian valleys of much greater depth than the Pliocene basin valleys. Throughout the northern slope of the Ozark plateau they vary between 100 and 200 feet in depth, while the upper troughs are but half as deep. Yet the latter are several times as wide, and from their character indicate a much longer period of erosion.

On the so-called "southern slope of the Ozarks" in Missouri (including the White River basin), the Ozarkian valleys are essentially of the same character as that of the Osage, having the meandering courses and the mural percipices. The canyon valley of White river in Missouri is scarcely 1,000 feet in width and 150 to 200 feet in depth. Winding about in a Pliocene basin valley from three to five miles in width and nearly 300 feet in depth, the contrast between them is extremely marked and significant. Nearly the whole of the James River valley and tributaries, such as Flat Creek valley, from the main Tertiary peneplain down, has the canyon form and winding course, but only the lower sixty to one hundred feet is Ozarkian in age, the 200 to 300 feet above the rock-terraces being of Pliocene age. In short, in this central portion of the Ozark plateau, while the Ozarkian valleys still occur in as characteristic a form and as great a development as in the Osage country, they are quite subordinate to the valleys above the Lafayette base-level. I wish to have this fact distinctly understood so that there may be no confusion as to the origin of the term, "Ozarkian." It was derived through the fact that the erosion products of the long epoch between the Lafayette and the earliest Glacial epoch are so well represented in the river valleys of the Ozark plateau, but even here not all the valleys belong to it. In the Ozark highland south of the Missouri line, the Ozarkian valleys are comparatively insignificant, and the name would be inappropriate, were it not for their fine development in south Missouri on the northern half of the Ozark plateau.

On the War Eagle fork and the main fork of White river in Arkansas, the Ozarkian valleys are small troughs, twenty to thirty or even fifty feet in depth and several times the width of the contained streams, trenched beneath the flat rock-floor of much larger valleys. In he Boston mountain region, no valleys can be pointed out as distinctively Ozarkian, although the bottoms of the deeper valleys on the southern slope must reach much below the Lafayette base-level. These valleys began to form at the close of the Cretaceous period, and have continued uninterrupted to the present day. They had not been cut down to a base-level before a new uplift occurred and the base-level of erosion was again lowered. But no sooner do we go out of the mountain region on the south, where the Lafayette base-level becomes apparent well up in the hills, when we find that here the Ozarkian valleys are quite large and deep, being comparable with those in Missouri. As the whole country sinks rapidly to the Arkansas river, these valleys become shallower, spread out to a considerable width, and finally pass into the southern Arkansas type of Ozarkian valleys, of which the lower trough of the Arkansas river is a good example.

Near Van Buren and Fort Smith, Ark., the highest hills near the river (about 200 feet above it) are remnants of the main Tertiary peneplain. Midway between it and the river-level, are the depressed areas, sometimes in terrace form and sometimes passing inland as gently rolling plains of solid rock sheeted with the Lafayette gravels, silt and clay (even "orange sand"). Below this level, the Arkansas has excavated a valley probably three to five miles in width and 100 feet in depth. This corresponds to the Ozarkian valleys of south Missouri.

On the eroded plain country south of the Arkansas river, and in the broad inter-montane basins to as far south as the Rich mountain, the streams have cut comparatively narrow valleys beneath the Lafayette base-level. These may average fifty to one hundred feet in depth and are usually of sufficient width to afford room for long, narrow farms on their flat bottoms. Their sides are steep, but mural precipices are rare. They are canyon valleys in distinction from the basin valleys above, but have the canyon form less typically than in south Missouri. In Polk county, which is on the divide between the Arkansas and Red river drainage systems and erosion is not active, the canyon valleys are hardly represented at all, the streams flowing in shallow depressions or "hollows" on the peneplain. Indeed, throughout the Ozark highland south of the Arkansas river post-Lafayette erosion has been insignificant in results attained, and one almost refuses to believe that the shallow post-Tertiary valleys of that region are the equivalents of the deep valleys of the Ozark plateau and the upper Mississippi regions.

The Modern valleys of central Arkansas.—Under this heading are to be discussed certain small canyons occurring along streams tributary to the Arkansas river in central Arkansas, and which belong to a system, it is beleved, not heretofore identified and defined in any other portion of the Mississippi hydrographic basin. That of the Little Cedar creek, northeast of Van Buren, was the most typical one observed, and a description of it may serve for all. The rock formation is a thin-bedded, calcareous shale of the Coal Measure series, dipping at a low angle but quite perceptibly toward the south. In this the creek has excavated quite a large Ozarkian valley, with steep sides and a flat rock-floor one-eighth to one-quarter mile in width. This rock-floor is very even and is sheeted with a few feet of silty alluvium. It bevels the edges of the outcropping shales, which dip down stream.

Now, the Little Cedar no longer flows over this old valley floor, but in a tiny canyon, mostly twenty to thirty feet in depth, but in places increasing to fifty feet, which it has excavated in the bottom of the Ozarkian valley. This canyon is scarcely anywhere wider than the stream, which is itself contracted to a swift mountain brook, and its walls are mostly perpendicular precipices, along which the rocky strata are finely exposed, showing that structure has had nothing to do with the existence of this canyon in the bottom of the vastly larger Ozarkian valley above. It has the appearance of extreme recency of inception. It is crossed by rock-ledges over which the stream cascades, and is obstructed by large blocks which have fallen from the walls. There is a freshness, a youthfulness about it which I have only observed heretofore in post-Glacial rock valleys in the Wisconsin drift area.

This recent canyon of probably Modern age (it is forming today) gives out before the Arkansas river is reached. It is a feature exclusively of the middle course of the Little Cedar (and similar creeks flowing down from the Boston mountain). The smooth valley floor above it could not have been formed while the stream had its present rapid rate of descent. This indicates a tilting of the valley toward the Arkansas river. This, with the presence of the canyon, postulates a very recent differential uplift of the Boston mountain region. It will be remembered that earlier in this discussion we found a remarkable monocline in the main Tertiary base-level between the Boston mountain and the Arkansas river. The Lafayette base-level partakes in this unusual deformation almost to the same extent as the Tennesseean. It was probably during the early part of the Quaternary era that this abnormal slope was mainly produced, but the testimony of the tiny rock-canyons of Modern age indicates that a movement of a similar nature has occurred in very recent times and may be in progress today. Certain peculiarities in the streams of southern Missouri, and the fact that there has been a wholesale change in the places of emergence of the springs in times very, very recent, once led me to believe in a pronounced uplift of the whole Ozark plateau in the Modern epoch (if it is not in progress today), and now these modern canyons of west-central Arkansas come to light to corroborate the idea, at least as applied to the Boston mountain region.

The preceding generalizations on the history of the physiographic development of the Ozark highland, may be briefly summarized as follows:

1. The entire region was reduced by subaërial erosion to base-level, forming the Cretaceous peneplain.

2. A great dome-shaped uplift was instituted over the site of the southern two-thirds of the present Ozark highland. The amount of elevation was 1,200 to 1,500 feet in west-central Arkansas, 500 feet in the Boston mountain region, 100 feet along the Missouri-Arkansas line near Eureka Springs, and nothing from the "crest of the Ozarks" north. The long Tertiary cycle of erosion again base-leveled this region, forming the main Tertiary or "Tennesseean" peneplain, except that residuals were left in the Ouachita and Boston mountains.

3. An uplift, general throughout the Ozarks, of seventy-five to one hundred feet, increasing to 300 feet in the White River country, enabled a Pliocene cycle of erosion to excavate the broad basin valleys and reduce much of the country to a new base-level. The close of this cycle of erosion was contemporaneous with the end of deposition of the Lafayette formation in the Mississippi embayment region.

4. Another general uplift, insignificant in amount south of the Arkansas river, but increasing to a maximum of *at least* several hundred feet in southern Missouri, enabled the streams to excavate the canyon valleys of Ozarkian age.

5. An undoubted local uplift of the Boston mountains and contiguous areas in the Modern epoch. As most of the Ozark highland is far above a base-level, it may be presumed that the late Quaternary elevation has been quite general, but has occurred so recently, geologically speaking, that only in a few limited areas are its effects as yet noticeable.

Nov. 15, 1899.

CORRESPONDENCE.

Troost's Survey of Philadelphia. Apropos of Dr. Merrill's interesting communication in the December number of this journal I beg to call attention to the fact that, safely housed in the library of the Academy of Science of Philadelphia along with other bibliographical treasures, is a copy of Dr. Gerard Troost's Survey of the environs of Philadelphia. It is apparently a direct counterpart of the work noted by Dr. Merrill. It is somewhat remarkable that Lea or Conrad should have been unaware of the volume in question and that the Marcous should have been unable to record its occurrence. Recently a Philadelphia bookseller offered a copy for sale. In regard to the German title mentioned by the Marcous, it may refer to a compilation on the geology and mineralogy of North America issued in Hamburg about 1827, to which Dr. Troost among others contributed. As far as I know this publication contained no map.

S. Harbert Hamilton.

New York Academy of Sciences, Section of Geology and Mineralogy, October 15, 1900. The following notes on the results of the summer's work by members were presented:

Mr. Gilbert van Ingen described the work of the party belonging to the Geological Survey of New Jersey, which, during the past two summers, has been engaged in tracing the outcrops of the palaeozoic formations of northwestern New Jersey, and collecting fossils. Of this party, Mr. Kümmel, the assistant state geologist, traces the boundaries and works out the tectonics, while Dr. Weller, of the University of Chicago, collects fossils at localities indicated by Mr. Kümmel. During July, Mr. van Ingen spent a week with this party in the field at Newton. Newton is situated on the shales of the Trenton group, there extensively quarried for slates. To the east is a low ridge of limestone which presents the same appearance as the Barnagat limestone along the Hudson river. The upper part of this limestone has yielded trilobites, probably *Dikelocephalus,* indicating that this portion is of upper Cambrian age. At other localities a trilobite described by Weller as *Liostracus jerseyensis,* shows that the rock there is also Cambrian—probably of the middle or upper division. In the vicinity of Franklin Furnace good specimens of *Olenellus* cf. *thompsoni* were found at localities described by Foerste. Further to the east of Newton, on the other side of the Cambrian ridge, is a wide belt of Ordovician rocks,—Trenton limestone overlaid by a thick series of shales. The limestone contains the typical Trenton fauna,—*Rafinesquin, Plectambonites, Pterygometopus* etc.,—and is very much like that found at Rosetown, Ulster Co., and at Rochdale, Duchess Co., N. Y. The shale has few fossiliferous beds, but occasionally one of the more sandy layers contains *Dalmanella testudinaria, Plectambonites and Rafinesquina,* the same combination found in the Hudson shales at Poughkeepsie, and at Rondout. At one locality was found a fauna with *Ampyx* and *Harpes.* In eastern New York these genera of trilobites are found only in the Chazy limestone, and the discovery is of great interest in that it indicates the presence of this formation at a distance of almost 250 miles south of what has hitherto been recognized as its southern limit. Further to the northwest, along the Delaware river, were found the Silurian and lower Devonian formations. The finest section is seen in the face of the cliff of the old Nearpass quarry, about five miles south of Tri-states where all the formations from the upper Ordovician to the Esopus shale of the lower Devonian appear, with numerous fossils. At Otisville the Shawangunk grit is finely exposed in a large quarry. All the evidence at hand points to the conclusion that this formation, of a thickness of at least a thousand feet, was formed as a flood plain deposit. Its characteristics, except color, are the same as the New Jersey and Connecticut valley Jurassic sandstones. Ripplemarks, sun-cracks, cross-bedding, channel-fillings etc., are abundant. In the railroad cut west of Otisville the grit lies upon the Hudson shales, with coincident dip. On the contact there occurs a few inches of clay, next to the shale is quite free from pebbles, while next the grit it is filled with quartz pebbles. This was interpreted to be residual clay caused by the decomposition of the shale, through sub-aërial agencies, before it became covered by the grit. The old notions regarding rock formation required the presence of a body of water in which the sediments might be deposited. Several of the geological subdivisions showed characters which would not have been present had these formations been laid down under water, for this mode of origin results in a sorting of the rock-forming materials, and no sorting is detected in these grits. Flood plain deposits are very irregular, both as to stratification and sorting of materials, and these features are well exhibited in the grits. Other formations that are probably flood-plain deposits are parts of the Potsdam sandstone in eastern New York, the Medina sandstone, the sandstones of the Catskill group, and many of the sandstones of the coal mesures of Pennsylvania and the Mississippi valley—in fact the geater part of the "barren measures."

Dr. Theodore G. White described his detailed study of the faunas of successive strata of the Lowern Ordovician in the Glens Falls, N. Y., section, and their relations to similar studies along the lake Champlain valley to the north, and the Mohawk and Black River valleys to the west. The section forms a low anticline along the shore of the Hudson. At the base is seen the Calciferous sandrock, containing *Ophileta* and fucoids. Conformable upon this is a layer a few inches thick, of barren black shale, which is very much crushed, and then the same beds of the ostracod, *Leperditia*, and their associated corals and peculiar forms of Strophomena, as have been found in the lowest Black River zones on Button island in lake Champlain. The zones of *Parastrophia* and *Triplesia* occuring near this portion of the series in localities to the north and west, were not found here. The succeeding coral beds of *Columnaria* were well developed. Above these are the cross bedded gray beds, which in some recent report have been considered to represent the Birdseye limestone, which seems to be lacking in this locality, unless met with at this unexpectedly high position. The upper portion of the section, which is of lower Trenton age, shows no unusual forms. The tendency of the lowest and the uppermost portions of the Ordovician sections in the region to wear away and appear wanting, owing to their prevailing softness, was commented on.

Dr. Henry S. Washington read a paper on "The Rocks of Lake Winnepesaukee, N. H.," as a preliminary report on work done by Prof. Pirsson and himself on mount Belknap and Red hill, near lake Winnepesaukee, N. H. The rocks of mount Belknap are shown to be prominently a quite uniform alkali syenyte, which is cut by many dikes of camptonyte and allied rocks, and of bostonytes, aplytes, and syenyte porphyries. These dikes also cut the surrounding porphyritic gneiss. At one place, near the border, is a mass of basic hornblende-gabbro, with large poikilitic phenocrysts of brown hornblende. A syenyte breccia also occurs. At Red hill similar syenyte, formerly described by W. S. Bayley, occurs on the summit, while toward the periphery, nepheline appears as a constituent, and a true foyayte is developed. The massif is also cut by dikes, both camptonitic and syenitic. The region is to form the subject of a petrographic study by the two geologists in the near future.

Professor Daniel S. Martin described a visit which he paid to the noted mineral locality at Haddam, Maine, during the summer. He described the manner in which the choicest specimens occur there, in veins of albitic pegmatyte, with tourmaline, muscovite and quartz along the contact with the wall of gneiss. The mica plates along the contact are often two feet in diameter.

Dr. A. A. Julien in his paper "The Geology of Central Cape Cod," reviewed the opinions of Mitchell, Davis, Shaler and others on the geology of cape Ann, with especial reference to the district from Chatham to Yarmouth. In the stratified deposits of sands and gravels which underlie the plains south of the morainal "back-bone" of the cape, the more frequent intercalation of clays was pointed out, and their occasional disturbance and flexure. Striated pebbles, although much water-worn, are quite largely interspersed. The discovery of true glacial silt at some depth, in one locality, indicates that the ice-sheet there rested, instead of floating. The kettle-shaped hollows and pond-basins were shown by the speaker to be largely connected with the damming of surface streams, and some observations on the pre-glacial drainage valleys and topography were discussed. The identification of certain transported fragments of quartz-porphyry with outcrops of the same near Marblehead indicates a pre-glacial movement from N. W. to S. S. E. To the fifteen changes of level which have been recorded, a final small elevation probably should be added, judging from the low terrace along this part of the coast. Examples of the facetted pebbles were exhibited and provoked considerable discussion among those present, as to the origin of these pebbles.

Prof. Richard E. Dodge recounted his pleasure in visiting the region of the Colorado canyon, during the past summer, in company with a party, and finding the physiography so graphically illustrated in the drawings in Powell's reports, to be a most faithful and non-diagrammatic portrayal of the features themselves. He then described the striking examples of gigantic geo-physical results seen in the Great Kaibab anticline, the Grand Canyon itself and the Kaibab plateau and its faults. He also described the appearance of the great basin of "Lake Bonneville."

Remarks on foreign localities visited during the summer, were made by Prof. J. J. Stevenson and Dr. E. O. Hovey.

THEODORE G. WHITE,
Secretary.

A SINGLE OCCURRENCE OF GLACIATION IN SIBERIA. During three seasons' professional work in Siberia I have been constantly on the outlook for signs of glaciation. It seems almost an anomaly that in a country covered for fully half the year with snow and ice, there should be found no glacial remains. Yet such is the case, in the great majority of instances. In European Russia, north of latitude 63 degrees, glacial drift, moraines and drumlins, have been found by the Russian geologists, as indicated on their maps, although specific references to their discoveries are rare. So far as is known the glacial indications do not extend over into the great northern plain of Siberia. The numerous lakes scattered throughout, not only the Ural, but the whole of west and central Siberia have been sometimes referred to as of glacial origin. A little close observation of these bodies of water is, however, sufficient to convince anyone that their origin is due to a different cause.

In the Steppe region, lying to the south of the Trans-Siberian railway, and extending from the Ural eastward for many thousand miles, until it merges with the Great Gobi desert, there are numerous topographic features, which would, by a hasty observer, be laid to glacial origin. Small mound-like hills, frequently beautiful in their dome-like symmetry, lie scattered over the treeless undulating plain. I have been led a mile or more off my route, by a desire to examine closely such occurrences. In every case they have proved to be merely curious forms assumed by the rock itself in process of erosion. In this same region of the Steppe, the presence of numerous lakes helps to bear out the deception, but when it is found that these are merely the remnants of former and greater lakes, many of them being salt at the present day, and that they have not been dammed, but merely occupy depressions in the gently rolling prairie, the glacial supposition must of course be abandoned. The Caspian is the most tremendous example of this kind, then come the Aral sea and the Balkash lake. In the case of lake Sheero, 200 miles to the west of Minnisinsk, I noted, surrounding it successively, at various hights up to 75 feet, rings or old shore-benches, each marking a stage of the lake's history. So gradual are the slopes in the Steppe that the last and highest of these rings was at least three miles away from the present water's edge.

In a valley of the Altai mountains, on the head waters of the Tom river, there was a most remarkable case of pseudo-glacial topography. While riding up the center of the valley, I saw, making off from the steep side of the mountain, what appeared to be a glacial esker. It was perhaps 500 ft. long, 40 ft. in hight, with a width of 60 ft. and possessed the rounded, ridge-like summit characteristic of this species of glacial topography. Its side had been broken away, and from the distance, about 600 ft. at which I saw it, the appearance was that of sand. Such a phenomenon in a region in which I had looked in vain for glacial signs was a novel and startling one, and I hurried toward it to make sure. In truth the material of which it was composed was sand, and I could bury my pick to the handle end in it, but alas it was a fine even grained dioritic *greisen*, nothing else. It was in itself a remarkable form of dike weathering and interesting on that account, but as regards glaciation it was only another of the negative signs of which I had accumulated an extensive category.

The Bazaika Creek valley, about 15 miles to the southeast of Krasnoyarsk, and across the Yenesei river from that city, furnished the only evidence of a fair sized glaciated area of a former age which I have seen.

Here is an area of 100 square miles or so, enclosed by high rock walls of granite, and sedimentaries, in which, although of purely local origin, and confined to local effects, glacial conditions have obtained. Drumlins of most perfect form may be found in the bottom of the valley, near the Bazaika creek and they extend up to a hight of 600 or 700 feet on the side of the mountain. The glacial cirque topography, so common in the high Rockies, has here its development on a very large scale on one side of the valley, in such a manner that a large amphitheatre is formed, along which the creek makes its way for a distance of ten miles. At the upper end of this stream, some sixty miles from its junction with the Yenesei, it is evident that a glacier must have existed whose detritus now encumbers the valley. Near the village at the base of the valley, inside a long spur of limestone which separates the creek from the Yenesei, lies on one side a beautifully bedded sand-plain, now nearly cut through in section by the stream itself. Such occurrences as this are too rare in Siberia not to attract attention, and although I was unable to find confirmatory evidence in the form of scratched pebbles, and am therefore open to the charge of assertion on non-conclusive evidence, yet so unusual an occurrence in Siberia, a non-glacial country, deserves a mention.

In the high Altäi the cirques at the head of the valleys, such as occur in Colorado, due to present freezing, melting and refreezing conditions, are common and may of course be called minute results of local glaciation. Present glaciers exist also in the Altai on the head streams of the Irtish river, near the Mongolian border. They occur, however, in mountain valleys, as in Switzerland, at hights of 10,000 feet, and are purely local in their effects.

In east Siberia, the gold-placer industry has led to a considerable study being made of the gravels which there encumber the valleys to depths varying from 10 to 150 feet. Their subangular character has led some observers to refer their presence to transportation by glaciers. From my own observations on the gravels they do not appear to me to have come from foreign sources. Their material can always be traced directly to the immediately enclosing hills. In no case have I ever found a scratched surface. The gravels are merely immense quantities of rubbish which have slid into the valleys when the mountains were of greater hight, have become covered in a comparatively short time with a carpet of turf and peat, due to the constant periodic growth and rotting of the almost tropical Siberian vegetation, and have thus lain there undisturbed, the gentle grades of the present streams not being sufficient to clear the valleys of these masses of detritus. Under any other than Siberian conditions, perhaps such thick beds of sub-angular and even angular irregularly disposed gravels might not be possible. A discussion of these conditions is, however, one that may be prolonged to a considerable length, and properly forms the subject for separate consideration.

Berlin, October, 1900. CHESTER WELLS PURINGTON.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Ueber Aulacamerella ein neues Brachiopodengeschecht: VON FRIEDRICH BARON HOYNINGEN-HUENE (Verhandlungen der Kaiserlischen Russischen Mineralogischen Gesellschaft zu Petersburg. Zweite (Serie. Band xxxviii, No. I.)

On the ventral valves of two species of brachiopods from the higher Lower Silurian (Ordovicean) of the Baltic provinces Baron Huene has founded the above genus with the following diagnosis: Ventral valve more or less convex, smooth or concentrically longitudinal, keel-like median fold. Beak almost entirely atrophied. Pedicle opening unknown. Inside there is a large triangular platform, without median support, connected at the sides with the shell. Hinge border slightly raised; hinge teeth rudimentary or lacking. Dorsal valve unknown, apparently flat or concave. Two species are known. The most remarkable peculiarity of this genus is the large even platform, with a concave space underneath. In this connection comparisons are made with *Merista* (?) *cymbula* Day, and for the medium plate or septum with *Orthisina* (Clitambonites) *diversa* Shaler. Comparisons are also made with Camarella and Syntrophia.

Five figures in the text and a plate of figures of the two species of the new genus are given. G. F. M.

Supplement zu der beschreibung der Silurischen Craniaden der Ostseelander. By the same author and published with the former article.

This is a continuation of Baron Huene's work on the Craniadæ which appeared about a year ago and was reviewed in this journal. In this are described a number of new species, Pholadops, one species, Philhedra, five species, (and notes on two others already described), Eleutherocrania (new mut.), Pseudocrania, notes on six species already described. Pseudometoptoma, notes on two species already described.

A table of the vertical and horizontal distribution of the forms of this family is given and following this some interesting remarks on the systematic place of Pholadops. A few paragraphs also are devoted to the changes which occurred in Philhedra from its first appearance until it gave place to Craniella and Eleutherocrania in the Horizon F. 2.

There are six text figures and three plates in illustration of the species treated of in this article, which add materially to its value.

G. F. M.

A text-book of important minerals and rocks, with tables for the determination of minerals. By S. E. TILLMAN. Octavo, pp. 176, $2.00. John Wiley and Sons, New York, 1900.

After a brief account of the crystal systems, and of the common physical and chemical properties of minerals, the author gives brief general descriptions of eighty-seven minerals or groups of minerals, especially adapted to amateurs and economic mineralogists. Each mineral description is followed by a statement of the uses and localities where the mineral is most abundantly found. The tables for the determination of minerals are compact and handy, the primary divisions being based on color. They provide for the discrimination of 135 species. Part II. is devoted to a condensed description of common rocks. The work is adapted to an elementary course in mineralogy in schools and academies. It is not at all encumbered by technicalities nor by symbols.

N. H. W.

The Progress of Mineralogy in 1899, an analytical catalogue of the contributions to that science during the year. By S. HARBERT HAMILTON and JAMES R. WITHROW (Bulletin No. 2 of the American Institute of Mining Engineers, 1900.)

This publication renders a distinct and noteworthy service to mineralogy and to mineralogists. It is the only one of its kind that we know of in the English language. It is not restricted to the United States, nor to English literature, but embraces all countries and languages. It is, however, confined to literature that was received in Philadelphia prior to the beginning of 1900. It is divided into seven essential parts, each part arranged alphabetically by authors' names, viz.: New minerals, new meteorites, new elements; chemical mineralogy; new analyses, determinations, methods etc.; physical mineralogy; new forms, determinations, crystallographic studies etc.; general mineralogy; new occurrences, economic mineralogy etc.; lithology; new rocks, petrographical descriptions etc.; bibliographical, historical etc.; new books, new apparatus etc.

In order to get this literature catalogued the authors have consulted 175 different serial publications from all parts of the world, a fact which shows that a journal devoted exclusively to mineralogy should be well supported and a great advantage. Besides its own articles such a journal should annually contain such a document as this. N. H. W.

New Species of Cambrian Fossils from Cape Breton. By G. F. MATTHEW. (Bulletin, Nat. Hist. Society of New Brunswick, vol. iv, p. 219.)

Under this head Dr. Matthew has described a number of Upper Cambrian species of trilobites and brachiopods that are of considerable interest.

A good deal is made of the internal character of the shells of the brachiopods, which are carefully described. The species belong to the genera Lingulella, Lingula ? Acrotreta and Schizambon. The example of the last genus is a small species more orbicular than the type, and of interest as carrying the genus back to Cambrian time. (The typical form described by Walcott is of Ordovician age.) The Acrotreta is remarkable for the heavily truncated mould of the ventral valve, and for the unusually strong medium septum of the dorsal valves.

Among the trilobites the largest species is a Parabolina distinct from others in the strongly arched front margin of the head shield. A very remarkable form is a species of Sphaerophthalmus, carrying a very large flat genal spine, differing from S. *alatus* in this and other respects. An Agnostus of generous size is a Canadian mutation of *A trisectus* Salter; it is peculiar in having a tubercle at the end of the rachis of the pygidium, and in other respects. These trilobites are of the Peltura fauna; the brachiopods chiefly of this fauna and that of Dictyonema (*D flabelliformis*).

A plate with figures of the species and mutations described accompanies the article. N. H. W.

The Action of Ammonium Chloride upon Natrolite, Scolecite, Prehnite and Pectolite; by F. W. CLARK and GEORGE STEIGER. (*Am. J.* Sci., *160*-345-351.)

The present paper is one of a series having for an object the study of the chemical constitution of certain silicates. The minerals were subjected to the action of ammonium chloride in sealed tubes at a temperature of 350°, and the resulting products analyzed. The action of a boiling, 25% solution of sodium carbonate was also tried on them. Both natrolite and scolecite are unattacked by the sodium carbonate solution and yield with the ammonium chloride the same compound $(NH_4)_2 Al_2 Si_3 O_{10}$, which is a simple replacement of the bases and acid hydrogen of the minerals by the (NH_4) radical. From these facts and an entirely new and complete analysis it is concluded that the two minerals are salts of the same silicic acid $H_8 Si_3 O_{10}$, and that their formulæ should be written $Na_2 Al_2 Si_3 O_{10} . 2 H_2O$ for natrolite, $Ca Al^2 Si_3 O_{10} . 3 H_2O$ for scolecite instead of the previously accepted orthosilicate formulæ $Al_2 (Si O_4)_3 Na_2 H_4$, and $Al_2 (Si O_4) Ca H_4 . H_2O$ respectively. Prehnite suffers no change when treated as above and is therefore of different structure. Pectolite, a meta-silicate $Na H Ca_2 Si_3 O_9$, although attacked strongly by the chloride, did not yield results leading to any new or more definite conclusions as regards its structure.

C. H. W.

Chemical Composition of Turquoise; by S. L. PENFIELD, (*Am. J. Sci.* *160*-346:350.)

The article records a re-investigation regarding the chemical composition of turquoise. A new analysis was made on material exceptionally suitable for that purpose. From the results thus obtained the author shows conclusively that the mineral is to be regarded as a derivative of the ortho-phosphoric acid in which the hydrogen atoms are largely replaced by the univalent, isomorphus radicals $Al(OH)_2^I$ $Fe(OH)_2^I$, and $Cu(OH)_1$. The formula may be written $[Al(OH)_2, Fe(OH)_2, Cu(OH), H]_3 PO_4$. The radical $Al(OH)_2^I$ always predominates. A careful consideration of former analyses shows them to be in close agreement with the results just mentioned and wholly disproves Clark's interpretation that turquoise is a mixture of the molecule $Al_2H\ PO_4\ (OH)_4$ with finely divided iron and copper phosphates as impurities. C. H. W.

A new Meteorite from Oakley, Logan County, Kansas, by H. L. PRESTON. (Am. J. Sci., *160*-410-412.)

The meteorite, which is the eleventh one reported from Kansas, weighed 61 lbs. 10 oz. and was 7½ x 10 x 12 inches in its greatest diameter. It consists of "olivine and enstatite chondrules imbedded in a very irregular groundmass of the same material, with numerous particles of iron and iron sulphides." An analysis gives its composition as follows;—metallic part, Fe 12.76%; Ni + Co 1.68%; silicates, 85.56%; total, 100%. C. H. W.

Cambro-Silurian Limonite Ores of Pennsylvania; by T. C. HOPKINS (Bull. Geol. Soc. Am., vol. 11, 475-502.)

Extensive deposits of iron ores occur as irregular pocket-like deposits in the residual clays of the Cambro-Ordovician limestones and slates of eastern and central Pennsylvania. The ores consist of the hydrous oxides of iron, chiefly limonite, associated with manganese ores, wavellite, quartz, chert and fluorite. The ores appear to have been derived from the original iron content of the limestones and slates, by a leaching and concentrating process in which carbonic and organic acids together with oxygen took part. In position the ores favor the contact of the limestones and underlying slate. C. H. W.

Chemical Composition of Sulphohalite: by S. L. PENFIELD. (Am. J. Sci., *160*-425-428.)

Considerable doubt as to the existence of the mineral sulphohalite recently described and assigned the formula $3\ Na_2\ SO_4\ 2NaCl$, having arisen by reason of the failure of several investigators to make an artificial salt of like composition, the re-investigation of the species described in this article was undertaken with the result that another constituent, fluorine, was discovered and the composition represented by the formula $2\ Na_2\ SO_4\ 2\ Na\ ClNaF$ assigned to the mineral. It is interesting to note that sulphohalite was associated with another triple salt, the mineral hanksite $9\ Na_2\ SO_4\ 2\ Na_2\ CO_3\ K\ Cl$. C. H. W.

Siliceous Calcites from the Bad Lands of South Dakota; by S. L. PENFIELD and W. E. FORD. (Am. J. Sci, *160*-352-354, with Pl.)

The crystals are rough in appearance, but show with some distinctness characteristic calcite forms. In chemical composition the crystals resemble the siliceous calcites from Fontainebleau, containing 40% of calcite and 60 of sand. The sand grains at times attain the size of small pebbles. It appears that these crystals represent a phase of sandstone formation where the calcareous cement was able to crystalise and preserve its external crystalline form. C. H. W.

Granites of Southern Rhode Island and Connecticut, with Observations on Atlantic Coast Granites in General. By J. F. KEMP. (*Bull. Geol. Soc. Am.*, *10*, 361-382.)

All the granites described are biotite granites, muscovite, though present, being very subordinate and hornblende failing entirely. The following types are recognized: Westerly gray, Westerly red, Stony Creek red, Stony Creek gray, and Lyme pink. The Petrographic descriptions of these types and of the contact phenomena and basic inclusions as well as of the associated apatite and pegmatyte, are followed by a discussion of the chemical composition based upon six analyses, four of which are new. The silica is quite uniform, varying from 68.40 to 73.05, but with only one below 70 per cent. The Rhode Island granites run somewhat higher in lime than the Connecticut granites. The magnesia is very low in nearly every case. The soda, in relation to the potash, is relatively high in some types and low in others; while one, the red granite of Stony Creek, proves to be one of the purest potash granites on record. The paper closes with a general review of the granites of the Atlantic sea board, which are believed to belong to several different geological periods and among which the biotite granites largely predominate. W. O. C.

Contact Metamorphism of a Basic Igneous Rock. By ULYSSES SHERMAN GRANT. (*Bull. Geol. Soc. Am.*, *11*, 503-510.)

The rock referred to is the Keweenawan gabbro occupying a roughly crescentic area of about 1,000 square miles in the northeast corner of Minnesota, between lake Superior and the Canadian boundary. The contact phenomena are described only for the northwestern border of the gabbro which the author regards as probably intrusive,, where it lies upon the Archæan, Keewatin and, especially the quartzyte, iron-bearing series, carbonaceous slate and graywacke slate of the Animikie. The metaporphism is very noticeable, and consists of a partial or complete recrystallization of the adjacent rocks. Complete recrystallizntiion is the rule near the contact, and in places this extends 500 feet from the contact; while a partial recrystallization is at times noticeable for two or three times this distance from the present margin of the gabbro. The rather normal metamorphic characters of the slaty members of the Animikie are first briefly noticed, and then the specially interesting contact phenomena of the iron-bearing series are more fully decribed. The original rock is regarded as having more or less iron carbonate. This rock has been widely altered by a regional metamorphism to a quartz-magnetite-amphibole slate commonly known as actinolite schist, which has in turn been profoundly changed by the gabbro, the resuling rock being a coarse-grained aggregate of quartz, magnetite, olivine or fayalite, hypersthene, augite, hornblende etc. The derivation of all these minerals, including those like olivine, augite, and hypersthene, which are characteristic of basic igneous rocks and rarely found in metamorphosed sediments, from the actinolite schist is shown to be possible; and the proofs that this contact zone really belongs to the Animikie and not to the gabbro are summarized. The contact phenomena of the Keewatin are said to vary greatly with biotite as a prominent feature. In the Archæan, the acid rocks or granites have escaped sensible metamorphism, while the basic rocks or greenstones, including gabbros, diabases and diorytes, have been profoundly altered, and usually in a way to make them difficult to distinguish from the gabbro itself. W. O. C.

Suggestions Regarding the Classification of the Igneous Rocks. By WILLIAM H. HOBBS. (*Jour. Geol., 8*, 1-31.)

After noting the importance of adapting the classification to the needs of the field geologist as well as the petrologist, the bearing of recent petrographical studies on rock classification, the definition of a rock as an object rather than as an integral part of the earth's crust, the importance of texture as a basis of classification, the need of combining chemical and mineralogical classifications as a basis for rock classification and of substituting quantitative for qualitative analyses, that rock relationships should be indicated by the combination of names into a binomial, or, of necessary, a polynomial nomenclature, the author introduces graphical methods as essential to a comprehensive study of rock analyses. The system of diagrams proposed by Brögger for this purpose is preferred. In these are set off on radius vectors the amounts of the eight principal chemical constituents reckoned in molecular ratios, ferrous and ferric iron being entered upon the same radius vector, and silica, because so much in excess of the others, being evenly divided between the two horizontal radius vectors. A broken line joining the intercepts on the eight radius vectors forms a polygon, which may be long and narrow, or short and thick, convex above or below, or re-entrant in any portion, left or right-handed etc., according to the chemical constitution of the rock. When viewed in this diagram the rock comes to have a handwriting by which it may be instantly recognized; and when drawn to scale the diagram not only shows the chemical character of the rock but all the results of analysis may be read from it numerically. The main purpose of this paper is to adapt the Brögger diagram to represent, not merely an individual analysis, but a rock species or type covering a considerable range of differing analyses. In other words, composite diagrams are proposed, each representing the average of a group of analyses. Examples are given for the principal types of plutonic and volcanic rocks. The possibilities of the method are farther illustrated by grouping the diagrams in natural series, which show progressive changes in form; and also by introducing a composite of each series. The numerous analyses upon which the diagrams are based are quoted in tabular form.

W. O. C.

The Nomenclature of Feldspathic Granolites. By H. W. TURNER. (*Jour. Geol., 8*, 105-111.)

Accepting the principle that the classification of granular rocks, if not of lavas, should be based on mineral composition, the author notes that this is equivalent to a classification based on molecular composition in so far as the minerals are composed each of one kind of molecules. But plagioclase is an exception, since it is composed of two kinds of molecules in ever varying proportions. The author proposes that the molecular classification be applied throughout; and hence in calculating the composition of the feldspathic rocks the plagioclase should be resolved into the constituent albite and anorthite molecules, and the name plagioclase should not be used. This is shown to be particularly necessary with the monzonytes and diorytes, which contain both orthoclase and plagioclase, since the plagioclase may vary from a basic labradorite to an acid oligoclase, thus giving rocks which could not properly be designated by the same name. It is suggested, therefore, that if we subdivide the feldspathic rocks on the basis of the ratio of the alkali-feldspar molecules (Or + Ab)g to the lime feldspar molecules (An) the true mineral and chemical relations of the rocks will be brought out and a better classification result. A graphic illustration is given in tables showing percentages of the alkalies and lime and the ratios of Or +Ab to An for the principal feldspathic types. The author further suggests the use of mineralogical terms in naming granolytes of simple composition, as orthosyte for a rock composed chiefly of orthoclase, albityte for one composed chiefly of albite etc., the names of other essential constituents to be used in substantive forms, as quartz-orthosyte or granite, and of accessory constituents in adjective form, as quartziferous syenyte etc. W. O. C.

Some Contact Phenomena of the Palisade Diabase. By JOHN DUER IRVING. (*School of Mines Quarterly, 20*, 213-223.)

This paper, which, after noting the gradation in texture, density and mineral composition between the central and peripheral portions of this great trap sheet, is based chiefly upon the exposures of the upper and lower contacts afforded by the new tunnel of the New York Susquehanna and Western railroad, confirms in the main the work of Andræ and Osann, who in 1892 studied the lower contact only, as exposed by the West Shore railroad. The earlier work recognized four metamorphosis phases of the Triassic shale and sandstone, as follows: (1) normal hornfels, (2) the same rich in tourmaline, (3) altered arkose containing green hornblende, (4) lime-silicate hornfels. To these Irving adds five others, three from the lower contact: (1) normal hornfels rich in spinel, (2) lime-silicate hornfels containing brown hornblende. (3) normal hornfels containing "augen" and green hornblende; and two from the upper contact: (4, 5) hornfels and arkose hornfels containing richly scattered crystals of andalusite. Each type is described in detail; and the evidence is shown to strongly support the intrusive origin of the diabase, the andalusite and the fact that the hornstone a hundred feet above the upper contact is baked as hard as any below the sheet, being especially conclusive in this regard. Another contact type is believed to be a leucite hornfels, although the analysis shows it to be too high in alumina and soda and much too low in potash for a pure leucite; the discrepancy being attributed to interstitial matter. Leucite has not been previously described as a contact mineral.

W. O. C.

Ueber grosse flache Ueberschiebungen in Dillgebiet, VON HERRN E. KAYSER in Marburg in Hessen. (Jahrbuch de Konigl preuss, geologischen Landesanstalt for 1900, Bohn, p. 7.)

This article describes the complicated structure of the Devonian and Culm in the neighborhood of Dill in southern Germany. A complicated series of upthrow and downthrow of faults is shown by the accompanying map, as cutting all the older formations, but not so much affecting the Culm though this formation is also cut by them. Several sections are given to show the details of the action of the force that produced these movements; and it is also shown that after the faults were produced a continuation of the movement caused the folding of the bed affected by the fault—(page 8).

Ueber den nassauischen Culm, von E. KAYSER. (Neues Jahrbuch für Mineralogie etc., 1900, Bd. I, p. 132).

In this paper Prof. Kayser refers to the discovery by Tornqvist in the Posidononia slate of Hebron of a species of Meek's North American genus Euchondria (*E. europaea* Tornq.) of which he himself had found a very perfect example. G. F. M.

Beitrage zur Kenntniss des Siberischen Cambrium, I. von EDUARD VON TOLL. (Memoires de l'Acad. Imp. des Sciences de St. Petersburg, viii Ser., vol. viii, No. 10.

This quarto of 57 pages with a number of cuts in the text and eight plates of figures of the fossils described, is one of the most important contributions to Cambrian literature that have appeared in the last few years; not only on account of the thorough treatment of the subject, but also because of the distant and little known geological field whose Cambrian fossils are described herein.

Both on the Yenesei, and the Lena the great rivers of Siberia, Cambrian deposits are now known to exist, and they supply most interesting links of association with the contemporary strata on the opposite side of the world.

Very noticeable is the fulness with which the archæocyathine reef builders were multiplied in the valley of the Jenesei, and their numerous species have to a large extent been identified by Baron Toll with Bornemann's species in Sardinia.

We are startled by the reference of these archaic and puzzling forms to the calcareous Algæ. They have been bandied by various authors from one class of the animal kingdom to another. Billings, who first described them, thought they were silicious sponges, and Prof. H. A. Nicholson and Mr. Walcott supported this opinion. Bornemann who had an excellent opportunity to study the Sardinian forms, concluded that they were a special group of Coelenterata. Dr. Hinde who re-studied the Canadian species concluded that one was a lithistid sponge, and the rest were to be referred to a distinct family of the Zoantharia-schlerodermata. Meek thought Archæocyathus (Ethmoprylluin) a true coral. Sir Wm. Dawson, however, thought two of the Canadian species to be Foraminifera.

Baron Toll discusses these conflicting opinions, and having described a new genus Rhabdocyathus, comes to the conclusion that through it he has reached the true solution of the zoological standing of the Archæocyathinæ, namely that they are a primitive development of the calciferous Algæ, and are related to the recent Acetabularia and the Tertiary Acicularia.

Among the material from Siberia Toll claims that he has found evidence of the embryonic stages of the archæocyathines, and figures a minute stalked cup with a detachable lid which he conceives to have been the starting point of an Archæocyathus. In his new genus, Rhabdocyathus, in which he sees a more primitive archæocyathine than in the others, the lower part of the tube has separate outer and inner walls, but in the upper part these walls come together forming a solid wall; in this genus there are no septæ, but the walls are perforate as in the others. Baron Toll regards the connecting tubules that pass from the inner to the outer wall in the archæocythines as passages for the spores, which thus escape from the inner cavity. While warmly advocating his view of the algoid relationship of the Archæocyathinæ he speaks of it as a hypothesis, thus inviting criticism of its soundness.

The earlier part of Baron Toll's work is devoted to a description of the literature of the Siberian Cambrian, in which he refers to the earlier work of Dr. F. Schmidt on a more limited collection of Cambrian fossils, from some of the localities from which the later collections came, that have been examined by Toll. Dr. Schmidt had placed some of these fossils as Devonian, but Toll correctly refers them to the Cambrian. One of these is a Dorypyge, three others are referred to the genera Anomocare. Loistracus and Solenopleura (?), (Plate II). A pygidium on the same plate referred to *Bathyurus howelli, Walc.*, has a wider flattened margin than is common in that species.

On plate I are figured a number of new species of trilobites etc., from the new localities whose fossils have been studied by Baron Toll. Two minute species which are referred to Ptychoparia might also with propriety be compared with the Strenuella type of Agraulos, and especially with *Strenuella attleborensis* S and F (Trans. Roy. Soc. Can., 2 Ser., vol. v, sec. iv., p. 77). An Agnostus of the Lœvigati group has unusual asosciations if occurring in strata with the interesting Microdiscus figured on this plate. This greatly resembles the species of this genus which occur with Olenellus; the Agnostus, however, is flatter than the typical species of the Paradoxides beds and may be an earlier form.

In this paper are described, of Ptyhoparia 1 new species, Microdiscus 2 new species, Agnostus 1 new species, *Kutorgina* (*cingulata Bill.*) and *Obolella* (*cf. chromatica* Bill.) The species are compared with those of Europe and America.

Any claim that Agnostrus occurs in strata below Paradoxides requires to be well supported. The type of the one that Ford thought he found at Troy, N. Y., is lost and the figure he gives scarcely supports the reference to this genus. Baron Toll thinks that *A. atavus* of Tullberg may be claimed for the Olenellus zone; but while Tullberg refers the group of strata in which it was found at Andrarum to the Olenellus zone, Olenellus (i. e. Holmia) is found only in the lower part of this set of beds, and Tullberg reports a Paradoxides in these beds *below* the layer which carries *Agnostus atavus.*

Descriptions and figures of F. Schmidt's species are given and a very full account of occurrences of the several forms of the Archæocyathinæ.

Table C (p. 55) is an endeavor to show diagrammatically the chronological relation of the several parts of the Siberian Cambrian, and the author's view of the bearings of the several groupings of species, and the nature of the sediments, on the probable depth of the Cambrian sea at the time these creatures of the Cambrian age were entombed.

In conclusion we may congratulate the author on having rescued from the unknown a new chapter of geological history, and on having placed us at a new point of view, from which we may regard the activities of the Cambrian reef-builders. G. F. M.

La Face de la Terre (*Das Antlitz der Erde*), par Ed. Suess, traduit avec l'autorisation de l'auteur et annoté sous la direction de Emmanuel de Margerie. Tome II, Paris, 1900.

This well-known classic on the physical features of the surface of the earth is considerably enlarged by original notes and references to later literature. This tome begins with the "third part," the seas. After a full description of the Atlantic and Pacific ocean, and a comparison of one with the other, the author enters upon the discussion of paleozoic seas, thus coming within the domain of geology proper. Here is abstracted and epitomized the result of all the study of the paleozoic both in America and Europe. The Mesozoic seas are treated in the same manner, then the Tertiary seas. In chapter VIII the author discusses the shore lines of Norway, their possible elevation, the glaciers and fjiords. A history of the temple of Serapis at Pouzzoles, as affected by earth movements, and by volcanic ejection, as well as the results of exhumation and its present state are included in chapter IX. The Baltic and the North seas during the historical period, and the Mediterranean during the same period, are subjects of long inquiry and important description. The work closes with a chapter devoted to the shore lines of the northern seas.

This work thus covers the whole field of modern geology, and brings within small compass the grand conclusions of the science on the main features of the history of the stratified rocks. The collaborators with M. Margerie, in this translation and in the new ma-
Six and M. Zimmerman. The new French edition of this German
treatise renders a great service to geologists in bringing it within
terial, are Aug. Bernard, Ch. Depéret, W. Kilian, G. Poirault, Ach.
reach of a wider circle of students. The only criticism that may be made is one that is a common fault of French works, viz: it has no index, and only the most general subdivisions and running heads. It is therefore much like a hidden mine which everyone must explore independently, without guides. English, and especially American, scientific books are far ahead of those of continental Europe in this particular. N. H. W.

A Record of the Geology of Texas for the Decade ending December 31, 1896. By F. W. Simonds. (Transactions of the Texas Academy of Science, vol. 3, pp. 1-280. Austin, August, 1900.)

This record begins where professor Hill's Bulletin No. 15 of the United States Geological Survey leaves off, and covers the decade which, as remarked in the author's prefatory note, has been more fruitful of results than any other and has placed the geology of Texas upon a solid foundation, notwithstanding the many details that remain to be worked out and errors that must be corrected.

It comprises 466 titles, numbered for convenient cross and index-reference, arranged alphabetically by authors, those of each author being arranged according to time of publication.

The entry of copious quotations, judiciously selected to show progressive or important features of most of the papers cited, and the preparation of brief abstracts of certain papers or parts of papers, have more than doubled the value of the record as a bibliographic production. In presenting these Dr. Simonds has been wisely impartial, avoiding entanglement in controversial geology and letting the principal results and contentions of authors speak for themselves.

Lists of fossils, minerals and rocks newly described or illustrated, or of which new knowledge is added in the papers cited, faunal lists of formations, condensed geologic sections, chemical analyses and economic statistics have been freely included.

Thus, in a form compact and convenient for reference, the *Record* embodies the best part of the known geology of Texas, and constitutes an admirable handbook of the latter and one that will be indispensable to all future students of the geology of the state or of North America at large.

Typographical errors do not recur with sufficient frequency to be burdensome.

An excellent index is provided, embracing topics, localities and authors. F. W. C.

Bulletin of the Hadley laboratory of the University of New Mexico. Vol. II, part 1, 1900. Published with the cooperation of Mrs. W. C. Hadley.

This publication embraces several articles, the leading one being devoted to the geology of the "Albuquerque sheet," of the United States Geological Survey, with the limits of which lies the territorial university. Its authors are C. L. Herrick and D. W. Johnson It is accompanied by a map and thirty-two plates, mostly of fossils, of which fourteen are new or undetermined. The article gives a convenient synopsis of the geological structure of the area included in the Albuquerque sheet, with incidental references to the surrounding country. The Tertiary forms a large central triangular mesa, extending from the Rio Grande to the Puerco, with a gentle general dip to the southeast. Volcanic rocks forming cones and flows pierce and lie upon the Tertiary, the most notable being the volcanoes a short distance west from Albuquerque. These are believed to be a part of a series that runs north and south, indicating a line of weakness and perhaps of fracture and faulting. It is interesting to note that some specimens of maize embraced in what was supposed to be a part of this lava were traced to a recent artificial origin, the "lava" being simply fused adobe, a part of an abandoned brick kiln. Thus the idea that man was contemporary with the lava was abandoned.

The Sandia mesa rises from the Rio Grande toward the east. The inclination is much increased near the Sandia range of hills a spur from which enters the area of the sheet. These hills are due to a great fault which has brought to the surface the Permian and Carboniferous the uplift being on the east side of the fault. This dynamic movement was accompanied by metamorphism and apparently by fusion of the rocks concerned, giving vent to granite.

In the Cretaceous of the western part of the area are lignite beds which have been considered Laramie but they lie below the Fox Hills of the Cretaceous. Some pre-Tertiary igneous rocks that pierced the Cretaceous and modified its beds, are found near the Puerco valley, west of Albuquerque, in the form of isolated trachyte cones, the surface lavas of which had apparently been eroded and lost prior to the Tertiary covering which has since been also removed by the erosion incident to the Puerco valley. The authors gave the petrographic characters of these rocks and of the Tertiary basalt.

Short paragraphs are devoted to the building materials, and especially the clays, and to irrigation.

Pres. Herrick also discusses in a short article the possibilities of salt, gypsum, cement, clay and graphite, in New Mexico.

The volume also contains "Report on a geological reconnoissance in western Socorro and Valencia counties, New Mexico," and "Identification of an Ohio Coal Measures horizon in New Mexico." which have appeared in the American Geologist; also "The Geology of the White Sands of New Mexico," from the Journal of Geology, and closes with "The Cyanide process in New Mexico" by V. V. Clark.

The publication indicates great activity and energy on the part of Dr. Herrick, who has produced this and the preceding bulletin in addition to his duties as president of the Territorial University. Such a publication must be one of much convenience and value to the people of the territory. N. H. W.

The Geology of Eastern Berkshire County, Massachusetts, B. K. Emerson. (Bull. 159, U. S. G. S.)

This bulletin is supplementary to the Housatonic folio, and treats of the area adjoining the Green mountain and Hoosac mountain regions, which have been the subjects of recent monographs.* The bulletin consists principally of lithological and petrographical descriptions.

The region described represents the central portion of a deeply eroded mountain region. It presents a complicated series of much folded and faulted pre-Cambrian and early Paleozoic rocks. Mr. Emerson distinguishes and describes six gneisses, three limestones, three schists and one quartzyte. He concludes with a lexicon of Berkshire county minerals.

The bulletin is somewhat fragmentary. It does not give a complete history of the region nor discuss any of the larger problems involved. Doubtless the Housatonic folio will treat of this side of the subject and as an appendix to the folio the bulletin will be of value. I. H. O.

MONTHLY AUTHOR'S CATALOGUE

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PERSONAL AND SCIENTIFIC NEWS.

The famous Clarence S. Bement collection of minerals which has attracted mineralogists from all over the world to Philadelphia for so many years, when they wished to see some of the finest specimens known, has been purchased by the friends of the American Museum of Natural History and has been presented to that institution. The donors' names are withheld from the public at present, though this is the largest and most valuable single gift ever made to the museum. The minerals in the collection are said on good authority to have cost Mr. Bement not less than $150,000, while the meteorites contained in it are said to have cost an additional $50,000. This great acquisition places the mineral collection of the North American Museum on a footing comparable with that of the greatest collections in Europe, and the meteorite collection is probably surpassed only by those at the British Museum and the Royal Museum at Vienna. The collection arrived at the museum during the last week of the old year, has been unpacked and its installation is proceeding as rapidly as possible. The old museum collection has been relegated to drawers for the present, but eventually the two are to be consolidated.

Prof. Henry Fairchild Osborn has resigned his position as assistant to the president of the American Museum of Natural History, in order to have time to attend to his new duties as vertebrate paleontologist to the United States Geological Survey. He retains, however, the curatorship of the department of vertebrate paleontology in the museum, and will continue as heretofore the building up of the collection the assembling of which has been under his direction for the past ten or eleven years.

Prof. H. C. Bumpus, of Brown University, has been called to the position in the American Museum left vacant by Prof. Osborn, and he assumed office as "assistant to the president" on the 1st of January. Recent invertebrates have been taken away from the department of geology and reptiles and fishes from the department of vertebrate zoology and erected into a new department, of which Prof. Bumpus has been made curator.

The old department of geology has been further subdivided by constituting a new department of mineralogy, of which Mr. L. P. Gratacap has been made curator. Mr. Gratacap also retains charge of the recent shells, of which he has had the care for several years. Prof. R. P. Whitfield remains curator of the reorganized department of geology and invertebrate paleontology, which these changes restore to the scope which it had when he came to the museum more than twenty-three years ago. Dr. E. O. Hovey, who has been assistant curator in the department for seven years, has been advanced to be associate curator.

Geological Society of Washington.—The following was the program for the meeting on January 9th: N. H. Darton, "Comparison of the Geology of the Black Hills with that of the Front Ranges of the Rocky Mountains;" A. H. Brooks and A. J. Collier, "Glacial Phenomena in the Seward Peninsula, Alaska;" A. C. Spencer, "The Physiography of the Copper River Basin, Alaska."

A sketch of Dr. Lucius Lee Hubbard, former state geologist of Michigan, is given in the Michigan Miner, vol. 3, No. 1, Dec. 1, 1900. The sketch is accompanied by a photograph and was written by Dr. Alfred C. Lane, the present state geologist.

A new "Geological Review" has been established in Germany, edited by Dr. K. Keilhack, at Berlin, published by Borntraeger Brothers, at Leipzig. The first number is dated Jan. 1, 1901, has thirty-two pages and embraces reviews of geological contributions from all parts of the world, printed in German, French and English. The American co-editors are F. D. Adams, H. M. Ami, W. H. Beal, E. Böse, W. M. Davis, F. P. Gulliver, Eugene Hussak, F. H. Knowlton, H. B. Kümmel, C. Palache, H. Ries, R. D. Salisbury, T. W. Stanton, and J. E. Wolff. There are sixty-three other co-editors. G. E. Stechert, New York, agent. Subscription, 30 marks.

The Department of Geology and Geography at Harvard University will move at the en dof this college year into the new wing of the University Museum, now being constructed for its use. This will relieve it from the cramped quarters which it has occupied for so long.

On Nov. 16 and 17 a party of Harvard students and instructors returned the visit of their Yale fellow workers. Friday afternoon was spent in visiting the museums in New Haven, the evening in social and scientific conference, and Saturday was given to trips to regions of geological interest near.

The first year men in research, in the Division of Geology at Harvard University are engaged in a very detailed survey of the Middlesex Falls, under the guidance of Dr. T. A. Jagger, Jr. This is on a larger scale than heretofore ever attempted. The contour map of the Metropolitan Park Commission is used as a basis. The area of survey is to be gradually extended.

Professor J. W. Gregory, of Melbourne, Australia, passed through the country in November, on his way to London to arange for a boat for the British Antarctic epedition, which is to start next summer. He made short stops at Chicago and at Cambridge, to meet the geologists there and look over their equipment.

Geological Society of Washington. The annual meeting for the election of officers was held on December 19th. At this meeting Mr. Whitman Cross gave the presidential address on "The Development of Systematic Petrography in the Nineteenth Century." At the meeting of December 12th the following program was presented:

C. W. Hayes:—Geological relations of the Tennessee brown phosphate.

Lester F. Ward:—The autochthonous or allochthonous origin of the coal and coal plants of central France.

E. E. Howell:—Exhibition of a geologic relief map of the United States.

The Petrographical Reference Collection of the U. S. Geological Survey at present numbers over 1,000 specimens, with complete card indices, and is now available for the use of petrographers. It is hoped soon to issue a descriptive circular for the information of all to whom such a collection may be of value. One of the features of this collection is the valuable series of the igneous rocks of the Christiania region which Prof. W. C. Brögger brought to this country when he came last spring to deliver the George Huntington Williams memorial lectures at Johns Hopkins University.

Mother Lode District, California. The United States Geological Survey has recently published Folio No. 63 of the Geological Atlas of the United States designated the "Mother Lode Survey District Folio, California."

The folio comprises two sheets of topographic maps, on the scale of one mile to the inch (1-63, 360), embracing an area six and one-quarter miles wide and about seventy miles long, two sheets showing the relation of the mining claims to topography and geology, two sheets illustrating the areal and economic geology, and two sheets of structure sections.

In the eleven pages of descriptive text, signed by F. L. Ransome, geologist, there is presented a concise and simple statement of the general geological features of the district. The history of the events which led up to the present geological, economic, and topographic relations is also briefly told.

The gold-quartz veins, which give to this region its chief importance, are discussed with reference to origin, structure, and relations to the inclosing rocks. This general account of the auriferous lodes is followed by brief notes on the prominent mines. The resources of the district, other than gold, are treated at lengths proportionate to their relative importance. The more important results derived from the investigation of the district, especially those which may be of value in its future economic development, are finally gathered together in a terse summary.

THE WASHINGTON ACADEMY OF SCIENCES is preparng a new directory of the membership of the Academy and of its nine affiliated societies. This will conform in general character to the directories of the scientific societies of Washington, D. C. heretofore published.

MR. T. C. WESTON has written and published a volume giving reminiscences of his thirty-five years connection with the Geological Survey of Canada, which began in 1859 and ended in 1894. These pages recall men who have been noted in Canadian geology—Logan, Hunt, Billings, Richardson, Barlow, Murray and others.

THE COLLECTION OF DUPARC'S GREAT RELIEF MODELS of structures of the Alps includes one that shows the Glarner double fold according to A. Heim. Others illustrate vividly symmetrical and unsymmetrical anticlinal folds; inverted arches and anticlinal folds and other interesting mountain structures. This collection of eight models in plaster of Paris was displayed at the Swiss national exhibition at Geneva, in 1896. It is one of the most important series available for museums or lecture-rooms. The cost is $100.

GRANITE MONOLITHS are being quarried at Vinal Haven, Maine, for the cathedral being built at Morning side Park, New York. Thirty-two of these columns are required to be 54 feet long and 6 feet in diameter, each weighing 160 tons, or two-thirds as much as Cleopatra's needle in Central Park. For dressing and polishing these granite columns they are mounted in a giant lathe and revolved so as to bring their exterior surface first against cutting tools and afterward on polishing materials. This lathe is 86 feet long and weighs 135 tons, and the rough stone which it reduces to dimension, weighs at first as much as 310 tons. This lathe was designed and patented by engineers of Boston, and was constructed in Philadelphia.—(*Sci. Am.*)

Fig. 1. VIEW IN THE GORGE, SHOWING THE JOINT STRUCTURE OF THE SCHIST.

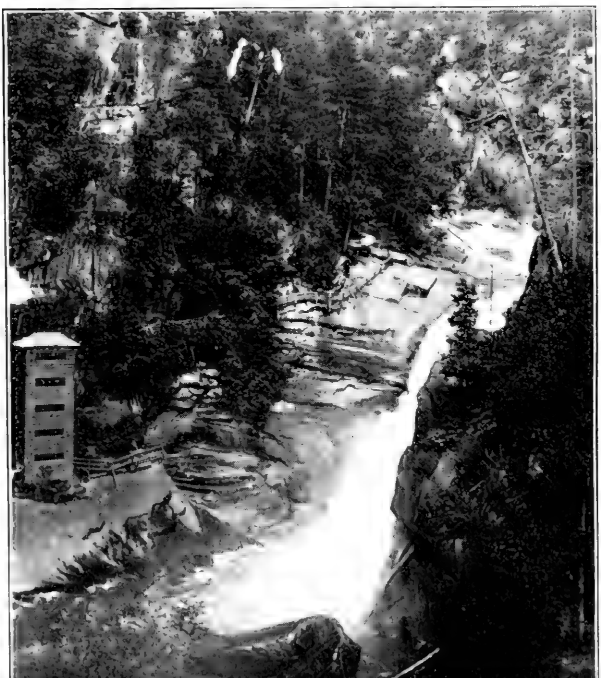


Fig. 2. A TYPICAL VIEW IN THE GORGE.

AMERICAN GEOLOGIST.

VOL. XXVII. FEBRUARY, 1901. No. 2.

THE GEOLOGY OF THE TALLULAH GORGE.

By S. P. JONES, Vanderbilt University, Nashville, Tenn.

PLATES IX–XI.

Introductory and general description.

In papers of a physiographic nature the Tallulah gorge in northeastern Georgia has been incidentally mentioned by different writers a number of times.

Nothing on it per se, however, has ever appeared, with the exception of an article of a rather general character by Dr. W. L. Jones, formerly professor of geology at the University of Georgia, published in the *Atlanta Journal* about 1892.

An opportunity was afforded the writer during the past summer to examine the region in detail, and the following paper is offered as a small contribution to the geology of Georgia.

The Tallulah river rises in western North Carolina just above the Georgia line, flows in a southeasterly direction through Rabun county in the extreme northeast corner of Georgia and, uniting with the Chattooga at the South Carolina line, forms the Tugaloo, a tributary of the Savannah.

Its entire course is within the Blue Ridge mountains, the easternmost of the southern Appalachians, its flow being down the southeastern slope and approximately at right angles to the axis of the range.

By reference to the accompanying topographic map (Plate X.) it will be seen that all the streams in the region under consideration have dissected deep valleys, while the more prominent peaks and ridges exhibit a close correspondence in altitude along a northeast southwest direction, with a fairly uniform increase in hight from the southeastern foothills to the crest of the range. It will also be noticed that the head waters of Panther creek, which empties in the Tugaloo a few miles below the mouth of the Tallulah, and those of Glade creek, a tributary of the Chattahoochee, are within less than a mile of each other with a low divide between them.

The investigations of geologists most familiar with the southern Appalachians have shown that the greater portion, if not all, of the province has been twice base-leveled—once during Cretaceous and once during Tertiary times.*

In the region around Tallulah falls, however, considerable areas seem not to have been reduced to base level and, owing to close proximity in altitude and other complicating conditions, the differentiation of the two peneplains in northeastern Georgia is not easy.

For the last four miles above its confluence with the Chattooga the Tallulah river cuts through the southeastern side of a series of broken ridges called the Tallulah mountains and it is here that the gorge and falls of the same name are located.

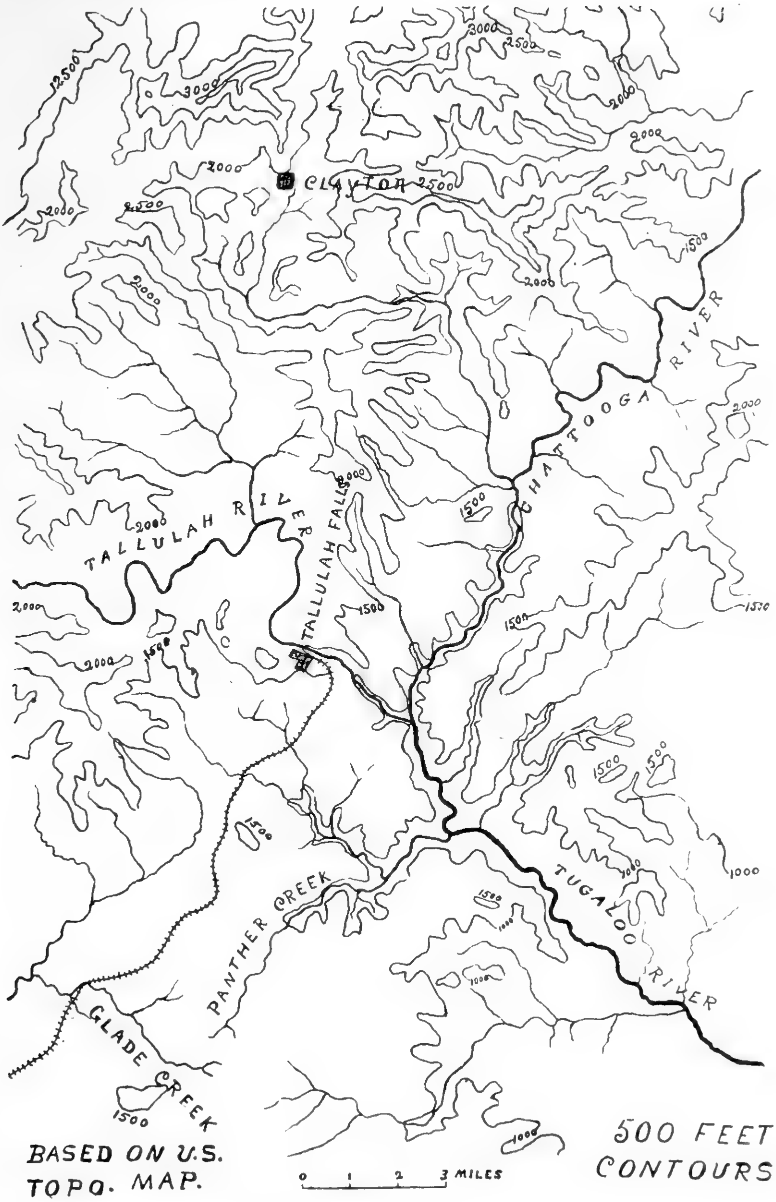
In the region of the gorge the river has a normal flow, as determined by Mr. B. M. Hall, hydrographer for the U. S. Geological Survey, of about 180 cubic feet per second.

The town of Tallulah Falls is on the western side of the river three miles above its mouth and an iron bridge, convenient in locating positions, spans the gorge on the road to Clayton, Georgia.

The gorge begins about a mile and a half above this bridge and runs all the way to the mouth of the river. From here it may be considered as being continued by the Tugaloo for about two miles.

Above the gorge the Tallulah presents the usual characteristics of a rapid flowing mountain stream with steep slopes on either side and sufficient valley land at places to afford small farm settlements. Below the gorge the Tugaloo presents a similar aspect characterized, however, by broader al-

*C. W. Hayes, and M. R. Campbell, Geomorphology of the Southern Appalachians. *National Geographic Magazine.* 1894, vol. vi, p. 63-126.



TOPOGRAPHICAL MAP OF THE REGION OF THE TALLULAH RIVER.

luvial borders and a more rounded contour of adjacent hills as it approaches the Piedmont plain.

The falls occur in a section of the gorge three-fourths of a mile long beginning half a mile below the bridge. Named in succession, they are: L'Eau d'Or, Tempesta, Hurricane, Oceana and Bridal Veil. None has a vertical fall of over ninety feet, though the total descent of the river from the first to the last fall is about 360 feet.

At the Indian Arrow rapids, just above the falls, the river is a hundred feet below the principal street of the town, somewhat arbitrarily assumed as the level of the upper edge of the gorge at this point. From here the gorge deepens and widens rapidly, reaching its greatest depth in the neighborhood of the horseshoe bend in the portion below the falls termed the Grand Chasm. Here the gorge is 530 feet deep as measured from the roadbed of the Northeastern Georgia R. R., which runs for a short distance along the brink of the chasm. Reference to the accompanying map and profile (Plate XI.) of a portion of the river will bring out these points more clearly.

From the Grand chasm to the junction of the two rivers the gorge is somewhat shallower and with less definitely defined walls than in the region just described, some strips of cultivated land bordering each side of the river near its lower end. It is in the region of the falls and Grand chasm that the typical gorge character is best developed and it was doubtless the wild, rugged scenery of this portion that suggested the Indian name "Tallulah" or "the terrible."

Geological Features.

Tallulah falls is situated within the region designated on any geological map of Georgia as the "Crystalline Area."

This formation embraces all the northeastern portion of the state and is made up principally of granites, gneisses and crystalline schists.

The exact position of these rocks in the geological time scale has never been determined. They are generally classed as pre-Cambrian.

In the small geological map accompanying this article (fig. 1.) three areas are shown—a quartz schist formation, a narrow belt of limestone and a biotite schist on either side of the limestone. The first merits special description, the gorge being confined to it.

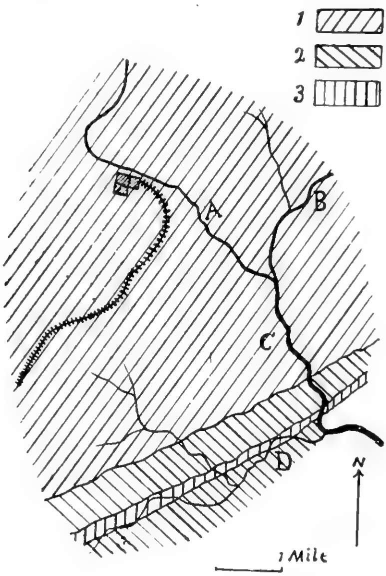


FIG. 1. 1 Quartz schist; 2 Biotite schist; 3 Limestone; A Tallulah river; B Chattooga river; C Tugaloo river; D Panther's creek.

This quartz schist, as far as mapped, exhibits an unusually well developed joint structure one of whose planes corresponds closely with the schistosity dip which is about 25° in a direction south 20° west.

If this schist was derived from pre-existing sedimentary rocks, as seems probable, the strike of the true bedding planes, which have since been obliterated in the perhaps several times repeated metamorphism of the region, must have corresponded with that of the limestone belt which, as can be seen from the map, makes a large angle with the schistosity strike.

The course of the Tallulah, and indeed of all the streams in the region under consideration, seems to show no evidence of close adjustment between the flow of the rivers and the dip and strike of the rocks.

Figures 1 and 2, plate IX. show very well the joint structure mentioned above and the relation of the river to the rock.

Megascopically the schist is a gray, medium grained, compact rock and exceedingly hard under the hammer. The schistose structure is not conspicuous in unaltered specimens, but shows plainly wherever weathering has taken place. Irregularly distributed masses of pyrite are quite abundant and on all exposed surfaces the iron oxide stain resulting from their decomposition is characteristic.

Under the microscope the rock is seen to be composed principally of quartz; this material probably amounting to 90^0 of the whole. Feldspars are next in abundance, muscovite probably next, pyrite, some biotite, occasional grains of magnetite, small crystals of apatite and a few isolated masses of some irregularly shaped, highly refractive substance showing low double refraction and giving no very satisfactory indications as to its nature.

The quartzes are in the form of irregularly shaped grains closely interlocked, many showing wavy extinction and all more or less shattered, with the cracks filled with subsequently deposited silica. Nothing in the nature of a zonal structure or anything indicating original sedimentary material is to be found, but owing to the evident crushing and metamorphism that has taken place this can only be regarded as negative evidence with reference to such a possible origin.

Of the feldspars, microline and plagioclase are the most abundant with some perthitic intergrowths of orthoclase and plagioclase. Much of the feldspar is broken and cracked like the quartz, but not to so great an extent.

Some of the muscovite has undergone alteration and is accompanied by granular epidote.

The biotite is frequently accompanied by sheaf-like masses of minute needle-like crystals showing very high interference colors—doubtless rutile. A chemical determination of the amount of silica present would enable the rock to be classified with greater certainty.

At several points along the gorge thin seams or lenticular masses of intercalated, highly graphitic margarite schist carrying crystals of tourmaline are noticeable.

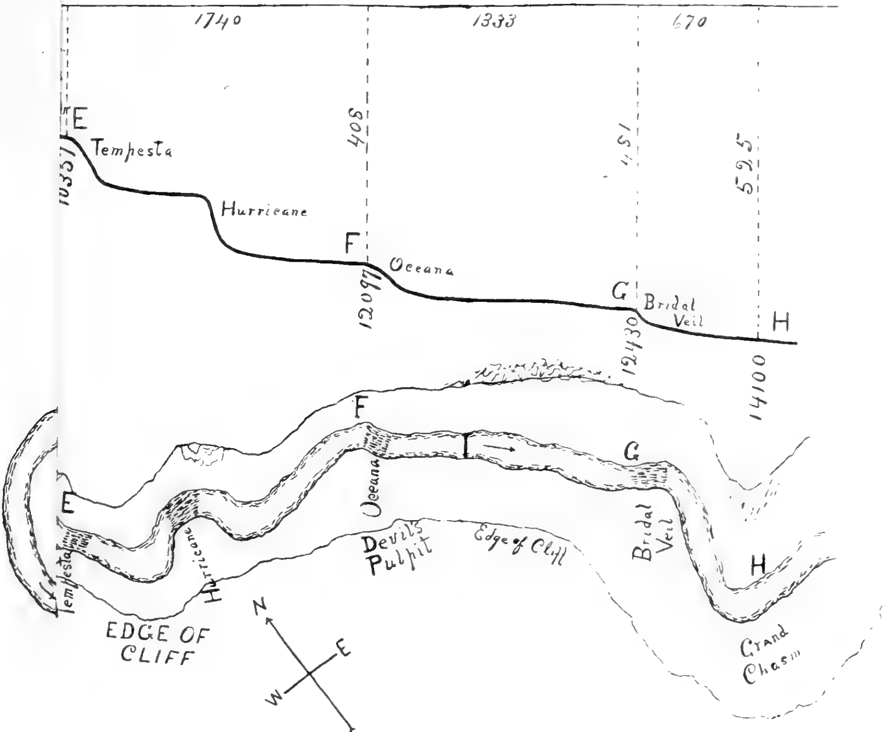
The limestone and biotite schist may have possibly had some influence in determining former drainage, but present no special features for present consideration.

Origin of the Falls and Gorge.

Detailed examination of the gorge and river with related topographic features brings out clearly two important facts —1st, that the gorge has been produced entirely by the erosive action of the river, assisted by atmospheric agencies, and, 2nd, that both the falls and gorge are, geologically speaking, of very recent age.

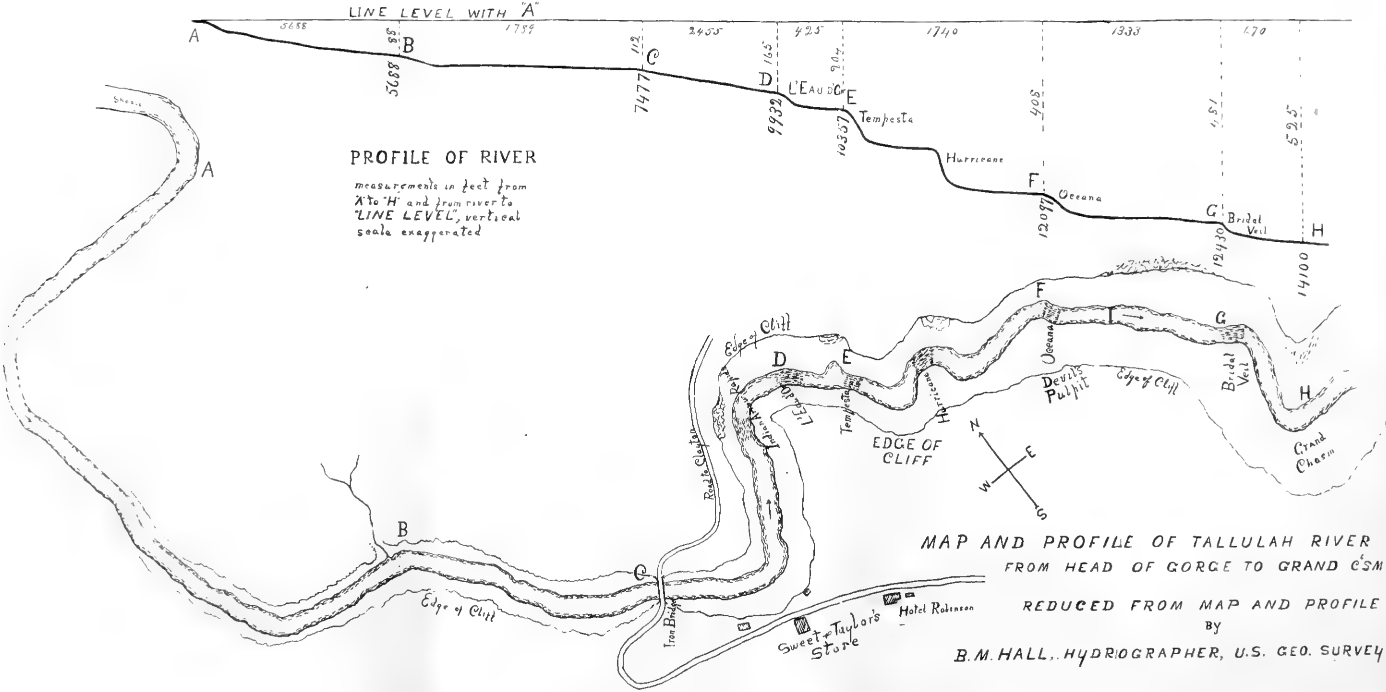
Evidences of marked stream erosion are everywhere visible along the margin of the river in the upper part of the gorge. At the Indian Arrow rapids, above the falls, the river has, by deflection and concentration of its flow, on the left bank exposed on the west side a considerable portion of bed rock, now a yard or more above normal water level. An instructive display of pot-holes is to be seen here in the hard, polished rock, some of them four or five feet in diameter and deeper than broad. A little farther down stream on the right bank a large pot-hole can be found about two yards above water-level, partially filled with decayed rock and vegetable mould and having in it the stump of a tree five or six inches in diameter. The absence of similar evidences of stream action along higher levels is to be noted and is due to the widening of the gorge that has taken place through atmospheric agencies. The well developed joint structure of the schist has greatly facilitated the rapid action of these agencies in a climate where alternate freezing and thawing is frequent during the winter season, and the tumbling in of large blocks has produced a recession of the walls of the gorge probably pari passu with the down cutting of the stream. Also the rock, though of a hard flint-like texture, weathers rapidly in the moist air of the gorge, the decomposition of the pyrite and feldspars allowing the quartz grains to fall apart. The greater width of the lower portion of the gorge bears testimony to its greater age and the longer continued action of these forces. The comparative youth of the gorge is indicated by the steep grade of the river and the presence and character of the falls as well as by the steepness of the walls.

The immediate location of the falls is not a permanent one, but they are constantly working up stream at a rate that may be rapid enough to admit of measurement, though inquiries



MAP AND PROFILE OF TALLULAH RIVER
FROM HEAD OF GORGE TO GRAND C'SM

REDUCED FROM MAP AND PROFILE
BY
B. M. HALL, HYDROGRAPHER, U.S. GEO. SURVEY


LINE LEVEL WITH "A"
PROFILE OF RIVER
measurements in feet from "A" to "H" and from river to "LINE LEVEL", vertical scale exaggerated
L'EAU D'OR
Tempesta
Hurricane
Oceana
Bridal Veil
Edge of Cliff
EDGE OF CLIFF
Devil's Pulpit
Grand Chasm
Road to Clayton
Iron Bridge
Indian Arm
Sweet & Taylor's Store
Hotel Robinson
MAP AND PROFILE OF TALLULAH RIVER
FROM HEAD OF GORGE TO GRAND C'SM
REDUCED FROM MAP AND PROFILE
BY
B.M. HALL, HYDROGRAPHER, U.S. GEO. SURVEY

among the old inhabitants of the neighborhood failed to throw any light on this point. There is nothing, however, to indicate that they have migrated from a definite, initial position as in the case of a fall like Niagara working back by undermining. Indeed, the presence of a number of sloping falls (they are all more or less sloping) instead of a single vertical one would preclude the idea of any such origin. They are rather to be looked upon as rapids or shoals of an accentuated type where the grade of the river is steepest in its course to the lower level of the Tugaloo.

Mr. C. W. Hayes thinks that the Chattooga river and the tributary Tallulah have been captured and diverted from the Chattahoochee to the Savannah drainage system by the Tugaloo and that the falls on the Tallulah show that the Tugaloo has not yet had time to subdue the recently acquired territory.* Mr. M. R. Campbell has also advanced views of a similar nature.†

As both these writers consider a case of stream piracy to have taken place here, the origin of the gorge will first be considered on such a supposition.

From the top of any prominent peak east of Tallulah river in the region of the gorge a long even-crested ridge, the Chattooga ridge, can be seen on the southeastern side of the Chattooga. A natural continuation of this is seen west of the Tallulah in the region of Panther creek, while a deep gap, through which a broad vista of the low country is obtained, marks the position of the Tugaloo. If a capture took place it was probably at a point a short distance above the mouth of Panther creek; the Chattooga originally continuing its course to the Chattahoochee along the valley of Panther creek and its west fork, the present reversed drainage of this creek being necessarily brought about by the lower grade of the Tugaloo. The divide between the western fork of this creek and several creeks tributary to the Chattahoochee is at its lowest point between 300 and 400 feet above the present level of the Tugaloo at the juncture of the three streams, and Chattooga.

*C. W Hayes. The Southern Appalachians, *Monograph*, National Geographic Society, 1896, vol. i, p. 327.

†M. R. Campbell. Drainage modifications and their interpretations. *Journal of Geology*, 1896, 4, 657-678.

While there is no way to measure the erosion that has taken place at this point since the supposed capture, nor the relative rapidity of the lowering of the land here, as compared with the lowering of the bed of the Tugaloo, yet as it is now the divide between the two creeks and is undergoing considerable erosion, it is not unreasonable to suppose that at the time of capture it was as much as 500 feet above the present level of the Tugaloo at the jucture of the three streams, and that the grade of the Chattooga at that point, and therefore necessarily at the mouth of the Tallulah, was before the capture that much above its present level at the mouth of the Tallulah.

From an examination of the profile of the Tallulah, as shown on the map (Plate XI), it will be seen that a line of level from the river bed at the head of the gorge to the Grand Chasm is 525 feet above the river at the latter point, or approximately coincides with the brink of the cliff at its highest point. In other words, if the Chattooga was once 500 feet above its present level where it is joined by the Tallulah the latter river could have reached it by an easy grade without having had to cut a gorge. On the capture, however, of the Chattooga at a point a short distance below the mouth of the Tallulah by the Tugaloo, the grade of the first named river would have been lowered sufficiently to necessitate the cutting of the gorge through which the Tallulah now flows. Careful search in the region across which the Chattooga would have had to flow failed to reveal anything like river gravel, but subsequent erosion may have entirely obliterated the old stream bed.

The theory of capture has lately received corroborative evidence from a comparative biological study showing similarity in a portion of the unione fauna of the Chattahoochee and Savannah rivers.* There is also some evidence of forms in the Savannah system that point to a round-about derivation from forms of the Tennessee river through former connection between it and the Coosa river in Alabama and between the Coosa and the Chattahoochee by way of the Etowah in Georgia, and from the Chattahoochee to the Savannah system by

*Chas. T. Simpson. On the evidence of the Unionidae regarding the former courses of the Tennessee and other Southern rivers. *Science*, vol. xii, No. 291, p. 133.

former connection at the locality under consideration.*

If the Chattooga originally belonged to the Savannah system, and no change of position has taken place, then the next theory that would seem to suggest itself as explanatory of the evident recentness of the gorge cutting would be that the differential movements that are known to have taken place at the end of the Columbia and LaFayette in some way caused particular activity in stream erosion at this locality.

Under either theory, however, the absence of a gorge of similar character in the adjacent Chattooga would appear to need explanation.

PALEONTOLOGICAL SPECULATIONS.

L. P. GRATACAP, Am. Mus. Nat. Hist., N. Y.

I.

In the search for those variations whose accumulated force ushers in new forms in the life series, and by whose influence on the organism as a whole a kinetic impulse is established in a new direction, no more useful field of observation can be chosen than the detailed results of a survey like that of New York. In these volumes devoted to palaeontology we have displayed with laborious care the whole series of species, with their variations and blendings, contrasts and modifications, which the active work of the field, the combined painstaking labors of many students, and the criticism of a final revision have gathered, prepared and published.

A very large amount of the material which formed the basis of these studies ,and a fair number of the type and figured specimens presented in the earlier volumes of the New York survey, and in the Reports of the Regents of the University are today permanently located on the shelves of the exhibition cases of the American Museum of Natural History. The exhaustive catalogue† of these alone, now partially prepared by Prof. R. P. Whitfield and Dr. E. O. Hovey, show their extent, while associated with them are numerous specimens, and many large slab groups of species, the whole collection forming, certainly not a complete, but a very instructive view of

*C. W. HAYES, and M. R. CAMPBELL, locality cited, p 131.
†Bulletin, *American Museum Natural History*, vol. xI.

palaeozoic life. From these, and the published results of the survey the following conclusions have been drawn. It is true that the eye cast over a page of expressive drawings meets more saliently relieved the physical characteristics, size, ornamentation, shape and sculpture of fossil shells and organisms than it does in a line of selected fossils where the number, the surficial dullness and imperfection perhaps fail to produce "at sight" the impression made by luminous and exactingly executed drawings. Still there can be no question that the "original specimen" can never be evaded, and for scientific purposes it is of incomparable value. In a field of general observation, devoid of the extreme precision of "species making," or taxonomic study, both figure and specimen can be usefully studied, and in this paper, conceived as a contribution to evolutional studies, they have been made to supplement each other, the lack of opportunity and material forcing me to rely on drawings perhaps more confidently than I should.

Dr. Sacco in his examination of the Tertiary mollusca of Piedmont* has been impressed with those gradations of form. sculpture, color, size, etc., which insensibly merge one species into another, and he deduces some general conclusions, which are of interest in the examination of any group or succession of groups of fossils at any horizon. He finds a species, in a typical condition, has grouped about it more or less aberrant forms, referable, however, to it; he thinks, by reason of priority a variety of species is given the name which should be assigned to the essential form, which through the custom of terminology receives another name. He finds some species mutable and evanescent, others less changeable and dirigible only between certain fixed limits of form; he finds the extremely variable the most vitalized, and they are those which continue for a long series of geological periods, as "their great oscillatory polymorphism around a typical form permits them to adapt themselves to the diverse conditions which succeed each other in the same region, in different geological periods," while more conservative forms disappear or become so fully modified, as to form new and serviceable species. He notes the fact that upon ornamented species the progress of change

*Le Variazioni der Molluschi, DOTT. FEDERICO SACCO; *Bulletino della Societa Malacologica Italiana*. 1893.

is most evident, that litoral species are more valuable, less stable than pelagic and abyssal forms, that the varieties of one period develop into the typical species of another, that this development attains a surprising rapidity in some instances, that faunas disappear, and again later, under presumably similar conditions, reappear. Dr. Sacco finds that variations of color are less important than those of form. He dwells, as many other observers, on the internal tendency and external circumstances as constituting the two influences determining change. Amongst the latter are first, biological circumstances, as nutrition, enemies, parasites; second, chemical, as nature of ocean floor, nearness of river mouths, material dissolved in the water; third, physical, as light, conformation of the sea bottom, depth, temperature; fourth, mechanical, water movements.

His canons of judgment in estimating change, are the addition or diminution of features, and the gradual increase of one feature. He insists on the adequacy of the shells of molluscs to resolve the problems of this development. His especial region of research, the tertiary basin of Piedmont, has furnished him with a most illustrative exemplification of these facts of variation, undisturbed by conditions of immigration, branchings, migration, etc. But he finds himself in carrying on the great work of Bellardi, involved in perplexities of terminology as to the limits and application of the terms sub-genera, variety, sub-species, sub-variety, forms, "mutations," etc.

Studies of this nature amongst invertebrates have engaged American palæontologists, and they have especially attracted the attention of Prof. Alpheus Hyatt, Dr. R. T. Jackson, Prof. H. S. Williams, Dr. C. E. Beecher, Prof. J. M. Clarke and Dr. W. H. Dall. At present the examination in its entireness throughout the palæozoics has not reached conclusive dimensions, and every additional contribution, if honestly conceived, cannot be regarded as unwelcome, unnecessary or inopportune.

Prof. H. S. Williams in Bulletins 3 and 80 of the U. S. Geological Survey has discussed the changing facies of faunas, Devonian and Carboniferous, and has indicated how variations have followed slightly changed conditions, and to what extent, in the area considered, groups of associated forms compose characteristic biologic groups that seem to appear and disappear with an exactitude that expresses their identical relations to similar environments. Indeed he says:* "the precision with which correlations may be made upon paleontologic evidence is determined by the knowledge possessed of the relations of the elements of organic form to geologic age, so that a fragment of a fossil in the hands of one who knows how to interpret the evidence may furnish a more correct diagnosis of the age of the formation than a bushel of fossils in the hands of one ignorant of the laws of organic life determining the form of the structure produced." He further in this notable essay alludes to the "laws of heredity and evolution," and to the "law of relationship of organisms to each other and to geologic time." And he concludes "comparisons of allied species in the same genus exhibits to him the rate and direction of modification taking place in the genetic history of the genus, and in the plastic or variable characters he finds a sensitive indication of the stage of development attained by the race when the particular individual lived."

A contribution to the genetic relationship of the invertebrate fossils of successive beds of the Tertiary was made in 1885 by Dr. Otto Meyer† who endeavored, upon the relevant evidence of evolutional changes, progressive in character, to overturn the recognized succession of the southern Tertiary Eocene. The succession of Claiborne (Middle Eocene), Jackson (Upper Eocene), Vicksburg (Oligocene), which had been defined and established by Hilgard, was inferentially reversed, and the Vicksburg became the oldest, and the Claiborne the youngest stratum. In this particular instance the paleontologist was worsted in an encounter with the less yielding and less supposititious data of the stratigrapher.‡ But Dr. Meyer's contribution lost none of its interest, because of a mistaken interpretation, as an index of the application of biological inferences to the questions of stratigraphy; at least Dr. Meyer's genealogical table was in the nature of a remonstrance against wholesale species making, and was a stalwart introduction of

*Correlation Papers, Devonian and Corboniferous, by HENRY SHALER WILLIAMS; *Bulletin* 80 *U. S. Geol. Surv.*, p. 263.

†*Amer. Journal Sci. and Art.*, vols. xxix. and xxx.; pp. 457, 60, 421.

‡See E. W. HILGARD, The Old Tertiary of the Southwest, *Amer. Jour. Sci.*, vol. xxx., p. 266.

the theory of derivation into geological problems.

Dr. Meyer's conclusions were based upon relationships of fauna, as that the lowest Claiborne is more nearly related in faunal features to the Jackson, than is the highest Claiborne, etc.; and upon a study of variations, where it was tacitly assumed that the typical form of a species varied from its first characters progressively in time, giving rise to new species, as the original or ab-original forms disappeared.*

Dr. Jackson in his now well known essay on the "Phylogeny of the Pelecypoda"† has engaged in the difficult labor of disentangling a line of descent for the Aviculidæ from a hypothetical nuculoid shell and a problematic genus Rhombopteria which he placed in the Lower Silurian and from which through divergent branches of descent incorporating the Devonian genera Actinopteria, Ptychopteria, Pterinopecten, Aviculopecten, Crenipecten, Lyriopecten, Pernopecten (?), he reaches Pecten, Spondylus, Plicatula, Placuanomia, Placuna, Perna, Ostrea, Vulsella Meleagurina, Malleus. This comprehensive examination of a special section was directed to the elucidation of a question of descent, and indicated no generalizations less exclusive than the origin and development of this group of shells.

Also in Jackson's and Jaggar's Studies of *Melonites multiporus,* and in the former's elaborate investigation of the Palaeechinoidea‡ the biologic processes of development and the morphological scheme of tesselation in the test the field of observation was necessarily restricted. In general treatises such as Gaudry's¶ *Les Enchainements du Monde Animal,* the speculative conclusions of evolutional relationship are only dwelt upon in the general outlines of animal genealogy.

In any general reference to studies of this nature, Dr. Beecher's essays on the Development of the Brachiopoda, Prof. Hyatt's work on the Phylogeny of the Cephalopoda, and Dr. Hall's "Hinge of Pelecypods and its Development" must be remembered. These are special treatises dealing, with

*A similar mistaken inference with regard to the zoological sequence in the Cambrian faunas, caused, for a long time, as Dr. Walcott has explained, the superposition of the Olenellus beds over those carrying Paradoxides.

†*Mem. Boston Soc. Nat. Hist.*, vol. iv., p. 277.

‡*Bull. Geol Soc. America,* vol. vii., 1895-6, pp. 135 and 171.

¶Les Enchainements du Monde Animal dans les Temps Geologiques; Fossiles Primares.

technical precision, with circumscribed questions. They involve great special knowledge and are based upon a careful comparison of observations along a particular line of zoological inquest. But the search for some general tendency, some broad teleological movement of forms, prevailing as a tectonic impulse over or through a diversity of animal groups has not been so extendedly followed. Such a search deals only with primary relations, as size, form, ornamentation, complexity, fecundity.

It deals with more general and simpler questions and it seems reasonable to expect can be answered by an inspection simply of the work of the specialists. For, as Dr. Beecher has said (Origin and Significance of Spines) "the history of a group of animals is the same. The first species are small and unornamented. They increase in size, complexity, and diversity, until the culmination, when most of the spinose forms begin to appear. During the decline, extravagant types are apt to develop, and if the end is not then reached, the group is continued in the small and unspecialized species, which did not partake of the general tendency to spinous growth." An adequate comparison then of the phylogenetic work done in different sections of animal life might reveal general tendencies or laws. It is not difficult to see that it does. In this paper the suggestions are derived from an inspection of the Hall Collection.

SIZE AND SKELETON MASS.

It is evident that in any animal series the primary members are small. It is inconceivable that a group of animals where the members attain any considerable size can on its first appearance in geological time assume complete physical development. An inspection of the Lower Cambrian faunas shows this diminutiveness. With the exception of trilobites the forms are small. The genera *Iphidea, Acrotreta, Linnarssonia, Lingulella, Kutorgina, Obolella, Orthisina, Fordilla,* the patelloids, (*Scenella, Stenotheca*), and the pteropods(?) all express molar immaturity. Organization preceded skeletal deposition.

This fact has considerable interest and appears to contain suggestions of phylogenetic importance. If we find in a fossil fauna well developed skeletons or thickened hard parts (shells, carapace, hinges, etc.), we may conclude that the group represented has attained functional equilibrium, and has existed longer than similar organisms of less physical mass or internal osseous or shelly deposits. The simple and obvious condition prevalent in individuals has an adumbrant genetic application.

While it is unquestioned that favorable conditions, stimuli both of health and food, accelerate the deposition of hard parts, yet it is certainly clear that age brings, of necessity accumulation of material, both because secretion has acted through a longer period of growth, and that in senility the turgor of the secreting membranes so increases as to give rise to heavier depositions of mineral substances (calcification).

And it seems a just inference that at the inception of a group of organisms their physiological relations precede the skeletal sequelæ of these relations, that if hard parts are secreted in the early stages of an organism's history the function of their secretion increases by use, by heredity, through time, and the habit of forming them is reinforced and extended as the organism is geologically older. It is conceivable that the mollusca began in shell-less or almost shell-less organisms,* that the acquisition of shell, the elaboration of hinge teeth and even the interlaminal deposition of "loops," "arms," or internal appendages as mineral or hard parts was slowly, with a slowness sensibly reflected in their palæontological phases, consummated. Or, in other words, the appearance of well developed hard parts internal or external, skeletal or tegumentary, marked an evolutional climax. This is really an ordinary assumption. The biology of the mollusca, and crustaceans, and echinoderms shows the secondary and subsequent development of the hard parts. They are themselves symptomatic of the finished phases of embryological changes. An incomplete power of secretion must have marked the earlier phases of histological growth. In the evolutionary process the heavier armored, thicker shelled, harder carapaced organisms must have followed the more slender fragile and tenuous covered animals.

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*Investigation seems to point to Lingula as a primal form of brachiopodous life. (See Die Silurischen Craniaden der Ostseelands mit Auschluss Gotlands, bei FRIEDRICH BARON HOYNINGEN HUENE. *Verhandlungen der Russisch-Kaiserlichen Mineralogischen Gesselschaft* zu St. Petersburg, 1899). Dr. Beecher has already furnished the evidence to show that the progenitor of the brachiopod phylum was Kutorgina.

Of course this is a general proposition. Selection might rapidly augment the growth of hard parts in some sections of animal life, and comparative immunity from attack or injury, retard or but laboriously develop them in others. There seems no advantage in either size or mass except so far as one or the other, or both, enable an animal to resist destruction or in predatory examples, chase its prey.

The impression, very quickly and keenly felt in examining Cambrian fossils, is that they are small and thin. The trilobites remain conspicuously contrasted with their associated fauna, and suggestions are also evident that the worms may have been large. The morphological impulse which produced large trilobites and worms and left everything else small is not without interesting suggestions, especially as the largest and strongest examples are Middle or Lower Cambrian.

But primarily, is it true that Cambrian life exhibits diminutive and fragile forms? It certainly seems to. There are no large brachiopods, no corals of appreciable size, no large lamellibranchs, no crinoids, few and insignificant univalves. The character of the fauna in these respects is provisional and introductory. The examples of Brachiopoda belong mainly to the inarticulate group wherein functional organization is high, but the later secretatory activities, those which made shells, loops, teeth, etc., which became excited and specialized under new conditions or accidents, were yet dormant. Dr. Walcott, in his "Fauna of the Lower Cambrian or Olenellus Zone," has furnished a review and exposition of what is known of the fauna of this early age. It presents a scattered and broken outline, as from the circumstances was inevitable, of the invertebrate forms of life. It can be, as far as research has gone, neither full nor complete. The forms of life are small and feeble. The trilobites alone, and the worms, present evidences of abundance and development and strength.

In the Hall cabinet *Lingulepis pinniformis, Obolella polita, Lingulella mosia, L. aurora, L. stoneana,* in the western Potsdam are numerous and indicate zones or areas of successful multiplication. In the Troy limestone beds *Lingulepis minima, L antiqua,* and *Obolella prima* seem also plentiful. The trilobites present in the western sandstones the familiar feature of great numbers. The annelidan indications are necessarily suggestive, but in *Scolithus linearis, Arenicolites woodi,* the *Myrianites* and *Nereograptus* of Waterville, Kennebec R., Maine, we have plentiful evidence of their wide distribution.

The significance of the trilobites and the striking annelid indications cannot be overlooked. Before passing to these the thought of *Size and Mass,* in connection with development, suggests, with reference to trilobites, an idea of discrimination in regard to age. If the development of exoskeletons, hard parts, hinges and bony or chitinous coverings, is a mark of advanced biogenetic age, then as between two groups of trilobites whose relative antiquity is under discussion that group which presents the greater surface of such members is the younger. Should such a consideration have led *a priori* to the assumption of the greater age of *Olenellus* as compared with *Paradoxides,* because of the marked pygidial enlargements in the latter over the former? For in *Olenellus* the lateral lobes of the pygidium are absent, the axis alone remaining, while slight pygidial wings are incipient in *Paradoxides.* The growth of pygidia is noticeable in the trilobites of the higher Cambrian series, as in Ptychoparia (Conocephalites), Dicellocephalus &c.

In Agnostus and Microdiscus the dual development of head and tail is certainly conspicuous, but their category of growth and relationship is entirely different from the multipleural forms represented in Paradoxides and Olenellus. Olenoides shows also a uniform growth of head and tail. The impression given by a study of these early trilobites is that they were separated in habits of life into two groups, a rapidly moving natatory group like Olenellus, Protypus and Paradoxides with well developed head shields from mechanical reaction against pressure, and a sedentary group in which glabella and pygidium were more evenly related. And that between these extremes Conocoryphe, Ptychoparia, Ellipsocephalus, Agraulos, etc., presented a less determined phase of activity or rest. These considerations, of course, have no reference to their morphological affinities. There is certainly a definable relation between activity and cellular deposition of hard parts. Embryology proves that. The early stages of many sessile organisms, which develop in their maturity hard parts and more or less significant exoskeletons, are marked by great motility and excursive power. Such are the free-swimming larvæ of the Mollusca, the Pluteus of the echinoderms, the Nauplius and Zoea of crustaceans.

At any rate in looking over this phase of fossil forms in the Hall collection the skeletal development of the trilobites is an impressive fact.

If we take the enumeration of species given by Walcott in Bulletin U. S. Geological Survey No. 30, we find the relative percentages of the zoological elements of the Cambrian faunas in North America to be as follows:

Algae	2.30	Brachiopoda	17.04
Spongiae	3.30	Lamellibranchs	.25
Hydrozoa	1.27	Gasteropoda	7.37
Crinoidea	.76	Pteropoda	5.09
Annelida	1.27	Crustaceans	3.81
Trilobites	57.50		

The number of species in the trilobites more than equals, in its percentage of all (?) tabulated species, that of all the remaining forms of life. And when we consider their numerical proportion in individuals, and examine the blocks of friable sandstone from St. Croix or Trempeleau, Wis., we find they rival in individual enumeration the brachiopods. In short the trilobites in the Cambrian clay clearly suggest *biological preferment.*

In the ninth lecture in Dr. Brooks' series on the Foundations of Zoology wherein the question discussed is natural selection and the antiquity of life, the author places, after the initial stages of zoological development, the scene of the faunal growth on the floor of the ocean. He says, "I shall give reasons for seeing, in the Lower Cambrian, another period of rapid change, when a new factor—the discovery of the bottom of the ocean—began to act in the modification of species, and I shall try to show that, while animal life was abundant long before, the evolution of animals likely to be preserved as fossils took place with comparative rapidity, and that the zoological features of the Lower Cambrian are of such a character as to indicate that it is a decided and unmistakable approximation to the primitive fauna of the bottom, beyond which life was represented only by minute and simple surface animals not likely to be preserved as fossils." Dr. Brooks' assertion that "on the old Cambrian shore the same opportunity to study the embryology and anatomy of pteropods, and the gasteropods and lamellibranchs, of Crustacea and Medusæ, echinoderms, and brachiopods, that he now has at a marine laboratory" seems, if literally interpreted, misleading. Neither is the assumption of a sea bottom, in any abyssal sense, for the Cambrian fauna, at all warranted. The fossils are found for the most part in shore and off-shore deposits. In looking over the Cambrian specimens in the Hall collection Dr. Brooks' speculation, taken in connection with suggestions made by Simroth, (Entstehung der Landthiere), give however a peculiarly fascinating provocation for a supplementary assumption. In a passage of Simroth's of much interest the following observation occurs: "*A priori* the contact of both (land and sea) must form the probable area of the original creation, where both essential factors engaged each other. Therefore the oceanic Bathybius, already discredited by observation, would be found, as source of life, theoretically impossible or at least improbable. And it remains to ask where, in that plane of contact between the atmosphere and the hydrosphere, the most strenuous exchange uninterruptedly occurred, whether on the open sea, or in the coast line. The answer to me appears unqualifiedly to indicate the latter. If we assign, as has been done, to the great waves of the ocean a breathing function, then the surface of the lung passages through whose agency the respiration is effected, must be sought in the tireless movements along the shore, which would be assisted by the foam-masses of the free waves, even if only intermittently aided by stronger breezes. In the high seas, air and water come in contact with one another, but at the beach, water and land, and here the saturation with gas and mineral solutions is equal. But as it is from these opposite elements all interaction issues and depends, then at this position the centers are to be sought from which the organic impulse took its rise, radiating in two directions, seaward and landward."

Such a provisional locus for the inception of life might have resulted, at that moment when the cooling elements had acquired a proper chemical intricacy, for its creation, in a series of protistic bodies such as Pfluger has assumed, unreasonably it seems, existed in one great single concretion. He says, "accordingly I would say that the first proteid to arise was living matter, endowed in all its radicals with the property of vigorously attracting similar constituents, adding them chemically to its molecule, and thus growing *ad infinitum*. According to this idea living proteid does not need to have a constant molecular weight; it is a huge molecule undergoing constant never-ending formation and constant decomposition and probably behaves toward the usual chemical molecules as the same behave towards small meteors."

These protistic bodies,* formed at the margins of the insular masses in the primeval ocean, and beginning the development of derivative forms shoreward and seaward as Simroth suggests, originated two faunal expressions, an annelidean type along shore, a molluscan type in deeper water, and this deeper water fauna shows, at least in its totality, an increase in size and skeletal mass. Do not these Cambrian remains lend support to these curious propositions?

In Europe practically the Cambrian rocks are shore deposits. Their general character has been summarized by Geikie as follows, "the rocks of the Cambrian system present considerable uniformity of lithological character over the globe. They consist of gray and reddish grits or greywackes, quartzites and conglomerates, with shales, slates, phyllites or schists, and sometimes thick masses of limestone. Their false bedding, ripple marks, and suncracks indicate deposit in shallow water and occasional exposure of littoral surfaces to dessication." In America, as is well known, the limestone beds are well marked. At Troy, New York, Rutland, Vt., and in Nevada, Cambrian limestone strata have been described by Ford, Wolff, Foerste, and Walcott. Limestone beds of this age also occur in the St. Lawrence valley, in Newfoundland, in Arizona and Utah.

But these limestone beds though they may be regarded as distinctively belonging to offshore or deep sea sedimentation do not properly express the Cambrian geological facies. They are essentially exceptional, sporadic and ultra-limital. They present an invasion of a sea, and one in which we believe was being formed that more adequate and complete molluscan faunal ex-

*In a biological sense it is not unreasonable to bring in relation with these the pre-Cambrian radiolarians and sponges found by L. Cayeux (*Bull. Soc. Geol. de France*, 1894; *Am. Soc. Geol. du Nord*, Vol. xxiii, 1895). The sponges found by M. Cayeux were enclosed in phtanytes, and gave evidence of strong marine currents in shallow water.

pression of the Ordovician time. To be sure the fossil remains from these limestones are mainly Cambrian, but apart from the fact that these limestones have not been thoroughly explored their relations to the shore fauna, (properly to be considered Cambrian) as an invasion of the deep sea would have led to the deposit of Cambrian genera and species within them, while their own more characteristic residents, beyond the continental limit, might not have at once followed them inland. The pteropodous species of these limestones are pelagic and might have naturally moved shoreward with the deepening of the Cambrian shore-line. Where indeed their fossil contents are typically Cambrian the limestone seems generally arenaceous or of a shore origin, and in these cases it is not clearly shown that the fossils are as numerous in individuals or species as those of the slates and sandstones, nor whether they represent fossilized individuals *in situ,* or current-transported specimens. In many cases the fossils of the limestone suggest the presence of an articulated brachiopodous fauna, or one of greater *size* and *skeletal mass,* as contrasted with the inarticulates of the Cambrian shallow waters. So in Ford's Troy section *Orthis,* and *Leperditia (Plectambonites)* appear, and in the limestones of the Nevada sections the predominance of *Agnostus** and *Ptychoparia* indicates an Ordovician affinity, while other genera of triolbites *(Protypus, Dicellocephalus, Olenoides)* being glabellate(?) and therefore of relatively more skeletal mass, are later forms than the *Olenellus* or *Paradoxides* and point to an outlying bathymetric fauna.

If this proposition receives further corroboration we are presented with a biological picture of this sort.

Along the Pre-Cambrian coast-waters a process of development or *creation,* ensued from such protistic bodies as may have secured proper elaboration, which resulted in a synthetic type of annelids. From these in divergent directions came the trilobites and the brachiopods, the latter deviating into the heavier shelled genera and families in deeper water, and represented in shallower depths by the ecardines, the former multiplying in swimming forms along the coast with the more

*Agnostus extends into the second fauna and also has a very wide geographical distribution in the primordial rocks. In fact Barande states the single connexion between the primordial and the following faunæ is through Agnostus.

carapaced, sessile, and seminatatory forms in deeper water.

This assumption is hardly violent to those who have watched the tendency of recent biological speculation. Ernst Haeckel in his History of Creation pointed out the archetypal character of the metameral vermes; "the phylum of Worms, on the other hand we have to conceive as a low bush or shrub, out of whose root a mass of independent branches shoot up in different directions. From this densely branched shrub, most of the branches of which are dead, there rise four high stems with many branches. These are the four lofty trees just mentioned as representing the higher phyla—the echinodermes, Articulata, Mollusca, and Vertebrata. These four stems are directly connected with one another at the root only, to-wit, by the common primary group of the Worm tube." In the communication of Prof. J. Beard of the Anatomisches Institut, Freiburg, to *Nature* (Vol. XXXXIX, p. 259) on "Some Annelidan Affinities in Ontogeny of the Vertebrate Nervous System" he remarks that "if we are ever to trace the ancestry of Vertebrates at all, the *nervous system* will probably form a significant factor in the solution." But it is the arthropods which resemble the ringed worms in possessing "a very *characteristic* form of the *central nervous system,* the so-called ventral marrow, which commences in a gullet-ring encircling the mouth." (Haeckel). If the nervous system then is an index of affinity, it serves in the case of the crustaceans to point also to their annelidan origin. Gegenbaur (Comparative Anatomy) shows that. He says "the nervous system of the Arthropoda resembles that of the Annelides with which it completely agrees in its fundamental characters." Simroth says emphatically "so entirely can we see the agreement of the ancient animals in a sum of features that, without further effort to unite them, we demand a common root for their common derivation. What was this? No one can conceive of anything else than an Annelid, and certainly, because of the development of the necessary paropodia for the growth of the articulate members, *of a marine Polychaeta.*"

The pre-Cambrian age was the age of Worms. The rocks of the Cambrian offer evidence of this. The annelidan traces in the Potsdam slates and sandstones, shales and flags exceed those of any similar beds throughout the palaeozoics.

Scolithus is prevalent in Potsdam layers, the chloritic slates of the Kenebec river, Maine, are thickly covered with the trails of worms (Chaetopods?), Arenicolites, as determined by Whitfield, fills broad spaces of the Barriboo beds in Wisconsin. Nathorst has indicated the numerous traces of annelidan tracks in Scandinavian Cambrian. Climactichnites and Protichnites may all be the reptant impression of large broad ringed worms.

It seems impossible to reject the patent suggestions of biology which are thus partially reinforced by the indeterminate but significant instances of fossil traces.

In considering further the hypothetical picture of primordial zoic tendencies the condition seems obvious that in shallow water forms—the trilobites and ecardines—we have chitinous integuments, in the deep water calcareous, mainly presented. This seems connected with initial histological peculiarities which no refinement of chemical biology can yet completely touch. The contrasting and separative features between a shore and a deep-water existence are of course primarily the longer exposure to light, and greater likelihood of mechanical violence, on the later removal from these vicissitudes and subjection to pressure with a richer supply of dissolved mineral materials.

Simroth in his interesting section "Einfluss der Atmosphare auf das Integument," has offered some instructive parallelisms, symptomatic, in the case of the shore animals, of the stages in their assumption of hard coverings. The hardening of the epidermis by exposure to air and light led he thinks to the gradual replacement of the hairy surfaces of the worms by soft chitinous coats, which grew stronger and thicker as the metamorphosis went on and the changes to such a triplicate exoskeleton, as the arthropods possess, were completed.

The Brachiopoda have been clearly considered referable to the annelids. Prof. Sedgwick believes "we must assign to the group the position of an independent phylum of the animal kingdom with affinities, by the form of their central nervous system and by their setae, by the presence of a well-developed perivisceral coelom and a canalicular haemocoel, and by the traces of an imperfect segmentation, to the *Annelida*." We find therefore the phosphatic thin shelled atrematous Brachiopoda and the chitinous covered trilobites well represented along the Cambrian beach line, and we are led to accept for them an annelidan origin. It is, as we pass upward geologically in the inspection of these classified fossils of the Hall collection that we meet, in the deeper seas of the Calciferous group, a development of *size and skeletal mass* in the heavy shelled brachiopods, gasteropods and cephalopods.

If the acquirement of hard parts by the shore fauna was due to the siccative influences of their position, their response to light stimuli, and their gradual assumption of protective coats against the violence of waves, the more robust and calcareous groups which succeed them may be related to water pressure and the bountiful supplies of dissolved mineral elements in the deeper seas. I do not know where to turn for evidence on this point. Barotaxis has been by Verworn distinctly indicated as a physiological agent. "Every degree of pressure can act as a stimulus, from crushing or cutting, which destroys the continuity of the substance, down to the slightest touch and the most delicate change in the pressure of the air or the water that surrounds the organism."

Now it is an accountable supposition that this pressure of water originally exercised a stimulating influence upon organisms prepared to secrete shelly coverings, and that while on the one hand the crustacean forms and inarticulate brachiopods in their evolution from annelidan ancestors along the shores, developed their thin chitinous and phosphatic tissues, the molluscan and coelenterate life in the deeper waters was forcing its energies into the manifold elaboration of calcareous coats and skeletons.

Dr. Dall in his address at the anniversary of the Biological Society of Washington on Deep Sea Mollusks indicated the conditions prevalent at the sea bottom. The great hydrostatic pressure, the presence of carbonic acid, sub-marine currents both acting as mechanical sweepers and food-carriers, darkness, the absence of vegetation, and a recourse for nourishment to Foraminifera and the rain of pelagic organisms from the surface are therein mentioned. But perhaps as bearing on this question of the sudden evolution of the next fauna above the Cambrian, and which it is intended here to regard as of deep sea origin, are his reflections on the absence of conflict in the abyssal or archibenthal (semi-abyssal) regions. He said "the animals belonging to the Mollusca which are found in the archibenthal and abyssal regions, especially the latter, do not live in a perpetual state of conflict with one another. A certain amount of contention and destruction doubtless goes on, but on the whole the struggle for existence is against the peculiarities of the environment and not between the individual mollusks of the area concerned. It is an industrial community, feeding, propagating and dying in the persons of its members and not a scene of carnage where the strong preys upon his molluscan brother who may chance to be weaker. Hence the course of evolution and modification, though still complex, is certainly much less so than in th shallower parts of the ocean." Now in the early seas there were probably no depths comparable with the abyssal spaces of modern oceans. The fauna which arose and may have been partially contemporaneous with the Cambrian and which as a stratigraphic fact we find overlying the latter, was evolved in an offshore, and not necessarily profound basin. If freedom from competition and from destructive foes is true today in deep sea animals it was, especially as fishes were absent, more markedly true of these primal groups, and this may have produced that uniformity, a general evenness and similarity of shell-life, without strong or salient variations, which certainly is apparent in the Cambro-Silurian beds of fossils.

At any rate it is certain that passing into the next section of the Hall fossils we encounter the evidences of a new fauna, one especially emphasized by the discoveries in Vermont of Profs. Brainerd and Seely. It is a limestone fauna, a deep sea fauna, and its development upon a scale of such magnitude with such diversity of fauna, with such a systematic zoological overthrust upon all Cambrian precedents, leads clearly to the conclusion that its growth extended far back in time and brought it, at its inception, into contemporaneity with the shore fauna of the Cambrian formations. Size and skeletal mass are now very obvious in molluscan life.

Conditions of life were probably identical with those of today so far as the propagation and maintenance of genera and species were concerned, and, as today extreme deep sea (abyssal) areas are inimical to animal abundance, the faunas, succeeding the Cambrian, if formed in deep water, may have moved shoreward upon a deepening of their former habitat when crustal shortening or the slow folding of synclinal troughs, from sedimentation, occurred.

While it seems naturally a fair speculation that the influence of pressure would have upon developing molluscan organisms the effect of hastening their secretive functions, and that such influence might have been the original cause of establishing the shell forming habits of molluscan animals, we may further consider the thermal conditions of deep water in those early days. It must have presented sensibly high thermal phases, and, to quote Verworn, "everywhere in living nature the law is met with, that within certain limits increasing temperature acts to augment vital processes."

This increase in temperature in the first days of oceanic life arose from the convexion of heat radiated from the cooling continental masses. The raising of lithic masses by contraction must have imparted heat to the seas while indeed their bottom waters rested upon the cooled surfaces of an original cosmic fireball. It was such thermal conditions that directly contributed to an increase in the mineral constituents of the sea water, and might have in this way also hastened the development of shelly parts in sea animals.

The Calciferous sandstone as revealed by Hall was a siliceous shore deposit, and only the records made in the Champlain (Seely and Brainerd) basin display its unequivocal bathic features. The fossil remains present a cephalopodous and gasteropodous fauna. Brachiopods of sensible dimensions and representing the articulate phylum appear, and we find that with the exception of corals and crinoids the palaeozoic biologic impulse has reached molar expression. The initial stages have been far passed. The divergences in genera and classes are thoroughly established. The partial introductory phase of the Cambrian day with its eccentric development of trilobitic forms and its thin shelled brachiopods has been succeeded by a multivarious and expounding series of organisms heavily armored in calcareous coverings.

From this point onward throughout the palaeozoic series the application of the significance of *Size and Skeletal Mass* is generally evident. Let us consider the separate fossil groups. The inarticulate brachiopods present noticeably larger forms, and in the Upper Silurian develop into the large and internally elaborated Trimerellidae.

The size and skeletal mass of the inarticulate brachiopods reached its maximum in the Upper Silurian. The articulate brachiopods show increasing size, and increasing internal shelly deposits (loops, hinges, cardinal areas, etc.,) from the Cambro-Silurian upward. The Rhynchonellidæ, Orthidæ, Strophomenidae gradually yielded their numerical supremacy, while advancing themselves greatly in size. They become diminished elements in the fauna of the upper rocks, as they become more numerously accompanied by the spiriferoids which attain large dimensions in the Devonian and Carboniferous and exemplify the extension of interior calcareous appendages and hinge growth. In the Carboniferous (lower) the families of Orthidae and Stropheodontidae also attain large size. The lamellibranchs increased in size continuously to the Devonian, and through the latter age became conspicuously developed. The gasteropods attained large proportions in the Devonian. The cephalopods were, in the straight forms, strongly developed quite early in the series and through the coiled genera continued their growth and accretion to the Jurassic, while in modern seas they have attained huge proportions, but without shelly coverings.

The crinoids were slender, small calyxed, long armed, in the Lower Silurian, and through manifold divergences, with sporadic and sudden offshoots reached the thick, heavily plated, short armed, stout pedicelled groups of the Devonian and Carboniferous.

When the separate genera or families are examined this progression of size and skeletal mass to certain maximum points, followed by an apparent decrescence immediately or subsequently introduced, is very striking. Its theoretical interest lies in the impossibility of referring this universal tendency in molar character to natural selection, or any series of influences purely external to the organism.

The considerations which warrant this conclusion are not so much drawn from particular instances as from the general tendency throughout these animal fossil forms. That size, stronger, larger shells, internal shelly partitions, surfaces of attachment, hinge definition and interior branchial elaborations might prove of material value in Mollusca, and through the aggregate effect of stability, power of resistance, and mechanical aptitude help any genius, enjoying these features, in the struggle of survival, and so lead to new and more advanced developments of the same elements, is quite possible, but it is clear that the fact of this development of size, skeletal mass, etc., throughout the organic impulse in the past, is more profoundly conditioned.

In the first place the perpetuity of slight, small forms is quite as great as that of larger forms. The Lingula has outlasted a wide range of heavier and more imposing brachiopods, and the unprotected cephalopods survive the marvellous "straight horns" and ammonites of ancient seas. The frail crinoids of our present ocean bottoms continue a line of descent quite contrasted with the well plated, high calyxed, tegmenated, and massive species of palaeozoic time. Gasteropods and lamellibranchs have continuously enlarged up to present times, but the mere aspect of size, thickened shells and involved hinges seems in their case also utterly incomprehensible on the supposition of a survival. All the more so as along with the increase there continues a stream of small forms. It shows a distant biogenetic tendency. Even if natural selection finds in increase of size and molar complexity a field of advantageous activity the continuous expression of these things reveals an implanted, not a succedaneous, motion in life, and, partially at least, illustrates Prof. Osborn's dictum (Cartwright Lectures, 1892,) "that evolution advances largely by the accumulation of definite variations, or those in which each successive generation exhibits the same tendencies to depart from the typical ancestral forms in certain parts of the body, and that these tendencies stand out in relief among the diffused kaleidoscopic or fortuitous anomalies."

It remains for the conclusion of this *first* part of the present paper to demonstrate the fact of the growth in size and skeletal mass of the invertebrate forms of palaeozoic fossils. It is true that there is no consecutive line of symmetrical growth traceable upward with uninterrupted precision to a climax, with a subsequent regular decrescence. It is also true that along with growth in size and solidity and skeletal thickenings and irregularities small primitive forms survive and new ones equally small appear. It is true that there are alterations and waves of advance and retreat, that a group of strongly developed organisms may be followed by less developed examples of the same groups. But looked at broadly and carrying the eye forward rapidly the impression is unmistakable that there is a tendency to molar expansion, skeletal growth, and that from some maximum point there may be recession and that both seem essentially independent of environment, and are inexplicable on the assumption of the "Survival of the Fittest."

To begin with the linguloid and obelloid shells can be traced upward to Trimerella through a series of increasing size and changing internal hard parts or shell buttresses, while nowhere do large sized individuals signalize the first appearance of a family. Dr. Clarke in the first particular instance offers convincing evidence. He points out (Pal. Vol. VIII., Geol. Surv., N. Y.) that a line of succession from a linguloid shell through two divergent lines can be traced to the large heavy Trimerellas with internal platform, prominent cardinal areas, solid and lengthened umbo. One line is through *Lingulella, Lingula, Lingulops, Lingulasma,* the second through *Obolella, Obolus, Elkania Dinobolus.* Whether this is a true genealogical series or not it is a very clear proof of assumption of size and skeletal mass through successive formations, of a group of ecardines, though *Lingulops* is a small shell, and serves the purpose only of advancing internal structure. *Lingulasma,* on the other hand, is a quadrate strong and well developed shell, and, as Dr. Clarke shows, is "to be regarded, in unison with other features, as evidence of progress in the assumption of the characters of the large thick-shelled Trimerellids." In the other hypothetical succession *Obolella* is a small sub-circular shell with an area; *Obolus* is a large shell, *Elkania* is a doubtful link and a small shell, *Dinobolus* is a large platform-bearing shell and in the American Niagara (*D. Conradi*) presents approximative features to *Trimerella.*

Again *Lingulepis* is a primordial linguloid shell, and is limited in its distribution to Cambrian beds, but increase of size is symptomatic even within these limits. The *L. minima* and *L. antiqua* of the N. Y. Potsdam are small, the former an inconspicuous shell, whereas *L. pinniformis,* the western form

(Minnesota), is a much larger, stronger and thicker shell, and the beds at St. Croix, where it is so numerous, are considered later or Upper Cambrian, indeed, might be so considered upon this evidence alone.

Obolella is a primordial genus, but the evidence of increased size, with geological age is not at all clear. The N. Y. species, *O. crassa,* is much larger than *O. polita* of Wisconsin, but if *Lingula prima* Conrad, is Hall's *O. polita,* as Prof. Whitfield claims, the argument still holds as the western form in this exact instance is much larger than its eastern and earlier representative.

Turning to *Discina* and *Crania* we find this general proposition still obviously sustained. If under *Discina,* so far as the elements of this inquiry go, we group the discinoid shells *Discinisca, Orbiculoidea, Schizotreta, Lindstroemella, Roemerella,* we find the increase of size well shown. The small *Orbiculoideas* of the L. Silurian becomes the large *O randalli* and *grandis* of the Devonian.

Lingulas increase in their dimensions from their first appearance, and it is the acuminate type which prevailed in the earliest faunas (Clarke) which is succeeded by the broader, more developed forms, while, as indicated by Clarke, *Barroisella,* with its deltidial hardenings, coming in in the Devonian, continues the Lingula type until there is "an evident tendency to span the interval between the so-called inarticulates and articulates."

Trematis, as confined apparently to American Silurian faunas, shows a sensible increase in size and general development, if *terminalis* of the Trenton is compared with *millepunctata* of the Hudson River group.

In the articulate brachiopods this same organic impulse is distinctly presented. In the feature of increasing articulation Dr. Clarke has said, "with rare exception these modifications in each group appear to be progressive, extending along certain lines of development, and finally acquiring an extravagant manifestation which may terminate abruptly or result in the degeneration and obsolescence of some of the parts."

The spiriferoids reach a climax of development in the Devonian and Carboniferous. The increased size and the amplified cardinal and hinge features reaching such complexity as is shown in *Syringothyris,* contrast with the incipient stages of growth and structure in the spirifers of the Silurian.

The strophomenoids from the leptænoid *(Rafinesquina)* shells of the Silurian show a constant enlargement with varying offshoots or auxiliary branches, to the huge Productus and Stropheodontas of the Devonian and Carboniferous.

The first pentameroid shells are small and the later species of the Upper Silurian attain magnificent proportions with increased internal calcifications.

As the heterogeneous commixture of forms originally placed under *Orthis* have undergone at Dr. Clarke's hands a thorough revision and reassortment, their continuity from formation to formation is considerably broken, and many of the new genera are restricted to single formations. But in *Platystrophia (Orthis biforata, O. lynx)* there is from the Chazy to the Clinton and Niagara, and especially prominent in the Cincinnati beds (Hudson River) the same obvious increase in size. *Dalmanella testudinaria* of the Trenton strengthens into *perelegans* of the Low. Helderberg, *Rhipidomella circulus* of the Clinton into *R. burlingtonensis* of the Carboniferous, *Schizophoria multistriata* of the Lower Helderberg. The atrypoid *Zygospira* becomes later enlarged into the true Atrypas, which themselves in the same species (*A. reticularis*) persistently increase in size (see Clarke's observations, Pal. N. Y., Vol. VIII., pt. II., pp. 167-172). It is unnecessary to pursue a self-evident contention further.

Wachsmuth and Springer have expressed (North American Crinoidea) in crinoids their unwillingness to construct a genealogical tree, "because such representations are generally unsatisfactory." But in this very general proposition the evidence of an inspection of the species from the Silurian to the Carboniferous shows conclusively that size and skeletal mass increased, and that whether or not "palaeozoic crinoids represent, in a broad sense, the larval stages of recent crinoids," the movement in massiveness from the Silurian to the Carboniferous is, amongst them, evident. The large heavily plated *Eucalyptocrinus* of the Niagara was a sporadic (Calyptocrinidae) and short lived development, but it would be an insupportable hypothesis that *Eucalyptocrinus* was an unannounced development.

The cephalopods of the Cambro-Silurian were small. *Orthoceras* (*Kionoceras*) *laqueatum, O. sordium, O. cornu-oryx, O. bilineatum, O. explorator* of the Chazy or Calciferous, and the species determined by Dwight, those of Billings' Palaeozoic fossils and Hall's examples were nearly all narrow, short species. In the Trenton the large Orthocerata appear. Similarly the Lower Silurian *Cyrtoceras, Gomphoceras, Phragmoceras* precede the Niagara forms sensibly heavier and more developed.

The trilobites which were large in the Cambrian, and thin skinned (?), become in later ages more calcified, heavier carapaced, with enlarged pygidia.

Variant, as at some points this conclusion may seem, the conclusion of growth in size and increased functions of mineral secretion is almost invariably forced upon us from an inspection of the fossil lines of growth. It utterly dispenses with any claim of novelty. But it seems as if it might be more generally recognized as a guide in the correlation of the horizons, geographically separated and characterized by the same fossil species. If we find a faunal expression in forms strongly developed, with larger fossils, and associated with increased skeletal deposition of parts, it is a reasonable conclusion that, apart from any or all considerations of improved food supply, climatic auspices, or freedom from enemies, the horizon is subsequent to those in other sections, possibly holding the same species, in which these fossils are less developed, generally smaller and unassociated with morphological complexity.

Questions of correlation are deservedly regarded as involving a momentous risk, in so far as dogmatic assertion goes, and the hope entertained to find in biological relations a definite guide has been realized only within indeterminate limits. Huxley's well accepted idea of "homotaxis" shows the unreasonableness of any exact inference as to simultaneity of faunas where there are the same fossil species, and writers on correlation have recognized the precarious virtue of an appeal solely to identity or similarity of specific forms.

Russell (Correlation Papers; The Newark System) has said, "the usefulness of the life history of the earth as a means of correlating geological terranes is still further complicated by a principle inherent in life itself; that is, development has been in progress, but has not taken place uniformly over the whole earth, but with local modifications depending upon local environment." White (Correlation Papers; Cretaceous) reiterates this in stating that "general biological evolution, while it has been progressive, has not progressed at a uniform rate throughout geological time, and in all parts of the world."

A less conservative and, it would seem, more reasonable reliance upon fossil indications is expressed by Walcott, Williams, Dall and Harris. Wolcott says: "The method of correlation by the comparison of fossils, or, as it has been called, 'matching,' is the one that affords the best results. It includes the comparison of species, genera, families, and the general facies of a fauna. It is the basis of paleontologic correlation and geologic classification of the sedimentary rocks, with the exception of the stratigraphic and lithologic correlation of local formations;" "all paleontologic reasoning is based upon known data. By the discovery of a new grouping of fossils, or a different range of known species, the identification of horizons may be materially modified." Dall and Harris write: "Paleontology holds the key to the problems of local and comparative stratigraphy," admitting also that there should be no neglect of "broad and general stratigraphic changes." Williams writes: "The law of paleontologic succession did not become a factor of correlation till the idea of the evolution of species furnished a rational basis of confidence in the naturalness of the observed order of sequence of forms. The idea of evolution suggests the true biologic system of correlation, in which the data of the classification are fossils, and the distinctions made are into periods in the history of organisms, the strata taking their relative position in the series according to the period in this history which their contained fossil remains may indicate."

The validity of fossils as determinants of geological position cannot be questioned, nor is it rational in our existing knowledge to deny the correlation strictly of horizons having the same or very similar fossils. Any possible chronological disparity is disqualified as an objection inasmuch as such disparity can be neglected, a few thousand years even, in a matter of geological contemporaneity being unimportant.

Whether such an apparently easy rule of judgment as the one here suggested can be advantageously or safely adopted is a matter for discussion. Are the molar, or, it might be termed, the molecular features of a fauna indication of comparative age? In any case it would be merely an auxiliary consideration. It might be easily misapplied and warrants in itself no ultimate decision. But is it not helpful?

Is it reasonable upon this suggestion to place the Spergen Hill beds, which, as Whitfield has said, "contain an intermingling of species known to occur in the Keokuk, St. Louis, and Chester limestones," below any of these from the immature condition of size and development of these fossils? By no means. The whole expression of the Spergen Hill fossils, as found in the limestone beds is one of repression. These depauperate forms have resulted apparently from a peculiar fecundity, or tidal concentration,which has, under some unfavorable conditions, produced a great number of interfering individuals. At Poynter's Hill and at Ellettsville, at no great distance from Spegen Hill, these same beds, with fewer fossils, show larger individuals.

But, on the other hand, it would seem reasonable to conclude that the western Hudson River, which as Hall long ago observed, contains a fauna of brachiopods, with corals, crinoids, Crustacea and trilobites, and in the same species far more developed than the fossils of its eastern equivalents, was later than the New York beds of the same age.

(To be Continued.)

THE PLAN OF THE EARTH AND ITS CAUSES*

By J. W. Gregory, D.Sc., Melbourne, Aus.

The Variation of Topographic Form.

Despite the extreme variability in the shapes of the continents and their apparently capricious distribution, geographers of all ages have believed that the arrangement of land and water on the globe is based on a regular plan. The plan can, of course, only be recognized in broad outline, for the shape of the land-masses depends on the structure of the Earth-forms, which vary indefinitely. Intricate mountain valley

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systems open out to wide-flung rolling prairie, stoneless alluvial flats are broken by the crags of rock ridges, volcanic cones stand isolated like pyramids while mountain chains run thousands of miles unbroken. Such contrasts are natural, as the land-forms are the result of the struggle of complex forces with varying powers of attack against complex rock-masses formed of materials having varying powers of resistance. Coast-lines, for example, project where hard rocks repel the surf, where rivers deposit alluvium more quickly than the tide can remove it, or where the winds build up sand-dunes, whose very weakness disarms the waves. Coast-lines are indented where soft beds crumble under frost and rain, and where dominant winds, the inset of an ocean current, or an undulation on the sea floor directs a jet-like stream of water against the shore. Topographical form depends on so many incalculable, inconsistent factors that the stages of its growth are often now untraceable. The missing links of geographical evolution are indeed as numerous as those of organic evolution, and the chapter of accidents is invoked by geographers to explain difficulties analogous to those for which naturalists appealed to the doctrine of special creation. But unexplained differences in the geographical units no more disprove an orderly progress in the growth of the continents than the existence of isolated, unexplained groups of animals is fatal to Darwinism. Such topographical differences are of secondary importance in contrast to the numerous coincidences and repetitions of the same essential form among the geographical units. Geographers accordingly have believed that there is a hidden continental symmetry which, when discovered, will explain the law that has determined the distribution of land and water on the globe.

This idea dates from the dawn of geographical science. The early classical geographers noticed how the seas radiated from the Levantine area, and opened to a broad boundless ocean. They accordingly described the land of the globe as an island, floating on a vast surrounding sea, whence channels converged towards the hub of the classical universe. This radial plan reappears in the mediæval wheel-maps, in which Jerusalem was accepted as the center of the world, whence the main geographical lines radiated like the spokes of a wheel.

These systems fell forever on the discovery of America, which could not be brought into conformity with the radial plan by even the ingenious devices of mediæval cartographers. Later on came an even worse blow. Geologists showed that, instead of the land areas being fixed and immutable, they are really more fickle and less enduring than the sea. The distribution of land is therefore constantly changing, owing to local variations in its level. The discovery of this truth seemed to destroy the very basis of any possible Earth-plan. Indeed, Lyellism, with its essential doctrine of the alternate elevation and subsidence of the land under the agency of local causes, seemed inconsistent with the existence of any general cause governing the geographical evolution of the globe as a whole.

But a truer appreciation of this later knowledge did not confirm these first deductions. America is now used as the typical or, to borrow a biological phrase, the schematic continent. And when, remembering the probability of local variations in land-level, allowance is made for them, new resemblances are revealed, and exceptions that once were serious difficulties are removed. For instance, the oceans all end in triangles pointing to the north. This is the case with the Pacific, the two sections of the Indian ocean, and the basins of the Mediterranean. The Atlantic alone is broadly open at its northern end. But Scotland and Iceland are connected by a submerged ridge, which is said to be capped by a line of old moraine. If this ridge were raised to sea-level, the Atlantic would conform to the general rule by tapering northward to a point between Iceland and Greenland.

Similarly with the land-masses. There seems at first sight no resemblance in shape between the Old World and the New. But the Old World is divided into halves by a band of lowland, which extends southward from the Arctic ocean to the Caspian, and northward from the Arabian sea up the Persian gulf. There is evidence to show that the sea recently covered these northern lowlands and occupied the Persian depression; while somewhat earlier, in the Miocene times, the intervening ridge was also submerged. Restore these conditions, and the continents would occur as three meridional belts, each broken across by transverse Mediterranean seas, viz. North and South America separated by the Caribbean depression; Europe and Africa (the Eurafrica of Prof. Lapworth) separated by the Mediterranean; Asia and Australasia divided by the Malaysian folds.

Hence the oscillating character of the land, which appeared fatal to the old faith in an Earth-plan, helps to justify it, now that oceanography and geology have shown us how much to allow for the obscuring action of these changes of level.

But it is inadvisable, in attempting to explain the existing plan of the Earth, to introduce any alterations in the distribution of land and water. For, although a geologist may have no doubt about such assumed changes, he cannot expect geographers to have an equal faith in them, or even to take much interest in a world thus modified. The geographer is concerned with the existing arrangement of the world, and not with the more or less problematical plans of former ages. The introduction of earlier and more primitive geographical systems, though it would simplify the question, is unnecessary, since the existence of a present Earth-plan is clearly revealed by three striking facts.

GEOGRAPHICAL SYMMETRY.

Two of these facts are stated in every geographical text-book. They are evident on the most casual examination of a map. The first is the concentration of land in the northern, and of sea in the southern hemisphere. The second is the triangular shape of the geographical units. The continents are triangular, with the bases to the north. The oceans are triangular with the bases to the south. Accordingly the land forms an almost complete ring round the north pole, and from this land-ring three continents project southwards. The oceans form a continuous ring round the south pole, and from it three oceans project northward into the angles between the continents. The belts of sea and land are fixed on the Earth's axis like a pair of cog-wheels with interlocking teeth. These two belts may be referred to as the northern land-belt and southern oceanic-belt.

The third striking feature in the Earth's physiognomy is less conspicuous, but is even more significant. It is known as the antipodal arrangement of oceans and continents. It is most easily recognized by examination of a globe; but it can easily be illustrated by a plain map. The antipodes of a point in the center of the continent of North America occurs in the Indian ocean; and if we mark on a map the antipodes of all the points in North America, we should find that the whole of that continent is exactly antipodal to the Indian ocean. Similarly, the elliptical mass of Europe and Africa is antipodal to the central area of the Pacific ocean; the comparatively small continent Australia is antipodal to the comparatively small basin of the North Atlantic; the South Atlantic corresponds—

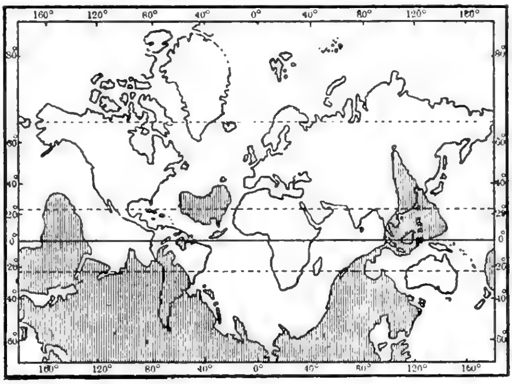


FIG. 1.—MAP OF THE WORLD, SHOWING THE DISTRIBUTION OF ANTIPODAL AREAS.

though less exactly—to the eastern half of Asia; and the Arctic ocean is precisely antipodal to the Antarctic land.

These, then, are the three fundamental facts in the existing plan of the globe. Our main problem is, Why are the geographical elements thus shaped and thus distributed?

THE EARTH'S CONCENTRIC SHELLS.

It simplifies the statement of the problem to remember that the Earth consists of three parts: there is the vast unknown interior, or "centrosphere," concerning which physicists have not come to any unanimous decision, some saying that it is throughout solid and rigid, others that it is partly fluid, and others again that it is partly gaseous. This interior mass is enclosed by a shell formed of two layers, the solid crust, or "lithosphere," and the oceanic layer, or "hydrosphere." It is possible that at first the two layers of the shell were regular and uniform, in which case the whole world was covered by a universal ocean; but before the dawn of geological history, this arrangement had been disturbed by the formation of irregularities in the surface of the lithosphere. Dry land appeared at the areas of elevation, and the waters gathered together into the intervening depressions.

The problem, then, of the distribution of land and water on the globe is the problem of the distribution of irregularities in the surface of the lithosphere. We are accordingly at once brought face to face with the question, When were the existing irregularities made? If, as many authorities say, these depressions date from the earliest days of the Earth's history, and have lasted unchanged in position throughout geological time, then we are thrown back upon some cause which acted when the Earth was in its infancy. In that case the question is astronomical and physical, instead of geological and geographical.

PRE-GEOLOGICAL GEOGRAPHY.

There have been several attempts to solve the question astronomically, of which the most important is that of Prof. G. H. Darwin. According to his luminous theory, the tidal action of the sun on the viscous earth formed two protuberances at opposite points of the equator; one of the protuberances broke away and solidified as the moon, which revolved around the earth much nearer than at present. As a new equatorial protuberance formed the moon pulled it backward, thus causing a series of wrinkles in the earths' crust, which persist as the main structural lines of the continents. These wrinkles ran at first north and south from the equator. But owing to the moon's strong pull on the equatorial girdle, this part of the earth would tend to revolve more slowly than the polar regions. Hence the primitive wrinkles were deformed; instead of being meridional in direction, they would trend northeasterly in the northern hemisphere, and southeasterly in the southern hemisphere. Prof. Darwin points out that some of the most striking geographical lines on the earth run in accordance with this plan. He instances the eastern coast of North America, the western coast of Europe, part of the coast of China, and the southern part of South America. But, with characteristically Darwinian frankness, he does not overpress the facts, admits that the resemblances are not so convincing as they might be, and that some cases, *e. g.* the western coast of North America, are absolutely inconsistent with the scheme.

Another theory that attributes the formation of the main geographical lines to pre-geological incidents is given in a paper by Prinz, "Sur les similitudes que presentent les cartes terrestes et Planetaires," which elaborates and gives an astronomical basis to ideas previously suggested by Lowthian Green and Daubree. His theory is that the northern part of the earth had a lower angular velocity than the equatorial and southern regions. Therefore the land masses in the southern hemisphere were gradually pushed forward towards the east. The line between the northern retarded hemisphere and the southern swifter hemisphere is the great line of weakness and fracture that runs from the Caribbean along the Mediterranean, down the Persian gulf and across Malayasia. Prinz has drawn a map (Fig. 2) showing how the main geographical lines agree with his assumed lines of torsion.

This map is interesting, for these primitve torsion wrinkles must have been formed in the same period as Prof. Darwin's primitive tidal wrinkles. It is significant that the lines do not correspond. The chief geographical lines which Darwin claims as his primitive wrinkles are inexplicable on Prinz's theory, and the great lines which Prinz claims to support his wrinkling are opposed to those of Darwin. The geographical primitive lines of the two theories are often contradictory.

A third theory assigning the geographical distribution to very ancient causes has been proposed by Prof. Lapworth. In an address to the geographical section of the British Association in 1892, and in a brilliant lecture on "The Face of the Earth," delivered to the Royal Geographical Society in 1894, Lapworth attributed the arrangement of oceans and continents to an intercrossing series of primitive earth-folds. The oceans, according to this theory, occupy ancient basins of depression; and the continental masses are domes of elevation.

"The surface of the earth-crust at the present day," says Lapworth, "is most simply regarded as the surface of a continuous sheet which has been warped up by two sets of undulations crossing each other at right angles. . . . The one set ranges parallel with the equator, and the other ranges from pole to pole." Prof. Lapworth contends that the intersecting of two simultaneous orthogonal sets of undulations explains

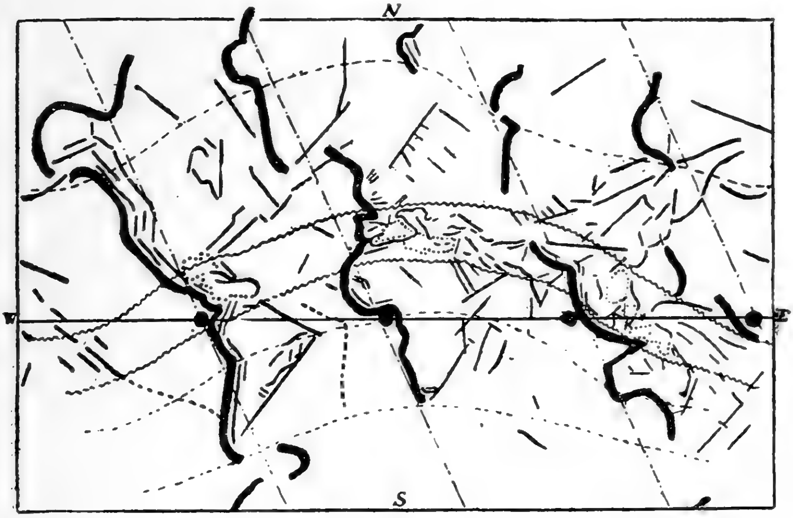


FIG. 2.—THE OBLIQUE COURSE OF THE MAIN GEOGRAPHICAL LINES. (AFTER PRINZ.)

the forms and dispositions of the continents, the triangular shapes of their extremities, the diagonal trend of their shores, and the course of the linear archipelagoes. In some interesting diagrams he suggests why the intersecting nodal lines which mark the divisions between the areas of elevation and of depression should coincide with the steep slopes that separate the ocean floors and the continental platforms; and why the existing shore lines should so often run diagonally between the meridians and parallels.

This theory, and that of Sir John Lubbock, which also attributes the continental forms to a double intercrossing series of folds, have the advantage over the astronomical theories of more detailed agreement with geographical facts; but Prof. Lapworth has not, so far as I am aware, explained what caused his intersecting folds. His theory is accordingly less complete than the others, as it is rather a statement of facts than an explanation of causes.

These suggestive theories are open to one objection which seems fatal to their application to the existing geographical plan. We should expect from them that the main geographical structure lines in the northern and southern hemispheres should be either symmetrically arranged or continuous on both sides of the equator. But that the land systems of the two hemispheres are asymmetrical is the most glaring fact in geography. It may be urged that the primitive folding, wrinkling and torsion formed a symmetrical or continuous land system, and that the asymmetrical arrangement is due to later movements. In that case the theories are geographically inadequate, because they give no explanation of how the existing geographical asymmetry was developed.

But there is another and still more serious objection which applies to all three theories. They not only explain too little but they explain too much. The primitive lines of these systems often coincide with features of modern development and are inconsistent with the old established geographical arrangements. For instance, Prof. Darwin quotes the trend of the western coast of Europe from Spain to Norway as in accordance with his scheme. Prinz makes the primitive line here run exactly at right angles to Darwin's line; and geological evidence favors Prinz. The coast-line from Spain to Norway is almost certainly of modern date, while the lines wrinkling, both Hercynian and Alpine, run transversely to the direction which they ought to have followed if due to tidal strain. Moreover, Prof. Darwin quotes the western coast of North America as inconsistent with his theory; but that coast is parallel to a line of primitive wrinkling, for there is an archean protaxis to the coast ranges and Rocky mountains.

Prinz's torsion wrinkles are no better. The most striking case of apparent agreement between his theory and geography is the trend of the Andes and Rocky mountains. Prof. Lapworth also lays stress on "the great Rocky Mountain-Andes fold . . . the longest and most continuous crust-fold of the present day."* The agreement was important so long as the Rocky mountains and the Andes were regarded as a single

*The term "Rocky mountains" is here apparently used for the Sierra Nevada and Coast Range series of British Columbia. The true Rocky mountains are at a great distance (ranging up to 1000 miles) from the Pacific coast, the trend of which they do not determine.

mountain system, connected into a continuous line by a mountain axis running north and south across Central America. But that axial mountain chain in Central America is a myth. Central America is traversed by a series of ridges which run east and west, and not north and south.* The watershed, it is true, runs along the Pacific border, but that is due to a movement later than the mountain ridges which are thus truncated. The continuation of the Andes is in the mountains of Venezuela, not in North America or the Sierra Nevada. The Andes and the mountain system of the western states of

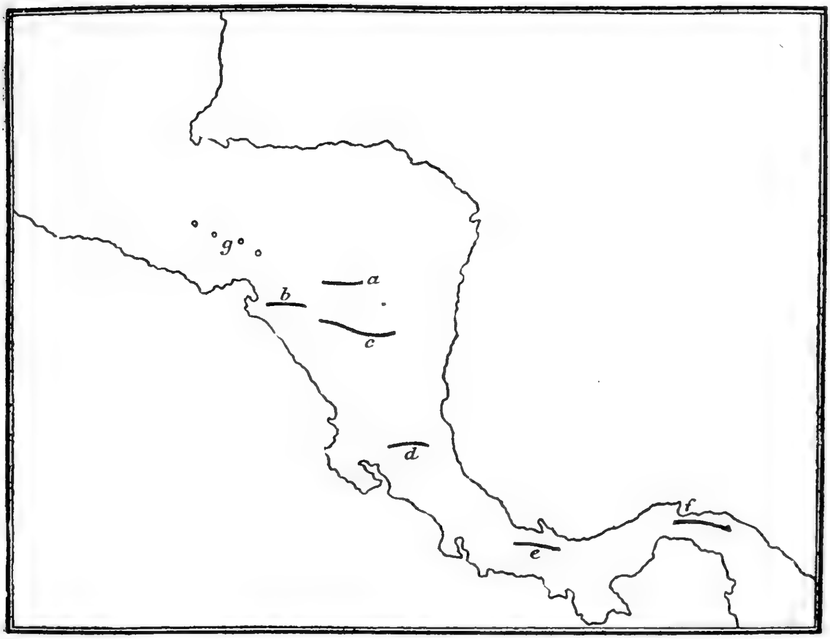


FIG. 3.—THE MOUNTAIN SYSTEM OF CENTRAL AMERICA. *a*, VOLCANIC CHAIN OF HEREDIA; *b*, SIERRA CANDELLA; *c*, CORDILLERA DE DOTA; *d*, SIERRA CHIRIQUI; *e*, SIERRA VERAGUA; *f*. CORDILLERA DE SAN BLAS; *g*, VOLCANIC CHAIN OF ALAJUELA.

America are essentially distinct; they differ in every important respect, geological structure, geographical characters, and dates of formation. Any theory which assigns the Andes and

**E.g.* the Sierra Candela, Cordillera de Dota, Sierra Chiriqui, Sierra Veragua, Cordillera de San Blas, etc.

the great mountain series on the western coast of North America to a common origin is thereby prejudiced, instead of being supported.

These three theories assign the earth-plan to a venerable antiquity; but there is a fourth theory, which carries it back to an antiquity even more venerable. Lord Kelvin attributes the oceanic and continental areas to a chemical segregation in the gaseous nebula which was the parent of the earth. According to this theory, "Europe, Asia, Africa, America, Australia, Greenland and the antarctic continent, and the Pacific, Atlantic, Indian and Arctic ocean depths, as we know them at present," were all marked out in the primæval gaseous nebula. These gaseous continents condensed to liquid continents marked off from the sub-oceanic areas by chemical differences; and these liquid continents were fixed as the solid continents, hightened by shoaling as the molten globe and its last lava ocean solidified.

That theory appears probable with one verbal amendment —the substitution of the term "archean-blocks" for continents. That these archean blocks—the earth's great corner stones—were embryonically outlined by chemical segregations in the molten or gaseous stages of the earth seems probable. But these archean corner stones, though the foundations of the continents, are not the continents. Lord Kelvin's theory suggests no explanation why chemical segregations should have assumed the shapes of the continents, so that his explanation rests on an unexplained cause; and even if his theory be amended by application to the archean blocks instead of to the continents, the theory is geographically insufficient, as it does not show the relation between the archean blocks and the existing continents.

THE PERMANENCE OF CONTINENTS.

That Lord Kelvin's nebulous segregations, Prof. Darwin's primitive wrinkling, Sir John Lubbock and Prof. Lapworth's double folds are all true causes seems probable. What is doubtful is whether any extensive trace of their influence can be discerned in the present distribution of land and water. A map of the world in early Cambrian times might show the influence of these pre-geological incidents; but their geographical effects seem to have been obliterated by the changes of geological times.

References to such changes reminds us that we cannot assume their occurrence without considering the unending controversy as to the supposed permanence of oceans and continents.

There are, it must be conceded, many weighty arguments in favor of the permanence hypothesis. Many of the last great mountain foldings follow the lines of much older movements; and if the mountain axes, the "backbones of the continents," have occupied the same positions, why not also the continents moulded upon them? Again, some of the great mountain chains, such as the Andes, run parallel to the nearest shore-line, as if the movements that formed them had been deflected by the ocean basin.

The character of the ocean floors, moreover, suggests that they have never been continental, as they are at present covered by deposits not known in the interior of the continents; and as they are supported by material much heavier than that which forms the foundations of the continents.

These arguments, however, are not conclusive. Great earth movements of one date often cut obliquely and transversely across those of earlier periods. Thus the old north-westerly and south-easterly movements of France and Spain have been cut across by the east and western movements of the Pyrenean-Alpine system. Mountain axes have not always been deflected by or limited by existing ocean basins. Thus the north Atlantic basin cuts directly across the old Hercynian mountain chains, which may at one time have extended across the whole Atlantic channel. This is rendered probable by three lines of evidence. Thus in north-western France, and in the south of the British Isles, there is a series of ranges trending north of west, which is cut off abruptly by the Atlantic slope. On the opposite shore of the Atlantic in Newfoundalnd, there is a similar series of truncated ranges formed at the same age as those of western Europe, and having the same trend. Bertrand maintains (1887) that the resemblance between the opposite mountain series is so striking that they should be regarded as parts of one mountain system, of which the central part has been sunk below the Atlantic. The well-known telegraph plateau on which the cables rest may mark the site of this sunken land. Palæontological evidence also supports the formation of the Atlantic by subsidence; for a shallow water, sub-tropical, marine fauna ranged from the Mediterranean to the Caribbean, and can only have crossed along a belt of shallow water in tropical or sub-tropical latitudes. Direct evidence of the existence of shallow water, continental deposits of the age required is given by the Azores, which, although now separated from Europe by a deep depression, contain shallow water deposits with fossils of the Mediterranean fauna.

Thus there is strong evidence to show that the Atlantic, in its present form, is of no great geological antiquity, and Suess' theory of its origin continually gains stronger support. Similar, though less complete, evidence shows that the other ocean basins have been broken up along certain lines, and emphatically denies their entire permanence throughout geological times.

ÉLIE DE BEAUMONT'S "PENTAGONAL RESEAU."

Hence, if the ocean basins were not formed pre-geologically, but have grown from the changes that have occurred during the long ages of geological time, then we must seek for a cause that has acted continuously, and is acting today. A more permanent cause is supplied by the contraction of the earth's crust, as the globe gradually cools. Since the cold, hard crust is less plastic than the hotter interior, it is necessarily crumpled as it is forced into a smaller space.

This idea is well known, as it has been invoked by geologists to explain the formation of folded mountain chains. That the mountain systems of the world were formed by this agency is improbable; but it is perhaps still too much to say that it is impossible. For Prof. G. H. Darwin has suggested that the contractility of the rocky crust has been exaggerated, and it has been shown that Reade's level of no strain may lie much deeper than was at first thought.

That secular contraction is the direct cause of the great fold-mountain systems is however less widely believed by geologists than it once was; but it may have an important influence in determining their direction. The trend of the great chains of fold-mountains is to us a significant question, because there is much truth in the phrase, proverbial since its use in 1682 by Burnet in his "Theory of the Earth," which describes the mountain chains as the "backbones of the continents." The first geological attempt to explain the plan of the earth was based on this belief. The author of this system was the French geologist Élie de Beaumont, whose theory of geomorphogeny was stated at length in his "Notice sur les systemes de montagnes" (3 vols.: Paris, 1852). This famous theory was based on a correlation of the mountain chains by means of their orientation. Élie de Beaumont accepts the view that the earth consists of a thin rigid crust surrounding a fluid, solidifying interior. The crust being thin, it necessarily collapses as the internal mass contracts. He assumes that these collapses occur at intervals of time, and that at these collapses the crust is broken along lines of weakness, which are crumpled up into mountain chains. He assumes that for practical purposes the earth's crust may be taken as homogeneous; hence that the fractures of the crust would be regularly distributed, and those of successive periods would cross one another along the lines of a regular symmetrical network.

Among the regular simple geometrical forms, that known as the pentagonal dodecahedron, which is enclosed by twelve equal regular pentagons, possesses an exceptionable degree of bilateral symmetry, *i. e.* it can be cut into exactly similar halves in an unusually large number of directions. Sections along any of the edges of any of the pentagons and through the center of the pentagonal dodecahedron divide it into equal and similar halves. So also do sections from the center of the pentagons to any of the angles, and likewise sections across the pentagons from alternate angles. Each face of a pentagonal dodecahedron may therefore be divided by fifteen planes of symmetry.

A sphere may be described upon the pentagonal dodecahedron, so that all the corners (or, to use the correct term, solid angles) occur in the surface of the sphere. By joining the corners by lines, the sphere is marked off into twelve spherical pentagons, which possess the same amount of symmetry as the plane pentagons. The lines where these planes of symmetry cut the surface of the sphere form a network of spherical triangles. Such a network Élie de Beaumont called his pentagonal network, and he used it in the following way. He studied the mountain ranges of the world, and by elaborate calculations showed their relative directions at a few localities which he chose as centres of comparison. He found that many mountain ranges have the same orientation, and that others cross the first set at definite regular angles. The directions of the different sets of mountain ranges coincide with the lines of his pentagonal network. Élie de Beaumont claimed that the mountains whose directions are parallel,* were formed at the same date. Successive mountain-forming movements raised chains parallel to different edges of the network; and thus the intersecting mountain lines of the world, and, consequently, the forms of the continents, were determined.

Élie de Beaumont had no difficulty in pointing out striking coincidences between important geographical lines and his pentagonal network. Thus the Mediterranean volcanic axis, passing through the Grecian archipelago, Etna, and Teneriffe, is parallel to the Alpine chain, and at right angles to the circle through Etna, Vesuvius, Iceland, and the Sandwich Isles. He was able to show a close geometrical relationship between those lines and the line of the Andes, with the pentagon that covers Europe. That the earth is traversed by great intersecting lines is undeniable. *E.g.* Daubrée showed that the valley system of northern France follows a line of rectangular fractures, which he called diaclases. The directions of the Greenland fiords is determined by a similar series of intersecting diaclastic fractures. Bertrand has shown that the movements in the Paris basin, the North sea, and English channel, have followed a double set of orthogonal intersecting lines.

But that the fracture lines or lines of weakness in the earth's crust should intersect more or less rectangularly is natural on any theory of their formation. And such coincidences as those pointed out by Élie de Beaumont in support of his system are inevitable in so crumpled a globe as ours; but they are not sufficiently numerous to be convincing, especially in face of the fundamental differences between the facts of geography and Élie de Beaumont's elaborate artificial system. His theory could

*For explanation and justification of this use of the word "parallel," see Hopkins, "Presid. Address, Geol. Soc.," *Quart. Jour. Geol. Soc.*, vol. ix. p. xxix.

only be applied to a symmetrical world;* in a dodecahedron the opposite faces are always similar and parallel; in Élie de Beaumont's network the antipodal areas are always similar. But, as we have seen, the fundamental fact in the plan of the world is that opposite areas are dissimilar. In crystallographic language the lithosphere is hemihedral, not holohedral; and no scheme based on a holohedral form will serve. It is the recognition of this principle that led to the next great advance.

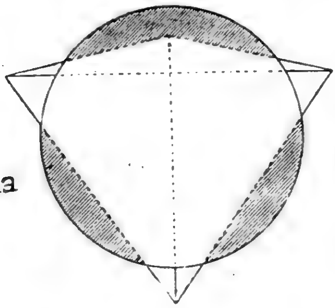
THE TETRAHEDRAL THEORY.

Élie de Beaumont's scheme is now mainly of historic interest, though Lefort's recent map of the Nivernais shows that it is still used as a working hypothesis by some French geologists. But Élie de Beaumont's theory marked an epoch in this subject, for it led to the system of Mr. Lowthian Green, which far better meets the requirements of the case.

This system was founded in 1875, by Mr. Lowthian Green, in a work which was neglected or ridiculed at the time of its appearance. Like his predecessor, Green assumes that the earth is a spheroid based on a regular geometrical figure. He adopted as his base the apparently hopelessly unsuitable figure of the tetrahedron, which is contained within four equal similar triangles. This form, with its four faces, six sharp edges and four solid corners, does not conform to the ordinary conception of the figure of the globe. Any comparison between them looks ridiculous. But if we place a three-sided pyramid on each face of the tetrahedron, its proportions are nearer those of a globe; and if these pyramids had elastic sides so that they could be blown out and the faces thus made curved, then the tetrahedron would become spheroidal and even spherical. Conversely, if a hollow sphere be gradually exhausted of air, the external pressure may force in the shell at four mutually equidistant points, and, by the flattening of these four faces, make it tend towards a tetrahedral form. Now the tetrahedral theory does not regard the world as a regular tetrahedron with four plane faces; it considers that the lithosphere has been subjected to a slight tetrahedral deformation, to an extent indeed only faintly (if at all) indicated by geodetic measurements, but

*This objection applies also to various later modifications of Élie de Beaumont's principle, such as those of Owen; or to the more than local acceptance of the diaclases of Daubrée, or orthogonal cross-folds of Bertrand.

yet easily recognizable owing to its influence on the distribution of land and water. As the centres of the flattened faces are nearer the earth's center of mass than the edges, the water will collect upon them. The ratio of the area of land to that of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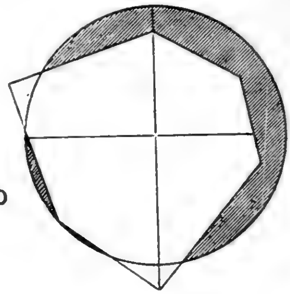
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FIG. 4.—RELATIONS OF A TETRAHEDRAL LITHOSPHERE TO ITS HYDROSPHERE. FIG. 4a REPRESENTS THE ARRANGEMENT IN A SIMPLE TETRAHEDRON. FIG. 4b ILLUSTRATES THE CASE OF A MODIFIED TETRAHEDRON (SUCH AS SHOWN FIG. 5b) BY A SECTION PASSING ON THE LEFT THROUGH A TETRAHEDRAL COIGN, AND ON THE RIGHT THROUGH THE OPPOSITE TETRAHEDRAL FACE. THE SHADED AREAS REPRESENT WATER.

water on the globe is as 2 to 5. If on a model of a tetrahedron we color the five-sevenths of the surface that is nearest the centre, the colored areas would show where the water would collect if the earth were a stationary tetrahedron. On the upper face there is a large central colored area in the position of the Arctic ocean. It is surrounded by a land belt, from which three projections run southward down the three lateral edges. These three land areas taper southward to a point, below which is a complete belt of sea. South of that, again, is our fourth projecting corner, which is above the water-level, and is the Antarctic continent. So that on the model the general plan of the arrangement of land and water is identical with its actual distribution on the globe. For the land occurs as three triangular equidistant continents, united above into a ring and tapering southwards; there is a great excess of water in the southern and of land in the northern hemisphere; and land and water are antipodal, since in a tetrahedron a corner is always opposite a flat face.

But of course in the earth the faces are not flat, but are convex. If the flat faces be replaced by projecting pyramids with curved faces, so that the form is globular, the arrangement of land and water remains the same, but the shore-lines are more complex. Green has shown what the shapes of the land

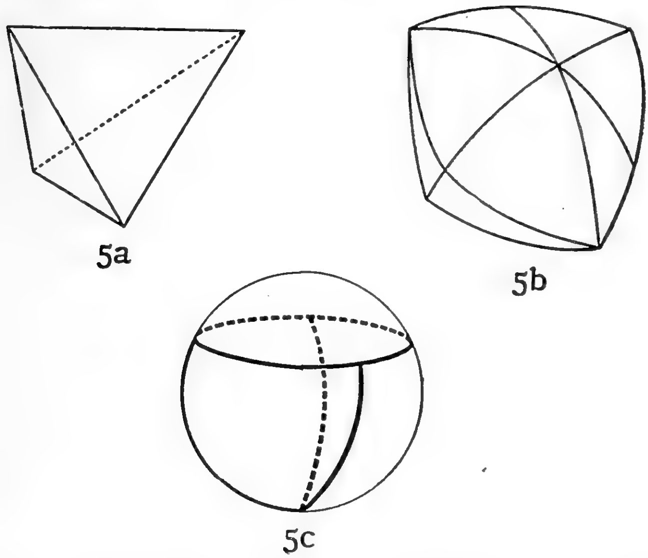

FIG. 5.—5a, DIAGRAM OF A SIMPLE TETRAHEDRON.—5b, DIAGRAM OF A TETRAHEDRON WITH A SIX-FACED PYRAMID WITH CONVEX FACES ON EACH OF THE FOUR FACES.— 5c, THE TRACE OF THE TETRAHEDRAL EDGES ON A SPHERE; THE THICK LINES SHOW THE POSITION OF THE TETRAHEDRAL EDGES.

and water areas would be in such a tetrahedron. The resemblance between his diagrammatic continent and Africa and S. America, and between his ocean and either the Pacific, Indian ocean, and S. Atlantic, is very striking.

THE TETRAHEDRAL COURSE OF GEOGRAPHICAL LINES.

The agreement between the facts of geography and the tetrahedral theory goes further. The four faces of a tetrahedron meet along six edges, which should be lines of elevation on a globe. The trace of the edges of a tetrahedron on a surrounding sphere forms a circle in the northern hemisphere, and three vertical or meridional edges meeting at the south pole.

In the earth the major watersheds have exactly this arrangement. The great watershed of Eurasia dividing the northern and southern drainages, runs, not along the main mountain axis, but far to the north of it, between the parallels of 50° and 60°. The northern and southern slopes of North America are separated by a divide along the same latitude. The southern watersheds, instead of following the lines of highest mountains, or the middle line of the continents, run close to the coast-lines; the three watersheds mark the three vertical tetrahedral edges, and they occur at almost the theoretical distances, 120° apart.

Similarly with the mountain chains. As Sir John Lubbock has pointed out, "in the northern hemisphere we have chains of mountains running east and west, the Pyrenees, Alps, Carpathians, Himalayas, etc.—while in the southern hemisphere the great chains run north and south—the Andes, the African ridge, and the grand boss which forms Australia and Tasmania." That is to say, the northen mountains are parallel to the upper edges, and the southern mountains are parallel to the meridional edges of the tetrahedron.

THE CAUSE OF THE TETRAHEDRAL PLAN.

The statement that the elevations of the lithosphere are tetrahedral in arrangement is not a hypothesis, but a simple statement of geographical fact. Is the fact a mere coincidence? On the contrary, there are good reasons why the earth should acquire such a tetrahedroid symmetry. When the earth solidified, it would (neglecting the influence of rotation) have contracted into a spherical shape. It would have tended to acquire this form because the sphere is the body which encloses the greatest volume for a given surface. But as the earth contracts it tends to acquire a shape in which there is a greater surface in proportion to its bulk. Now, among the regular geometrical figures with approximately equal axes, the tetrahedron is that which contains the smallest volume for a given surface. Hence every hard-shelled body which is diminishing in size, owing to internal contraction, is constantly tending to become tetrahedral in form. Fairburn's experiments (quoted by Green) illustrate this tetrahedral collapse for short tubes; and that it is considered probable by some geodists is shown by the following quotation from E. D. Preston: "Nothing is more in accordance with the action of physical laws than that the earth is contracting in approximately a tetrahedral form. Given a collapsing homogeneous spherical envelope, it will assume that regular shape which most readily disposes of the excess of its surface dimensions; or, in other words, the shape that most easily relieves the tangential strains; for, while the sphere is of all geometrical bodies the one with a minimum surface for a given capacity, the tetrahedron gives a maximum surface for the same condition. Experiments on iron tubes, on gas-bubbles rising in water, and on rubber balloons, all tend to bear out the assumption that a homogeneous sphere tends to contract into a tetrahedron."

(To be continued.)

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Jovellania triangularis im Mitteldevon der Eifel, von E. KAYSER (Centralblatt für Mineralogie etc., 1900, p. 117.)

The occurrence of this well known Devonian species of Archaic in loose fragments along with a characteristic middle Devonian fauna at Lissengen in the Eifel is described. G. F. M.

A brief review of the titaniferous magnetites. By J. F. KEMP. (*School of Mines Quarterly, 20.* 323-356; *21,* 56-65.)

The known deposits of magnetic iron ore may be conveniently classified into two groups on the basis of chemical composition; the titaniferous and the non-titniferous. This grouping not only corresponds to the chemical composition, but also to the geological relations and to the present utilization and non-utilization.

Among the magnetic ores the non-titaniferous are today the only ones mined and smelted and even their productiveness has decreased notably in recent years, because of the great influx of cheap and easily reduced hematites from lake Superior. The Cornwall banks in Pennsylvania are almost the only large American magnetite mines now in active operation. The geological relations of the non-titaniferous ores are variable, and, in one place and another, they have resulted from very different originals and by strongly contrasted processes, but if titaniferous iron sands are omitted, the massive titaniferous ore-bodies may be said to be closely allied in character and origin wherever they have been studied. With one or two exceptions the titaniferous magnetites are associated, so far as known, with rocks of the gabbro family and furnish a distinct type of ore body, that is singularly uniform the world over. They constitute, in most cases, large irregular masses in the midst of intrusions of igneous rock and seem to have been produced by the segregation of fairly pure titaniferous iron oxide, either before or during the process of cooling and consolidation. In less common instances the entire mass of the dike or stock is so enriched with the iron-bearing mineral as practically to be considered an ore. Although the ores are not at present the objects of active mining, yet the quantity is so large and the iron afforded has such peculiar advantages of its own, doubtless owing to certain chemical elements generally present in the ore, that it seems improbable that they will long go without utilization. The wall-rocks, referred to as belonging to the gabbro family, form an extended series including anorthosyte, true gabbro, noryte, diabase and peridotyte. To them must be added the Brazilian nepheline-plagioclase rock and the nepheline-syenyte at Alno, Sweden. In their mineralogical composition the ores involve both ilmenite and titaniferous magnetite. The latter may be strongly magneitc while high in TiO. The strong magnetism of some titaniferous magnetite shows the improbability of removing the titanium by magnetic concentration. In most cases, while the iron is increased in the concentrates by the elimination of the ferro-magnesian silicates, the titnium is also increased. In their chemical composition the ores are characteristic and marked. As a rule, but not invariably, phosphorus and sulphur are notably low or entirely absent. Vanadium, chromium, nickel and cobalt are almost always present, and they may together amount to several per cent. Magnesia and alumina are often far in excess of what would be required for silicates and then they are doubtless combined with more or less iron in spinels. Lime is of course involved in the presence of the pyroxenes and related minerals and manganese is often, but not invariably, at hand. This paper consists after the brief introduction, of summary descriptions, in geographic sequence, of the chief deposits of titniferous magnetite now known. The descriptions are accompanied by analyses to the number of more than one hundred seventy which illustrate for each region the range in composition. This work is thus a complete resumé; and the citations place the reader in command of the literature. W. O. C.

The Origin of Kaolin. By HEINRICH RIES. (*Trans. Am. Ceramic Soc.*, 2, Feb. 1900.)

Defines kaolin as any residual clay sufficiently free from iron to burn to a white or nearly white color, and derives kaolin from feldspathic minerals, in part through the agency of carbon dioxide and the ordinary weathering processes (shallow deposits) and in part, as suggested by Von Buch and Daubrée, through the agency of ascending acid vapors, including chiefly hydrofluoric acid (deep deposits). Collin's experiment and analyses are cited in support of the latter explanation; but all the economic deposits of the United States are referred to the former. Kaolins containing undecomposed mica can not be referred to the fluoric type. The practicability of correlating rational analyses of kaolin with the original minerals and the method of deriviation is also considered. W. O. C.

Igneous Complex of Magnet Cove, Arkansas. By HENRY S. WASHINGTON. (*Bull. Geol. Soc. Am.*, *11*, 389-416.)

This paper is an able and timely review, in the light of the modern ideas of magmatic differentiation, of the limited and isolated area of plutonic rocks so carefully mapped and described to J. F. Williams ten years ago. The scope of the paper is clearly and tersely indicated in the author's summary, from which the reviewer quotes. The structure of the complex is briefly described, and from the evidence of its broadly elliptical outline, relations to surrounding shales, the presence of an overlying zone of metamorphosed rocks, the arrangement and serial petrographical and chemical characters of the main types, together with other minor points, it is shown that the igneous complex is probably a laccolith, and certainly a unit or integral mass of intruded magma. The component abyssal types are not due to successive injections as was suggested by Williams, but are the products of a differentation in situ of the originally homogeneous mass of intruded magma ("laccolithic differentation" of Brögger). The main rock types are briefly described, some new analyses being given; and they are shown to form a regularly graded series, ranging from foyayte, through leucite-porphry, shonkinitic syenyte, normal ijolyte and biotite ijolyte to jacupirangyte. This serial and common genetic character is shown both mineralogically and chemically. It is probable that the dikes of tinguayte and nepheline porphyry are aschistic (undifferentiated injections of the still fluid differential zones into the surrounding rocks), while those of the monchiquitic rocks are diaschistic (products of a still farther differentiation of these zones). The arrangement of the abyssal rocks is abnormal and differs radically from most other cases of differentiated masses, in that there is progressive increase in acidity toward the periphery, the analagous case at Umptek in Kola being especially mentioned. An explanation of this is based on a process of fractional crystallization or freezing of the magma, which is regarded as a solution, the solvent crystallizing first, is given; and the hypothesis is applied to other cases. It is suggested that all laccoliths and similar masses of magma may be referred to at least four different types, dependent on the chemical composition of the magma as a whole, the differences between which would be satisfactorily accounted for by the hypothesis. In the opinion of the reviewer, the explanation of this contrast between the normal centripetal acidity and the abnormal centrifugal acidity of plutonic masses might be strengthened and simplified by recognition of the important role as a solvent of water, which, so far as known, is universally present in magmas, and is the one important constituent which never freezes. W. O. C.

A Granite-Gneiss Area in Central Connecticut. By LEWIS G. WESTGATE. (*Jour. Geol.*, *7*, 638-654.)

This is purely a petrographic paper, describing an elliptical area of gneissoid granite on the Connecticut river east of Middletown. The phenomena and inclusions of the inclosing schists prove the granite to be intrusive, in spite of the marked and persistent foliation. It assumes frequently the character of an "augen"-gneiss. Basic segregations or schlieren of dark color and fine grain are a common feature, strengthening the proof of an igneous origin, as do the asociated dikes of pegmatyte and the contact zone of granulyte. The component minerals, from which the chemical composition may be approximately deduced, are chiefly quartz, various feldspars and biotite, the feldspars including most abundantly orthoclase, with an acid plagioclase and subordinate microcline. The accessories include titanite and a very little apatite and magnetite. In the granulyte garnet is the chief or only accessory. W. O. C.

The Origin of Nitrates in Cavern Earths. By WILLIAM H. HESS. *(Jour. Geol., 8,* 129-134.)

The nitrates are not derived from the excrement of bats, as popularly supposed, but have their origin in the oxidation or nitrification of organic matter in the surface soil through the agency of bacteria, and the subsequent leaching of the nitrates so formed downward into caverns, where they slowly accumulate with other salts as the water escapes by evaporation. This explanation is in harmony with the fact that bats penetrate but short distances from the entrance to a cavern, while the distribution of the nitrates is entirely without reference to the entrance, the cavern earh of the Mammoth cave having been worked for nitrates for a distance of over five miles from the only opening to the surface. Three analyses show that nitrates form but a small part of the soluble salts of the cavern earth, which include also sulphates and chlorides, and may aggregate as much as 13 per cent. The general conclusion as to the origin and source of the nitrates is sustained by a comparison of analyses of the soluble portions of (1) subsoil from the surface above the Mammoth cave, (2) cavern earth from the subjacent part of the cave, (3) bat guano, and (4) cavern earth immediately below the bat guano. A comparison of bulk analyses of bat guano and cavern earth follows; and it is suggested that the calcium phosphate of the latter cannot be referred to the former, since the insolubility of this salt makes it a necessary residuary product of the solution of limestone. Analyses show that the water dripping from the roofs of caves is not markedly different from ordinary sub-drainage waters. The nitrates and other soluble salts accumulate only in the earths of relatively dry caverns, or where the inflow of water does not exceed in amount the water removed by evaporation; and numerous analyses show that all dry caves contain nitrous earths. Nitrates found under overhanging cliffs are of a similar origin—evaporation of water which has percolated through the soil; and essentially the same explanation will fit the case where nitrates accumulate on the surface of a manure heap, through the joint action of capillary attraction and evaporation. W. O. C.

Igneous Rock-Series and Mixed Rocks. By Alfred Harker. (*Jour. Geol., 8,* 389-399.)

A rock-series is defined as an assemblage of rock-types, with a certain community of characters, associated in the same district, belonging to the same suite of eruptions and holding a similar position in the scheme of igneous rocks belonging to that suite. According to the differentiation hypothesis, they are derivatives of the same order from one common source, resulting from differentiation along similar lines and tc the same degree. The fundamental characteristics of such a series, having regard to chemical composition, are of two kinds: (1) those belonging to the individual rock-types and shared by all the types included in the series; and (2) those belonging to the assemblage of types as a whole, depending upon variations in the composition of the members as compared with one another. These characteristics admit of very clear graphic presentation. For this purpose the method of two equal rectangular co-ordinates first used by Iddings is recommended, silica being referred to one axis and bases to the other; and the resulting curves are briefly discussed. The origin of ingeous rocks by admixture rather than by differentiation is next considered, and three principal cases are distinguished: (1) mixture of two fluid magmas; (2) permeation of a solid rock by a fluid magma; and (3) inclusion of rock fragments in a fluid magma. The second and third cases are practically limited to igneous rocks of cognate origin; and the distinction of the included and permeated rocks or xenoliths as accidental and cognate is regarded as important; the latter only yielding by their absorption new rocks of any considerable extent or importance. Several cases are considered, including the admixture of two rocks of the same rock-series, and the solution by a magma of extraneous quartz, and of limestone. The admixture of the extreme types of a series will not, in general, give exactly any of the intermediate types. The rock-analyses of Clarke and Hillebrand are cited in illustration of this principle; and it is pointed out that mixtures, even of two normal igneous rocks and still more of an igneous and a sedimentary rock, must often be abnormal in chemical composition. The relations of the chemical composition of the magma and of foreign admixtures to the mineralogical compostion are also considered.

The Sundal Drainage System in Central Norway. By R. L. Barrett. (Bulletin American Geographical Society, No. 3, 1900.)

The young Sundal drainage system, on the northern coast of central Norway, possesses deep gorges and canyons which drain northwest into the Atlantic. It is closely related to, but divided from, the comparatively shallower and more or less disconnected valley system of the Opdal, which drains northeast but also reaches the Atlantic.

The divide between these two systems has been shifted from east to west, as has been the case in a less degree in the two drainage systems just south of the Sundal, the Eikedal and the Ronesdal.

The paper presents facts to prove that the divide in question once stood near the head of the Sundal fjord, more than sixty-five kilometers west of its present position, and also shows that the processes which shifted the divide and reversed the drainage are largely responsible for the peculiar features of the Sundal system, namely, its deep canyons and high shallow tributary valleys.

The author reconstructs the mature valley system (Opdal), describes the young canyon system, shows the relation existing between the two and offers explanations for these relations. He discusses as factors in the reversal of drainage: guided headward erosion by the Sundal system and capturing of the Opdal branches, unguided headward erosion and capturing, erosion by the outlets of ice-dammed lakes which overflowed from the Opdal to the early Sundal system and glacial erosion.

The text is accompanied and elucidated by five diagrams which put the whole story in clear and concise form. The paper is an admirable result of thorough investigation in the field and laboratory.

F. B.

Bulletin No. 4, of the South Dakota School of Mines, Department of Geology. PROF. C. C. O'HARRA. April, 1900. Rapid City, S. Dak.

This pamphlet, containing 88 octavo pages, with several plates reproducing old maps, furnishes an exact and very useful epitome of the literature of the geology of the Black Hills. Many of the old papers, now very rare, beginning with those of Dr. Prout in 1846, are annotated. The first portion of the bulletin sketches rapidly the progress of geological investigation in the Black Hills region, giving some account of the parties and the routes they followed. The earliest mention of the hills is in Lewis and Clarke's report of their expedition in 1804-05-06, where they are credited with glaciers, although this must have been incorrect—or at least it cannot now be affirmed of the region known as the Black Hills. The author mentions fully the work of Dr. Evans in the "bad lands," reported by Dr. Owen in his report on Iowa, Wisconsin and Minnesota, of Dr. F. V. Hayden and Mr. F. B. Meek, Dr. Leidy, Lieut. G. K. Warren and others to 1900.

N. H. W.

MONTHLY AUTHOR'S CATALOGUE

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PERSONAL AND SCIENTIFIC NEWS.

DR. OTTO NORDENSKJOLD, of Upsala, is preparing a south polar Swedish expedition which will be ready to start probably, in the fall of 1901.

DR. R. A. DALY of Harvard University is planning the organization of a summer excursion to Iceland, western Greenland and Labrador, conditioned on the formation of a sufficiently large party leaving Boston on or about June 26, returning about September 20.

PROFESSOR E. H. WILLIAMS, Jr., of the department of mining and geology, has equipped a geological laboratory for the microscopic study of rocks at Lehigh University.

PROFS. A. J. MOSES AND L. M. LUQUER contribute to the *Journal of Applied Microscopy* abstracts of mineralogical literature, American and foreign.. These are particularly valuable in the mathematical and physical, especially the optical, characters.

PROF. H. B. PATTON, of the Colorado School of Mines, Golden, Colo., offers a list of rare Colorado minerals and of rocks, for exchange with institutions which may have others for such disposition.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of January 23rd the following was the program: "The geologic age of Shell bluff, Ga., one of Lyell's original localities," T. Wayland Vaughan; "Trias in northeastern Oregon," Waldemar Lindgren; "Comparison of the Ouachita and Arbuckle mountain sections, Indian Territory," J. A. Taff; "Age of the coals at Tipton, Blair county, Pa.," David White.

THE LAKE SUPERIOR MINING INSTITUTE will hold its seventh meeting in the copper district of Michigan on March 5 to 8. The headquarters will be at Houghton.

GEOLOGICAL SOCIETY OF AMERICA.—The regular winter meeting was held at Albany, N. Y., presided over by Dr. G. M. Dawson, who gave an ex-augural address on "The Geological record of the Rocky Mountain region." The session continued through Dec. 27, 28 and 29, and was attended by about thirty geologists. A large number of papers were read. A reception was given the Society by the state geologist, Dr. F. J. H. Morrill, at his residence, evening of Dec. 28, and the usual subscription dinner occurred Dec. 27. The Society assembled, and held its meetings, in the Albany Boys' Academy, in the room in which Henry demonstrated publicly the possibility of the electric telegraph. The president-elect is

C. D. Walcott. The next winter meeting is planned to occur in Chicago.

GEOLOGICAL SOCIETY OF AMERICA, CORDILLERAN SECTION—The western, or as it is called the Cordilleran section of the Geological Society of America, was established by a few of the geologists of the western coast whose distance precludes them from joining their fellow members of the eastern part of the continent, save on rare occasions. The second annual meeting of this section was held on Friday and Saturday, the 28th and 29th of December, at the State University of California, at Berkeley. Prof. W. P. Blake, of the University of Arizona, presided on the former day and Prof. W. C. Knight, of Laramie, Wyoming, on the latter.

The first meeting was held in the council room of the California Academy of Science at San Francisco, and the other at the state university, Berkeley, where all arrangements for the convenience of visitors had been made by the secretary and other resident members. Prof. Andrew Lawson, of Berkeley, secretary of the section, was also the secretary of the meeting.

The following summary will show the course and scope of the proceedings:

Prof. Blake read the first paper, and in it he gave the evidence for the existence of any ancient, probably Cambrian, sandstones and quartzytes, on the granite of Arizona. He also mentioned the existence of limestone with *Atrypa reticularis* and of quartzytes with Devonian fossils. In the Santa Catarina mountains are uncrumpled strata, probably the equivalents of the Huronian and Laurentian of Canada, and also much crumpled beds of mica-slate standing nearly vertical.

Reference was also made to beds of pegmatyte and in the discussion that followed to very thick strata of Cambrian dolomytes with strata of quartzytes penetrated by intrusive granites of Cambrian date. The paper was followed by considerable discussion, in which most of those present took part.

Prof. E. W. Claypole, of Pasadena, next spoke of the structure of the Sierra Madre and the valley of Pasadena. This range is apparently a continuation of the ranges of the Santa Lucia and the San Rafael mountains, and consists of two materials. The front or southern face is composed of a very highly hornblendic granite which by the oxydation of iron is subject to rather rapid and deep weathering. Corrosion is consequently severe and the existence of crags and cliffs is rendered difficult. Behind this and forming the higher portion is a white felspathic gneiss containing very little hornblende and weathering less rapidly. Of this consist the crags and scarps so conspicuous from the valley. The valley is almost entirely made up of detrital material derived from the destruction of the Sierra—often many hundreds of feet deep and consisting of strata of gravel and clay. These form the great water-storage of the region and during the past dry season they have been exploited in the search for water and have proved vastly more productive than had been previously believed. The possibility of largely increasing the productiveness of the valley of Pasadena and the plain of Los Angeles has consequently been rendered almost a certainty. The paper concluded with a few notes on the method now in course of adoption for further increasing and storing the rainfall.

On Friday afternoon Prof. E. W. Hilgard, of the agricultural department of the University of California, spoke on the soils of the state and the mode of their formation, the power of kaolinization, the effect of wind and the origin of adobe. He pointed out the difference between the soils of the dry and the humid regions, maintained that few of them needed "liming" or, as it is called, "marling," as there is usually present from 1 to 2 per cent of lime in some form or other, a large part of which is the carbonate. He showed that most of these aluminous soils retain the potash resulting from the decomposition of the orthoclase and that in many cases this, in the soil of the surface alone, amounts to 1200 to 1800 pounds per acre.

Much of the sandy soil of the state needs only water to become abundantly fertile, if tolerably free from alkali (chiefly carbonate of soda) and the dryness of the superficial soil forces the roots to penetrate it to a much greater depth than roots do in moister regions. In consequence of this fact crops which there would be killed by a long drought are here able to survive and even flourish for months without any rain.

F. M. Anderson, of Berkeley, described the river system of northern California and the Klamath mountains. The latter, he said, contain two sets of flexures at nearly right angles to each other but not coeval. The streams have the level intermontane areas, in many cases, by narrow canyons, indicating an immature topography. Deposits of Chico, or Upper Cretaceous, age occur on the north and south sides of the Siskiyou river, shaly below and conglomeratic above.

The lavas of the Cascade mountains are of different ages; the oldest eruptive are certainly of a date before the deposition of the Chico, or Upper Cretaceous, beds and between them and the later beds lie the Ione deposits. Near the head of the Siskiyou river there are indications of four distinct periods of volcanic activity. In some of the tuffs are petrified fragments of wood and under some of the andesitic beds are specimens of unmineralized wood, black and scorched. This and the drainage of the region which is antecedent indicate the very recent date of the eruption.

H. W. Fairbanks, of Berkeley, spoke on a group of volcanic peaks called "The Three Sisters" in central Oregon. They rise to a hight of 10,000 feet, and among them lies a glacier nearly three miles long and half a mile wide. The paper was illustrated by a number of slides, showing the mountain and the topography of the region. The recency of volcanic activity is proved by the superposition of the lava on glaciated surfaces of the rock and by the presence of a small volcanic cone in the path of the glacier which has not been able to destroy or seriously erode it.

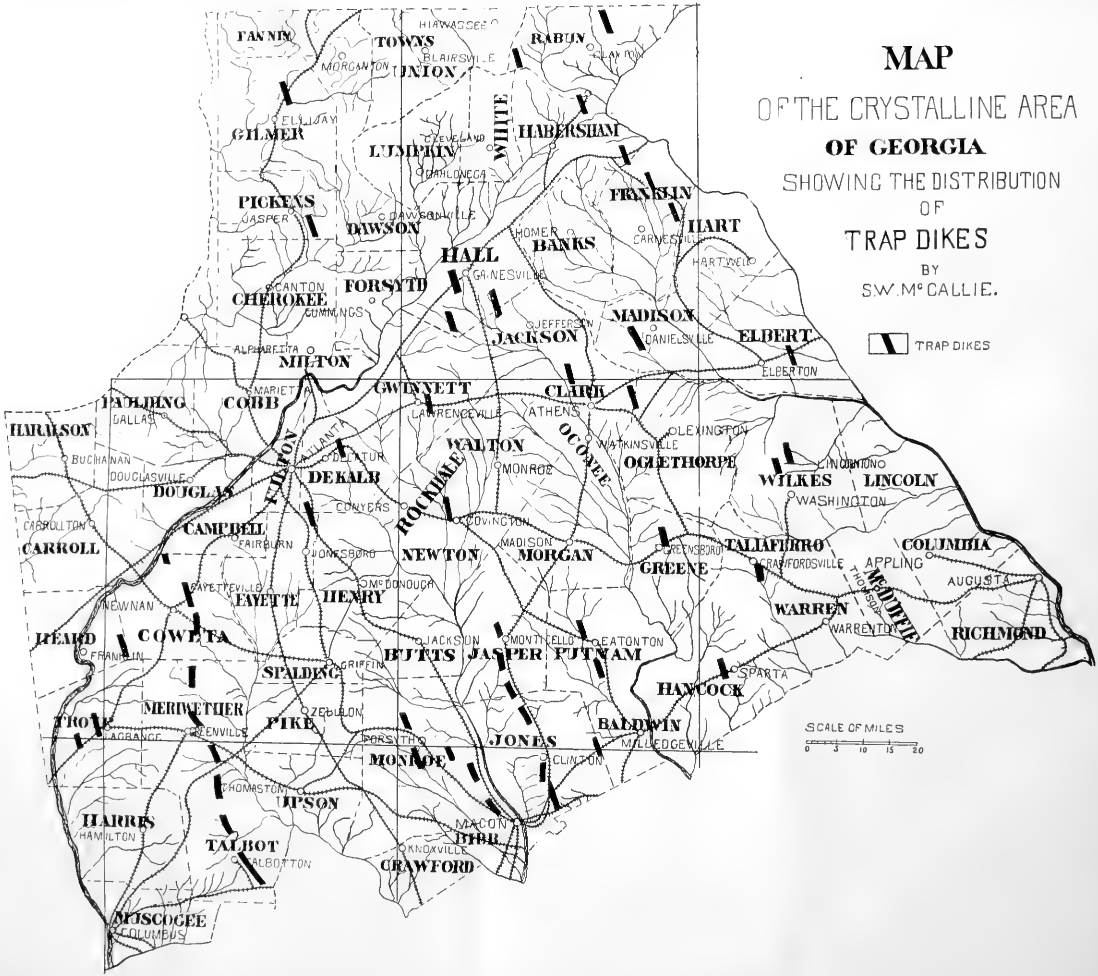
Prof. A. C. Lawson presented a series of arguments drawn from the superficial structure of the region tending to show that the elevation of the Sierra Nevada was in date later than that of the Coast ranges. He argued that the river-valleys of the two regions presented marked differences—that the drainage in the Sierra Nevada is consequent and the system therefore immature, while in the Coast range the drainage is subsequent and the geomorphy mature. Illustrations were drawn from the branches of the Klamath, Eel and Sacramento rivers in support of the views advocated in the paper.

Prof. Lawson also spoke briefly on a specimen of feldspar-bearing corundum, from Plumas county, California, which occurs as a dyke cutting serpentine on the eastern flank of Spanish peak. He spoke of the rocks as supersaturated with alumina, and said, the feldspar was an oligoclase containing by an analysis 16 per cent of corundum.

Prof. J. C. Merriam, of Berkeley, spoke of the John Day beds exposed on the river of the same name. The canyon is cut through an immense series of strata about 10,000 feet in thickness and ranging from the Jurassic to the Quaternary and composed of nine or ten distinct beds. These include large quantities of volcanic tuffs and ashes, with andesitic and rhyolitic lavas lying on the John Day beds and tilted with them to an angle of 30° over which are seen 1,500 feet of Columbian lavas. The abundance of land shells of such genera as *Helix*, the scattering of the bones of the skeletons and the absence of fish remains were mentioned as tending to cast some doubt on the lacustrine nature of the deposit. Ten skeletons have been found whole and very few plant remains occur. The Cretaceous beds are of the age of the lower Chico.

Mr. H. M. Turner, of Washington, D. C., spoke on the Geology of the Great Basin in California and Nevada. The address was illustrated with lantern slides. The ridges of the western edge of the Great Basin in Nevada and eastern California, are usually very complex in structure and composition. They comprise sediments of Paleozoic and Juratrias age much disturbed at some points by intrusions of granolytes. In Tertiary time there were extensive lakes, and contemporaneous with these lakes, and also later, lavas and tuffs in large amount, chiefly rhyolytes, andesytes and basalts. The formation of the ranges or at least their latest uplifts date from the Tertiary or post-Tertiary. They were elevated along normal faults, the valleys being subsided areas, often of the nature of rock basins, whose rims are made up of rocks older than the desert detritus.

There are some gneisses pretty certainly of pre-Cambrian age. These gneisses underlie lower Cambrian slates and limestone There is an extensive chert series rich in graptolites supposed to be of lower Silurian age. There are also lower Trias beds in the Inyo range and in the Pilot mountains Jurassic limestone and slate. The Tertiary lava beds contain abundant plant, molluscan and fish remains.



MAP OF THE CRYSTALLINE AREA OF NORTH GEORGIA, SHOWING THE DISTRIBUTION OF TRAP ROCK.

MAP

F THE CRYSTALLINE AREA

OF GEORGIA

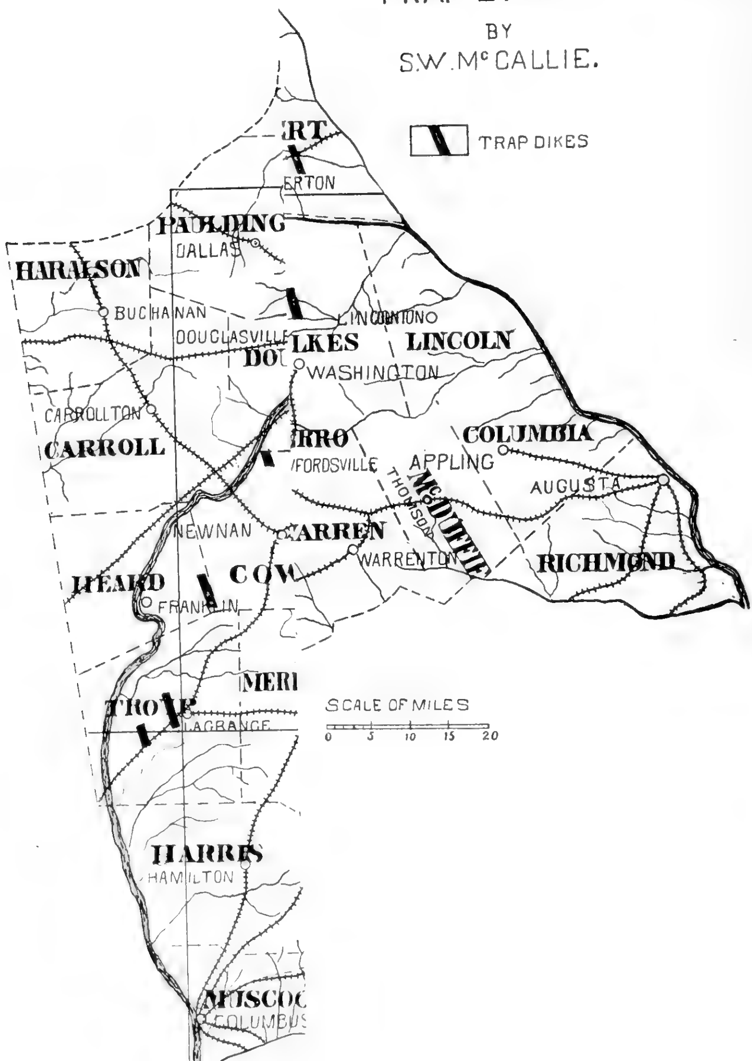
SHOWING THE DISTRIBUTION

OF

TRAP DIKES

BY

S.W. Mc CALLIE.



RAP ROCK.

Exposure of a Trap Dike on the Central Railway, Four Miles East of Newman, Coweta County, Ga.

THIN SECTION OF OLIVINE DIABASE, FIVE MILES NORTH OF MACON, GA., AS IT APPEARS UNDER CROSSED NICOLS X 75.

THE

AMERICAN GEOLOGIST.

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SOME NOTES ON THE TRAP DIKES OF GEORGIA.

By S. W. McCallie, Atlanta, Ga.

Plates XII–XIV.

The trap dikes of Georgia are confined to what is known as the Crystalline area, an old land surface, occupying the central and northern part of the state. This area is made up largely of schists and gneisses with numerous intrusive bosses of granite. The schists and gneisses occur chiefly in alternate bands or zones having a northeast-southwest trend. The dikes are pretty evenly distributed throughout the area and are found mostly in groups which consist of one large, or mother dike, paralleled on one or both sides by smaller dikes.

The larger dikes often attain a maximum width of 200 feet and sometimes extend for many miles with but few interruptions. A good example of one of the larger dikes is to be seen in a cut on the Central railroad, a few miles east of Newnan in Coweta county. This dike continues for about sixty-five miles in a southern direction through Coweta, Meriwether and Talbot counties, finally disappearing beneath the Columbia sands some four miles south of Talbotton. Within this distance there occur a few breaks or interruptions a mile or more in length due either to an actual discontinuity of the dike or its burial beneath the residual products derived from the enclosing schists.

The smaller dikes vary from an inch to a yard or more in width and never continue for more than a few hundred rods. In some localities these smaller dikes are quite numerous. On the Georgia railroad near Covington as many as seven of these dikes are to be seen within a short distance of each other. The dikes as a general rule all have a vertical dip, and a northwest-southeast trend, thereby invariably cutting the gneisses and schists at a considerable angle. In some instances the large dikes, owing to their slow weathering, have given rise to low, flat ridges whose sides are usually strewn with innumerable rounded bowlders, locally called "nigger-heads."

All of the trap dikes throughout the Crystalline area appear to be of the same age and are formed of similar rock material. They are evidently of a comparatively recent geological age as is shown by their undisturbed condition. They rarely ever reveal any evidence of shearing or any other indication of a general earth movement. Along the southern margin of the Crystalline area between Macon and Milledgeville at a point on the Georgia railroad, near James' Station, a dike comes in contact with clay beds which have been classed by Dr. Geo. E. Ladd as Tertiary beds.* The exposure here, however, is limited and gives no satisfactory evidence as to the relation of the dike to the Tertiary clays. A further study of the dikes along the above contact will probably demonstrate that they are of Jura-Trias age, and belong to the same system as the trap dikes of the Carolinas and Virginia.

The rocks of the dikes are quite compact, fine-grained and of a dark-gray, or almost black color. They are typical diabases made up of plagioclase and augite with olivine and magnetite as the chief accessory minerals. The plagioclase occurs in the form of long, slender, lath-shaped crystals, which are frequently enveloped in large irregular plates of augite, thus exhibiting a beautiful ophitic structure.

THE PLAN OF THE EARTH AND ITS CAUSES

By J. W. GREGORY, D.Sc., Melbourne, Aus.

(*Continued from p. 119.*)

THE EARTH A GEOID.

But it may be said this tetrahedral theory is impossible, because we know from our elementary text-books that the earth is not terahedral, but is an oblate-spheroid—that is to say, a sphere slightly flattened at the poles.

The oblate spheroid is no doubt the form that rotation would have caused the earth to assume as it solidified, if the

* *The American Geologist*, vol. xxxiii, pp. 248.

earth were quite homogeneous. But the earth is not homogenous; it varies in strength and density, and an unequal load on the earth in any area leads to a divergence there from the circular shape. It is, I believe, now universally admitted that the earth is flattened laterally at the equator as well as at the poles. The question was long disputed between the astronomers, who, from theoretical considerations, declared what the shape of the world ought to be, and the geographers, whose measurements showed what the shape actually was. There is now a general agreement that the geographers were right; that the equatorial section of the earth is elliptical, similar to a section through the earth passing across the poles. The earth is therefore not a true spheroid, and it was accordingly regarded as an ellipsoid with three unequal axes. But there is good reason to believe that the earth is not even an ellipsoid; for the northern and southern hemispheres are unlike, and the earth is therefore shaped like a peg-top. This is shown in two ways. It is a well known property of the ellipse that degrees measured along the flatter side are longer than degrees measured near the sharper end. It was by proving that a degree of latitude in Lapland is longer than a degree of latitude in Ecuador that the French astronomers in the seventeenth century definitely proved the earth's flattening at the poles. In continuation of these observations, La Caille, in 1751, measured the length of a degree at the Cape of Good Hope. His measurements showed that the southern hemisphere was also flattened, but to a different extent than the northern hemisphere. This anomalous result of La Caille's was confirmed and extended by Maclear.

The inequality of the two hemispheres has also been shown by the variations of gravity in the two hemispheres, which, as it is more easily tested, has been more widely applied. The principle is simple. A pendulum swings more rapidly the nearer it is brought to the centre of the earth. A pendulum swings more slowly on a mountain-top than at sea-level. It was because Richer, in 1672, found that a clock which kept correct time at Paris lost two minutes a day in French Guiana that the polar flattening was first suspected. So many observations have been made that maps have been compiled showing the variation of the force of gravity throughout the globe. Fig. 6 is a

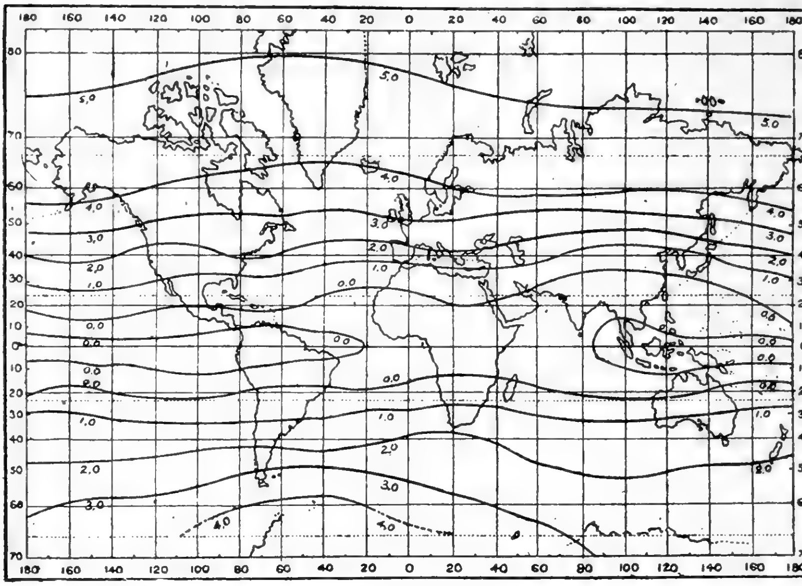

FIG. 6.—STEINHAUSER'S MAP, SHOWING VARIATION IN ATTRACTION OF GRAVITY, AS INDICATED BY LENGTH OF THE SECOND-BEATING PENDULUM. 0 = LENGTH IN EQUATORIAL BELT; 1-5 = NOS. OF MILLIMETRES BY WHICH A PENDULUM HAS TO BE LENGTHENED IN ORDER TO BEAT SECONDS AT DIFFERENT LATITUDES.

copy of Steinhauser's map, in which the variation of gravity is illustrated by showing how many millimetres have to be added to the length of the pendulum which beats seconds at the equator, to make it vibrate at the same rate elsewhere. In both northern and southern hemispheres the second-beating pendulum has to be steadily lengthened as we approach the poles, but the deviation is at a different rate for the two hemispheres. The surface of the southern hemisphere does not approach the earth's centre of mass at the same rate as the northern hemisphere. If the earth's centre of mass is at its geometrical centre, then the earth's form is elongated southward like a peg-top. It is often held that the earth's centre of mass is to the south of its center of form, because of the accumulation of water in the southern hemisphere. It is held that the water is piled up there, owing to the greater density of the southern hemisphere. If that be the case, then the peg-top elongation is all the greater.

Morevoer, there is evidence to show that the earth's figure is still more irregular than that of a peg-top.* Sir John Herschel, although taking the astronomical side in the controversy, aptly stated the facts in the statement that " the earth is earth-shaped." Listing's name of geoid, which expresses this view, has now supplanted the old oblate spheroid from everything except the text-books. That there are local deformations in the earth's shape is demonstrated by the differences between the astronomical and trigonometrical determination of positions. Places have two different longitudes, the astronomical longitude obtained by astronomical observations, and geodetic longitudes determined by terrestrial measurements; the differences are often considerable. It was calculated, *e.g.*, that the trigonometrical and astronomical determinations of the stations used in the delimination of the Canadian and United States frontier should have agreed within 40 feet, or 0.4 of a second of arc; but the average error was more than five times as great, and ran up to eighteen times as much as it should have been.

Astronomical determinations, moreover, are often not only inconsistent with geographical measurements, but they are often inconsistent with themselves. For example, one of the most refined estimations of longitude that have yet been attempted, is the series undertaken by the "K. K. topographische-militar Institut" of Vienna. To ensure accuracy during these observations, the most elaborate precautions were taken. Corrections were even made for the effect of the doses of quinine which the astronomers took when working in malarial climates. In one of the series of observations, the difference in longitude between Vienna and Milan was determined first directly, and then by determining the difference between Vienna and Brescia and that between Brescia and Milan. But in spite of all the care, the results did not tally. The sum of the two differences was not the same as the single difference. The whole, in fact, in this case was less than the sum of its parts.

To astronomers it may seem an unnecessary waste of time to devote so much to proving these deformations from the "spheroid of reference." But as the idea is less familiar to

* As Prof. Darwin suggests, potato-shaped would be a more correct simile.

geographers and geologists, the insistence on this deformation may not be useless. It may be worth while adding a quotation from Prof. C. A. Young,* to show that the spheroid of reference is only a convenient assumption. "On the whole," says Prof. Young, "astronomers are disposed to take the ground that since no regular geometrical solid whatsoever can *absolutely* represent the form of the earth, we may as well assume a regular spheroid for the standard surface, and consider all variations from it as local phenomena, like hills and valleys."

As deviations from the assumed spheroid of reference exist, it remains to inquire whether there is any evidence that they agree in position and arrangement with the theory of the tetrahedral deformation of the lithosphere.

The evidence already quoted of the dissimilarity between the northern and southern hemispheres and the elongation of the latter, is geodetic proof of the northern flattening and the antarctic projection, *i. e.*, of one face and one tetrahedral corner.

The three flattened lateral faces and three projecting vertical edges are sufficiently demonstrated by the three great oceans and the land-lines that have divided them. Practically, all the theories agree upon that point. It is well known that gravity is greater than was expected at most oceanic islands. Lallemand and de Lapparent have suggested that this is due to those islands being below the level of the ordinarily accepted figure of the earth, and therefore nearer the earth's centre of gravity.† Fisher has suggested that the Pacific ocean is the hollow left by the loss of the material which forms the moon. Faye has explained the ocean basins and the greater density of the crust below them as due to more rapid refrigeration below the cold oceanic abysses. According, therefore, to Faye, the rocks below the oceans contracted more than those below the continents, became denser, and accordingly sank.

Thus from all points of view the three oceans represent areas of depression, and the three land-lines of South America, Africa, and Australia mark intervening projections. The oceans mark the low areas in the lithosphere as obviously as

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* C. A. Young, General Astronomy,' p. 101. 1889.

† This explanation is inadequate, as it does not explain the deviation of the pendulum on coast-lines towards the ocean. The excess vertical attraction of the islands has been explained as due to the attraction of the mass of the island and its base.

the bubble of a spirit-level marks its higher end; and they give, therefore, evidence of the triangular lateral flattening of the southern half of the globe.

But as, on the mathematical figure of the earth, such lateral flattening is more improbable than variations along the axis of rotation, let us consider whether there is any geodetic proof of these flattened faces and projecting edges.

There has been a long controversy as to whether Bessel's or Clark's ellipsoid better represents the figure of the earth. Clark's figure was the later in date, and is generally considered as the more exact. Helmert therefore expresses some surprise that the gravitational observations in central Europe along the 52d parallel of north latitude agree with Bessel's curve better than they do with Clark's; this is the case all across the area on which Bessel's work was done. But as soon as we get into the Volga basin, the gravity line diverges from Bessel's curve and approaches that of Clark. The change comes due north of the Eurafrican meridional edge. The anomalies are at once removed if we assume that both ellipsoids are locally correct; that Bessel's curve is true for Europe, and Clark's correct for Asia; and that the two merge into one another north of the line of the Eurafrican tetrahedral edge.

On the tetrahedral theory, there ought to be a projection north of this tetrahedral edge. And gravity determinations show a great deficiency in gravity in western Russia in an appropriate area along the Volga basin. It is true that the figures have been queried. There is a natural tendency to query all facts that do not agree with theory, and the notes of interrogation in this case may illustrate that tendency. But on the view that there is an upward deformation of the earth in this area, the anomalous deficiency in gravity observations is at once explained.

It may be replied that the existence of a normal gravity attraction at Moscow negatives the assumption of a superficial deformation; but the relative excess of attraction there is possibly due to the outcrop of Palæozoic rocks, of greater density than the loose sediments of the Russian lowlands.

Passing from Russia to the area in North America, where the next tetrahedral corner should occur, there is another area of deficient gravity, which may also be due to that area being a tetrahedral elevation. The deficiency is explained by the assumption of vast subterranean blocks of very light material. But that explanation is prohibited in the Russian case, since, as Helmert has shown, the deviations of a plumb-line from the vertical are inconsistent with the existence of such blocks. In reference to the North American case, Helmert has remarked that the light subterranean blocks must have descended for several kilometres; and Mildenhall has shown that no reasonable assumption will suffice to explain the facts.

It would be too much to claim that geodetical evidence at present available proves the tetrahedral theory, for accurate data are not yet available for a sufficient proportion of the earth to show whether the major deviations are based on a regular plan; but papers, such as that of Mr. E. D. Preston, show that geodesists are more inclined to regard the theory with favor. It is at least clear that geodesy does not disprove the hypothesis, and that some puzzling geodetic anomalies receive a simple solution if the theory be true.

GEOLOGY AND THE TETRAHEDRAL COIGNS AND EDGES.

Let us now turn to geology, to see if its evidence as to the past history of the world refutes or supports the theory.

The geological evidence ought to be of especial value, as we should expect to determine the position of the tetrahedral coigns on the face of the earth.*

If the tetrahedral theory be true, the four tetrahedral coigns should be areas of unusual stability and strength. Comparison of the three meridional land-belts shows that each of them begins in the north with a vast block of Archean rocks. The Eurafrican zone, in longitude 20° E, begins with a block occupying Scandinavia, Finland, and Lapland, which Suess has termed the "Scandinavian schild." It is an area of great geological antiquity, which has long remained above sea-level; bands of marine deposits of different ages sweep round it, but the block may never have been below sea-level. It has unquestionably remained as a solid impassive block, which has dominated the whole geological history of northern Europe. South of the Scandinavian coign are the transverse east and western chains of the Alps and the Atlas, with the Mediterran-

* They were assigned to their geometrical positions by Green, and in the nteresting recent tetrahedral volcanic map of M. Michel-Levy.

ean trough between; and far to the south we have the old plateau of South Africa.

Let us now go 120° westward to the American zone. It begins with another block of old Archean rocks, forming what Suess has called the "Canadian schild." It occupies Canada, Labrador, and most of Hudson bay and Baffin's Land, and underlies Greenland. Bands of marine deposits surround it, but it has perhaps never been itself below sealevel; its geological age, at any rate, is enormous. South of the North American coign we have again a pair of east-west mountain chains, forming the highlands of Cuba and Venezuela, separated by the Caribbean trough. This zone also ends southwards in an old plateau resting on Archean rocks.

The third meridional zone repeats the same characters. It begins with a block of Archean rocks, of which we may speak as the "Manchurian coign." South of this coign are the east and west ridges of Malaysia and the depressions parallel to them; and south of that, again, we have the Archean plateau of Australia.

The three main land axes of the world have remarkable resemblances in structure, and they present three equidistant blocks of great stability at the three tetrahedral corners. We may, therefore, speak of the "schild" as the three northern coigns or corner-stones of the earth.

The existence of these massive coigns* at the three tetrahedral corners has produced one point of divergence in the earth-plan from the geometrical figure of the tetrahedron. The existence of three such broad massive blocks naturally strengthens the line between them; and, as we have seen, the main divide in the northern hemisphere runs from coign to coign. The tetrahedral edges would naturally be lines of weakness and of movement; but in the northern hemisphere, the horizontal lines of yielding are deflected southward by the stability of the band supported by the earth's three northern coigns. Hence the great band of disturbances is subtropical, and runs from the Caribbean to the Mediterranean, across the Persian gulf and the Malaysian archipelago.

*** This suggestion of the word "coign" for "corner" I owe to Mr. L. Fletcher, to whom I am indebted for much helpful advice. The term is suitable, as it is used for a printer's wedge as well as for the corner-stone of a house.**

In the case of the vertical edges, however, the agreement in position, as well as direction, is exact. Precisely below the three corner blocks, there are three lines of instability coinciding with the vertical tetrahedral edges. Below the Canadian coign there is the line of the Andes (long. 75°), which, according to some geologists is still undergoing elevation. Almost 120° east of the Andes, and below the Scandinavian coign, is the Erythrean rift-valley (mean long. 40°), in which some of the earth-movements are unquestionably of very recent date. Again, nearly 120° eastward, and due south of the Manchurian coign, is the recent line of movement represented by the eastern coast of Australia.

The main mountain systems of the world correspond, then, in direction or position, or in both, with the edges of the tetrahedron. The mountain lines run east and west in the northern hemisphere, and run meridionally in the southern hemisphere —that is, always parallel to the tetrahedral edges.

But it will be said there are three great exceptions, for the Ural mountains, the Appalachians, and the Rocky mountains are meridional instead of transverse, and that they therefore contradict the scheme. The contradiction is only apparent. The existing mountain ranges date from two main periods of mountain-building—the Upper Cainozoic and the Upper Palæozoic. The Upper Tertiary system includes the Alps, Andes, Himalaya, Pyrenees, Caucasus, and Atlas, etc. The Urals, Rocky mountains, and Appalachians belong to the Upper Palæozoic system. Before we can say whether these chains confirm or refute the tetrahedral theory, we must determine the distribution of land and water at the time when they were made.

Now, we know that in upperPalæozoic times one land fauna and flora ranged round the southern hemisphere from Australia to India, and thence to the Cape and South America. Instead of there having then been a continuous ocean-belt separating triangular points of land, there was then a southern land-belt, which was supported by three great equidistant corner-stones, the Archean blocks of South Africa, of Australia, and of Patagonia and the Patagonian platform.

What the south pole was doing then is hidden by our deplorable ignorance of that area; but there is evidence that to the south of this southern land-belt there was a cold, ice-laden sea.

Now let us consider the state of affairs in the arctic regions at the same period. At the present time the Mollusca of the Behring sea and North Atlantic belong to two essentially distinct faunas. But in upper Palæozoic-Triassic times, one fauna occupied both regions, and that fauna moreover extended uninterruptedly round the northern hemisphere, and apparently, along certain lines, extended some distance to the south. There was, in fact, a northern ocean-belt, which apparently surrounded a cold arctic land. The distribution of the land and water was then on the same plan as at present, but with land and water exactly reversed. There were two opposite interlocking belts of land and sea, the former based on three Archean corner-stones, the latter projecting toward the equator between three Archean plateaux.

Thus the plan was the same as at present, but the conditions were reversed. This gives us the clue to the mountain chains of the same period. That also was a double system. There was a sub-tropical mountain girdle, the ruins of which we can trace right across the old world from eastern China to western Europe, where it is cut off by the Atlantic slope. And projecting meridionally from that equatorial girdle, opposite the three coigns, we have three mountain ranges running along the meridional edges. These are the Ural mountains (60° E.) north of the eastern continuation of the South African coign, the Appalachians (80° W.) north of the western part of the old Patagonian coign, and the old broken axis of Kamtschatka (160° E.) north of the coign of Australasia.

Deformation and Recovery.

Such a change in the position of the flattened faces is by no means improbable in the case of a revolving globe. In the case of a stationary body, a tetrahedral deformation once begun would be strengthened by every fresh contraction. But owing to the world's rotation, the tetrahedral collapse is steadily resisted, and confined within narrow limits. The deformation formed by one period of slow, quiet contraction may be lost on the restoration of equilibrium at an epoch of great crustal disturbance. When deformation begins again in consequence of renewed contraction, the flattening may occur elsewhere.

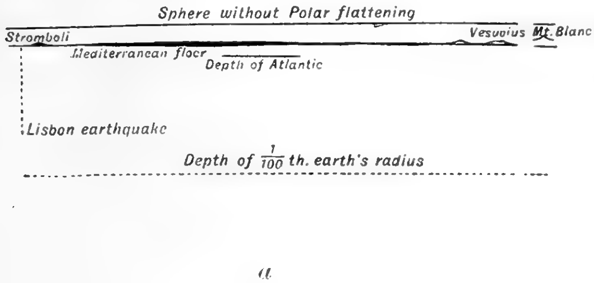
This hypothesis of the alternation of periods of deformation with periods of spheroidal recovery is geologically useful, as it suggests an explanation of a certain periodicity in geological phenomena. For instance, the later half of Palæozoic time may have been a time of slow tetrahedral collapse, culminating in an instability which led to the great mountain movements which closed the Palæozoic; then followed a quiet period of slow restoration of the spheroidal form, causing the series of marine "transgressions" which are the dominant feature of the geological history of the Mesozoic era.

Vertical Range of Deformation.

Reluctance to admit the possibility of such changes is reduced when we recollect how insignificant are the differences in level, when compared with the size of the earth. The use of exaggerated diagrams leads to unconscious magnification of the extent of the polar flattening, and of the difference between the continental summits and the oceanic depths. The study of large-scale maps has been authoritatively recommended. The examination of true scale curves and outlines may help us to realize the actual conditions. The accompanying figure* shows a section of the earth's crust from Stromboli to Vesuvius. The thick black band represents the section cross the Mediterranean; the line *ab* marks the depth of the Atlantic; the upper curve shows where the surface would be if there were no polar flattening. The lowest line marks the depth of one-hundredth of the earth's radius. The thickness of this zone in comparison with the size of the earth is shown on Fig. 7, *b,* which is a sector of a circle, with the zone of *a* shown, reduced to its true relative size. The polar flattening is barely recognizable, and the difference between sea-bottom and mountain summit is marked only by variations in the thickness of a line.

The diagram illustrates the insignificance of the deformations required; and that crustal disturbance occurs much deeper than the layer with which the tetrahedral theory is concerned is shown by the fact that the estimated centre of origin of the Lisbon earthquake lies far below.

* Based on Lingg's 'Erdpofil.'



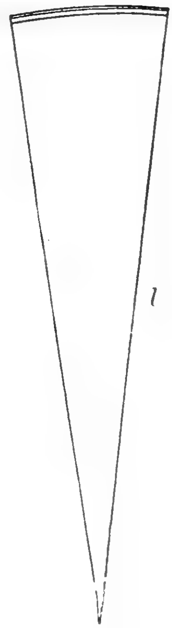


FIG. 7.—DIAGRAM OF RELATIVE EXTENT OF INEQUALITIES ON THE EARTH'S SURFACE. *a*, A TRUE SCALE CURVE OF PART OF EARTH'S SURFACE; *b*, SECTOR OF CIRCLE, SHOWING RELATIVE SIZE OF ZONE INCLUDED WITHIN *a* TO THAT OF THE EARTH.

This diagram also serves to show that the amount of contraction in the earth necessary to allow tetrahedral deformation is very small. This is important because, as Lord Kelvin has shown, the amount of contraction allowable during the later stages of the earth's history is very limited. But geologists have the authority of Prof. Darwin for accepting a certain amount of contraction. "A cooling celestial orb must contract by a perceptible fraction of its radius after it has consolidated," he tells us, and his considerations "only negative the hypothesis of any large contraction of the earth since the moon has existed."* And, unlike the contraction theory of the origin of mountain chains, the theory of the tetrahedral deformation of the lithosphere requires only a small amount of radial contraction.

Finally, it may be urged that even such deformation as the tetrahedral theory requires is impossible, since physicists have taught us that the earth is rigid. To this objection it is only necessary to reply that Lord Kelvin's rigidity argu-

* *Phil. Trans.*, vol. 170, pp. 522, 523.

ments apply to the earth as a whole, and not to its crust; they deny the fluidity of the interior of the Earth, and do not pro- deny the fluidity of the interior of the earth, and do not prohibit any local deformations of the exterior crust. The once prevalent astronomical belief in the absolute invariability of the earth's shape and in the absolute fixity of is axis of rotation (expressed, *e.g.*, by Sir J. Herschel in 1862) no longer hinders progress. In fact, astronomers tell us that, instead of the absolute fixity of the pole, it now shifts its position to an appreciable extent under the influence of the movements of the atmosphere, the unequal melting of the polar ice, and by heavy falls of snow on the Siberian highlands. These movements of the pole are important, because they are taken to prove a certain elasticity in the earth. The movements demonstrated by actual observations are so far minute; but they at least allow geologists to say that, as such slight causes as those mentioned produce appreciable effects, more powerful causes acting for longer periods would work greater changes.

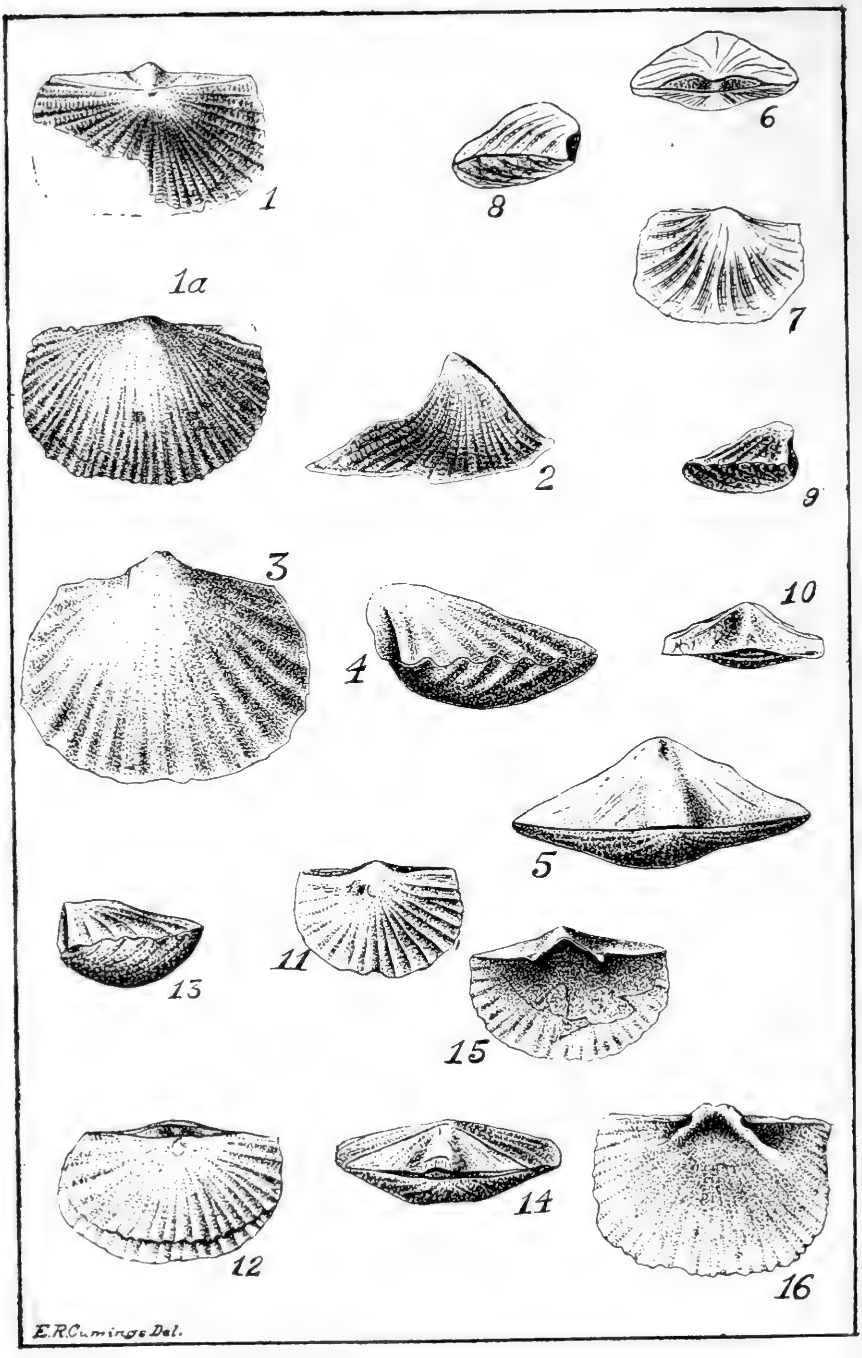
Summary.

The object of the paper is to show that the old belief in a definite plan of the earth is justified, since the distribution of land and water on the globe has been determined by the tetrahedral arrangement of the elevations and depressions in the surface of the lithosphere.

This tetrahedral plan is shown by the existence of (1) a northern land-belt, surrounding a northern ocean, and giving off three meridional land lines, which taper southward; (2) the southern ocean belt surrounding a south polar continent, and the three meridional oceans; (3) by the antipodal position of land and water; (4) by the course of the main watersheds and mountain chains.

It is held that this arrangement was not established in the earth's infancy, and therefore has to be attributed to some agency which has acted throughout geological history.

There are reasons for believing that a contracting sphere with a hard crust would undergo tetrahedral deformation, and the evidence of geodesy shows that the earth has been deformed from its spheroidal form. Its present figure may be defined as a geoid, which has been derived from a spheroid by irregular tetrahedroid deformation.



ORTHOTHETES MINUTUS, N. SP. FROM THE SALEM LIMESTONE.

If such tetrahedral collapse be granted in the case of the earth, then the existing arrangement of oceans and continents receives a natural explanation.

The changes in the distribution of land and seas in the past may be explained as due to the conflict of two opposing forces, collapse caused by the earth's contraction producing deformations, which are reduced by the effects of the earth's rotation. Geological history affords evidence of the alternation of periods of tetrahedral collapse and spheroidal recovery.

The plan of the earth may, in short, be attributed to the continual foundering of the earth's external shell, owing to the unceasing shrinkage of its internal mass.

ORTHOTHETES MINUTUS, N. SP. FROM THE SALEM* LIMESTONE OF HARRODSBURG, IND.

By E. R. CUMMINGS, Bloomington, Ind.

Plate XV.

The specimens described in the present paper are from the abandoned quarry known as the Cleveland Stone Company's quarry located one mile north of Harrodsburg, Monroe county, Indiana. This quarry is in the Salem limestone, and the specimens come from the top layers of the quarry and also from near the summit of the formation. They are associated with abundant representatives of the entire Spergen hill fauna, and are so far as I can ascertain specifically identical with the forms from Spergen hill referred by Hall† to *Streptorhynchus (Orthis) umbraculum* Schlotheim.

DESCRIPTION OF PLATE XV.

Fig. 1. Ventral valve of a specimen 4.75 mm. broad.

Fig. 1a. Dorsal valve of a specimen 5.5 mm. broad by 4 mm. long.

Fig. 2. Profile view of a specimen 5 mm. long.

Figs. 3, 4, 5. Ventral, profile and cardinal views of a specimen 0.9 mm. broad and 0.6 mm. long.

Figs. 6, 7, 8. Three views of a specimen 2 mm. broad which has an abnormally convex ventral valve and an abnormally short area. Only one such specimen was found and it is possible that it may prove to belong to a distinct species.

* The name *Salem* is suggested by the writer in a paper now in press in place of the name *Bedford* as applied to the oolitic limestone of Indiana, the latter name having been for many years preoccupied as the name of the Bedford shale of northeastern Ohio.

† *Trans. Alb. Inst.*, vol. iv, p. 12; *Indiana Geol. and Nat. Hist.*, 12th Annual Rept., p. 325.

Figs. 9, 10, 11. Three views of a specimen 2 mm. broad.
Figs. 12, 13, 14. Specimen 2.5 mm. broad.
Figs. 15 and 16. Ventral and dorsal interiors of two mature specimens.

DESCRIPTION OF SHELL.

SHELL semi-ovate to subquadrate in old individuals; hinge-line usually less than the greatest width of the shell, especially in young individuals; cardinal extremities forming an obtuse, or sometimes a right angle with the lateral margins. Surface firmly plicated; plications increasing toward the margins by interstitial implantation. Crests of the plications crenulated by numerous equally spaced fine concentric lines.

VENTRAL valve concave, with a pronounced tendency to irregular growth about the beak. In mature individuals the beak becomes strongly retrorse and greatly elevated, equalling in hight one-half the length of the shell. Area well defined, flat, showing in well preserved specimens a low ridge on each side of the prominent deltidium and parallel with its margins. The younger specimens sometimes show a perforation of the apex of the deltidium.

DORSAL valve regularly convex, greatest elevation about one-third of the way from the beak to the front margin, though there is considerable variation in this respect in individuals of different age. Usually some flattening at the cardinal extremities. Area very narrow or scarcely at all conspicuous.

INTERIOR of ventral valve showing rather prominent teeth which diverge widely. Cardinal process in the dorsal valve elevated, projecting somewhat beyond the hinge-line; notch shallow, the grooves on the posterior faces of the apophyses very faint.

Ratio of breadth to length of an average adult individual about as eleven to eight.

OBSERVATION. This form cannot be referred to the *O. (Terebratulites) umbraculum* of Schlotheim*, from which it differs in the less length of the hinge-line, fewer plications, greater proportionate elevation of the ventral beak which in the present species becomes strongly retrorse, and the sub-

* SCHLOTHEIM, PETREFK, I. 256, II. 67; SCHNUR, BRACHIOP. DER EIFEL, 216, t. 38, fig. 2; t. 44, fig. 4; BRONN LETHÆA, GEOG. I, 361.

quadrate rather than semi-circular outline of the shell. The figures of Schlotheim's species also show a strongly quadrilobate cardinal process, while in the present species the notch is very shallow and the grooves are very faint. The species to some extent resemble *O. lens* from which it differs in the form of the cardinal process and the greater proportionate length of the latter species.

DEVELOPMENT. In the search for specimens of this rather rare species (about fifty specimens were found among several thousand of the commoner Spergen hill forms) a number of very young stages were obtained. While even the adult individuals share in the general stunting so characteristic of the entire Spergen hill fauna no complete specimen in the writer's collection having a length of more than 5 mm., nevertheless these larger individuals present the usual features of maturity.

The smallest individual observed has a length of 0.6 mm. and a breadth of 0.9 mm. In this specimen the ventral valve is roughly conical in shape, though slightly more convex toward the beak which projects conspicuously beyond the hinge-line and is very prominent. The surface shows eighteen plications at the margin as against forty in the largest individual observed, while the posterior third of the shell is without ornamentation except a few obscure concentric markings. The area is high and the large deltidium less sharply marked off from it than in the older individuals. The breadth at the hinge is conspicuously less than farther forward.

The dorsal valve has its greatest convexity at the center and is also smooth for a considerable distance from the beak. It shows no sign of an area.

Individuals of the length of 2 mm. have the area perpendicular to the plane of separation of the valves, and the ventral valve showing a slight convexity toward the front. The number of plications has increased from eighteen to twenty-two or twenty-three, and the region of greatest convexity in the dorsal valve has approached somewhat the beak. The youngest individual shows a marked conformity to the generalized type of brachiopod, as was found by Beecher and Clarke to be the case in the species of the Waldron fauna.*

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* *Memoirs of the New York State Museum*, vol. i., No. 1.

NOTES ON PETROLEUM IN CALIFORNIA.

PROF. E. W. CLAYPOLE, D.Sc., Pasadena, Cal.

The existence of petroleum in California has been known from very early times. The old Mission Fathers in the Spanish days made use of it, or rather of its solid residue after evaporation (usually natural), under the name of "brea," or asphaltum, for various purposes, chiefly for roofing. Many attempts have also been made during the past half century to refine it but from various causes they have all failed more or less completely until recently.

Prof. B. Silliman's report in 1865 was the earliest scientific statement concerning the Californian oils, and during the following fifteen years the attempt to establish a profitable industry were several times renewed. One of the causes of their failure was the nature of the materials which differed from that of the eastern oils, and presented problems not solved by eastern experience.

The memory of men not beyond middle life will easily supply illustrations of the wild craze that swept over Pennsylvania about 1865, when the desire to become suddenly rich was met by the opportunity as the two have seldom met before. The mad excitement that almost carried the sober Keystone state "off its legs," to speak figuratively, has perhaps not been equalled since the day of the "south sea bubble" in the lifetime of Robert Walpole. The narratives of both read in the present day more like fiction than the literal facts of history. In reality the facts surpass fiction.

But the craze passed in California as it passed in Pennsylvania and petroleum-getting has settled down into a steady industry. Less steady, it is true, than in Pennsylvania, because the ground is less investigated and consequently the element of chance is a larger factor in the problem than in the East. The conditions are less understood. Pennsylvanian experience is not necessarily or always useful in California. The high price of fuel on the Pacific coast renders profit attainable in places and among circumstances which would, in the Atlantic state, entail only loss. Consequently operators have been compelled to a large extent to exploit the new field under new conditions and are now beginning to eliminate the element of chance which so heavily hampered most of the early efforts.

GEOGRAPHY OF PETROLEUM IN CALIFORNIA.

Up to the present time the following so-called "oil-fields" have been proved and to a certain extent developed. Most of them are in the southern part of the state. That others will be discovered in the future we can scarcely doubt, and that before many years have gone by the present yield of petroleum will be largely increased, is equally certain.

The Newhall field was among the earliest to yield a profitable return to the investigators. As far back as 1875 a productive bore-hole was put down a few miles to the northwest of Newhall with the primitive appliance of a spring-pole and auger, from which a flow of oil was obtained at the trifling depth of thirty-five feet. This very moderate success so near the surface stimulated further effort and next year a standard outfit was obtained and another hole begun. This resulted in a greater success and as Col. Drake's first bore at Oil City set Venango county on fire, so this well in El Pico cañon kindled a blaze in California that has not yet died out. The well has been flowing uninterruptedly ever since and has yielded nearly two million barrels without at present showing any signs of failure.

Naturally such success stimulated further experiment and a large number of wells have been drilled in Pico and Elsmere cañons with varying individual success, but the result on the whole has led to the laying of a pipe line from the wells to the wharf at Ventura forty-four miles distant. Many miles of branch lines also run through the district.

The latest field developed in Los Angeles county is at Whittier, a few miles southeast of the city. Since 1896 work has been going on there continuously and successfully and it is now one of the most productive spots in southern California. Figures cannot be easily obtained and are not always exact, but from more than twenty wells is obtained an average yield of above 500 barrels, at least, daily. This is conveyed in a steel pipe to Los Metos station a distance of three miles.

The Puente hills extend from Los Angeles southeastward for about twenty-five miles. While scarcely equalling the records just given, yet the fifty or more wells drilled in this field have yielded a steady supply for more than a dozen years and are still pumped. Their total yield is estimated at not less than one and a half million barrels and one of the wells is reported to have given during its first year 50,000 barrels. The oil from this field, or rather the residuum after refining, goes by a pipe-line to the beet-sugar factory at Chino, sixteen miles away, which has used about 100,000 barrels a year.

Not until 1892 was any successful attempt made to develop the various oil indications in the city of Los Angeles. In that year a small well was drilled to the depth of a little more than 200 feet, and a yield of oil obtained which though slight, was a stimulus to greater undertakings during the following years until now in 1901 there are within the city limits 600 or 700 wells yielding nearly 1,200,000 barrels yearly. The total yield from the field since it was opened is reported between 7,000,000 and 8,000,000 million barrels but the annual production has fallen off since 1897. Wells have been bored too close together and the *sand* which is neither deep nor thick, shows signs of speedy exhaustion. The derricks stand thicker on the ground at Los Angeles than at almost any place in Pennsylvania.

Passing to the central part of the state we find the oil-field of Fresno county with Coalinga and Oil City as its two central points. Numerous attempts had been made to find petroleum before 1895 but only since that year has the region come into the list of California oil-fields. Its yield now cannot be less than 35,000 to 40,000 barrels monthly.

Not a few of the Coalinga wells are petroleum-geysers which spout oil for a few minutes and then rest until the gas again accumulates and develops pressure enough to force the oil to a hight of some feet above the ground. This oil is piped to the Southern Pacific railway.

South of Fresno in Kern county and near its chief town, Bakersfield, lies another of the California oil-fields. It is situated near the southern end of the great valley of California —the San Joaquin—and not far north of the point where the Sierra Nevada and the Coast range come together and throw the rampart of the Tehachapi around its southern end. In this nook in 1897 near Bakersfield, a shallow trial well was dug which yielded a considerable quantity of oil at the small depth of sixty feet. So striking a result immediately attracted attention and wells rapidly multiplied in number and increased in depth. The *sand* thickens to the north and west and is so reliable that few or no dry holes have been sunk in this field. The sand has been tested for about ten miles in one direction and on an average for a mile and a half in the other.

An unusual circumstance connected with the Kern county field is that the strata are almost undisturbed and few indications of oil are seen on the surface. The greatest depth of the *oil-sand* is about 1,000 feet but the average is much less. The quantity contained in the ground must be enormous, the *sand* being more than 300 feet thick and containing, by conservative estimate, ten to fifteen per cent of oil.

Ventura county was the first paying oil-field of California but until within the last twenty years the results were small. Then began a more thorough exploration and some wells exceeding 2,500 feet in depth were sunk in Adam cañon. There are at present more than three hundred wells in Ventura county, most of them productive, but on the whole their paying life is not long for in a year or two their yield by pumping falls below paying level. Some have started with 300 barrels daily and are already practically dry after yielding probably 100,000 to 150,000 barrels during their lifetime.

Summerland in Santa Barbara county is remarkable among oil-fields everywhere because the work is carried on partly under the sea. Not only are wells drilled close to the water but many are sunk from wharves run out into the ocean for the purpose. Of these very few disappoint reasonable expectations. Some of these marine bores have reached a depth of 800 feet penetrating two *oil-sands* and oil has sometimes leaked into holes dug on the beach to the depth of only six or eight feet. No one of them gives a great yield of oil, a few barrels a day being the average, but almost all are in a paying condition.

The view from the beach at Summerland is unique resembling no other in the world. Slender wharves of seemingly frail construction run out from the beach and are crossed by others like themselves so that the bay is a maze of timber work on which stand at short intervals the derricks of the oil-men. So close are they that it seems almost impossible for all to obtain oil, yet failures are rare.

Orange county to the south of Los Angeles can scarcely be said to have begun operations until 1896, but during the interval its experiments have been attended with very promising results and already a number of companies are busy in developing its resources. A pipe-line to the sea at San Pedro contributes in no slight degree to the success of the operation in this field.

Without going into too much detail for which this is not the place, the above named districts summarize the results of the exploration for petroleum in southern and central California. That other fields will be found is almost certain. San Diego is making great efforts on the southern line of the state but the results thus far are small.

The prospects in California are good and that the State has in her oil-fields a supply of mineral fuel, to her invaluable, is already obvious. The high prices of coal and wood have been a barrier, almost insuperable, in the way of her advance in manufactures, but with the removal of this she will be in a position to take a new start in the industrial race.

Already the railways are adopting the new fuel. With the aid of some of the many devices for burning it, which scarcely come within our province here, it is found more economical, clean and efficient at $1.25 or $1.50 a barrel than coal at $6.00 to $7.00 per ton. By experiment engineers have found that two or three barrels of crude oil will do the work of a ton of good coal without making smoke or ashes.

Other important advantages accruing from the use of oil will at once present themselves before the mind of an engineer in California, where conditions are very different from those of the eastern states.

The present consumption of crude oil for purposes of heating and steam raising is immense, but to state it in figures is impossible. It can, however, scarcely be put at less than a quarter of a million barrels yearly and this would be a moderate estimate.

As a general rule the California petroleum differs from that of Pennsylvania and Ohio etc., by having as its base or more solid portion, not paraffine but asphaltum. In the mode of "getting" it little difference exists between the two regions. Nor do the processes of refining differ to any important degree. But there are great and noteworthy differences between the products of the various fields. For example a part of the Newhall field yields an oil almost as clear as the refined coal-oil of Pennsylvania and fit for use in a lamp without refining. It is worth at least $4.00 a barrel at the wells. There is no difficulty in realizing the effect which the sinking of such a well yielding 100 barrels of the oil daily would have upon the local market. These are the famous oil-wells of the Placerita cañon. A heavy oil carrying a large amount of asphaltum is found in some parts of Kern county and perhaps not half a mile distant a lighter one more like some of the eastern oils. Most of the Californian oils however are dark and heavy and consequently yield a lower percentage of kerosene. The gravity varies from twelve or fifteen or even less in the Kern river and Santa Barbara districts to thirty and thirty-five at Puente and to fifty in some wells near Newhall.

OIL PRODUCTION OF CALIFORNIA.

1876	12,000	barrels.
1880	40,552	"
1885	325,000	"
1890	367,300	"
1895	1,208,482	"
1896	1,252,777	"
1897	1,903,411	"
1898	2,257,207	"
1899	2,665,709	"

Geology. Not the least surprising fact to the geologist accustomed to the conditions in the East is the recency of the oil-bearing strata and the shallowness of the wells. Most of California is a young state geologically and no one of her petroleum yielding rocks is of earlier than Cretaceous date, whereas in Pennsylvania and other eastern states few are later then the Chemung of the Devonian and many of them, as in Ohio, as early as the Trenton of the Ordovician system. Indeed in the western and central parts of the state, strata of earlier date than Cretaceous are comparatively rare, almost the whole surface being composed of late Mesozoic or Cenozoic formations. The following table will illustrate this detail:

Stockton,	Quaternary.
Puente, Los Angeles, and Kern Co.	Pliocene.
Ventura, Los Angeles, Kern Co., Newhall.	Miocene.
Ventura, Fresno, Kern Co.	Eocene.
Colusa Co. and Sacramento Valley.	Cretaceous.

The *general* horizons only of the oil-bearing strata are here represented. Minute details are not yet attainable, nor would it conduce to the clearness of the outline to crowd it with detail.

The oil-bearing strata are usually sandstones interlaminated with shale as in the East, and both often show traces of petroleum, but the accumulations are in the sandstones. Signs of disturbance also are visible in many places sometimes accompanied with some degree of metamorphism.

In considering this subject we should bear in mind the fact that the geomorphy of California indicates intense orogenic action at a very recent time. Strata of late Tertiary date are contorted and compressed that they stand vertical over large areas. The *final* elevation of the Sierra Nevada and Coast range is not apparently earlier than the Pliocene, perhaps even later. The proportion of living species among the fossil forms abundantly proves the recency of the strata. The energetic and extended volcanic action visible in so many places is evidenced by lavas so new that they have apparently only just cooled and are scarcely yet touched by erosion.

The Anticlinal Theory. The accuracy of the anticlinal theory of the accumulation of oil and gas, as developed by Prof. I. C. White, in Pennsylvania, has received abundant confirmation from California. In many of the fields the line of development on the surface clearly coincides with the anticlinal line underground, and even where the strata are very slightly disturbed exact data will probably reveal undulations of low angle or irregularities, such as those that govern the accumulations in many places in the east.

Where the anticlinal ridges can be traced they are in most cases relied upon as safe guides for extending the investigation.

As might be inferred from a map the strike of the Californian anticlines is usually northwest and southeast or nearly so. Many of their ridges though of so recent formation have been eroded and consequently their oil, or at least its more volatile portion, has escaped leaving either no residue or only the "brea' or asphalt to indicate its former presence.

These facts supply a rational base for the belief that when the strata are deeply covered, numerous yet unknown oil-fields will be found that at present lie below the depth explored and can only be detected by systematic geological study and judicious exploration with the drill. The greater degree of erosion in the northern counties is also the probable explanation of the present limitation of the oil-fields to the south of the state. At the same time we must recollect that holes more than 1,000 or 1,500 feet in depth are almost unknown.

Nature and use of the oil. Probability scarcely indicates that Californian petroleum can compete with the Pennsylvanian product as a source of illuminating oil. It more resembles the Russian and the Ohio and Indiana petroleum in this respect. But as already mentioned its great value to the State will be its fuel value. Where the lighter grades are produced the illuminating ingredients will doubtless be distilled off and the residue will then be of equal or greater value as fuel. This is already done. The heavy oils will however find their value and use in taking the place of coal and supplying heat in many cases where the cost of coal would be an insuperable barrier. The lower price of oil, its transportation by pipes, its supply to the furnace by gravity, the absence or slightness of the smoke and ash, the avoidance of stoking, all these are advantages which cannot be over estimated in a comparison of the two fuels. To say that the exploitation of petroleum has given California an open door where before it seemed hopelessly closed, is not an exaggeration of the fact or too roseate a picture of the prospect.

The Future. It is too soon of course to prophesy the future by predicting the duration of the supply. But in spite of all anticipation of a speedy failure, the eastern yield has not yet run out. It has continued beyond most calculations or prognostications made forty years ago and there is even now reasonable ground for expecting early exhaustion. Nor is there any reason for hoping less in California. That the supply is finite is of course undeniable, but though finite it is so vast that the present generation and perhaps one or two more that will come after it may be enriched by this wonderful fund of latent power stored in the distant Tertiary era from the remains of Tertiary life.

The California conditions, moreover, render many wells which in the East would be useless, because unprofitable, sources of profit to their owners. Wells yielding one barrel of oil daily would scarcely be valued in Pennsylvania but here they are, to say the least, quite above the line of "no profit." The initial cost is small often not above $200 or $300, and the pumping can be done at a price not exceeding fifty cents daily, while the price is seldom below and often above one dollar at the well. If the bore is deeper and the cost therefore higher the oil obtained will probably be lighter and consequently of greater value in the market.

The duration of the individual wells also is not very different from that expected in Pennsylvania. Some have been pumped for twenty years and still are yielding a paying amount of oil. There is, therefore, no more ground for distrusting the duration of the Californian wells than there was thirty years ago for distrusting those of Pennsylvania.

Besides the kerosene produced from the crude petroleum a large quantity of lubricating oil is obtained occasionally in a pure form, otherwise by distillation. Then there is the asphaltum base of the oil, either left after the lighter portions have been distilled off or found in beds in the earth—the produce of natural distillation. At first an annoyance as a by-product and a waste, tending to cause smoke on burning the kerosene, it is now one of the valuable products of the refinery. Masses of it are even thrown up on the beach in some places—the product of petroleum escaping from the sea-bottom. Elsewhere, as at Obispe, near Terminal island, huge masses of this mineral are quarried in the cliff, as rock, refined and sent abroad and to the eastern states chiefly for paving purposes. It occurs in disjointed and contorted strata or seams, often many feet thick and in quantity can be compared only with the great pitch deposits on the south American continent or the lake of Trinidad. It is sent largely to the eastern states where it is sold at a good profit. Being a solid it canot be passed through pipes but a very ingenious device has been recently adopted to transmit it. The asphaltum is dissolved in naptha and in this condition of solution passed through the pipe-line from the mines of Santa Barbara county to the coast where the naptha is evaporated and sent back for another load of asphaltum.

Little has been said here about the gas that accompanies the petroleum, though its quantity and value are large, because it has not yet come extensively into use as an illuminant. Unfortunately the wells where the gas pressure is greatest are usually far removed from cities and sufficient confidence is not yet felt in its persistence to warrant the laying of pipes to carry this most valuable and convenient fuel from the place of production to the place of consumption. Should its flow continue and increase there is no doubt that the day of its utilization will soon arrive. As yet, however, no Murraysville or Grapeville or New Washington has been evolved in California.

Since the above paper was written news has come from Texas of a discovery of petroleum which may fairly be compared with some of the greatest on record. At Beaumont, near the mouth of the Nachet, a tributary of the Sabine river, a bore-hole was drilled with the intention of experimenting but apparently without any very strong confidence in the result.

Allowing for considerable exaggeration in the early reports, we cannot doubt that a new and important factor has come into the problem and one which may have great consequences. It must equal most of the great gushers even if it fall far short of the 25,000 barrels a day first reported. From a six-inch hole the oil is said to jet to the hight of 200 feet.

For four days the flow continued and to check it was impossible. Before this was at last accomplished it was estimated that 150,000 barrels had flowed out much of which had been saved in hastily constructed earthen tanks. The well has been since reported to yield 8,000 barrels daily. It is only twenty miles from the coast.

Later still comes a similar report from the older oil-field of Indiana which, though on a rather smaller scale indicates that the days of "oil-strikes" have not yet altogether gone by

SOME SALIENT FEATURES IN THE GEOLOGY OF ARIZONA WITH EVIDENCES OF SHALLOW SEAS IN PALEOZOIC TIME.

By WILLIAM P. BLAKE, Tucson, Arizona.

The geology of the northern portion of the territory of Arizona including the grand cañon and the plateau region has been studied and mapped by Powell, Dutton and others of the U. S. Geological Survey. Blandy has published some papers relating to central Arizona; the writer has contributed some special papers and desultory notes in reports to the governors of the territory and elsewhere, but in regard to the country south of the great plateau region very little systematized information has yet appeared in print.* An explanation may be found in the fact that the region is vast and difficult of access and until recently has largely been under the domination of the savage Apache.

Capt. Dutton in his monograph upon the Tertiary history of the grand cañon district, frequently refers to an unknown "Arizona Land." In this he shows a mental reaching out for far off shores from which a portion, at least, of the mighty mass of sandy sediment in the basin of the Colorado could have been derived.

Investigations in southern Arizona sustain the idea of the former existence of such shores, not perhaps as continental margins but as island ridges; crests of submerged mountain ranges rising at intervals above the waves of shallow seas, and with a trend or direction corresponding essentially to the trend of the mountain ranges of the region.

A cross-section of the territory in a northeast direction from the head of the gulf of California, the sea of Cortez, to the line of New Mexico, a distance of nearly 350 miles shows a succession of mountain ranges separated by long trough-like valleys often broad plains or mesas. There are some fifteen such main lines or axes of elevation with a general northwest and southeast trend. Commencing first at the gulf we have in suc-

* Since this paper was written a memoir has been published by DR. THEO. B. COMSTOCK, in the *Transactions of the Am. Inst. Mining Engineers*, entitled "The Geology and Vein Phenomena of Arizona."

A partial bibliography of contributions to the Geology of Arizona may be found in *Bulletin No. 127 of the U. S. Geol. Sur.* and also in the *Report of the Governor of Arizona for 1899.*

cession the Gila range; Mohawk and Castle Dome; Growler Ajo; Maricopa, and Quijotoa, Baboquirari; Tucson, Santa Catalina, and Rincons, (extending northward to the Bradshaw group of elevations), the Santa Ritas (east of the valley of the Santa Cruz), the Huachucas and Whetstones; the Dragoons and Mule mountains (Tombstone), extending north into the Galiuro; the Pinaleno and Chiricahua, the Piloncillos east of the San Simon plains; ending with the Natanes and Prieto plateau and the Four Peak mountains.

These several mountain ranges may be considered as successive axes of uplift, or structure, with well-defined occurrences of Palæozoic strata, generally resting upon a foundation of granite and Archæan gneiss. Regular anticlines and synclines are rare. Monoclines are the rule, as for example in the Huachucas and Santa Ritas.

The presence in all these ranges of massive strata of quartzyte, and frequently of coarse conglomerates referable in age to the Paleozoic, or earlier, bears conclusive testimony to the existence of shore-lines and of shallow seas in that early period of continent making. But there are also deep sea lime-stone of Devonian and Lower Carboniferous age and other limestones probably Silurian.

Coal Measures. In the Chiricahua mountains we also find evidences of Coal Measures and vegetation of that period in the shales and uplifted beds of graphitic anthracite several feet thick. So, also, in the San Carlos region, and northwards, heavy strata of the Carboniferous occur with seams of coal, but so far as yet determined of limited thickness and value. These occurrences are, however, sufficient to show a far western extension of the vegetation of the Carboniferous and consequently the existence of dry or swamp land at that time. The most western point in the latitude of Arizona at which Coal Measures have before been found was in the Rocky mountains near Santa Fe.* Thickly bedded limestones of dark color and of Carboniferous age occur in the mountains west of Tucson. The limestones in the Quijotoa mountains at the Vekol lead-

* In 1857 I collected fossil ferns near Santa Fe which the late MR. LESQUEREUX identified as specifically the same as several species found in the Pennsylvania coal measures. PROF. DANA, in his fourth and last edition *Maunal of Geology*, p. 658, says "A Carboniferous formation without coal is the great fact for the western half of the continent," a statement which in the light of the above facts needs some modification.

silver mines contain an abundance of cyathophylloid corals and are referred to the Carboniferous. The dark colored limestones of the Mule mountains, at Tombstone,* and also those at the American mine in the Swisshelms are similarly referred, and are doubtless a part of the extensive series of limestone and shaly beds of the northern portion of the Santa Ritas; and a portion of the strata of the Whetstone range and of the Dragoons, and of the Galiuro mountains are of the Carboniferous age.

Cambrian. Most of the outcrops of massive quartzyte uplifted and in contact with granite at several distant places are referred with some hesitation to the Cambrian. Such outcrops are found from western Sonora in nearly all the chief uplifts as far east as the Chiricahuas. In northern Sonora near the boundary line in nearly the southeastern continuation of the Gila and Mohawk uplifts, a well defined ancient quartzyte stands in vertical beds alongside of an intrusive granite. This quartzyte is marked by perforations like those of the Potsdam and probably properly referable to *Scolithus.* Conglomerates and quartzytes occur in the Buboquirasi range and in the Tucson mountains where there is a great thickness of strata in regular folds, probably representing a large part of the Palæozoic. Massive conglomerates with thoroughly rounded pebbles firmly cemented together occur near the source of the Cañada de Oro in the northern part of the Santa Catalina mountains; also at the American Flag rancho in the same mountain range. We again find coarse conglomerate opposite the mouth of the Arirapa near the site of old Fort Grant where quartzytes also occur resting on granite. Thickly bedded conglomerates occur over wide areas south of Tucson in the region of Ariraca and again in the northern portion of the Chiricahuas. It is not at present possible to correlate all these occurrences which no doubt represent different horizons, but they are all believed to be Palæozoic, or older. They bear united testimony to the former existence of shore-lines and rapid currents.

Beginning of Arizoña Land. The Santa Catalina, Rin-

* See my paper on the Geology and Veins of Tombstone, *Trans. Am. Inst. Min. Engrs.*, X, 334.

con, and Rillito group may be regarded as the northwestern extension of the great mass of mountains in central Arizona generally known as the Bradshaws. All these mountain ranges consist largely of granitic, gneissic, and schistose rocks of pre-Cambrian age with a highly complex folded structure, and exhibiting a high degree of meta-morphism. Taken together, these mountains may be regarded as the main axis of ancient uplift, and of insular land areas in the pre-Cambrian and Palæozoic periods, the beginning of the "Arizona Land."

Gneiss. The gneiss of the southern side of the Santa Catalina near Tucson is regarded as Archæan. It is remarkable for its regularity of stratification and its great thickness, probably over 10,000 feet. It occurs in great tabular masses made up of thin layers which when seen laterally give the appearance of evenly stratified shales and sandstones. The beds are, however, essentially granitic with the feldspar spread in nodules which make protuberances on the cleavage surfaces of the rock, and thus form a porphyritic or augen-gneiss rock.

Sheets or veins of granite are common in this gneiss. It is remarkable that this rock has such an even tabular structure without plication, wrinkling or folding and that it rests at a low angle generally not exceeding twenty degrees upon the massive nucleus of the Catalinas dipping southward and passing under the modern detrital accumulations, or "wash", from the mountains. These beds rise nearly to the summit of the Catalinas and then break off precipitously forming a line of cliffs facing the central part of the range. Some obscure traces of an anticlinal fold are visible on the western side.

Huronian or Arizonan. In the same range, but on the northeastern side, facing the valley of the San Pedro, another formation of thinly bedded and highly crumpled mica schist in sharply defined zig-zag folds is referred to the Huronian. This is the formation to which I have given the name Arizonan. Still further north occur the heavy conglomerates, red beds, quartzytes and limestones in which last corals referable to the Devonian occur. A section carefully measured in detail made here may be generalized as earthy limestone in thin layers with sandstone and quartzyte at the base. The strata dip eastwardly at a low angle. Their exact stratigraphic relation to the underlying red shales and sandstones has not been satisfactorily determined.

Devonian. Near Greaterville in Prince county on the eastern side of the Santa Rita mountains I have found a locality of Devonian fossils in limestone, and have collected *Spirifer hungerfordi, Atrypa recticularis Bellerophon* and the coral *Acervularia davidsoni,* besides others not yet determined.* These occur in a massive bed of light colored limestone standing nearly on edge contiguous to a thick stratum of limestone conglomerate made up of rounded pebbles of limestone, unquestionably derived from some older beds.

In the Box cañon which cuts through this mountain from east to west there is a remarkably interesting section. Resting upon a coarse porphyritic granite at the western side we find in nearly vertical attitude a pebbly conglomerate overlaid by quartzyte and this in turn by a thick series of red shales probably over 1,000 feet thick. At the eastern end a last exposure ot this section, the fossiliferous limestone, the equivalent of that at Greaterville and like it, accompanied by the calcareous conglomerate, crops out in such a way as to render its relation to the red shales obscure. There is seemingly a break and want of conformity as at the Catalina section farther north.

Faulting. There have been great faultings and displacements over the entire area of Arizona, notably along the valley of the San Pedro northwest and northeast.† In the Huachuca mountains on the western side of this valley the dominant characteristic section is a very heavy regularly stratified quartzyte surmounted by limestone and resting upon porphyritic granite and presenting bold escarpments towards the east. In the section of these mountains thick beds of red shales are found like those of the Santa Ritas, while higher in the range there are massive strata of limestone conglomerate apparently not conformable with the red shales. This conglomerate appears to be the equivalent of that found in close association with the Devonian limestone of Greaterville.

Silurian and Cambrian. We are without evidence by fossils of the existence of Silurian terranes, but the identification of a

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* In the identification of the species mentioned I have had the assistance of Prof. C. E. Beecher of the Peabody Museum, Yale University.

† Such faultings have been noted and described by Dr. Comstock.

Devonian horizon permits us to believe that we have representatives of the Silurian and Cambrian in the underlying strata. The relation of the Devonian limestones to the sub-jacent beds is under investigation. It is believed that representatives of the Silurian and Cambrian systems will be found and that in the basal quartzytes and conglomerates we have Cambrian beds.

Extensive outcrops of fine-grained mica and clay slates are found in the Dragoon uplift north of Russellville, and beyond northward.

A region in the eastern part of the territory covered by the White mountain Indian reservation is as yet but little known.

Crystalline Rocks. The underlying foundation rock in southern Arizona is a coarse-grained porphyritic granite which much resembles the typical granite of Belihen in the Vosges.* This granite is found in the Santa Ritas, in the Huachucas at Guma, and at and beyond Oracle at the north end of the Santa Catalina uplift. Here it extends northward to Mammoth and beyond towards Riverside, the Superstition mountains and Salt river east of Florence. It underlies the tufas and lavas at Gila buttes at the head of the Florence canal. It presents generally a broad apparently eroded surface and here and there includes belts and portions of fragmentary rocks, quartzytes, and limestones, as for example in the Gold Field region east of Mesa and on the road from Tucson to Oracle. Large areas of granite exist in the Bradshaw mountains, notably at and around Prescott. These are granite which weather into fine large bowlders of decomposition at Peeple's Valley, Yarapai county; at points north of Phœnix, at Tombstone and other localities notably north of Dragoon Summit near the Wolfram veins. Plutonic intrusions in the form of dykes abound both in the crystalline and fragmentary formations. Distinct local metamorphism is common where dikes of porphyry cut through limestone with the production of bordering masses of garnet rock often penetrated by copper sulphide.

A large extinct volcano, Pinacate, rises just below the southern border near the head of the gulf of California, but it is not comparable in magnitude and grandeur with San Francisco mountain near Flagstaff and the neighboring cones dominating the plateau south of the grand cañon. Lava streams of compar-

* Vide the series of typical rocks from Krantz of Boun.

atively modern date geologically are more abundant in the southwestern portion of Arizona than in the central and eastern portions, but there are considerable areas of rhyolyte in the Chiricahuas and of volcanic tuffs and lavas at Tucson, and in the valley of the Hassayampa south of Prescott.

Mesozoic. Formations of the Mesozoic are not absent in southern Arizona. The massive red sandstones north of Phœnix, of Tempe and Mesa in the Salt river valley are referred to the Trias. So also the extensively developed red beds of the southern side of the Bradshaws at Castle creek. East of Tucson near Vails and Pentano, stratified sandstones and shales are probably Mesozoic. A wide area of disturbed red sand stones and shales between Oracle and the Gila at old Camp Grant and apparently unconformable to the uplifted conglomerate, quartzyte and limestone are probably Mesozoic.

There are evidences of the presence of Mesozoic sandstones in the Sulphur Spring valley. The Trias is largely represented south of the international boundary line in Sonora. But the identification in all these localities rests upon stratigraphical and lithological characters rather than upon fossils.

The recent discoveries of remains of Elephas and of the Mastodon at several distant points, and of the horn cores of a giant form of Bos all indicate former conditions of greater precipitation and of more abundant vegetation than now exist.

Pleistocene Lakes. We also have evidences of extensive interior lakes in the later Tertiary or in the Pleistocene period. The valley of the San Pedro exhibits a great thickness of horizontal lacustrine clays, generally of red color, extending from the Mexican border northward to and beyond Benson on the Southern Pacific R. R., where they are cut through by the river to a depth of 600 feet or more. The northern barrier of this lake was probably in the narrow valley between Benson and Dudleyville. By the cutting away of this barrier the lake has been drained. For this ancient lake I have proposed the name Quiberi, the ancient Indian name of the San Pedro valley and river.

The great Sulphur Spring valley between the Dragoon mountains on the west and the Chiricahua mountains on the east is also regarded as the dried up bed of an ancient lake of great extent.

Detrital Deposits. The detrital deposits of the Pleistocene, or Quaternary, are developed on an enormous scale in southern Arizona. They everywhere skirt the mountains in the form of extended slopes often twenty miles or more in length which arrest the eye by their wonderful regularity of outline truly represented in a photograph or picture by a straight line inclined two or three degrees to the horizon.

THE LAKE SYSTEMS OF SOUTHERN PATAGONIA.

By J. B. Hatcher, Carnegie Museum, Pittsburgh, Pa.

Plate XVI.

Until recently, the interior of Patagonia has remained practically an unknown country. A few of the earlier travelers had, it is true, penetrated into the interior, but for the most part they followed one of two routes. Some chose the Santa Cruz river, which, discharging into the Atlantic at about the fiftieth parallel of south latitude, forms an unbroken waterway, for vessels of light draft, from the sea to lake Argentino at the base of the Andes, 150 miles to the westward. Others, starting from the same point, selected a more northerly route, and after leaving the mouth of the Santa Cruz river, followed the old Indian trail that, for centuries, has formed the highway of communication between the southern Tehuelches and the Araucanians and other Indian tribes inhabiting the country watered by the Chubut, Negro, and Colorado rivers, far to the northward.

This trail, after leaving the Santa Cruz river near its mouth, assumes a northwesterly direction, and taking advantage of the valley of the Rio Chico which has cut a practical highway through the broad lava beds that cover most of the central plains of southern Patagonia, it ascends this stream to a point some forty miles distant from the eastern base of the Andes. At this place a tributary valley enters the main river valley from the north. This valley connects with other similar lateral valleys tributary to the drainage systems lying to the northward and thus there is formed a continuous highway extending parallel with the base of the Andes from the Rio Chico to the Rio Negro.

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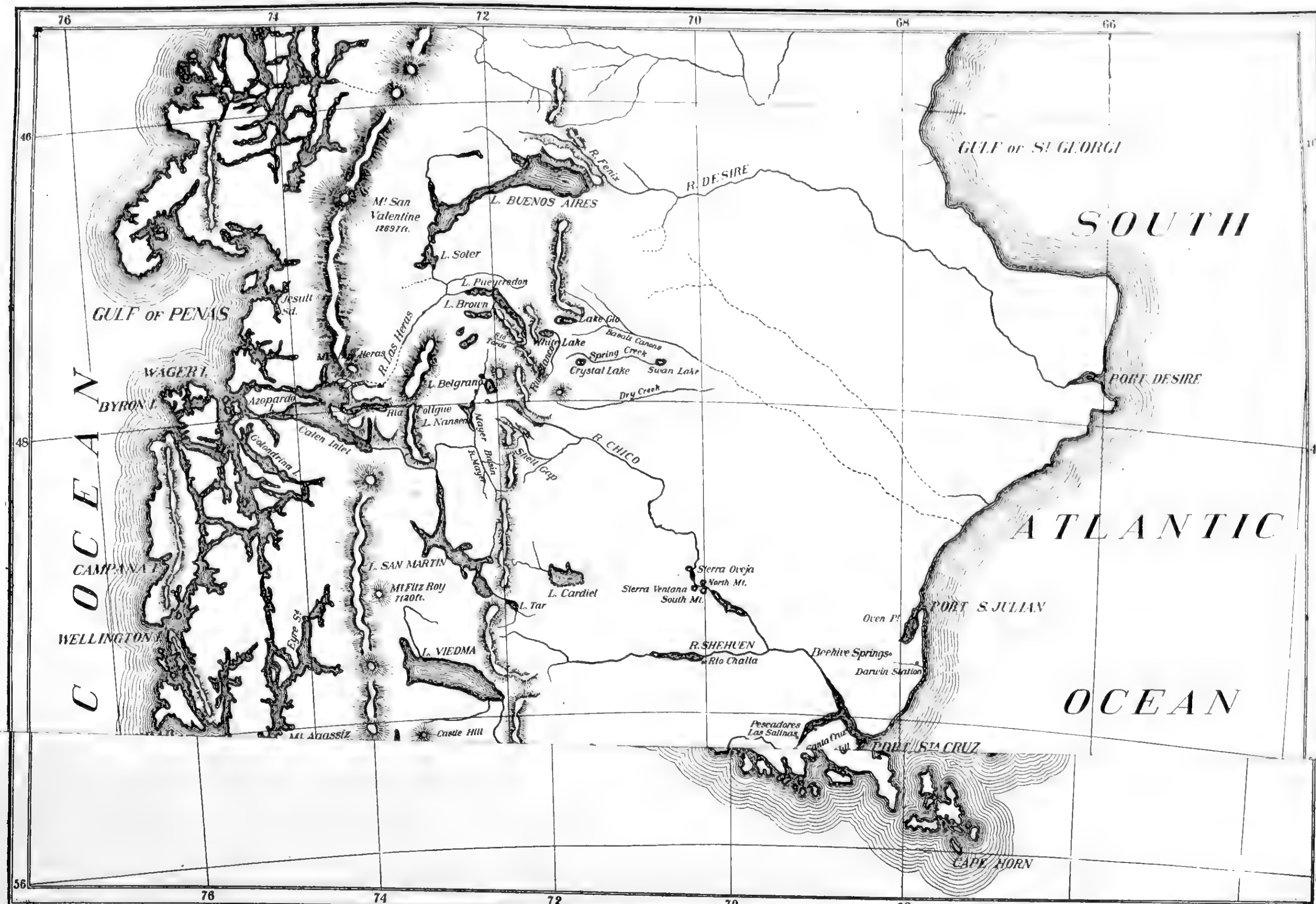
* From the *Bulletin of the Geographical Society of Philadelphia*, vol. ii, No. 6.

The northern of these two routes was the one traversed by Lieut. Musters more than thirty years ago; while the southern was chosen by Darwin, Moreno, and others. Few travelers diverged far from either of these natural highways, so that much of the interior of Patagonia remained a *terra incognita* until quite recently. Within the last five years, however, our knowledge of the interior of this country has been very greatly increased. This has been accomplished chiefly by the explorations of the Argentine and Chilian boundary commissions, supplemented, perhaps, by the expeditions conducted by the present writer in southern Patagonia in behalf of Princeton University. To these explorations must be accredited the discovery of many new lakes, rivers, mountains, and other geographic features, as will at once become apparent by a comparison of the sketch map accompanying this paper with any of the older maps of the same region. This is especially true of that region lying between the Rio Santa Cruz and the forty-sixth parallel of south latitude.

It is not the purpose of the present paper to chronicle any of these discoveries, but rather to discuss the origin of some of the geographic features, and more especially of the lakes which, as will be seen by a glance at the accompanying map, constitute an important part of the physiography of this region.

The lakes of southern Patagonia may be divided according to their origin into three classes, viz.: *residual, glacial, and tectonic.* Of by far the greater importance are the lakes of tectonic origin. By referring to the map, an intricate series of lakes will be seen to extend in a line approximating that of the seventy-second meridian of west longitude throughout the entire length of the region under discussion. The exceedingly irregular outline of nearly all these bodies of water distinguishes them at once as true mountain lakes. Though the eastern extremities of many of them occupy lateral valleys that have been cut through the eastern range of the Andes and project well out into the great plain that extends from the mountains to the Atlantic, yet they one and all penetrate far to the westward, extending quite through the eastern foot-hills and sending out numerous arms and ramifications into that labyrinth of deep mountain gorges that separate the eastern lateral range of the southern Andes from the central and main range of the same mountain system.


GULF OF PENAS
WAGER I.
BYRON I.
CAMPANA I.
WELLINGTON I.
OCEAN
Mt San Valentine 12897ft.
L. BUENOS AIRES
L. Soler
L. Pueyrredon
L. Brown
R. Las Heras
L. Belgrano
Azopardo
Caten Inlet
Golondrina
L. Nansen
Nager Basin
Shell Gap
R. CHICO
R. DESIRE
R. Fenix
Lake Glo
Basalt Canons
White Lake
Spring Creek
Crystal Lake
Swan Lake
Dry Creek
L. SAN MARTIN
Mt Fitz Roy 7120ft.
L. VIEDMA
Eyre St.
Mt Agassiz
Castle Hill
L. Tar
L. Cardiel
Sierra Oveja
North Mt.
Sierra Ventana
South Mt.
R. SHEHUEN
Rio Challa
Beehive Springs
Darwin Station
Oven Pt.
PORT S. JULIAN
Pescadores
Las Salinas
Santa Cruz
PORT STA CRUZ
CAPE HORN
GULF OF S. GEORGI
SOUTH
ATLANTIC
OCEAN
PORT DESIRE
76
74
72
70
68
66
64
46
48
56


MAP OF
SOUTHERN PATAGONIA
FROM A MAP OF
SOUTHERN ARGENTINA
BY DR. FRANCISCO P. MORENO,
with additions and corrections by
J. B. HATCHER
Scale of Miles
H. Logan
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
GULF OF ST. GEORGE
PORT DESIRE
PORT S. JULIAN
PORT STA CRUZ
PORT GALLEGOS
SAN SEBASTIAN BAY
ST OF MAGELLAN
TIERRA DEL FUEGO
GULF OF PENAS
WAGER I.
BYRON I.
CAMPANA I.
WELLINGTON I.
MADRE I.
HANOVER I.
QUEEN ADELAIDE ARCHIPELAGO
DESOLATION I.
KING WILLIAM LAND
SKYRING WR
OTWAY WR
BRUNSWICK PENINA.
Punta Arenas
Dawson I.
HOSTE I
NAVARIN I
Beagle Chan.
Ushuaia
Mt Darwin
Three Brothers
LE MAIRE St
STATEN I.
CAPE HORN
L. BUENOS AIRES
R. DESIRE
L. Soler
L. Pueyrredon
L. Brown
L. Belgrano
R. Las Heras
Mt San Valentine
Crystal Lake
Swan Lake
Spring Creek
Dry Creek
White Lake
R. CHICO
L. SAN MARTIN
Mt Fitz Roy
L. VIEDMA
L. Cardiel
L. Tar
Sierra Oveja
Sierra Ventana
North Mt.
South Mt.
R. SHEHUEN
Rio Chalia
Beehive Springs
Darwin Station
Oven Pt
Castle Hill
R. SANTA CRUZ
L. ARGENTINO
Direction Hill
Mt of Observation
Coy Inlet
Mt Stokes
Mt Viscachas
Rio Aubone
R. Coy
Laguna Leona
R. Gallegos
Gallegos
R. Chico
Los Frailes
L. Balmaceda
Mt Aymond
L. Blanca
Cape Virgin
Last Hope Inlet
L. Maravilla
Peel Inlet
Eyre St
Calen Inlet
Obstruction Sd
USELESS BAY
Cockburn Chan.
STALNES I.

Many of these lakes, like Argentino, Viedma, San Martin, Pueyrredon, and Buenos Aires, are of large size, fifty to 100 miles in length, or even longer. None of them have as yet been fully explored and accurately charted. All of them are, except on their eastern shores, surrounded by lofty, precipitous mountains. The summits of the latter are covered with immense fields of snow and ice, from which descend glaciers that occasionally extend quite down the mountain slopes into the waters of the lakes. Huge blocks of ice are frequently detached from the front of such glaciers and float off into the lake as icebergs of no inconsiderable proportions.

The basins occupied by these lakes are largely of tectonic origin and they are chiefly due to the unequal folding of the strata that took place during the elevation of the southern Andes in late Tertiary times.*

With the exception of lakes Viedma and Argentino, this great series of lakes all discharge their waters into the Pacific, notwithstanding the fact that they lie entirely to the eastward of the main range of the Andes, and that the eastern extremities of most of them project even into the great plain of eastern Patagonia.

Just to the eastward of this series of lakes of tectonic origin and situated on the plains, entirely without the foot-hills of the Andes, there is a second series of lakes evidently of glacial origin. For the most part these lakes are of small size and of minor importance, though some of them, like Lagoona Blanca, lake Cardiel and lakes Colhue and Musters (the two latter are not shown on the accompanying map, since they lie somewhat beyond the forty-sixth parallel) are of considerable dimensions. These lakes have for the most part originated from the damming of preglacial drainage systems with glacial detritus during the recession of the glaciers that occupied these valleys at the close of the glacial period. Like the lakes just mentioned they contain fresh water. Although for the most part they have no surface outlet, the circulation permitted by the confining glacial drift is usually sufficient to keep the

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* For a further discussion of the origin of these lakes, see "Some Geographic Features of Southern Patagonia, with a Discussion of their Origin," by J. B. Hatcher: *Nat. Geogr. Mag.*, vol. xi, pp. 41-55.

waters sweet, but a few of them do in very dry seasons become somewhat brackish.

Scattered all over the Patagonian plains from the strait of Magellan to Bahia Blanca are great numbers of salt lakes. Such lakes are usually of quite limited area and of exceedingly shallow depth, though they occasionally attain to considerable dimensions. In reference to their origin I have called these salt lakes *residual lakes.* I have elsewhere advanced the theory that these lakes have resulted from confined bodies of water, cut off from the sea, during the process of elevation, which began at the close of the Tertiary and which resulted in the final recovery of this region from the ocean. I have held that the salt of these lakes has been derived directly from sea water and has not resulted by evaporation from the surface of an originally fresh water lake with no outlet. No doubt some of the salt and other saline matter found in these lakes has been derived in this manner, but I believe that for the most part it has resulted directly from the evaporation of confined bodies of sea water. From the paleontologic and geologic evidences it is apparent that for a considerable period in late Tertiary times this region was elevated above the sea and subjected to erosion. During this period of late Tertiary elevation all the more important of the present drainage systems were outlined. Near the close of the Tertiary there was a subsidence just sufficient to permit the ingress of the sea. This submerged condition prevailed only for a relatively very short period, but sufficient for the deposition over the previously eroded surface of a thin layer of sedimentary rocks with characteristically marine fossils. At the close of the Tertiary a period of very gradual elevation set in, resulting in the final rescue of what is now southern Patagonia from the sea. As this land-mass gradually emerged, the higher table lands separating the previously eroded water courses would be the first to appear as islands and peninsulas separated by narrow channels and bays formed by the valleys of the drainage systems mentioned above. As the elevation continued the bottoms of such valleys would be successively brought above the water level and numerous small bays would be formed in all the smaller tributaries. Across the mouths of such bays bars would be thrown by the action of the tides. The formation of such bars, together with the gradual elevation constantly taking place, would tend to decrease the circulation between the waters of the bay and the ocean. By the combined action of these two agencies, the circulation would be more and more impeded until a stage would be reached in which this circulation would become intermittent. The two bodies of water would then be entirely separated, except during periods of unusually high tides, when the waters of the sea would rise sufficiently to overflow into the bay, or lake as it might now be more properly termed. At first the obstruction would not be so great but that the bi-weekly high tides occurring with each full and new moon would produce a flow of water from the sea into the lake, thereby replenishing every two weeks the water lost by surface evaporation with a new supply of sea-water. After a time the obstruction would become so great that only the exceptionally high semi-annual tides would suffice for its submergence, and the replenishing of the waters of the lake would then occur only once every six months. After this a stage would be reached when ordinary spring tides would no longer suffice, and only an exceptionally high tide brought on by a continued strong easterly wind, acting in conjunction with the sun and moon at the period of spring tide, would pile up the waters of the sea sufficiently high to overflow the isthmus separating it from the lake. Such conditions would, of course, occur only at irregular intervals and would constantly become less and less frequent, until finally all communication would cease and the smaller body of water would become entirely separated as an inland salt lake, gradually diminishing in area after the last overflow, by evaporation from its surface until a point would be reached when the loss by evaporation would just balance the gain from tributary streams and springs, which latter, in the lakes in the region now being considered is exceedingly slight.

It was during these stages of intermittent communication that the salt deposits were formed. These deposits are now found often covering the bottoms and adjacent shores of the lakes to a depth of several feet. During periods when communication between the lakes and the sea was suspended, the volume of water in the former would be greatly reduced by evaporation, thus increasing its salinity until an oversaturated solution would be attained, resulting in the precipitation of considerable quantities of salt. With the next ingress of the sea a fresh supply of salt would be introduced in solution, to be deposited in the same manner during the next period of suspended inter-communication. Such conditions, continued over a long period, have resulted in the deposition of the considerable bodies of salt now found in and about these lakes.

In the manner just described series of salt lakes were formed and may still be seen occupying slight depressions over the bottoms of all the abandoned water courses of Patagonia; while every stage in the process of the formation of such lakes may be observed in and about the heads of the different inlets all along the coast. Exceptional advantages for studying the origin of these salt lakes are offered at the head of the bay of San Julian and in the valley extending from the bay into the interior for a distance of 100 miles. In the bottom of this valley are numerous salt lakes, while in the region about the head of the bay there is a succession of lakes and inlets, showing every stage in the process of lake formation as detailed in the foregoing lines.

Dr. Otto Nördenskjold has taken exception to this theory of the origin of these salt lakes, holding that they are not residual lakes, and that the salt has not been derived directly from the sea as I have maintained. He holds that the salinity of these lakes is due to the fact that they have no outlets and that the salt has been derived, as in many other salt lakes in other countries, from the surrounding rocks by the tributary waters. To my mind there are two very conclusive arguments against this theory and in favor of that of considering these as residual lakes. *First:*—None of these lakes are fed by perennial streams, their supply of water being almost entirely limited to freshets due to occasional heavy showers, and to melting snow in the immediate vicinity, so that it is entirely made up of surface water and necessarily contains very little, if any, saline material. *Second:*—Those lakes found nearest the coast and whose connection with the sea has only just recently been completely closed, are found to contain quite as important salt deposits as others situated many miles inland where the connection with the sea has long been severed; thus showing that the amount of salt in the latter has not been appreciably increased during the long period that has elapsed since their final severance. These facts, together with the observations made illustrating the method of formation of these lakes about the heads of many of the inlets of Patagonia, lead me unhesitatingly to pronounce them residual in origin, and as having derived the beds of salt found in and about them almost entirely from the sea direct.

Of the three systems of lakes described above, the first, or those of tectonic origin, are in point of size of vastly more importance than either of the other two. When Patagonia is finally opened up to civilization and its many natural resources are fully recognized and taken advantage of, this superb series of magnificent mountain lakes will come to be more generally realized and appreciated. They will then, no doubt, achieve an importance and consideration commensurate with their exceptional size and beauty. Hitherto, owing to their inaccessibility, few indeed are those who have been enabled to see them; but, buried deep in the recesses of one of the most lofty and rugged mountain systems to be found anywhere on the surface of our earth, by those favored few they will ever be remembered as masterpieces of creative ingenuity. Extending from the barren lava beds and bleak, cheerless plains of the east through the forest-clad slopes of the foot-hills on into the remote and silent recesses of the central range of the Andes, whose summits, rising ever higher, are finally lost in immense fields of snow and ice, they present along their shores a greater variety of physiographic and geologic features than may be observed elsewhere in an equally limited area.

Of the three systems of lakes described above those of glacial origin are, perhaps, economically of the least importance of all. Yet, lying among the drumlins and terminal moraines of the ancient glaciers, where are now to be found the best pasture lands of the Patagonian plains region, they will become of ever increasing importance as these lands are more and more occupied for pastoral purposes.

The salt from the residual lakes will always supply the local demand for that useful article and permit also of the annual exportation of considerable quantities.

EDITORIAL COMMENT.

CROLL'S THEORY REDIVIVUS.

Glacialists will read with much interest the discussion of the climate of Mars by Mr. Percival Lowell, published in the Proceedings of the American Philosophical Society,* Philadelphia.

Twenty-five years ago, when Croll's theory was tested by an appeal to the testimony of Mars on the bearing of eccentricity on glaciation, it was because Mars presented appearances suggesting polar ice-caps, and because he is in eccentricity and tilt favorable to the application of Croll's theory. It was immediately discovered that Mars, on the assumption that other conditions were similar to those of the earth, afforded no support to that hypothesis. One pole showed as large a cap as the other. Eccentricity therefore did not seem to affect precipitation about the pole.

But since then the examination of the physical conditions of Mars has proceeded. It has been discovered that the assumption of similarity with the earth was a mistake, and that Mars presents the opposite of similarity with the earth, "and with the flight of the similar the cogency of the argument departs." In the light of this change Mr. Lowell re-opens the case and proceeds to discuss anew the bearing of the planet Mars on the hypothesis of Croll.

Accepting the suggestion of Sir William Herschel, that the white spots that appear on Mars about his poles, are due to accumulations of ice and snow, and noting that they increase alternatingly and diminish again "in a certain chronometric cadence," he confronts at once the theory that those spots are due rather to congealed carbonic acid, for carbonic acid in extreme cold not only assmues a solid form, but that form is as white and delicate as snow. He calls attention to the reluctance of carbonic acid to remain in a liquid form. It passes almost immediately from a solid to a gas. There are, however, certain features that appear about the margins of those white caps that show rather plainly that they disintegrate as they shrink, giving rise to belts and bays of different color. These marginal features behave precisely as if they were affected by the

* Op. cit., vol. 39, Oct.-Dec., 1900.

variations of the seasons, and are hence due to changes of temperature, and are to be attributed to the same cause or causes that produce the increase and diminution of the white spots. Water is the only known substance that will remain in the form of liquid sufficiently long and in sufficient quantities to answer all the conditions. Certainly it will not be allowed to assume an ocean nor rivers of liquid carbonic acid.

The state of things seems to be this: so soon as either cap begins to shrink, there proceeds to surround it a blue belt. The belt increases with the increased rate of diminution of the cap and decreases as that diminution falls off. Meanwhile it keeps pace with the cap, shrinking with it so as to always border its outer edge.

It is difficult to conceive how anything could more conclusively proclaim itself the liquid product of the disintegration of the cap. This badge of blue ribbon seems to mark the substance as H_2O.

To this conclusion, however, there are two drawbacks. One consists in the less heat received by Mars from the sun, which, as compared with the earth, distance for distance, would be only a moiety, and would interfere with any assumption of H_2O in liquid state on Mars in such large quantity. The other is a thinner air at the surface than we know, and therefore the absence of a blanketing atmosphere to keep out the cold of space. But these objections are not fatal to the assumption that the liquid substance that follows the margin of the white cap consists of water.

In the first place the greater amount of clouds and vapor of water in the earth's atmosphere causes the earth to reject a far greater proportion of the sun's heat. Much of the sun's heat intercepted by the earth does not reach its surface, quite apart from what is necessarily reflected. But the Martian sky is clear from clouds, perpetually. "All the heat a pure sky permits to pass falls unhindered upon the soil. Thus receptivity makes up what distance denies."

Secondly, the earth's blanket consists not in its atmosphere, contrary to what has been thought, but in the watery vapor that it contains. This has been shown by Tyndall. He stated that on an average day in England the atmospheric vapor of water exerts a hundred times as much reaction against the sun, and hence against the cold of space, as the atmosphere itself. Mr. Lowell concludes that if one seventieth part of the Martian atmosphere is watery vapor, and the atmosphere one-seventh of our own at sea level, it may render as effective a covering as our own. While not affirming that this is the case, he notes simply "how little we need go out of our way in possibilities to furnish Mars with a sufficient covering."

After sufficiently showing that these phenomena on Mars are due to ice and snow about the poles, and to the production of water as the caps recede, Mr. Lowell notes some peculiarities by which they differ from the snow caps of the earth. In many respects they are comparable and similar, but ours have greater extension, reaching, in the northern hemisphere, in their maximum, southward to about the latitude of 45°, producing a snow-spot about 90° in diameter. It would thus appear to an outside observer. "In this we live and move and have our being for some four months, and it is at least a pregnant thought that to such an outsider the highest development of life upon our planet should seem thus for nearly half the year to have its existence within the polar cap." From this maximum our snow cap, as viewed from Mars, would appear to dwindle till, about two months after the summer solstice, it would measure only about 40° across. The southern cap, from incomplete data, seems to be larger than the northern, both at maximum and at minimum.

On Mars the northern snow cap has a maximum of 70°, about 53 of its own days after winter solstice. It recedes then to a minimum of 3° which occurs about the same time after the summer solstice, and it retains the minimum size some time. Comparing therefore the northern caps of the two planets, it is apparent that that of the earth is greater than that of Mars at each extreme. As to the maximum this happens in spite of the fact that the Martian year and therefore the Martian winter is nearly twice as long as our own.

Again the ratio between the maxima and minima on the earth are as five to one, while on Mars they are as 130 to one. "To the belief that Mars lacks warmth this comparison is calculated to give a shock of surprise."

A still more remarkable contrast exists. This is the difference in behavior of the two Martian caps. The southern cap is bigger than the northern in winter and smaller in summer. It surpasses it in accumulation and again in dissipation. This can be affirmed, although the data of observation on the northern maxima are not satisfactory.

As to the cause of these differences between the south polar cap and its counterpart on the north pole Mr. Lowell shows that, under the law of the radius vector, to which both gravitation and light, or heat, are amenable, eccentricity can have no effect; nor axial tilt, since that brings the two hemispheres in turn under the same though varying conditions—as variant for one as for the other.

"Not the amount of heat but the manner of its reception, then, is responsible for the differences we observe," between the maxima and minima of the Martian snow caps. The difference between the maxima is rationally attributed to the surpassing length of the Antarctic winter, which is 75 of our days longer than the northern. The total heat received from the sun by the two hemispheres is the same, but it is intensified in a short season in the northern. The contrast between the minima of these snow caps is not so easily explained. The southern snow cap is more reduced in its short summer than the northern in its longer summer. Mr. Lowell mentions two factors that spring from the planet itself which may account for this (a) The more intense diurnal heat of the southern summer provokes greater volumes of water during its prevalence, and this adds to the readiness with which the snow cap as a whole could shrink. (b) The cloudiness at night (for every day is perfectly clear) is increased by greater daily dissolution of the cap, and hence the proportion of watery vapor is increased in the southern latitudes of Mars during the summer months. This increased blanket conserves the heat of the day before so that the following day, and every following day, is reinforced by the greater proportion of conserved heat. The two conspire to waste the Antarctic snows more rapidly than the northern. It appears then that on Mars eccentricity has no tendency to form a northern ice-cap, or about the pole of that hemisphere that has its summer solstice near perihelion, but that the permanent accumulation there is actually less than at the south pole.

In transferring this argument to the earth we are confronted at once with a differing total amount of moisture and the presence of oceans. This involves greater precipitation, and the formation of a larger amount of winter ice. Mr. Lowell shows that under increasing precipitation the Antarctic minima increase, relatively to the Arctic, faster than the Arctic, and hence that they finally reach and surpass the Arctic minima. In other words with precipitation increased equally over the whole planet the size of the perpetual ice-cap over the southern pole would finally surpass that about the northern one. "Whereas, then, with moderate precipitation the hemisphere with the extremes of summer and winter climate would have the less perpetual ice of the two; with more precipitation the result would be reversed. * * * Thus a glacial period might be produced with us under the very same conditions which would bar it on Mars. It would come about in consequence of the eccentricity of the orbit, but not chiefly because of that eccentricity. Rather we may say, because of the amount of moisture capable of being manufactured. For were the moisture to fall below a definite amount, not only would no glacial period result, no matter what the eccentricity, but actually a sort of anti-glacial epoch would be brought about by that very same cause."

"Our survey of the Martian polar caps, then, leads us to some curious conclusions. It starts with apparent contradiction of Croll's theory to end in final confirmation of it. It comes to curse and stops to bless. But it does more. It shows that eccentricity of orbit by itself not only causes no universal glaciation, but actually produces, on occasion, the opposite result in more than offsetting by summer proximity what winter distance brings about. Eccentricity needs water, and a great store of it as handmaid before its glacial work can be accomplished. Could our earth but get rid of its oceans, we, too, might have temperate regions stretching to the poles."

The vast blue-green areas of Mars are interpreted as grassy plains or forests. They prevail in the southern hemisphere. They wax and wane with the season, slightly changing their color. The dark bands that cross them are perhaps channels filled with slow running water derived from the annual dissolution of the southern snow caps, wasting away toward the tropics.

The eccentricity of the southern snow cap, which is marked from maximum to minimum, is supposed to be due to a depressed area, rather than to elevated lands. In this depression the permanent ice accumulates in greatest quantity, and survives through the intense summer. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Contributions to the Tertiary Fauna of Florida. By WILLIAM HEALEY DALL, A. M.

Part V. of the Contributions to the Tertiary Fauna of Florida by professor Dall is at hand in Part V. vol III., of the Transactions of the Wagner Free Institute of Science of Philadelphia. The publication bears date December, 1900. The present contribution deals with the Teleodesmacea: Solen to Diplodonta, and is a continuation of the work on the Tertiary fauna appearing in the previously issued publications of the Institute. It was found impossible to complete the discussion of the large family Veneridæ for publication in its appropriate place in the present part of the volume, and so it is deferred till the publication of the next part which it is believed will contain all that remains to be written to finish the subject. Some work on the Tertiary shells of Florida was published in volume I of the Transactions of the Institute, but it remained for professor Dall, in volume III. to take up the study of this most prolific and interesting fauna with a thoroughness that could not previously have been attempted. The fact that there are nearly 140 new species in the present part will give some idea of the practical newness of the field which professor Dall has so successfully cultivated, and of how little was really known about it when the author began his studies. Every such thorough-going contribution, dealing exhaustively with a single fauna, marks a real advance; it brings a whole new field within the known province of Paleontological science.

S. C.

Geology of the Boston Basin; vol. I *part* III. *The Blue Hills Complex;* by WILLIAM O. CROSBY. (Occ. papers, Bos. Soc. Nat. Hist.; pp. 289-964, pls. 15-39, No. 4, 1900.)

This paper completes the detailed study of the southern edge of the basin, carried on so long and well by Prof Crosby, from the Atlantic coast west to the valley of the Neponset. The author defines the complex as "the area of granitic and associated Cambrian strata which includes the Blue Hills proper, and extends thence eastward across Quincy and the northern parts of Braintree and Weymouth." It is a distinct geological unit.

The Cambrian strata occur largely on the north and south margins of the area, and consist of fine, poorly bedded slates, which are thought to have been deposited in a quiet area of some depth, one shore of which was perhaps to the northwest. The base of these slates is nowhere exposed. Prof. Crosby believes, although upon what data is not made clear, that the quartzytes northwest of the basin and the limestones of Shoreham and Newbury are lower Cambrian; and from that time continuous deposition occurred, through the middle Cambrian and a now denuded upper Cambrian series. Probably, also, sedimentation was prolonged through the Ordovician, and the detritus has since been removed.

Not later than early Devonian time the strata had been sharply folded, and were intruded by an igneous series almost entirely acid. The theory advanced for its origin is melting of the base of the slates, due to the blanketing effect of prolonged deposition; and formng an acid magma above the abyssal basic one. No estimate of the thickness of this stratified cloak is given; but to produce the existing effect there would be required a depth of sediment far greater than we have any warrant for inferring, and especially, such view seems inconsistent with the almost surface character of the igneous mass, not only near its summit but far down the sides, as exhibited in the aporhyolytes. It is much more probable that the intrusion burst through the base of the Cambrian series

In cooling, the batholith became differentiated both in texture and composition, being finer and more basic toward the periphery. For explaining the latter, the author uses Becker's theory of fractional crystallization. The results are two types of granites, biotitic and hornblendic, forming the main mass; and at the margins three phases, dioryte, fine granite, and aporhyolyte, the last grading into the granite. The later stages of refrigeration were apparently accompanied by further dike intrusion of granite, and dikes and flows of aporhyolyte.

The Carboniferous sediments, which make up a large part of the present basin, are thought to be really one formation, deposited delta-like, during slight oscillations; and while coal was being deposited elsewhere, the bottom here was too deep. This last conclusion is not borne out by the fossils discovered recently by Messrs. Burr and Burke; nor by the large amount of coarse sediment present, much of which can be proved to have traveled but a short distance. Very likely the reason is to be sought rather in the almost open-coast conditions, by which the sea action was too rigorous. The melaphyr, which is so characteristic of the southern part of the basin, is considered as a series of contemporaneous flows, and never intrusive. It may be pardoned, perhaps, if some students of the region still regard the evidence as pointing to intrusion.

The Appalachian revolution gave the present structure to the basin as a whole, which, however, then extended far beyond its present limits. The larger faults, particularly on the margin, result each from two disturbances—one during the deposition of the Carboniferous sediments, the later at the close, during the general orogenic action. The result, according to Prof. Crosby's interpretation, is a *graben* of sediments between two crystalline walls.

As far as know, the region has been above sea level since Carboniferous times, except during a portion of the Pleistocene. Erosion has removed the strata on either side of the graben, and much of the complex and basin. The granite has proved less resistent than the aporhyolyte, and the slate than either. The Blue

Hills mark the level of the Cretaceous peneplain, dominant farther inland. Below this is a "coastal peneplain," which rises westward and bevels off the earlier and higher level. Below this, again, is the basin. The discussion of the surface geology presents nothing new, in the chief author's part. This is followed by a paper entltled "Lake Bouvé, an extinct glacial lake in the southern part of the Boston Basin," by Dr. A. W. Grabau. An entirely separate chapter closes the work, on the "Palæontology of the Cambrian terranes of the Boston Basin," also by Dr. Grabau. Both papers are full, containing new material as well as a summary of existing knowledge; and they should be reviewed separately.

Altogether, this third part of the Boston Basin papers is a notable contribution on a difficult field; and shows most pains-taking labor. It is much to be regretted that the society has not completed its publication by issuing the geological map of the area which, the text states, accompanies the report. Also, the great care shown in gathering the field details does not appear to have been extended to all parts of the make-up of the paper. There is neither table of contents nor index, nor list of illustrations; nor is there any reference in the title to the two important contributions of Dr. Grabau. More summaries scattered through the work would prove a help, and the igneous part suffers much from almost an absence of chemical analysis. In places, too, theory is presented before evidence, and the two are not always dissociated clearly. The illustrations are excellent, the photographs being reproduced by gelatine process, and the original drawings of fossils successfully treated in the same way.

J. E. W.

Notes on the Tellurides from Colorado. By CHARLES PALACHE. *(Am. J. Sci., 160,* 419-427.)

The article gives the results of a careful and admirable crystallographic study of the mineral sylvanite together with a chemical investigation of the same. The analyses show the composition to be represented by the formula $Au\,Ag\,Te_4$, thus confirming the conclusions previously reached by Pearce from analyses made by him on massive material from Cripple Creek. The goldschmidtite of Hobbs is shown by Dr. Palache to be identical in crystallization with sylvanite. Owing to this identity it is thought that the analyses made by Hobbs may have been rendered inaccurate by the extremely small quantity with which he worked, and in a note incorporated in the article, Prof. Hobbs withdraws the name goldschmidtite as representing a distinct species. The article is concluded by a note on the crystal habit of hessite from Boulder, Colorado. C. H. W.

Mohawkite, Stibio-Domeykite, Domeykite, Algonodite and some artificial copper arsenides. By GEORGE A. KOENIG. (*Am. J. Sci., 160,* 439-448.)

The copper arsenides occurring in the Keweenaw copper formation of Michigan are found only in veins intersecting the bedded deposits of native copper, and have so far, been observed only near the foot of the formation toward the south-east. The new mineral mohawkite occurs in a vein at the Mohawk mine associated with other copper arsenides in a gangue of quartz and calcite. The mineral is massive, structure granular to compact, color a gray tinged with yellow taking readily a brassy to purplish tarnish. It is brittle, hardness about 3.5 with a specific gravity of 8.07. A chemical analysis gives its composition as follows: Cu=61.67, Ni=7.03, Co=2.20, Fe= trace, As=28.85, which gives the mineral the formula $(Cu, Ni, Co)_3As$. The author shows also that nickel and cobalt are present in small quantities in the mineral domeykite Cu_3As, and, that the specific gravity of the latter should be 7.94 instead of 6.7 to 7.5 as given by the mineralogies. By volatilizing arsenic over red hot copper in a combustion tube sealed at one end two arsenides were obtained, one having the composition Cu_2As and resembling chalcocite, the other consisting of groups of minute crystals and identical with domeykite in composition. By the name stibiodomeykite the author designates a mineral from the Mohawk mine closely resembling domeykite but containing a small percentage of antimony; and by the name mohawk-whitneyite a very intimate mixture of the two minerals mohawkite and whitneyite. The results of several analyses of these last mixtures accompany the article. The correctness of the formula $(Cu\ Ni\ Co)_4As$, which was assigned to mohawkite by Dr. Ledoux and reported in the April number of the *Mining Journal* for 1900, is strongly denied by Dr. Koenig. He concludes his paper with a new analysis of algodonite, confirming the formula Cu_6As. Its specific gravity was found to be 8.383 instead of 7.62 as previously given. C. H. W.

The analyses of Italian volcanic rocks. By H. S. WASHINGTON. (*Am. J. Sci., 159,* 44-45)

Analyses are given of the following types of rocks: ciminyte, from Monte Cimino, Viterbo; mica trachyte (selagyte), from Monte Catini, Tuscany; andesyte, from Radicofani, Tuscany; leucityte, from Capodi Bove, Alban Hills. A discussion is made of the analyses, the mineralogical composition of the rocks and their classifications in accordance therewith. C. H. W.

Occurrence of native lead with copper and other minerals at Franklin Furnace, N. J. By W. M. FOOTE. (*Am. J. Sci. 156,* 187-188.)

Small irregular masses of lead 1 to 2 mm. in diameter, associated intimately with native copper and a variety of minerals—among them axinite, garnet, willemite and phlogopite—have been found on a few specimens taken from the 800-foot level of the Parker shaft on North mine hill. The rarity of native lead and its associations at Franklin make the discovery interesting. C. H. W.

Occurrence of sperrylite in North Carolina. By W. E. HIDDEN. (*Am. J. Sci., 156,* 380-381.)

The mineral sperrylite a di-arsenide of platinum—is described from Macon county, N. C., where it was discovered in the sands of Cowee creek, associated with a little gold and the minerals monazite, zircon and menaccanite. The sperrylite consisted of a few very minute, nugget-like particles and crystals, the latter showing the combination of the cube and octahedron. C. H. W.

Thomsonite, mesolite and chabazite from Golden, Colorado. By HORACE B. PATTON. *Bull. Geol. Soc. Am., vol. 17,* pp. 461-474. pls. 43-49.

The paper gives a detailed description, supplemented by excellent plates, of the occurrence and habits of the above named zeolites, found in a scoraiceous band of the basalt flow which caps what is known as Table mountain near Golden. C. H. W.

Beiträge zur Burtheiling der Brachiopoden. Von DR. F. HUENE. (Centralblatt fur Mineralogie &c., 1901.)

This pamphlet is a critical review of the studies of F. Blochmann on the Brachiopoda, and a comparison of his results with those of Beecher and Schuchert.

The part of these studies so far published refer to Discina, Discinisca Lingula and Crania and they bring to light some important characters in the morphology of the Inarticulata not heretofore recognized. The reviewer lays considerable stress upon an important distinction between the Articulata and Inarticulata in the properties of the pedicle. In the latter division the motions of the pedicle are automatic and it has no attached muscles, in the former the pericle itself is immobile, and its motions are governed by muscles attached within the shell.

Another important point brought out by Blochmann is that the opening of the valves in the Inarticulata is effected by the contraction of the "Cutanei" or muscles of the body-wall which by squeezing the viscera and cavity in which they are contained, force the valves apart; he claims that the internal muscles have very little power for this purpose.

Another important observation of Blochmann is that the pedicle is a continuation *backward of the ventral valve,* and is in organic connection with it; the supporting substance of the pedicle within its cuticle being an *extension of the body-wall of the brachiopod.*

Blochmann finds that the circulation of the mantle in the sinuses &c. is of a respiratory nature, and shows how the observations of Morse of two inlet and one outlet current in Lingula are in accordance with his observations. There is no venous circulation in these passages, the blood being contained in tubes of microscopic size.

The notation for the muscles in Blochmann's work differs from that lately current in English literature. The only laterals recognized are the "j" laterals; the other laterals with the transmedians are "oblique." As the pedicle is automobile, no muscles are required for it within the shell, and the connected threads are "nervi."

The observations in this review are made more instructive by a number of figures in the text, cited from Blochmann's work, and showing the various points of structure discussed in this review. Dr. von Huene directs deserved attention to the important work of Beecher and Schuchert on the classification and morphology of the

Brachiopoda, though he lays a strong emphasis on the distinction between the "Ecardines" and "Testicardines" (=Inarticulata and Articulata.) G. F. M.

Kleine paleontologische Mittheilungen. von DR. F. HUENE in Tübingen, mit 2 Taf. (Neu Jarb. für Mineralogie &c, 1901, Bd. 1, s. 1-8.)

In this article Baron v. Huene describes a new species of Medusa (*Medusina geryonides*) from the Murchisonia slate of Wiesenteig in Wurtemburg of which the preserved impression exceeds an inch in diameter and is quite distinct and characteristic.

He also gives figures and a descripion of a new Cycad *(Zamites infraooliticus)* from the Blagdini zone near Langenbruck in Switzerland. The oroginal of this species is in the museum of Lausanne.

G. F. M.

Action of Ammonium Chloride upon Analcite and Leucite. By F. W. CLARK AND STEIGER. (*Am. J. Sci., 159,* 117-124.)

The article records the results of an investigation on the action of ammonium chloride upon the minerals analcite and leucite when the latter are heated separately with this reagent in sealed tubes at 350°C; also the meaning which the results obtained have in regard to the chemical constitution of the two minerals. Both minerals suffer a substitution of their alkali by ammonium, yielding the same compound whose composition is that of an ammonium leucite, $NH_4AlSi_2O_6$. This fact is believed to indicate an original similarity in the two minerals which is also borne out by crystallographic and other resemblances. A further study of the chemical properties of the ammonium derivative leads the authors to think that analcite and leucite are not true metasilicates but either salts of a polymeric metasilicic acid or a mixture of ortho and tri-silicates. C. H. W.

Chemical Study of the Glaucophane Schists. By H. S. WASHINGTON. *(Am. J. Sci., 161,* 31-59.)

A consideration of the chemical and mineralogical composition of the above class of metamorphic rock as shown by a series of admirable chemical analyses of specimens from some seven localities, leads to conclusions concerning their classification and origin which are briefly and concisely given by Dr. Washington in his summary as follows: "The Glaucophane schists belong to two main groups, sharply separated from each other. The larger one is basic, composed chiefly of glaucophane and epidote, often with abundant garnet, zoisite, diallage, and sometimes smaller amounts of mica, feldspar and quartz, and rutile and titanite as frequent accessories. Chemically these closely resemble the composition of the rocks of the gabbro family, and are apparently divisible into two sub-groups, one high in CaO, the other low in it. These are in most cases almost undoubtedly derived from such igneous rocks or their tuffs, but also possibly in rarer cases from sediments or slates of similar composition. These basic glaucophane schists scarcely differ in composition from the amphibolites and eclogites, and the difference in their formation is probably to be ascribed to differences in the conditions of metamorphism. A smaller but widely spread, group is acid in composition, and these are composed largely of quartz and glaucophane, with mica and sometimes albite. These are derived from cherts, quartzites or quartzose shales and sandstones. The existence is indicated of a third, still smaller group of intermediate mineralogical composition, and chemically like the diorites. The glaucophane schists are apparently the result of both regional and contact metamorphism, and in many regions they occur together. This last seems to be the rule in glaucophane schist areas of any size, and where only the one kind is found the area is apt to be small." C. H. W.

The Mode of Occurrence of Topaz Near Ouro Preto, Brazil. By ORVILLE A. DERBY. *(Am. Jour. Sci., 161.* 25-34.)

The article gives the results of a study of the associated earths and rocks where the topaz is found. The mineral itself is found in a dark-colored earth, thought, from its mineralogical character and its geological relations, to represent the remains of an igneous dike in which the topaz was an original mineral. What the exact nature of the igneous dike was cannot be told on account of its state of extreme alteration. C. H. W.

Carnotite and Associated Vanadiferous Minerals in Western Colorado. By W. F. HILLEBRAND and F. LESLIE RANSOME. *(Am. J. Sci., 160.* 120-144.)

The paper embodies the results of investigations concerning the occurrence and nature of the uranium and vanadium ores of western Colorado. A somewhat detailed description of the various ore deposits is given by Dr. Ransome from a study of the region made by him and Dr. A. C. Spencer. He concludes that the ores are recent impregnations in the sandstones. The chemical researches made and recorded by Dr. Hillebrand furnish, not only valuable data concerning the composition of the ores and their constituent minerals, but afford the chemist excellent descriptions of the analytical methods involved in the analysis of the uranium and vanadium ores. The summary made by the authors is as follows: "The body called carnotite is probably a mixture of minerals of which analysis fails to reveal the exact nature. Instead of being the pure uranyl-potassium-vanadate, it is to a large extent made up of calcium and barium compounds. Intimately mixed with it and entirely obscured by it is an amorphous substance—a silicate or mixture of silicates—containing vanadium in the trivalent state, probably replacing aluminum. The deposits of carnotite, though distributed over a wide area of country, are, for the most part, if not altogether, very superficial in character and of recent origin. The green coloring and cementing material of certain sandstones near Placerville, Colorado, is a crypto-crystalline alumino-vanadio-potassium silicate resembling roscoelite, but with the percentage proportions of Al_2O_3 and V_2O_3 reversed. It constitutes over 25 per cent. of the sandstone at times, and contains nearly 13 per cent. of V_2O_3, the latter amounting in the maximum case observed to 3.5 per cent. of the sandstone. As yet these highly vanadiferous sandstones have been found only at Placerville, where it is intended to work them for vanadium. Carnotite is associated with them in only trifling amount. Other sandstones noticed owe their bright green color to chromium. In yet another case where the color was dull green, this was not due to either chromium or vanadium. C. H. W.

A Contribution to the Natural History of Marl. By CHARLES A. DAVIS. *(Jour. Geol., 8,* 485-497.)

This valuable contribution to the chemistry of marl is based upon observations made in certain small lakes in Michigan; but the principles which it embodies undoubtedly admit of general application. The marl is nearly pure carbonate of lime, the source of which is to be sought in the solution by meteoric waters of limestone or other calcerous strata, the drift of limestone districts and, more remotely, the carbonation of lime-bearing silicates. The real problem is the deposition of this dissolved carbonate of lime in the form of white chalky marl, which consists only to a small extent of shells or fragments of shells. After pointing out the inadequacy of animal life, evaporation and escape of carbon dioxide on relief of pressure, as causes of the precipitation of the carbonate of lime, the author discusses at length the only alternative hypothesis, namely, that the calcium salts are precipitated through the agency of plant life. In the marly lakes aquatic plants of all kinds become incrusted with calcium carbonate, which is not a true secretion of the plants, for it is purely external, and the same species in other districts are not incrusted. The deposit is formed incidentally by chemical precipitation upon the surface of the plants, probably only upon the green parts, and in performance of normal and usual processes of the plant organism. All green plants inhale carbon dioxide and exhale oxygen; and these are two possible causes of the calcareous incrustation. If the calcium carbonate is in excess in the water and is held in solution by carbon dioxide, then the absorption of the latter by the plants causes precipitation of the carbonate upon the parts (stems and leaves) abstracting the gas. But if the proportion of calcium corbonate in solution is so small that it would not be deposited even if there were no carbon dioxide present, the precipitation is explained by the action of the oxygen set free by the living plants in converting calcium bicarbonate to monocarbonate:

$$CaH_2(CO_3)_2+O=H_2O+CaCO_3+CO_2+O.$$

Plants vary greatly in their power of precipitating the calcium carbonate; and the algae, and especially the Characes or stoneworts, are most efficient. Analyses are given showing that plants may precipitate mineral matter equal to several or many times the weight of their own dried tissues, that this mineral matter consists of CaO_3, 93.76; $MgCO_3$, 2.93; SiO_2, 2.40; and iron and aluminum oxides 0.89 per cent. It is shown that the structure and distribution of the marl are entirely in harmony with the view that a species of Chara is an important agent in its formation; but it is recognized that a species of Zonotrichia has always played an important part, explaining, especially, the more solid and nodular forms of the marl. W. O. C.

The Composition of Kulaite. By HENRY S. WASHINGTON. (*Jour. Geol., 8,* 610-620.)

Kulayte is the name given by the author several years ago to a subgroup of the basalts in which hornblende occurs as an essential constituent and surpassing augite in quantity and importance. The original analysis by Röhrig showed, for basalts, abnormally high soda, as well as very high alumina and low magnesia. There seemed to be no mineral present which would account for the high alkalis, and to determine this and other points two new analyses were undertaken, one of normal kulayte, and the other of a leucite kulayte. The first showed in comparison with Röhrig's analysis, about two per cent. more Fe_2O_3 and as much less K_2O; and the second differed rather widely except for the MgO, CaO and Al_2O_3. It is surprising to find that all these differences are regarded as probably due to the different analytical methods used. The normal and leucite kulaytes are found to agree closely except in the minor constituents TiO_2 and P_2O_5; and the author next considers the place in the classification indicated by this composition. The alkalis and alumnia are shown to be high for a true basalt; and for these reasons and also becuse of the higher SiO_2 and the lower iron oxides, MgO and CaO, they cannot be referred to the subgroup of hornblende basalts. They are, in fact, properly leucocratic, while the hornblende basalts are melanocratic; and the closest analogues of the Kala rocks are to be found among the nepheline-tephrytes and the nepheline-basanytes, notwithstanding that many of these are markedly lower in SiO_2, Al_2O_3, and Na_2O. A resemblance to the monchiquytes is also noted, the main difference being the higher H_2O content of the latter. Except in the glassy varieties, the essential hornblende has been partially or entirely altered to hypersthene, diopside and magnetite, The component minerals are calculated from the analysis, and nepheline, the presence of which was indicated by the gelatinization and fuchsine tests, is fully confirmed. Certain anomalies of the mineral composition, such as a large proportion of orthoclase in the more basic type, and of leucite in the type running highest in SiO_2 and lowest in K_2O, are explained by reference to difference in pressure and rate of cooling; and the author favors basing the classification of this and other rocks directly upon the chemical composition. W. O. C.

A Topographic Study of the Islands of Southern California. By W. S. TANGIER SMITH. (Bull. of the Department of Geology, University of California, vol. II, pp 179-230, 1900.)

The islands described in this bulletin were studied principally from maps, and the conclusions reached are intended to be rather preliminary and suggestive than final in character. The topographic feature of the islands are outlined and a general discussion given of the characteristics of the various kinds of shore terraces and of the conditions leading to their formation.

There follows an interesting account of the oscillations of the Pacific coast in Miocene and Pliocene time. The information in this account is not new. The principal point which the present paper aims to establish is that the most recent general movements have been the same for the islands as for the coastline of southern California. I. H. O.

A Remarkable Marl Lake. By CHARLES A. DAVIS. *(Jour. Geol., 8,* 498-503.)

This paper supplements the preceding, describing the truly impressive deposit of marl in Littlefield lake, Isabella county, Michigan, and showing that it is unquestionably due to the precipitating agency of Chara and Zonotrichia, chiefly through the exhalation of oxygen.

W. O. C.

CORRESPONDENCE.

NOTES ON THE KANSAS-OKLAHOMA-TEXAS GYPSUM HILLS.—From the time of the earliest explorations of the great plains the gypsum hills have been objects of particular interest. Long and Marcy, among early explorers, and Hay, Cummins, Cragin, Prosser and Grimsley, among later geologists, have written extensively concerning these very interesting formations. Conspicuous on account of topography, color and position, these hills have ever excited an interest both popular and scientific.

Geologically the gypsum hills are a part of the "red-beds" and are located near the center of that series. The red-beds consist of more than 2,000 feet of prevailingly red clays, shales and sandstones. The series extends from near the great bend of the Arkansas river in southern Kansas across Oklahoma and far into Texas before it finally disappears beneath the later Mesozoic and Cenozoic deposits. The age of the rock has long been a mooted question. In Texas it has been correlated with the Permian. In Kansas and Oklahoma it was for a number of years classified as Triassic, but the later geologists have inclined to the opinoin that the red-beds of this region are of the same age as those of Texas, *i. e.,* Permian. No fossils have been found in the Kansas beds and until the past year very few in Oklahoma. During the summer of 1900, however, the Oklahoma Geological Survey collected fossils from several localities in the red-beds. These fossils—vertebrates from the lower part of the series, and invertebrates from the upper part—indicate that in Oklahoma at least the red-beds belong to both the Permian and Triassic.

Throughout the entire thickness of the red-beds the rock is strongly impregnated with mineral salts. In the lower part common salt predominates. In Oklahoma there are no fewer than four large salt planes, and numerous smaller ones. In general the salt planes are confined to a definite horizon. Even among the saliferous horizons gypsum is of frequent occurrence. Seams of selenite and satin spar are often abundant.

Some 200 feet above the salt beds the gypsum reaches its culmination. At this horizon there are thick ledges of massive white gypsum which lie level and extend for long distances across the country. Ordinarily there are two of these ledges, each from 10 to 30 feet thick separated by 10 to 20 feet of red clay shale. Professor Cragin has given this massive gypsum the name "Cave Creek gypsum," from a creek in Comanche county, Kansas. The lower (and usually thicker) gypsum ledge he calls the Medicine Lodge gypsum, and the upper ledge the Shimer gypsum. The intervening clays are designated as the Jenkins clays.* It frequently happens, however, that this clay entirely disappears, in which case the single gypsum ledge is as much as 50 feet thick. On the other hand in certain sections there are three ledges of gypsum, a thinner ledge coming in below the Medicine Lodge.

The gypsum hills are hills of erosion. The soft clays below the massive ledges are readily acted upon by water. The ledges themselves are relatively much harder and consequently resist erosion. The slope of the country is to the east, while the ledges lie comparatively level. This causes the greater erosion to the east, and as the underlying clays are removed the gypsum ledges remain as a cap forming the escarpment of the hills, which rise like a wall from the level plains to the east. The slopes below this escarpment are often as much as 200 or 300 feet high, and consist of blood red clays, sometimes grass-covered but more often barren of vegetation. These slopes are often covered with selenite crystals, which on a clear day reflect myriads of light-points and have given to one part of the hills the characteristic name "glass mountains."

Throughout the region of the gypsum hills there are numerous pronounced erosion forms. Deep and narrow canyons, flat-topped mesas, pinnacles and turrets, mansard mounds and buttes, and natural bridges and caves may be found in most localities. These forms are due not only to the solubility of the gypsum ledges but also to the fact that the underlying clays are so easily eroded. The gypsum caves are of particular interest. They are of all sizes from mere cracks in the rock to immense caverns a mile or more in length with sometimes dozens of chambers leading off in all directions. In southern Kansas and northern Oklahoma many of these caves are known locally as "bat caves" from the fact that they are the home of multitudes of bats. These animals remain inside during the day and in the evening pour out of the mouth of the cave in a continuous stream, sometimes for an hour at a time.

The gypsum hills extend in a general northeast and southwest direction for a distance of nearly 500 miles from southern Kansas to west-central Texas. The northern limit so far as I have been able to observe is in northwestern Barber county, Kansas, on the north bank of the Medicine river, near Sun City. From this point the hills trend southeast and approach within six miles of Medicine Lodge,

* *Colorado College Studies, vol. vi,* March, 1896, pp. 27-39.

where a bold outlier east of the main line of hills overlooks the valley of the Medicine river. The line of hills crosses the Salt Fork at the state line and approaches the Cimarron in the northeastern part of Woodward county, Oklahoma. Throughout nearly its entire course in this county, a distance of 40 miles the Cimarron flows in a narrow valley enclosed between the hills. In places the valley is little more than a canyon with precipitous walls 100 feet or more in hight. The gypsum hills trend southeast along the south side of the Cimarron as far as the Glass mountains in southern Woods county, and then gradually retreat from this river and approach the North Canadian near El Reno. From this point at which the hills find their most eastern limit, they trend southwest across the Kiowa and Commanche reservation to the Red river. In Texas extensive gypsum deposits occur at Quanah, Hardman county, and in Stonewall, Kent and Knox counties as far as Sweetwater on the Texas Pacific railroad.

Throughout this area, from Kansas to Texas, the region of gypsum deposits is from 10 to 50 miles wide and is in all places much cut up with canyons and streams. Certain parts of the range have received particular names, as for eaxmple: Glass mountains, Chautauqua mountains, Stony hills, Cedar hills and Gray Eagle and Wild Cat buttes. For the entire range in Oklahoma the name "Marcy" range has been proposed, but it need scarcely be feared that any other name will ever take the place of the good old cowboy phrase, "Gyp." hills.

In regard to the economic importance of the gypsum it is but necessary to add that mills for manufacturing the product are in operation in all three states in which the hills are found. Of these perhaps the most important are located at Springvale and Medicine Lodge, Kansas, Okarche, Oklahoma, and Quanah, Texas. As the supply of material is inexhaustible it is but a matter of time when the gypsum from the Gypsum hills will become one of the important sources of income from the region. CHARLES NEWTON GOULD.

University of Oklahoma, Feb. 1, 1901.

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PERSONAL AND SCIENTIFIC NEWS.

Lake Superior Iron Trade During the Year 1900. Considering the fact that the close of the century marks also the end of the first half-century of activity in the iron mining region of lake Superior, the development has been one of the most astonishing of this wonderful age. It is a short half-century, too, for no mining of importance could be done until there was water connection between lake Superior and the east, and this did not come until 1855. In that momentous year the first ship canal at the foot of lake Superior was cut and the Jackson mine began small shipments of ore. For years the industry was small, it was the day of 8-ton railway cars or, still more primitive, of mule railroads, of 500-ton ships, hand drills, black powder, open pit mining and the like. It was the day of beginnings and of small things, in a word. For some years the product of the lake Superior mines was handled over a mule tram road to Marquette. Up to ten years later or nearly to 1870 a 700-ton ship was an enormous craft and the loading of this great ship required two days and its unloading more than that. Many men of today remember sales of ore at Pittsburg at $18, or about the price of steel billets now. Instead of the tram road there are eight great railways engaged in the ore business hauling cars loaded with 50 tons each behind locomotives of 240,000 pounds weight. Instead of the 700-ton ships, those of the beginning of the new century carry 7,000 or 8,000 tons, and instead of consuming four or five days in loading and unloading they are loaded in two hours and emptied in ten. Instead of ten to twelve trips a year they are making twenty to twenty-five. In connection with this, instead of old time prices ore is now bringing on lake Erie docks little more than the actual mining cost of early years, and in the past three years has actually sold when delivered at Cleveland at less than the mining expenses of as late as 1887. Not longer ago than 1871 a drift was driven at the Cleveland mine at a cost of $100 per foot. Now it could not cost $15. Nitro-glycerine and power drills have been the humanizing and civilizing agencies in great measure, and civilizing these have surely been, for where would be our supremacy today but for the reduction in costs they have brought about?—*D. E. Woodbridge in Mines and Minerals for February.*

Mr. Frank Leverett has completed and submitted for publication by the U. S. Geol. Sur., his second monograph: "The Glacial Formations and drainage features of the Erie and Ohio basins."

The Field Columbian Museum has arranged a course of nine free lectures to be given in the Museum lecture-hall in March and April. These are to be illustrated by stereopticon views: The geological lectures are by Dr. E. R. Buckley and Prof. Wm. H. Hobbs.

Science Club of Northwestern University. At the meeting of February 1st Prof. U. S. Grant spoke on "Some methods of geological field work," and at the meeting of March 1st Prof. A. R. Crook spoke on "Minerals of the Chicago area."

Geological Society of Washington. The following was the program of the meeting held February 27th: "Memorial of Thomas Benton Brooks," Bailey Willis; "Morphogeny of southern Alaska," G. K. Gilbert; "Mountain structure in the trans-Pecos province," Robert T. Hill.

The Geological Survey of Georgia has just issued Bulletin No. 10—A, entitled "A preliminary report on a part of the iron ores of Georgia, Polk, Barton and Floyd counties." The report is made by Mr. S. W. McCallie, assistant geologist.

Mr. F. A. Lucas, geologist of Washington, D. C., who has been drilling for oil in Texas for about two years, was rewarded by the discovery, on Jan. 10, of a great oil basin. The flow of oil at Beaumont is said to be greater than from any single well ever sunk in the United States. It is estimated by experts that every twenty-four hours it flowed 20,000 barrels of oil, and that 150,000 barrels escaped from it before the flow could be regulated. It is not an illuminating oil, but is similar to that now so abundant at Los Angeles, California.

OIL HAS BEEN DISCOVERED IN THE PHILIPPINES, and is extracted in Panay, Luzon, Mindanao and other islands. In most cases it is in a stratum of rock about 350 feet below the surface The working is done by the natives, but largely with machinery from America.

W. H. WEED, WHO HAS RECENTLY SPENT SOME TIME in Mexico, has returned to this country, and is now engaged in the final investigations at Butte, Montana, preliminary to the publication by the U. S. Geological Survey of an exhaustive report upon the economic geology of the Butte district. Mr. Weed expects to complete his studies at Butte in about a year, and will then probably commence the study of the copper region of New Mexico.

C. W. CLARK, son of U. S. Senator W. A. Clark, of Montana, has endowed the Chair of Mining Engineering in the Montana State School of Mines, located at Butte, Montana. The chair thus established has not yet been filled.

THE ANACONDA COPPER MINING COMPANY has presented to the Montana State School of Mines a rock cutting and a rock grinding machine of the best make, and equipped with all accessories. It has also presented to the Museum a specimen of chalcocite weighing 3,500 pounds—doubtless the largest of its kind anywhere on exhibition. It was taken from the Never Sweat mine, one of the Anaconda group at Butte.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its next annual meeting at Denver, Colorado, August 24 to 31.

THE AMERICAN INSTITUTE OF MINING ENGINEERS. The eightieth meeting (being the thirty-first annual meeting) was held in Richmond, Va., beginning Tuesday evening, February 19.

MR. J. EDWARD SPURR, at one time connected with the Minnesota Geological Survey, and more recently with that of the National Government, has been appointed geologist to the Sultan of Turkey, at a liberal salary and all traveling expenses for himself and family, and will shortly depart for his new field of labor, with leave of absence for one year from the U. S. Geological Survey. It is understood that he is also to have a share in any discoveries that he may make, and that he is to be provided with suitable assistants and a body guard of soldiery.

MAJ. A. W. VOGDES, who has been at San Juan since the Spanish war, has returned to New York, and has his address at Fort Hamilton.

A BRONZE BAS-RELIEF of the late Dr. J. S. Newberry has been presented to Columbia University by his children.

TRIBUTE TO VICTORIA. At a postponed meeting of the Ottawa Field Naturalists' Club held on the 29th day of January, 1901, one week after the death of Her Majesty Queen Victoria, the following resolution was unanimously passed: "In common with all the sorrowing subjects of His Imperial Majesty King Edward VII. the members of the Ottawa Field-Naturalists' Club desire to express their deep sense of sorrow and loss at the demise of their beloved Sovereign Lady, Queen Victoria, during whose glorious reign of sixty-four years, scientific work and research, such as our Club aims to accomplish, have received unprecedented impetus." At the last meeting of the same Club, held on Tuesday, Feb. 12th, Dr. R. W. Ells read his paper entitled, "Ancient Channels of the Ottawa River."

THE TECHNICAL STAFF of the Canadian Geological Survey is being rapidly depleted. Amongst those who have resigned are: Dr. A. C. Lawson, Dr. F. D. Adams, and Messrs. Eugene Coste; E. B. Kenrick, W. P. Ferrier, A. J. Cole, J. B. Tyrrell and A. P. Low.

DR. OTTO KUNTZE IS UNDERTAKING to supply a series of typical Monticuliporoidea in thin sections with specimens to those who may desire to purchase them. Whether these fossils are Bryozoa or are corals may be left for specialists to decide. The materials offered by Dr. Kuntze will in either case be of great value as an aid to the study of monticuliporoids.

MR. A. P. LOW, of the Geological Survey of Canada, it is understood has accepted a lucrative position in connection with one of the Nova Scotia trusts. Mr. Low has been regularly employed on the staff of the Geological Survey of Canada since 1882 and was last year appointed one of the Commissioners for Canada at the Paris Exposition.

MR. R. D. LACOE, a well-known geologist and collector of Carboniferous fossil plants, of Pittston, Pa., died Feb. 5, 1901.

BILLINGS MEMORIAL PORTRAIT. A fine oil portrait by Moss, R. C. A., of the late ELKANAH BILLINGS, was recently presented to the director of the Geological Survey of Canada and can now be seen adorning the wall of the stairway in the front hall leading to the museum of the survey, on Sussex street, Ottawa. The portrait was presented by a committee of the Ottawa Field-Naturalists' Club, who acted on behalf of the subscribers to the Billings' memorial portrait fund, and the following inscription accompanies the portrait:

ELKANAH BILLINGS, Esq., F. G. S.
Palæontologist from 1856 to 1876.

Presented to the Geological Survey of Canada by a Committee of the Ottawa Field-Naturalists' Club, Dec. 11th, 1900, on behalf of his friends and admirers.

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THE GRANITIC ROCKS OF GEORGIA AND THEIR RELATIONSHIPS.*

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PLATES XVII-XXIV.

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INTRODUCTION.

In the present paper it is proposed to give a summary of the results obtained from several years' careful field and laboratory study of the granitic rocks, comprised within the limits of the Piedmont Plateau region of Georgia.

* Published by permission of the *State Geologist of Georgia*. The writer wishes to acknowledge his indebtedness to PROF. JAMES F. KEMP, of Columbia University, for kindly reading and criticizing this paper in manuscript.

The Piedmont plain in Georgia represents the southern prolongation of the similar physiographic province in Virginia and the Carolinas. It is a well dissected low-land plain of holocrystalline rocks, crossing the state in a south of west course, and skirting the southeastern border of the Appalachians with a gentle seaward slope, and passing on the southeast beneath the Coastal plain sediments. The plateau has a general average elevation of 350 to 450 feet above sea level, along the line of contact with the Coastal plain formations, and an average elevation of 1,000 feet along its northwestern border. A few unreduced areas—residuals—of moderate elevation, rise above the general level of the plain, which, as a rule, represent parts of harder rock-masses remote from the major streams.

The prevailing rocks forming the Plateau-crystalline-complex are mica-schists, gneisses and massive granites. The schists more particularly, are cut by numerous well-defined dikes of basic eruptives, diabases and diorytes,* which vary from several inches to as many hundred feet in width; and, in one or two cases, have been traced for some miles in length.

The mica-schists form a large part of the rock-complex. They vary somewhat in color; are thinly foliated rocks, and show considerable variation according to locality in the proportion of mica and quartz and often feldspar. More or less feldspar is invariably present. The increase in this constituent may possibly mark in places the transition from schists into certain gneisses of granitic composition. This can in nowise apply, however, to the gneisses thus far studied in this area, since, in many instances, sharp contacts are plainly marked between the two rocks. The basic dike rocks vary from fine to coarse granular in texture; they are occasionally porphyritic and frequently banded in structure, and gray to black in color. The usual normal rock-types are present, which, as a rule, present no unusual features in mineral composition. The dikes are limited for the most part, to the enclosing schists and are rarely actually seen cutting the granitoid rocks. The granitic rocks are traceable across the entire width of the state, and are accordingly of wide distribution throughout the Piedmont area;

* Other basic rocks usually laminated or thinly schistose in structure and somewhat porphyritic in places, simulating dikes and grouped for the *most* part at present, as amphibolytes have not been sufficiently studied to warrant definite statements.

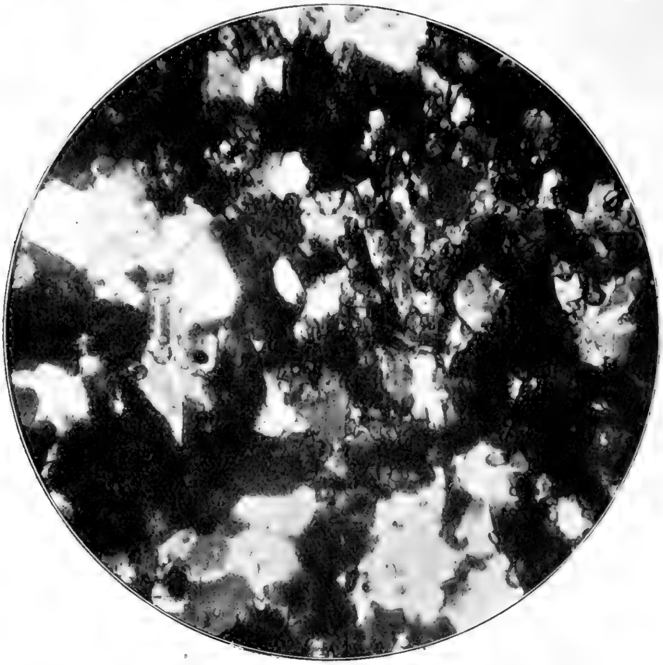

PLATE XVII. FIGURE 1. PHOTOMICROGRAPH OF HORNBLENDE SCHIST (AMPHIBOLITE) CONTAINING MUCH EPIDOTE. FOUR MILES SOUTHEAST OF LAWRENCEVILLE, GEORGIA. CROSSED NICOLS x74.

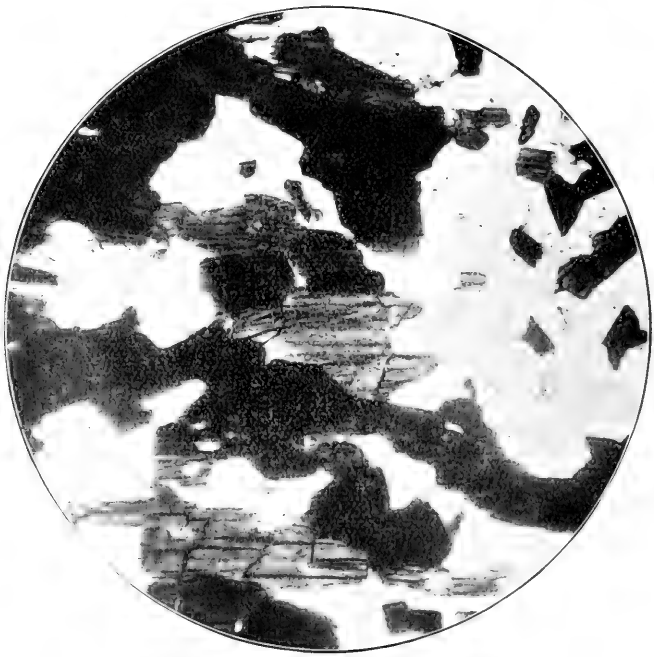

FIGURE 2. PHOTOMICROGRAPH OF HORNBLENDE GNEISS (AMPHIBOLITE). MERIWETHER COUNTY, GEORGIA. x74.

and are associated with similar rocks continuously into South Carolina.

In the western section of the plain, near the Alabama line, somewhat extensive belts of very dark-colored, thinly banded hornblende gneisses or amphibolytes are met. [Plate XVII, figures 1 and 2.] They are strongly contrasted with the granitic gneisses with which they are intimately associated. In thin sections, hornblende of a greenish-brown and blue color makes up half the rock or more. Plagioclase is the prevailing feldspar, but orthoclase and quartz in variable amounts always accompany it. Epidote is a frequent characteristic accessory.

On general textural and structural grounds, the granitoid rocks are grouped and separately treated under three general headings: (a) The even-grained, normal, massive granites, (b) porphyritic granites, and (c) granite-gneisses.* The relationships of the three phasal aspects of the granite rocks are established in the succeeding paragraphs.

(A) THE EVEN-GRAINED, NORMAL, MASSIVE GRANITES.

Granites of superior quality and variety, well-suited for general building and monumental work, have long been known in Georgia. Their extent, distribution, physical, mineral and chemical characters, however, are almost entirely unknown, since no systematic geological work has been undertaken. Until quite recently, the famous Stone mountain light-gray biotite-bearing muscovite granite was the only type of Georgia granite known outside the state. Within the past few years, however, several areas yielding a high grade monumental granite have come somewhat prominently into favor in some sections of the United States.

PETROGRAPHY.

With two exceptions, all the granites are biotite granites. Muscovite is prevailingly present in variable amounts, and very prominent as an accessory in some places; while hornblende fails entirely. They are described under the following types: The Oglesby-Lexington blue-gray; the Elberton-Echol's Mill light-gray; the Campbell-Coweta-Meriwether counties' medium blue-gray; the Stone mountain light-gray.

* The term granite-gneiss is used in this paper to denote gneisses derived from massive granites by metamorphism, and therefore igneous in origin, as contrasted with those gneisses of known sedimentary origin.

Numerous smaller areas are widely distributed over the Piedmont region, but, in the cases studied, they naturally fall into one or the other of the types mentioned above, separate descriptions of which are unnecessary and beyond the scope of the present paper.

THE OGLESBY-LEXINGTON BLUE-GRAY GRANITE. The Oglesby-Lexington belt of dark-blue granite is continuous for thirty miles in a northeast-southwest course, with an average of four to six miles in width. Practically no variation in texture is noted within these limits, but appreciable color variation is apparent in places, according to the quantitative variation in the biotite constituent.

This variety consists of anhedra of an average size, 0.5-1.5 millimeters. [Plate XVIII, figure 1.] The texture is hypidiomorphic granular. Simple Carlsbad twins among some of the feldspars are readily recognizable in many of the hand specimens. The principal minerals are quartz, orthoclase, microcline, plagioclase near oligoclase, biotite, some muscovite, a little included apatite and zircon, and occasional grains of magnetite and pyrite. Secondary chlorite, epidote, muscovite and kaolin are present to some extent. In addition, as an interstitial constituent, quartz is frequently present in drop-like inclusions in the larger feldspar individuals; and, at times, is intergrown with a part of the feldspar in the form of ovals or rounded discs of micropegmatitic intergrowths. The period of growth of the quartz and feldspar was in part simultaneous. Orthoclase is the predominating feldspar present, and frequently exhibits microperthitic intergrowths with a second feldspar, probably albite. Microcline varies in quantity, but at times may equal the orthoclase. The habit of simple Carlsbad twins is common to the two potash feldspar varieties. The plagioclase is always inferior in amount to the potash feldspars, and, as a rule, gives low extinction angles in basal sections. The percentage of lime in the analyses given below with the microscopic evidence indicates oligoclase as the triclinic feldspar present. The biotite is regularly distributed through the rock in irregular drawn-out single shreds and foils, deep brown in color and strongly pleochroic. It is intimately associated with foils of muscovite and is partially altered to chlorite. The remaining accessories present no note-worthy features.

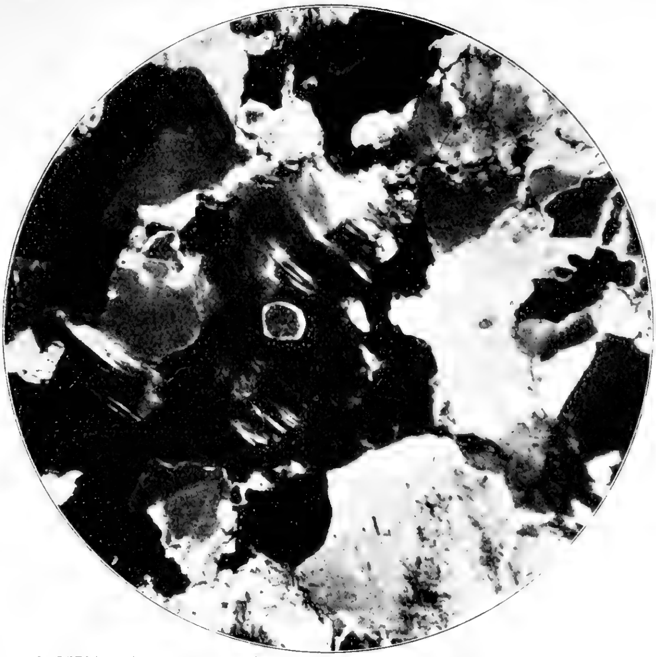

PLATE XVIII. FIGURE 1. PHOTOMICROGRAPH OF THE OGLESBY DARK-BLUE GRANITE. ONE MILE SOUTH OF OGLESBY, ELBERT COUNTY, GEORGIA. CROSSED NICOLS —x74.

PLATE XVIII. FIGURE 2. PHOTOMICROGRAPH OF THE ECHOL'S MILL LIGHT-GRAY GRANITE. ELEVEN MILES NORTHEAST OF LEXINGTON, OGLETHORPE COUNTY, GEORGIA. CROSSED NICOLS x74.

CHEMICAL ANALYSES OF THE OGLESBY-LEXINGTON DARK BLUE GRANITE.

	I	II	III	IV	V	VI	VII	VIII
SiO_2	70.38	70.30	70.18	70.03	69.74	69.64	69.53	69.36
Al_2O_3*	16.47	16.17	17.30	15.62	16.72	17.21	16.46	17.23
Fe_2O_3†	1.17	1.19	1.20	1.31	1.45	1.32	1.15	1.43
CaO	1.72	2.61	2.03	2.45	1.93	2.14	2.10	2.14
MgO	0.31	0.31	0.64	0.52	0.36	0.66	0.85	0.59
K_2O	5.62	4.88	4.77	5.42	5.33	4.95	4.91	4.57
Na_2O	4.98	4.72	4.36	4.82	4.84	4.53	5.00	5.17
Igni	0.31	0.63	0.35	0.77	0.47	0.35	0.91	0.33
Total	100.96	100.81	100.83	100.94	100.84	100.80	100.91	100.82

I. Biotite granite from Swift & Etheridge quarry, 4 miles west of Elberton, Georgia.

II. Biotite granite from Diamond Blue Granite Co.'s quarry, near Hutchins, Oglethorpe Co., Ga.

III. Biotite granite from Brown & Deadwyler quarry, Madison county, Georgia.

IV. Biotite granite from Lexington Blue Granite Co.'s Quarry, Lexington, Georgia.

V. Biotite granite from Coggin's Granite Co.'s quarry, near Oglesby, Elbert county, Georgia.

VI. Biotite granite from Coggin's Granite Co.'s quarry No. 2, near Oglesby, Georgia.

VII. Biotite granite from outcrops near Hutchins, Oglethorpe county, Georgia.

VIII. Biotite granite from the Child's quarry, near Oglesby, Georgia.

THE ELBERTON-ECHOL'S MILL LIGHT-GRAY GRANITE: This type is represented by a belt of approximately the same dimensions and general direction as the Oglesby-Lexington blue-gray granite, which it limits immediately on the southeast. The two areas are contiguous, and while well differentiated as to color, and in a less degree texture, in their extreme portions they undoubtedly form parts of the same general area, as the gradation is well shown near Elberton and Carlton.

The Elberton-Echol's Mill light-gray type does not differ essentially in mineralogy from the Oglesby-Lexington dark blue granite, although they are strongly contrasted in the hand specimens. The difference is essentially one of color, with the biotite distributed at greater intervals and in somewhat stouter aggregated shreds in the light-gray granite. As a rule, the light-gray type is slightly more coarsely crystalline than the dark-blue variety. The same minerals are present in nearly the same proportions and show the same characteristics in the two types. Quartz, orthoclase, microcline, plagioclase, biotite,

*Contains traces of P_2O_5, TiO_2 and ZrO_2 when present.
†All iron estimated as Fe_2O_3.

a little muscovite, apatite and zircon are all present. [Plate XVIII, figure 2.]

CHEMICAL ANALYSES OF THE ELBERTON-ECHOL'S MILL LIGHT-GRAY GRANITE.

	I.	II.	III.
SiO_2	69.45	69.25	68.81
Al_2O_3	15.93	16.04	17.67
Fe_2O_3*	1.31	1.72	1.13
CaO	1.91	1.89	2.17
MgO	0.55	0.31	0 50
K_2O	5.16	4.94	3.90
Na_2O	4.33	4.52	4.97
Igni	0.50	0.43	0.30
Total	99.14	99.10	99.45

I. Biotite granite from Swift and Wilcox quarry, 1 mile south of Elberton, Georgia.

II. Biotite granite from Tate and Oliver quarry in the limits of Elberton, Georgia.

III. Biotite granite from Echol's Mill, 12 miles northeast from Lexington, Georgia.

THE CAMPBELL-COWETA-MERIWETHER COUNTIES' MEDIUM BLUE-GRAY GRANITE: In addition to the normal massive granites, coarsely crystalline porphyritic granites and granitic gneisses of essentially the same mineral and chemical composition, are found in intimate association over parts of Campbell, Coweta and Meriwether counties.

The even-granular massive type of granite is of two varieties. One, the medium gray, is an average fine-textured crystalline rock consisting of anhedra of an average size, 0.5-1.5 millimetres. [Plate XIX, figures 1 and 2.] The other, a dark-blue-gray, occurs in the southwest section of Meriwether county. [Plate XX, figure 1.] It is more coarsely crystalline and darker in color and contains a larger proportion of biotite, than the medium gray type.

The medium gray type traverses Campbell, Coweta and Meriwether counties, in a nearly north-south course, with quarries opened near the respective county seats, Fairburn, Newnan and Greenville. The variation in color and texture, in general, is very slight. The northern part of the granite-mass, in the vicinity of Fairburn, is somewhat lighter in color, with the middle and southern parts near Newnan and Greenville, correspondingly darker. This type is closely similar in mineral and chemical composition to the Oglesby-Lexington

* All iron estimated as Fe_2O_3.

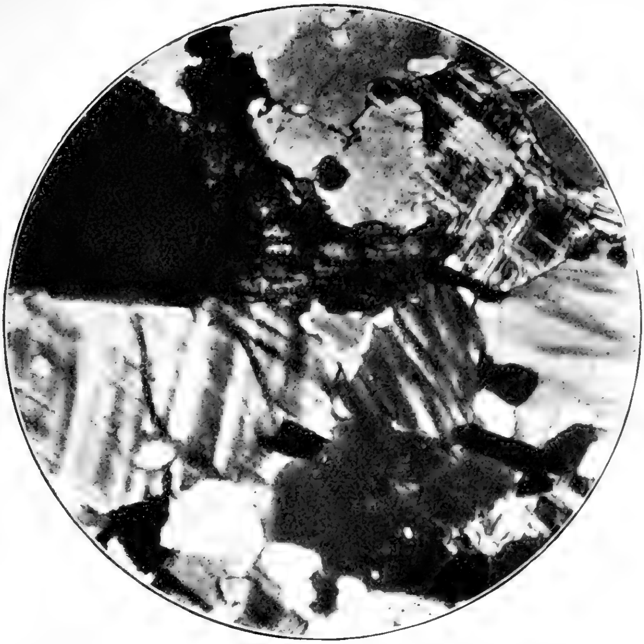

PLATE XIX. FIGURE 1. PHOTOMICROGRAPH OF THE CAMPBELL-COWETA-MERIWETHER COUNTIES' MEDIUM BLUE-GRAY GRANITE. TWO MILES NORTH OF FAIRBURN, CAMPBELL COUNTY, GEORGIA. CROSSED NICOLS x74.

PLATE XIX. FIGURE 2. PHOTOMICROGRAPH OF THE GREENVILLE MEDIUM BLUE-GRAY GRANITE. GREENVILLE GRANITE COMPANY'S QUARRY, GREENVILLE, MERIWETHER COUNTY, GEORGIA. CROSSED NICOLS x74.

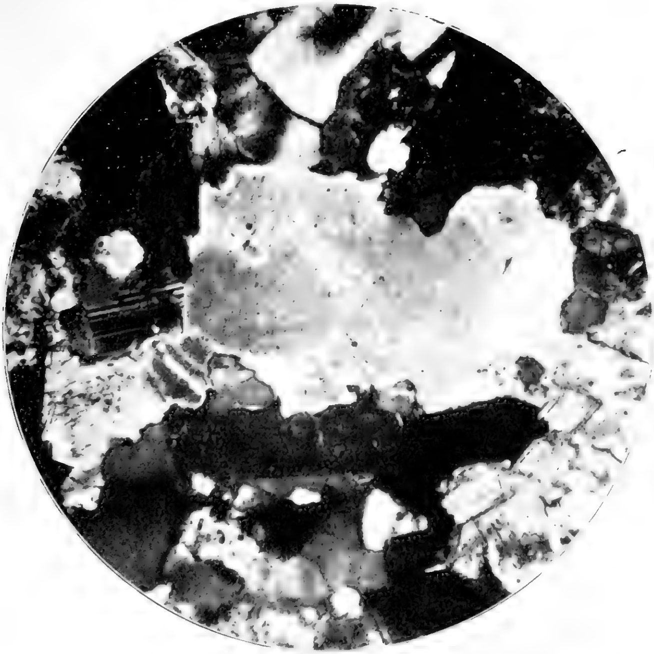

PLATE XX. FIGURE 1. PHOTOMICROGRAPH OF DARK-BLUE-GRAY GRANITE NEAR ODESSADALE, MERIWETHER COUNTY, GEORGIA. CROSSED NICOLS X74.

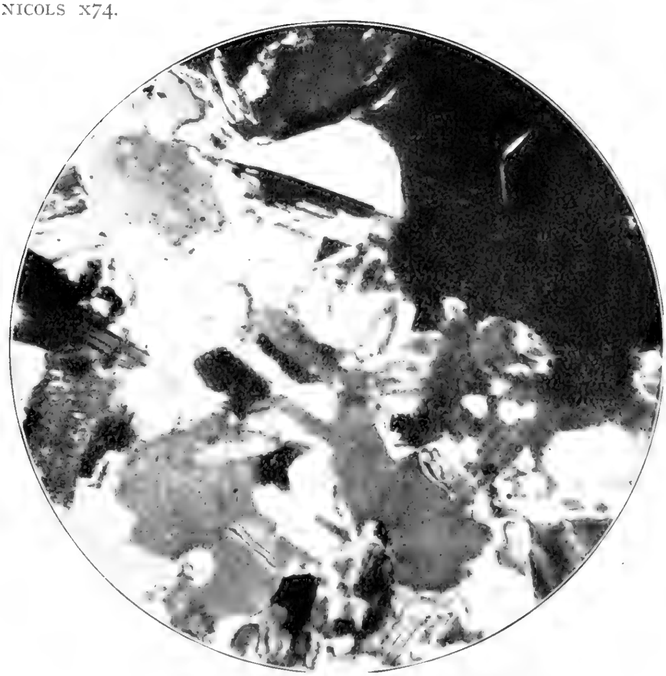

PLATE XX. FIGURE 2 PHOTOMICROGRAPH OF THE STONE MOUNTAIN LIGHT-GRAY GRANITE. STONE MOUNTAIN, DEKALB COUNTY, GEORGIA. CROSSED NICOLS X74.

blue-gray, and the Elberton-Echol's Mill light-gray types, and is intermediate in color and texture between the two latter varieties. The component minerals are quartz, orthoclase, microcline, plagioclase near oligoclase, biotite, a little muscovite, apatite and zircon. Some secondary epidote and chlorite from the alteration of feldspar and biotite are usually present. Several small garnets have been noted in one or two places in the northern part of the belt. The orthoclase is microperthitic in structure and is the predominating feldspar. Microcline nearly fails in places and is very abundant in others. Plagioclase is of the usual kind noted above. Rounded disks of micropegmatitic intergrowths of quartz and feldspar are common. Biotite is present in variable amounts intimately associated with muscovite. Muscovite is always subordinate to biotite in amount. The biotite is deep brown in color with strong absorption and variously altered to chlorite. Epidote, in the form of irregular grains and idiomorphic crystals, is somewhat abundant in thin sections of the Cole quarry granite near Newnan. The increased percentage of lime in the analysis of this rock corroborates the microscopic evidence (see analysis I.)

CHEMICAL ANALYSES OF THE COWETA COUNTY MEDIUM BLUE-GRAY GRANITE.

	I.	II.	III.
SiO_2	69.08	69.07	68.79
Al_2O_3*	17.67	16.56	16.48
Fe_2O_3†	1.41	1.37	0.98
CaO	3.27	1.83	1.76
MgO	0.64	0.76	1.30
K_2O	3.29	5.02	5.85
Na_2O	4.56	4.65	4.74
Igni	0.56	0.92	0.38
Total	100.48	100.18	100.28

I. Biotite granite from the Cole quarry, near Newnan, Georgia.

II. Biotite granite from the Overby quarry, 10 miles northeast from Newnan, Georgia.

III. Biotite granite from the Hill quarry, 3¼ miles southeast from Newnan, Georgia.

The dark gray variety is more coarsely crystalline than the preceding and contains more biotite and perhaps more plagioclase as a rule, with slightly less quartz. The specific gravity

* Contains traces of P_2O_5, ZrO_2 and TiO_2 when present.
† All iron estimated as Fe_2O_3.

and chemical analysis given in table A, corroborate the above inferences. The component minerals are essentially the same, but in slightly varying proportions, as for the preceding types.

THE STONE MOUNTAIN LIGHT GRAY GRANITE: The Stone mountain light gray variety is strongly contrasted with all other types of granite in the state. In mineralogy it differs only in the reversed proportion of biotite to muscovite, and is a biotite-bearing muscovite granite. Biotite is a constant accompaniment, but is greatly subordinated to muscovite in quantity. This type is uniformly light gray in color over the entire area, but shows some variation in texture, in places. It is intermediate in texture between the other types of normal granite on the one hand, and the coarsely crystalline granite matrix of the prophyritic granites on the other. As a rule, the Stone mountain type consists of anhedra ranging in size from 1.5-2.5 millimetres. [Plate XX, figure 2.] The potash feldspars predominate with orthoclase usually in excess of microcline. The orthoclase is commonly interwoven with a second feldspar in microperthitic structures. Microcline is subject to considerable variation in amount, at times, equaling that of the orthoclase in places, and sinking to a minimum in others. Plagioclase is only subordinate to the postash feldspars in amount, and occurs as stout laths with the characteristic polysynthetic twinning, lamellæ affording as a rule low extinction angles on the base. Quartz, in addition as irregular interstitial grains, is common in drop-like inclusions in the feldspars. Muscovite occurs either as individual flakes or aggregates with strong double refraction and often a faint yellowish tinge. The ray vibrating parallel to the cleavage shows appreciable absorption in many flakes. Biotite, as single foils with the usual pronounced color and absorption, is associated with the muscovite. Accessory apatite and zircon, and secondary chlorite, complete the list of microscopic minerals present. (See analysis I, table A.)

Several minerals not met in thin sections of the Stone mountain granite are frequent microscopic accompaniments in the rock. The most abundant one of these is black tourmaline. This mineral is present, in every block of stone quarried, in the shape of aggregated small prismatic crystals usually without terminal faces, embedded in a perfectly white irregular oval-shaped area of quartz and feldspar, from which the two micas, muscovite and biotite, have been excluded. As a rule, the white areas containing the tourmaline bunches are only a fraction of one inch to several inches in diameter, though larger ones are by no means exceptional. Small crystals of red garnet are not uncommon. The joint planes exposed in several quarries on the north side of the ridge are coated with a sulphur-yellow incrustation, which, upon chemical investigation, proved to be a mixture of uranophane and hyalite, with the former in excess.

Approximately 12 miles southwest from Stone mountain in the same county, is a second exposure of a biotite-bearing muscovite granite, light gray in color and finely crystalline in texture. The rock has been used to some extent as a monumental stone. It consists of the same materials in the same proportions as the Stone mountain granite. Micropegmatitic intergrowths of quartz and feldspar are common. The prismatic inclusions of apatite in the quartz are frequently bent and broken, and, in some cases, the parts have slipped past each other.

Some effects of strain are frequent in all the above types of granite, indicating that they have suffered from partial dynamic metamorphism. The microscopic evidence strengthening this conclusion is undulatory extinction in the quartz; fracture lines crossing the quartz and sometimes the larger feldspar anhedra; and somewhat increased microcline in places, manifesting some evidence of a strained condition. In Meriwether county, and several of the nearby counties, areas of rather pronounced foliated granites of the same mineral and chemical composition, resembling in other respects the massive phases, are found. The gradation, if such exists, between the massive and foliated granites could not be satisfactorily traced in the field, in this area, but the laboratory evidence strongly favors such. If this be true, the traceable gradations in the field are rendered impossible on account of few exposures and the very heavy covering of residual decay. In thin sections of the foliated rocks, the evidence of pressure metamorphism is increased in some peripheral shattering of the larger quartz and feldspar individuals. Pressure metamorphism is further made evident in the Stone mountain type in a slight pseudo-foliation.

(B) THE PORPHYRITIC GRANITES.

The porphyritic facies of the Georgia granites are elsewere described and discussed at some length by the writer.* The individual areas are described in detail and their relations to the normal granite facies stated. For the purposes of the present paper, it is only necessary to note their distribution and briefly describe them as a whole, detailing their chief characters so far as they bear on the present problem.

More than a half-dozen well-defined separate areas of coarsely crystalline porphyritic granites are noted within the limits of the Piedmont Plain of Georgia. In every case, they are associated with an even-granular facies of the same rock, having the same mineral and chemical composition. The porphyritic areas have been designated as follows: The Campbell-Coweta-Fayette counties' area; the Pike county area; the Fulton county area; the Brinkley place-Holder's Mill area; the Sparta area; the Milledgeville area; the Greene county area; the Columbia county area.

General Description: Certain general features are common to all the porphyritic areas, although the rocks are strongly contrasted in many. With one exception, they are all massive in structure, without, as a rule, trace of the primary or secondary foliated structure. The exception is in the Brinkley Place-Holder's Mill area, where the rock has a pronounced schistose structure, clearly due to pressure metamorphism. The porphyritic granites are prevailingly coarse-grained and light to dark gray in color, according to the amount of biotite present.

PETROGRAPHY.

The groundmass or matrix is a typical coarse biotite granite without the foliated structure. It consists of anhedra measuring 3 to 8 millimetres in size. [Plate XXI, figures 1 and 2.] The principal minerals are quartz, orthoclase, microcline, plagioclase, biotite, a little muscovite, apatite and zircon. Some chlorite and epidote derived from the alteration of the feldspar and biotite occur. Quartz is abundant and the feldspars have the same general characters as in the even-granular types of

Journal of Geology, 1901, vol. ix, February-March number. A Preliminary Report on the Granites and Gneisses of Georgia, *Geol. Sur. of Ga.*, in press.

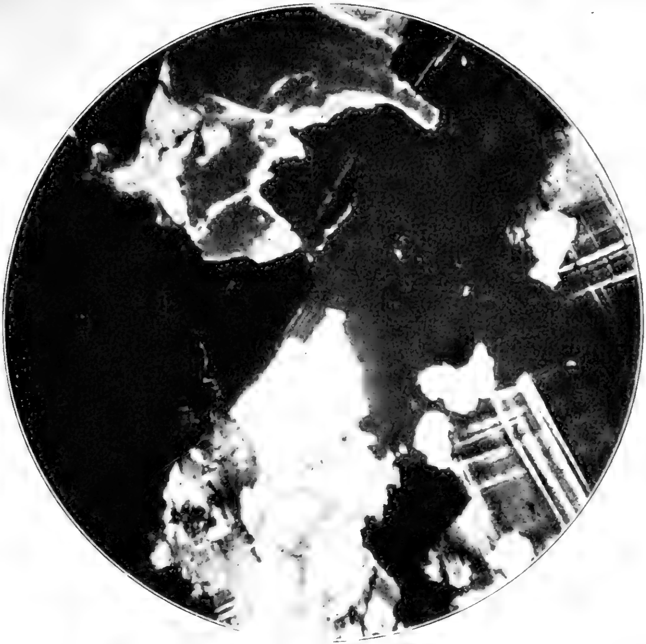

PLATE XXI. FIGURE 1. PHOTOMICROGRAPH OF PORPHYRITIC GRANITE TEN MILES SOUTH OF GREENESBORO, GREENE COUNTY, GEORGIA. CROSSED NICOLS x74.

PLATE XXI. FIGURE 2. PHOTOMICROGRAPH OF PORPHYRITIC GRANITE NEAR COWETA STATION, COWETA COUNTY, GEORGIA. CROSSED NICOLS x74.

granite described above. Microcline is possibly subject to more variation than in the normal granites, and plagioclase is, as a rule, slightly increased. The feldspars are usually white opaque in color, with greenish-white and pink tints not uncommon. The interstitial feldspar is transitional into the phenocrysts in several areas. The quartz frequently crystallized simultaneously with the feldspars, resulting in the formation of ovals of micropegmatitic structures, common in the thin sections from all the areas. Biotite is variable in amount but occurs in stout plates, deep brown in color and strongly pleochroic. Apatite is very abundant in the form of stout prismatic inclusions in some slides and almost fails in others.

The phenocrysts are usually opaque and white in color with pink tints common. They vary from 10-50 millimetres long and 5-10 millimetres across; and vary from allotriomorphic to idiomorphic in crystal outline. The idiomorphic type prevails, however; flat, tabular parallel to the clinopinacoid (010), with (001) and (101) cleavages well developed. They display the usual habit of simple Carlsbad twins. Only the potash varieties, orthoclase and microcline, are porphyritically developed, and, as a rule, are intergrown with a second feldspar in microperthitic fashion. They invariably contain inclusions of all the groundmass minerals, which with other evidence, indicates simultaneous growth with the interstitial components. The inclusions of biotite plates are always macroscopic in size and, in many cases, the included mica is equally large as the same interstitial mineral. The IN PLACE as against INTRATELLURIC origin for the phenocrysts has been elsewhere pointed out.

Analyses of carefully selected fragments of the feldspar phenocrysts from two of the areas yielded the following results:

	I.	II.	
SiO_2	64.64	64.40	
Al_2O_3	19.64	18.97	
Fe_2O_3	0.37	0.37	
CaO	0.67	0.59	
MgO	tr.	tr.	
K_2O	10.00	11.40	
Na_2O	3.06	3.60	
Ignition	0.22	0.19	
Total	98.60	99.52	
Sp. Gr.	2.60	2.55	(Thoulét solution.)

I. Feldspar phenocrysts from Columbia Co. porphyritic granite mass.
II. " " " Coweta " " " "

(See analyses IX, X, XI, XII, XIII, XIV, and XV of Table A.)

Gradation from the porphyritic facies, peripherally, into a medium coarse-textured non-porphyritic granite facies of the same mineral and chemical composition is traceable in some of the areas. The lack of field evidence favoring gradation in the other areas is probably due to absence of exposures. As a rule, the rocks in the Georgia area, as well as in the southern states in general, are covered by a heavy mantle of residual decay, and exposures of fresh rock are limited and by no means continuous.

(C) THE GRANITE-GNEISSES.*

Extensive areas of gneiss of granitic composition abound in the Piedmont Plain, and in abundance, becomes one of the most, if not the most important rock in the plateau-complex. The gneisses vary from medium to coarsely crystalline rocks with a pronounced banded or schistose structure. The planes of schistosity vary from moderately irregular to highly contorted lines with the banding exceedingly irregular; from very thick to very thin layers. They are closely related genetically to the massive granites from which they differ only in the banded structure, secondarily imparted through dynamometamorphism. The two types—gneisses and massive granites—are essentially alike in mineral and chemical composition. The minerals found in one are invariably present in the other. Furthermore, the minerals most abundant in the one also predominate in the other. Like the massive granites, the acid gneisses are all biotite gneisses. Muscovite is an invariable associate but is subordinated in every case to the biotite in quantity; and hornblende is never present. The acid gneisses studied are believed for these and other reasons stated later, to be metamorphosed irruptive granites and are therefore designated granite-gneisses.

Separate descriptions of the individual areas can not be detailed here, but instead, several of the larger and representative ones will be briefly described as illustrating their composition.

* There may be and probably are gneisses of sedimentary origin in the Plateau-crystalline-complex, but the areas of gneiss so far studied afford no evidence of such origin. The discussion is entirely limited to those areas studied.

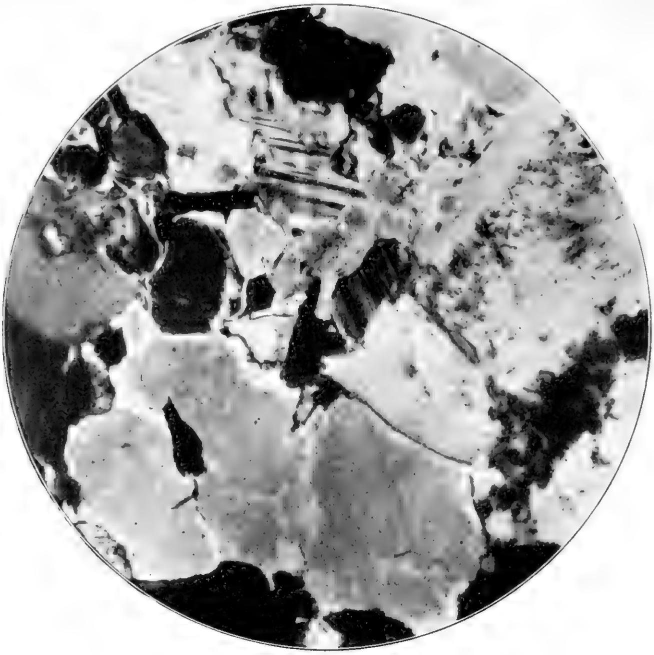

PLATE XXII. FIGURE 1. PHOTOMICROGRAPH OF THE LITHONIA CONTORTED BIOTITE GRANITE-GNEISS NEAR LITHONIA, DEKALB COUNTY, GEORGIA. CROSSED NICOLS x74.

PLATE XXII. FIGURE 2. PHOTOMICROGRAPH OF A FINE-GRAINED DARK-BLUE BIOTITE GRANITE FROM A DIKE FORTY FEET WIDE, CUTTING THE PORPHYRITIC ,GRANITE-GNEISS, NEAR CAMAK, WARREN COUNTY GEORGIA. CROSSED NICOLS x74.

The Lithonia belt of contorted gneiss: The Lithonia belt of gneiss is continuous over a large part of three contiguous counties, and lies immediately adjacent on its north and west sides to the famous Stone mountain light-gray granite area. The belt takes its name from the town of Lithonia, located near the centre of the quarrying industry. The rock has been quarried very extensively as blocks and curbing for street paving, and has been shipped to the principal cities in the south and middle west.

It is an irregularly banded, highly contorted, biotite granite-gneiss, medium light-gray in color, and composed of anhedra ranging in size from 0.5-2.5 millimetres. [Plate XXII, figure 1.] The principal minerals are quartz, orthoclase, microcline, plagioclase, biotite, a little muscovite, apatite, zircon and magnetite. Some secondary chlorite, epidote, kaolin and muscovite occur. Idiomorphic crystals of red garnet are very common in some of the quarries. The garnets form in some cases distinct lenses and layers alternating with bands of the principal minerals, and are also scattered as single crystals through the rock. Small areas of black tourmaline are distributed in a similar manner through the granite-gneiss to that of the Stone mountain granite, with the exception that the areas are by no means so frequent in the former rock as in the Stone mountain type.

Orthoclase is the predominating feldspar and in part is microperthitic in structure. Microcline is subject to much variation with a general average increase, somewhat larger for the gneisses than for the granites. The increase in this constituent in the foliated granitic rocks over the massive types can probably be accounted for on the basis of pressure metamorphism, as numerous pieces of the mineral show some indications of a possible induced structure, such as might result from excessive strain. A large percentage of this constituent however, is undoubtedly primary in origin, while the remainder is somewhat doubtful. Plagioclase is also variable in amount and is present in the form of stout laths with characteristic polysynthetic twinning, affording small extinction angles in basal sections. Biotite, as deep brown-colored and strongly pleochroic foils, is drawn out along roughly parallel lines. It is associated with smaller amounts of muscovite, and, as a rule, carries microscopic inclusions. Quartz, with occasional grains of feldspar, are common in drop-like inclusions in the larger feldspar individuals. Micropegmatitic intergrowths of quartz and feldspar do not fail entirely in thin sections of the granite-gneiss, but are less frequently met than in the massive granites.

A second area of similar highly contorted gneiss begins in Troup county in middle southwest Georgia near the Alabama line, and crosses Meriwether county in an east-west course. Hand specimens of the rock from the two areas are indistinguishable and are identical in mineral and chemical composition.

The other areas of gneiss are strongly contrasted, and vary in degree and regularity of the foliated structure, and in color and texture. The relationships, while not entirely clear in the field, possibly suggest that several of the areas may be the transitional foliated phases of the massive granites, but so far as the writer's observations extend, the conditions strongly point to no gradation of the typical gneisses into the equivalent massive rocks. They are all, however, biotite granites with the same minerals present in nearly similar proportions. This fact is further corroborated in the table of analyses where the rocks are seen to be nearly identical in composition. (See analyses XVI, XVII, XVIII, XIX, XX, XXI, XXII, and XXIII Table A.)

That the schistose or foliated structure is entirely secondary, resulting from pressure metamorphism, and not primary, is plainly manifested in the thin sections of these rocks. The quartz and feldspar grains are invariably rimmed by crushed zones of the two minerals; the quartz extinguishes irregularly; and numerous lines of fracture are common to both quartz and feldspar. The Lithonia area of contorted gneiss, however, affords but slight if any evidence of peripheral shattering, which likely indicates recrystallization of the minerals through profound metamorphism.

PLATE XXIV. FINE-GRAINED BIOTITE GRANITE DIKE CUTTING MICA SCHIST NEAR ATLANTA, GEORGIA. BOTH THE GRANITE AND ENCLOSING SCHIST ARE DEEPLY WEATHERED.

CHEMICAL ANALYSES OF THE LITHONIA CONTORTED GRANITE-GNEISS, DEKALB COUNTY.

	I.	II.	III.
SiO_2	76.00	75.16	72.96
Al_2O_3	13.11	13.74	14.70
Fe_2O_3*	0.92	0.91	1.28
CaO	1.06	0.91	1.28
MgO	0.27	0.17	0.07
K_2O	4.69	5.05	4.73
Na_2O	3.88	3.76	4.18
Ign.	0.31	0.32	0.23
Total	100.24	100.02	99.43

I. Biotite granite-gneiss from the Crossley quarry, near Lithonia, Georgia.

II. Biotite granite-gneiss from the Arabia Mountain quarries 3 miles from Lithonia, Georgia.

III. Biotite granite-gneiss from the Southern Granite Co.'s quarry, near Lithonia, Georgia.

Intrusive nature of the granites.

The evidence of the igneous origin of the Georgia granites is essentially the same as for similar irruptive acid masses studied elsewhere. The evidence is from, (1) field relations; (2) chemical composition; and (3) mineral composition,

1. Field relations.

STRATIGRAPHIC FEATURES: The exposures of the granites in the field point to rounded or elliptical forms common to intruded granite masses. The two granite facies—porphyritic and non-porphyritic—may be considered as one, since in many of the granite areas the porphyritic structure grades peripherally, into a non-porphyritic granite facies of the same mineral and chemical composition, and are from necessity of the same origin. In the case of the foliated phases of the granites, the schistosity is not co-incident with that of the surrounding schist, but cuts across the foliation of the latter.

Near many of the larger granite-masses well-defined granite dikes, slightly different in texture from, but of the same mineral and chemical composition as the mass, occur, which would commonly be regarded as apophyses in case the rock is regarded as eruptive. [Plate XXIV.] These dikes or apophyses project outward from the main rock-mass and cut abruptly into the adjacent rocks. A chemical analysis of spec-

* All iron estimated as Fe_2O_3.

imens collected from a 40-foot dike cutting the porphyritic granite-gneiss near Camak on the Brinklley place, yielded the writer the following results:

SiO_2	68.76
Al_2O_3	16.80
Fe_2O_3	0.99
CaO	2.72
MgO	1.00
Na_2O	4.82
K_2O	3.70
Ignition	0.29
Total	99.08

A comparison of this analysis with analyses of the normal even-granular granites reveals practically no difference. The acidity, as will be observed, is essentially the same.

In addition to the quartz, feldspar varieties and biotite, thin sections showed inclusions of apatite and zircon, and drop-like inclusions of quartz and feldspar grains in the larger feldspar individuals, along with rounded disks of micropegmatitic intergrowths of quartz and feldspar. [Plate XXII, figure 2.]

CONTACT PHENOMENA: In all cases where contacts of the granitic rocks and schists were visible, they were, in the opinion of the writer, plainly eruptive. Although many contacts have been examined, they are not so numerous as might be expected, on account of the deep covering of residual decay. The line of contact is usually sharp and somewhat irregular in the localities where best exposed. No considerable contact metamorphism of the surrounding rocks was visible, however, in any exposure. Since the surrounding rocks are equally completely crystalline, as a result of profound metamorphism, any considerable alteration would hardly be expected. Many granite intrusions into crystalline rocks showing little or no contact metamorphism have been observed in different localities by various writers. None of the commonly associated minerals of contact phenomena are present in the sections examined. In some areas, garnets, and tourmaline are very common, but their occurrence is as frequent away from the contact as near it, and cannot be considered a result of contact metamorphic action between the rocks. In no case has any definite gradation from the acid rocks into the schists been observed in the field, but the two appear strongly differentiated.

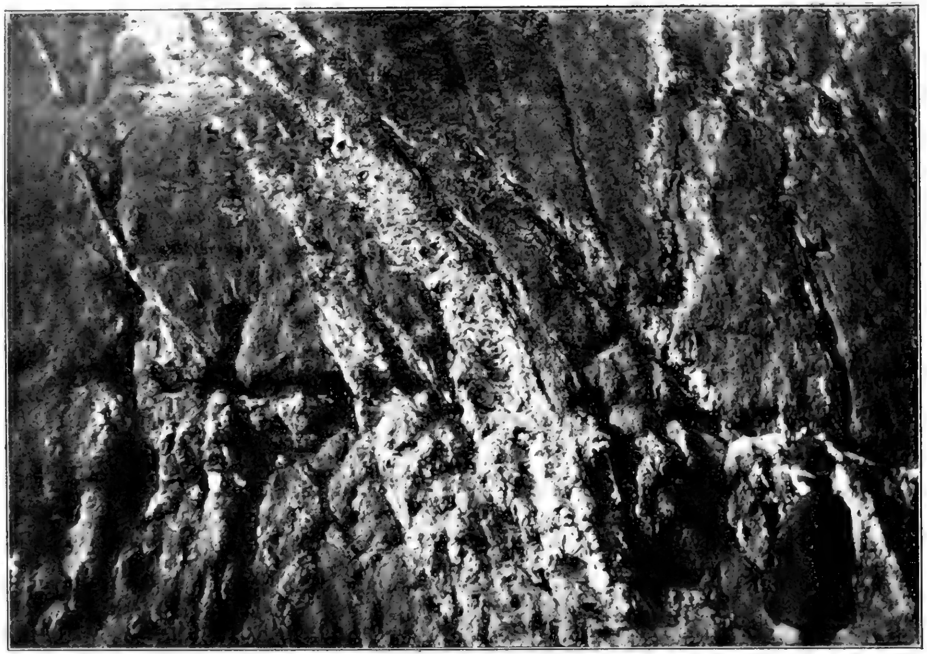

Plate XXIII. Pegmatitic dikes cutting mica schist near Atlanta, Georgia. The inclosing schists are weathered to a ferruginous residual clay in which the schistosity planes of the fresh rock are well preserved.

Basic inclusions: Another form of evidence strongly favoring the irruptive nature of the granitic rocks is that of inclusions darker in color and considerably more basic in character than the parent rock, met in many of the masses. It has not been possible to distinguish in every instance between inclusions of the inclosing rock and that of darker material—schlieren—basic segregations of the granite magma. In the majority of cases, the darker areas plainly represent basic segregations, which form so common a feature of slowly solidifying granite magmas. They are especially abundant in many of the quarries; are darker in color than the parent granite and consist chiefly of biotite with subordinate quartz, orthoclase, plagioclase and apatite, with no evidence of foliation. They are rounded and irregular in outline and, in case of the gneisses, form lenticular patches and bands in extreme cases. As a rule, they are finer-grained in texture than the inclosing rock, but in some cases they are coarser crystalline. Inclusions of this character are regarded by many writers* as strong evidence of the eruptive origin of the rocks in which they are found.

Pegmatitic Dikes: Closely associated pegmatitic dikes of varying width and granitic composition are numerous throughout the Plateau-crystalline complex, and are unquestionably genetically connected, in many cases, with the granite-masses. They vary from those of granitic composition to pure quartz. Under this heading two kinds of material are met. Some are true pegmatitic intrusions, while others are true veins of segregation. Both are common to the porphyritic and non-porphyritic granite facies and to the gneisses, and are equally characteristic of each. They are characterized by the usual coarse-grained structure and consist almost exclusively of lustrous, cleavable pink and white-tinted feldspar with some quartz, and a much smaller proportion of biotite, and occasional muscovite. [Plate XXIII.] In many cases they are very extensive and deep-seated, while in others they are very limited in extent and are entirely surrounded by the granitic rock. They are very irregular in outline, conforming to no uniform orientation, but cut the rock in numerous directions and at various

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* Rosenbusch, Massige Gesteine, p. 62.
Williams, G. H., *15th Annual Report, U. S. G. S.*, p. 662.
Kemp, J. F., *Bull. Geol. Soc. Amer.*, 1899, vol. x, pp. 371-372.
Westgate, L. G., *Journ. of Geol.*, 1899, vol. vii, p. 643.

angles. Thin sections of several of these masses show microcline, orthoclase and plagioclase feldspars, with occasional microperthitic structures, a few shreds of biotite and some quartz. Hand specimens of others showed nearly equal proportions of feldspar and quartz with occasional biotite plates.

2. CHEMICAL COMPOSITION.

The following analyses give a good idea of the range in composition of the granitic rocks described above. These analyses present several points of interest, chief among which may

A. TABLE OF CHEMICAL ANALYSES.

GRANITES.

	I	II†	III	IV‡	V	VI§	VII‖	VIII
	Stone Mt.	Lexington	Greenville	Oglesby	Campbell county	Elberton	Coweta county	Meriw'r county
SiO_2	72.56	69.95	69.88	69.86	69.55	69.17	68.98	63.27
Al_2O_3′	14.81	16.08	16.42	16.98	16.72	16.54	16.90	19.93
Fe_2O_3*	0.94	1.21	1.96	1.31	0.99	1.38	1.25	2.82
CaO	1.19	2.38	1.78	1.99	1.69	1.99	2.28	2.89
MgO	0.20	0.56	0.36	0.51	0.27	0.45	0.90	0.49
K_2O	5.30	5.07	5.63	5.04	3.94	4.66	4.72	4.85
Na_2O	4.94	4.84	4.45	4.77	5.88	4.60	4.98	4.14
Igni.	0.70	0.77	0.39	0.36	0.27	0.41	0.62	0.86
Total	100.64	100.86	100.87	100.82	99.31	99.20	100.63	99.25
Sp. Gr.	2.684	2.666	2.662	2.663	2.658	2.656	2.694	2.739

PORPHYRITIC GRANITES.

	IX	X	XI	XII	XIII¶	XIV	XV
	Fayette County	Pike County	Columbia County	Baldwin County	Sparta	Fulton County	Greene County
SiO_2	70.38	70.24	69.77	69.37	69.33	69.17	69.13
Al_2O_3′	15.86	16.78	17.05	16.99	16.26	16.47	17.14
Fe_2O_3*	1.77	1.46	1.60	1.99	1.84	1.23	1.52
CaO	1.79	2.00	2.21	2.03	2.28	2.02	1.85
MgO	0.93	0.76	0.99	0.84	0.36	0.61	0.79
K_2O	4.64	5.03	4.08	4.54	4.56	4.41	5.49
Na_2O	3.94	3.70	3.97	3.44	5.07	4.89	4.06
Igni.	0.49	0.50	0.44	0.55	0.42	1.06	0.52
Total	99.80	100.47	100.11	99.75	100.12	99.86	100.50
Sp. Gr.	2.659	....	2.674	....	2.675	....	....

* All iron estimated as Fe_2O_3.
† Average of 3 analyses representing different quarries.
‡ " " 5 " " " "
§ " " 3 " " " "
‖ " " 3 " " " "
¶ " " 3 " " " "
′ Contains traces of P_2O_5, TiO_2 and ZrO_2 when present. With several exceptions, the usual qualitative test failed to indicate the presence of TiO_2 in the Georgia acid rocks. P_2O_5 and ZrO_2 are invariably present in small microscopic proportions as prismatic inclusions of apatite and Zircon.

GNEISSES.

	XVI Meriw'r County	XVII Gwinnett County	XVIII Rockdale County	XIX Heard County	XX° Lithonia	XXI Coweta County	XXII Newton County	XXIII Clarke County
SiO_2	76.37	75.86	75.45	74 96	74.70	73.95	71.20	69.51
Al_2O_3′	13.31	14.02	13.71	13.71	13.85	14.23	15.46	16.32
Fe_2O_3*	1.21	0.71	0.92	0.90	1.03	1.29	1.17	2.38
CaO	1.13	0.70	0.94	1.02	1.08	1.07	1.36	1.84
MgO	0.10	0.12	0.18	0.24	0.17	0.23	0.38	1.28
K_2O	3.68	5.56	4.30	4.79	4.82	5.29	5.30	3.47
Na_2O	4.02	3.64	3.87	4.68	3.94	4.61	4.96	3.82
Igni.	0.20	0.28	0.40	0.44	0.28	0.25	0.52	1.11
Total	100.02	100.89	99.77	100.74	99.87	100.92	100.30	99.73
Sp. Gr.	2.642	2.642	2.643	2.648	2.686	....	....	....

B. MOLECULAR RATIOS OF THE OXIDES.

GRANITES

	I	II	III	IV	V	VI	VII	VIII
SiO_2	1.209	1.165	1.164	1.164	1.159	1.152	1.149	1.054
Al_2O_3	.145	.156	.160	.164	.163	.160	.164	.195
Fe_2O_3	.005	.007	.012	.008	.006	.008	.007	.017
CaO	.021	.042	.032	.035	.030	.035	.040	.051
MgO	.005	.014	.009	.012	.006	.011	.022	.012
K_2O	.056	.053	.059	.053	.041	.049	.050	.051
Na_2O	.079	.078	.071	.076	.094	.074	.080	.066
K_2O } Na_2O	.135	.131	.130	.129	.135	.123	.130	.117

PORPHYRITIC GRANITES

	IX	X	XI	XII	XIII	XIV	XV
SiO_2	1.181	1.170	1.162	1.156	1.155	1.152	1.152
Al_2O_3	.155	.164	.167	.166	.157	.163	.168
Fe_2O_3	.011	.009	.010	.012	.011	.007	.009
CaO	.032	.035	.039	.036	.040	.036	.033
MgO	.023	.019	.024	.021	.009	.015	.019
K_2O	.049	.053	.043	.048	.048	.047	.058
Na_2O	.063	.059	.064	.055	.081	.078	.065
K_2O } Na_2O	.112	.112	.107	.103	.129	.125	.123

GRANITE–GNEISSES

	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XIII
SiO_2	1.272	1.264	1.257	1.249	1.245	1.232	1.186	1.158
Al_2O_3	.130	.137	.134	.134	.134	.139	.151	.160
Fe_2O_3	.007	.004	.005	.005	.006	.008	.007	.014
CaO	.020	.012	.016	.018	.019	.019	.024	.029
MgO	.002	.003	.004	.006	.004	.005	.008	.010
K_2O	.039	.059	.045	.050	.051	.026	.056	.044
Na_2O	.064	.058	.062	.075	.063	.074	.080	.070
K_2O } Na_2O	.103	.117	.107	.125	.114	.110	.136	.114

* All iron estimated as Fe_2O_3.

° Average of 3 analyses representing different quarries.

′ Contains traces of P_2O_5, TiO_2 and ZrO_2 when present. With several exceptions, the usual qualitative test failed to indicate the presence of TiO_2 in the Georgia acid rocks. P_2O_5 and ZrO_2 are invariably present in small microscopic proportions as prismatic inclusions of apatite and Zircon.

No. of Anal.	K_2O : Na_2O	
I	1 : 1.41	Granites.
II	1 : 1.47	
III	1 : 1.20	
IV	1 : 1.43	
V	1 : 2.29	
VI	1 : 1.51	
VII	1 : 1.60	
VIII	1 : 1.29	

No. of Anal.	K_2O : Na_2O	
IX	1 : 1.28	Porphyritic Granites.
X	1 : 1.11	
XI	1 : 1.49	
XII	1 : 1.14	
XIII	1 : 1.68	
XIV	1 : 1.65	
XV	1 : 1.12	

No. of Anal.	K_2O : Na_2O	
XVI	1 : 1.64	Granite Gneisses.
XVII	1 : 0.98	
XVIII	1 : 1.37	
XIX	1 : 1.50	
XX	1 : 1.23	
XXI	1 : 3.07	
XXII	1 : 1.42	
XVIII	1 : 1.59	

be mentioned their marked uniformity or very close agreement throughout for the three rock phases. A distinguishing feature is their relatively high percentage of Na_2O, which is observed to be above the average for normal granites. The percentages of Na_2O and K_2O approximate nearly equal amounts in a majority of the analyses, but in many the K_2O exceeds the Na_2O, while in others the Na_2O is in considerable excess over the K_2O. The high Na_2O in the Georgia granites is traceable to three sources: (1) the presence of comparatively appreciable amounts of single laths of an acid plagioclase; (2) the abundance of microperthitic intergrowths of the potash feldspars with a second feldspar, probably albite; and (3) in the potash feldspar varieties, a part of the potassium is replaced by sodium. See analysis on page 209. The general high range in total alkalies—Na_2O+K_2O—is a very noteworthy feature in the analyses. The general average for total alkalies is from 8.79 per cent. in the gneisses to 9.44 per cent. in the granites.

For the sake of ready comparison the following percentages obtained from the average of 21, 10 and 12 analyses, respectively, of the normal granites, porphyritic granites and granite-gneisses are hereby tabulated:

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O
Normal granites	69.67	16.63	1.28	0.55	2.16	4.73	4.71
Porphyritic granites	69.28	16.73	1.75	0.72	2.13	4.33	4.59
Granite-gneisses	73.76	14.52	1.03	0.29	1.14	4.16	4.63

No appreciable difference is noted in any one of the seven constituents in case of the normal granites and their equivalent porphyritic facies, but a comparison of the analyses of the granite-gneisses with those of the granites, discloses several interesting differences among the more important constituents. An increased percentage of about 4 per cent. in the SiO_2, and somewhat regular corresponding decreased percentages in the

Al_2O_3 and CaO, and to a less degree in the Fe_2O_3 and MgO over the two granite facies, are shown in the granite-gneisses; while the alkalies—$Na_2O + K_2O$—remain very uniform and constant for the three rock phases.

It will be further observed from an examination of the table of individual analyses, that with one or two exceptions the Georgia granitic rocks are normally acid granites, showing a general average of approximately 70 per cent. in SiO_2, while the percentages of iron and magnesia are somewhat below the general average for normal granites.

The molecular ratios of the oxides given above show a tendency in the Al_2O_3, Fe_2O_3 and CaO to gradually increase as the SiO_2 decreases for the three rock phases. The gradual rise in Al_2O_3 with decreasing SiO_2 is well illustrated in the case of the granite-gneisses. The table of molecular proportions further shows the alkalies in sum total remain fairly constant with only slight variation.

These statements would seem to indicate, that no absolute relation exists between the Al_2O_3, SiO_2 and alkalies, since the tendency is for the Al_2O_3 to increase as the SiO_2 decreases, while the $Na_2O + K_2O$ remain approximately the same.

3. MINERAL COMPOSITION.

From the preceding descriptions, the Georgia granitic rocks are seen to be made up of mixtures of the essential minerals, quartz, feldspar and biotite, with varying amounts of muscovite intimately associated with the biotite. The potash feldspar varieties predominate; and, in two cases, biotite is subordinated to muscovite. The entire absence of hornblende in these rocks is a marked feature. Besides these, the usual accessory minerals common to granite rocks in general, occur, and have already been mentioned. The relative proportions of the essential minerals in the granites, excepting the Stone mountain type, may be expressed thus: Feldspar including all varieties present > quartz > biotite > muscovite. For Stone mountain the proportions become: feldspar > quartz > muscovite > biotite.

There is nothing especially noteworthy about the bulk of the minerals present in the Georgia acid rocks, and therefore, they do not require extended details further than given under the descriptions of the various granite-types. There are several minerals present, however, which from their association and conditions of environment require further descriptions. These are microcline and muscovite.

The prevalence of intergrowths with a second feldspar common to the three rock phases, in case of orthoclase and to some degree microcline, in the form of microperthitic structures, has already been remarked on under the descriptions of the individual types.

MICROCLINE: The abundance of feldspar grains showing the characteristics cross-grating structure is a striking feature in most thin sections of the Georgia granites. The twinning lamellæ thin out in many cases, and do not always show perfectly parallel sides. Crystals are often met in which the microcline structure is developed in only a part of the individual and entirely failing in the other parts, leaving the untwinned area optically indistinguishable from orthoclase. These granites have been subjected, as elsewhere shown, to intense dynamometamorphism, which fact, coupled with the prevalence of this feldspar, affords strong indications of a part of this mineral having acquired its structure. A part of the microcline is unquestionably primary. Similar conditions are recorded in granite masses in different localities by various writers.*

MUSCOVITE: Since the occurrence of primary muscovite in an eruptive granite has been questioned, it is of interest to note a similar occurrence of this constituent in many of the Georgia granites to that observed by Keyes† in some of the Maryland granites, where primary origin affords the best explanation. In many of the Georgia granite areas, especially the Oglesby-Lexington dark blue granite area, large and sharply bounded plates of fresh appearing muscovite, are distributed through the rock in intimate association with the biotite. The two micas are frequently grouped together as aggregates in which the individuality of the separate crystals is well preserved. They not infrequently form parallel intergrowths,

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* KEYES, C. R., *15th Ann'l Rept., U. S. G. S.*, 1893-94, pp. 711-712.
VON RINNE, NEUES JAHRB, ii, 1890, pp. 66-70.
BEUTELLE, ZEITSCHR. f. Kryst, viii, p. 373.
SAUER & USSING, Ibid, xviii, 1891, p. 196.
BROGGER, Ibid, xvi, 1890, p. 561.
} Quoted by Keyes.

† KEYES, C. R., *15th Ann'l Rept., U. S. G. S.*, 1893-94, pp. 703-704.

and at times the distinctly bounded muscovite plates penetrate and cut across the biotite foils at various angles. The relations of the two micas to each other, very strongly point to contemporaneous crystallization of the two minerals. The large shreds of supposed primary muscovite are in marked contrast in the same section to the muscovite of known secondary origin associated with kaolin, and resulting from feldspathic alteration. The cleavage lines are less distinct, and the muscovite presents greater irregularity of outline in case of the mineral of secondary origin. Still another portion of the muscovite in a part of the Georgia rocks has developed as a result of dynamometamorphism, and it is not always easy to distinguish between this and the same supposed primary constituent.

The marked similarity in mineral composition of the granites and gneisses is plain from the above descriptions. No mineral is found in one, that does not occur in the other; and those minerals most abundant in one predominate in the other. Their mineral composition conforms in every essential to that of known igneous granites occurring elsewhere. They are composed of minerals which most commonly make up the masses of normal eruptive granite. Not a single mineral among the list of primary and essential ones are included in the three rock phases, that does not characterize an igneous granite. The essential minerals are present furthermore, in the usual proportions common to such rocks. The rock types studied are entirely free from such minerals as staurolite, andalusite, cordierite and kyanite, frequently characteristic of sedimentaries. Garnet is sparingly present in some of the granites and becomes very abundant, in places, in a part of the gneisses, but it is unquestionably, in these cases, a product of metamorphism, and is as readily produced by such action, in igneous rocks, as in sedimentaries.

Hardly without exception, the thin sections of these rocks disclose an abundance of ovals or rounded disks of micropegmatitic structures—intergrowths of feldspar and quartz—which from their nature, in this case, are unquestionably referred to a primary product of the magma, and therefore represent simultaneous crystallization of the quartz and feldspar.

WEATHERING: Not only are the three phases of granitic rock alike in the above respects, which are in accord with similar rocks of igneous origin, but the form and manner of weathering are those of igneous rocks. The more perfectly banded phases,—gneisses—weather in process and topographic outline closely similar to the massive granites. The chemical and physical processes involved in the disintegration and decomposition of these rocks are the same, and are described and discussed elsewhere.*

RÉSUMÉ: From the preceding facts, there can apparently be little question as to the origin of the granites and their banded equivalents. The rocks appear like eruptives in the field. The clastic grains, when present and seen in thin sections of the foliated phases—gneisses—are evidently dynamic in origin; all are sharply angular, and none have the outline of water-worn grains. The structure of the gneisses is similar to that of like rocks occurring elsewhere, and shown to be metamorphosed eruptives. Therefore, since they conform with such regularity in mineral and chemical composition, and field evidences as well, to the massive granite type, there can be no reason for believing them to be anything but altered igneous rocks. No evidence of any kind is, at present, apparent to support the belief that the gneisses so far studied are water-deposited sediments, subsequently recrystallized by metamorphic processes.

As to the origin of the massive granites and their equivalent, porphyritic phases, there can be no doubt.

STRUCTURAL FEATURES: The structural phases of the various granite types have already been noted. Joint planes are very common in many of the larger masses and are as a rule, only slightly developed in others; and they traverse the rock with great regularity. They may conform to several different directions but usually they have uniform directions over the entire region. The best developed ones have nearly due east-west and north-south courses, approximating in some quarries northwest-southeast directions. Considerable subsequent movement in the granite-masses is manifested in many of the larger quarries, in pronounced slicken-sided surfaces of the joint planes. The slickened surfaces are, as a rule, coated with

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* Read by title at the Albany, N. Y., meeting of the *Geological Soc. of Amer.*, and presented in abstracted form by DR. GEO. P. MERRILL.

A preliminary report on the granites and gneisses of Georgia by T. L. WATSON, *Geol. Sur. of Ga.*, in press.

a moderately thick veneering of perfectly smooth, somewhat yellowish-colored sericitic material, frequently more or less grooved and striated from the movement.

Two sets of intersecting material differing widely in texture and mineral composition, and in origin, are common to the granitic rocks. These are: (1) True granite dikes, which vary in width from a few inches to many feet, cutting the rocks in a nearly vertical position; are dark blue in color, and fine even-granular in texture; and are composed of the same minerals in the same proportions, and have the same chemical composition as the even-granular granites. [Plate XXIV.] Since this class of intersecting material is not found in the more massive adjacent granites it is regarded in the nature of apophyses from these massifs. (See page 214 for chemical analysis.) (2) True pegmatitic dikes and veins of variable dimensions are common to the three rock phases and are composed of coarsely crystallized feldspar and quartz, with varying small proportions of the two micas, biotite and muscovite. [Plate XXII.] These are described in some detail on page 215.

AGE RELATIONS OF THE GEORGIA GRANITIC ROCKS.

No sedimentary rocks whose age is definitely known occur in the Plateau-crystalline-complex to admit of the definite determination of the age of the granites. In the absence of such, we can only hope to arrive at their relative ages by careful study of the contacts and the relative amounts of dynamic metamorphism the rocks have suffered. A careful field examination of the granitic rocks in the Plateau region of the state, shows considerable contrast in the amount of foliation or banding secondarily induced by pressure. All thin sections of the rocks studied showed some evidence of dynamo-metamorphism. This evidence is detailed above. The strongly banded gneisses differ from the massive phases of the rocks, simply in the pronounced schistose structure. In some areas of the massive granites an imperfect partial gneissoid structure is visible, which becomes rather noticeable in the Stone mountain area.

While no case has been observed in the field, where the highly contorted gneissoid phase was definitely traced into the massive type, owing perhaps, if they exist, to lack of exposures there are a few areas where conditions very strongly point to such gradation. Hayes* has described an extensive porphyritic granite area near the Cartersville fault in Bartow county, Georgia, in which the gradation from partially massive to a highly schistose granite is plainly visible. The stratigraphic relations of this igneous mass, to the surrounding sedimentaries of known age, cannot be mistaken, and Hayes has shown the intrusive granite, subsequently rendered highly schistose from intense pressure metamorphism, to be pre-Cambrian—Archæan—in age.

There appears to be, however, in most cases a sharp line of demarkation between the massive and slightly gneissoid granites, and the extreme foliated gneisses. In many areas where the schistose and massive granites occur, a part of the gneisses are cut by true granite dikes having the same mineral and chemical composition, as the massive granites, which they resemble in every respect. As elsewhere stated, the dikes are regarded as probable apophyses from the massive type of rocks. If then schistose structure secondarily induced or degree of metamorphism be taken as an index to age relationship, in the case of the Georgia granitic rocks, and accepting the evidence so strongly pointing to igneous origin for the highly banded gneisses, at least two different periods of intrusion of closely similar acid material are represented. The query naturally follows then whether all of these rocks have originated from the same parent magma?† Chemical and mineralogical composition more than suggest such condition.

A very close relationship in mineral and chemical composition is observed in the Georgia granites to similar rocks existing to the north in the Atlantic Coast region. Kemp,‡ after a careful study of our present knowledge of the Atlantic Coast granites, has emphasized the great predominance of mica-granites, especially the biotitic types over others; and, with other investigators§ has remarked their definitely known intruded character at different geological periods. Keyes¶ remarks in his studies of a part of the Maryland granites: "Certain

* HAYES, C. W., *Trans. Amer. Inst. Min. Engrs.*, Washington meeting, February, 1900.

† KEMP, J. F., *Bulletin Geol. Soc. America*, 1899, vol. x, p. 382.

‡ IBID, pp. 378-382.

§ WILLIAMS, G. H., *15th Ann'l Rept., U. S. G. S.*, 1893-94, pp. 666-670. DR. WILLIAMS reviews the distribution and relative ages of igneous granites in the Appalachian Crystalline belt and, gives numerous bibliographic references thereto.

¶ KEYES, C. R., *15th Ann'l Rept., U. S. G. S.*, 1893-94, p. 733.

it is that the acid eruptives [granites] were among the last igneous intrusions to disturb the rocks of the eastern Piedmont Plateau." The same author states in a preceding sentence, that the granite may have been intruded as late "as the last great disturbance of the region preceding the Appalachian uplift."

After a study of the Newark rocks of the "Richmond basin" in Virginia, Shaler and Woodworth,* in commenting on the age of the underlying rocks or "fundamental plexus", including granites and gneisses, say, "they probably date to Laurentian or Huronian time." (p. 418). And again on page 421 of the same report, the authors say, "The age of these rocks [granites and gneisses] is not locally determinable." The granites and gneisses of this area were grouped by Rogers† as Archæan.

Field and laboratory study of the granitic masses in the Georgia area certainly indicate, that they were not all contemporaneous in origin. Some of them are pre-Cambrian, while others may possibly be later in age. The youngest acid intrusives could not have been later however, *if as late,* which appears improbable from the existing facts and conditions, as the last great Appalachian disturbance or uplift.

Whatever age or ages be assigned the granites of this region, it is certain that the most massive types of the rocks exhibit strong proofs of mechanical strain, which indicates that since the intrusion of the last granites the region has suffered profound metamorphism.

METAMORPHIC FORMATIONS OF NORTHWESTERN CALIFORNIA.

By Oscar H. Hershey, Berkeley, Cal.

INTRODUCTION.

That portion of the Klamath mountains lying west of Shasta county, California, is not quite a terra incognita to geologists, as it was visited by one of Whitney's exploring expeditions‡ and has since been partially studied by Diller,§ Fairbanks,‖ Anderson and the writer; but all that has been written

* *19th Annual Report, U. S. Geol. Survey*, 1897-98 (1899) Pt. ii, pp. 385-515.
† *Geology of the Virginias*, 1884.
‡ *Geological Survey of California*, vol. i.
§ *Fourteenth Annual Report, U. S. Geol. Sur.* pp. 403-443.
‖ *Bulletin of the Geological Society of America*, vol. vi, pp. 71-101.

about it was of a rather desultory character, hardly calculated to give one a comprehensive and correct knowledge of its geology. The present writer has been engaged in prospecting for the precious metals in the Klamath region for nearly two years, during which many sections of the territory have been traversed and although there was not carried on a systematic study of any particular geological problems, it has resulted, it is believed, in the accumulation of sufficient knowledge of the structural relations of the formations of that region to make possible a classification of the metamorphic rocks.

DESCRIPTION OF FORMATIONS.

The pre-Cretaceous rocks of the entire Klamath mountain region (aside from the eruptives occurring in batholiths and dikes and unquestionably of an intrusive character) may be classified into seven great formations as in the following table which represents their structural positions although not necessarily their age relations:

1. The Upper Slates or Bragdon formation.
2. The Greenstone or Clear Creek formation.
3. The Lower Slate Series
4. The Hornblende Schist or Salmon formation.
5. The Mica Schist or Abrams formation.
6. The Serpentine or Trinity formation.
7. The Gabbro or Tamarack formation.

The structural relations and age of the serpentine constitute the great problem in the geology of the Klamath region. In the Coast range region a petrographically similar serpentine is an altered peridotyte, unquestionably intrusive in the Franciscan series, of an age at least not earlier than the Jurassic; but in the Klamath region I cannot find the same evidences of the serpentine being intrusive in the metamorphic sedimentaries. The subject is a complex one, and requires further field work for its solution; hence, in this paper I shall confine my attention to the schists, slates and associated formations.

The Abrams mica schist.—Large bodies of schists of a prominently micaceous character are not of common occurrence in the rocks of the Klamath region except as constituting a single well-defined formation, for which from its relations to neighboring terranes being best worked out in the upper

Coffee Creek region, I propose the name of the Abrams post-office of that section. It is composed of thin folia of muscovite of dull colors, such as gray, light brown, yellow and dull red, separated by irregular layers of white quartz, representing the original laminæ. Throughout it is very highly siliceous and doubtlessly portions of it would by some be called micaceous quartz schist. In certain belts the silica predominates to such an extent as to cause it to outcrop like great veins of very glassy, white and dark blue quartz. The relatively great amount of this primary quartz is particularly characteristic of this formation. There are, also, in places thin folia of hard blue crystalline limestone, sometimes thickening and clearing to a beautiful white marble. The foliation of the formation is parallel to the top and bottom and in general to the original lines of stratification.

This particular schist formation occurs in a long narrow belt bounding the great serpentine area of northeastern Trinity county on the west. Beginning somewhere in Siskiyon county, west of Callahan, it runs continuously in a southerly direction across the valley of Coffee creek, the head of the south fork of Salmon river, and thence through the mountains just a little west of Weaverville. From here its course is southeasterly in conformity with the strike of all formations in southern and western Trinity county. The cañon of Weaver creek is cut principally into it and it is finely exposed along Trinity river near Douglas City. From here southward it widens out into a belt several miles in width and constitutes the mass of Bully Choop mountain, on the southern slope of which it sinks beneath the Cretaceous formations of the Sacramento valley.

In the southern portion of this schist belt it appears to be folded into at least two main anticlines along the axes of which serpentine outcrops in the form of narrow belts constituting the so-called dikes. I wish particularly to call attention to the fact that serpentine is commonly associated with this mica schist formation. The normal succession of the strata in the direction of the dip is invariably serpentine, mica schist and hornblende schist.

Another narrow north-south belt of mica schist crosses the south fork of Salmon River valley at the village of Cecilville.

Here it is bounded on the east by the great hornblende schist formation and along its west border occurs a narrow belt of serpentine.

The only remaining area of this formation known to me is developed in the vicinity of Yreka and Fort Jones in Siskiyon county where again it is associated with serpentine.

The thickness of the Abrams mica schist in the upper Coffee Creek section is estimated at about 1,000 feet, but it seems to thicken to the southward and at Bully Choop may be much greater.

This is undoubtedly a highly metamorphosed sedimentary. Originally it was a series of argillaceous sandstone beds in large part finely laminated. The action of the metamorphism has been to convert the nearly purely siliceous laminæ into quartzyte layers, while folia of mica were developed in the shaly partings between the layers. In portions of the formation shearing such as usually produces schistosity has been nearly absent and the structure is rather that of a shale than a true schist. Yet this thermometamorphic action has been so intense that the original detrital granular nature of the material has been completely destroyed. Certain pure quartz sand layers have been converted into the apparent large quartz veins, which have a definite position in the series, are always parallel to the strike, and grade upward and downward into the distinctly laminated schist, yet rarely display the sub-granular texture of a typical quartzyte.

The Salmon hornblende schist. Whenever the boundary between the mica and hornblende schist has been examined by me, as in the south fork of Salmon River country and the Hay Fork section south of Trinity river, the former was found to grade into the latter through a thin series of graphite schist and actinolite schist. The black graphitic schist is particularly characteristic of this horizon and occurs nowhere else in the series. It was originally a highly carbonaceous layer in the succession of sandstones and shales and probably deposited under much the same conditions as veins of coal in the carboniferous rocks. The actinolite schist, so far as my observation goes, is also confined to this horizon. Usually it is of fine texture, light green in color and has a peculiar bladed structure, but locally there is developed a coarse-textured type yielding fine specimens of crystalline aggregates of actinolite. The graphite and actinolite schists combined usually have a thickness of no more than five to fifteen feet and in the presence of the broader belts of other schists on either side may escape detection in many sections unless especially searched for.

The hornblende schist is remarkable for its uniformity throughout a thickness of probably not less than 2,500 feet. It consists of elongated or blade-shaped crystals of dark green and black hornblende, separated by irregular thin layers of white quartz, with feldspar locally developed. It is moderately fine-grained and its general color is a dark green; it outcrops in rugged peaks of black rocks. Certain layers are highly calcareous, abounding in curiously contorted folia of crystalline limestone, even increasing to one- and two-foot layers of impure marble. Much of the formation has a schistosity developed by shearing, but in places the original lamination can be distinctly discerned and it is often highly contorted. There are other portions in which quartz is nearly absent and the rock consists of massive aggregates of comparatively coarse hornblende crystals, producing a type resembling a truly igneous hornblendyte. Indeed, hand specimens of this formation have frequently been identified as dioryte and even some who correctly discriminate it as hornblende schist consider it an altered igneous rock. I propose to show that it is a highly metamorphosed sedimentary.

The largest area of hornblende schist is traversed by the south fork of Salmon river between its head and the vicinity of the village of Cecilville. It constitutes a broad, shallow, synclinal trough, trending north to south and probably ten miles in width. On each side the strata are upturned to the extent of allowing the mica schist to come to the surface from under them. Both north and south from the river the synclinal is further disturbed by the upthrust of the hornblende schist against huge batholiths of granite and quartz-mica-dioryte At the center of the structural basin thus formed, the formation has been less modified by metamorphic action than usually. The strata are but little tilted and the original bedding planes are quite distinct. Before its conversion into hornblende schist it passed through a stage of thin-bedded slate, the structure lines of which yet remain. Interbedded with the schists there is a two to four-foot layer of dark gray, fine-grained compact quartzyte. In several places this shows shaly partings. Undoubtedly there is here evidence of the clastic character of the formation.

In the Hay Fork section of Trinity county, the Salmon hornblende schist is well developed as a belt several miles in width lying between the mica schist on the east and the black schistose slates of the Devono-Carboniferous on the west. In this area the schistosity is not so strongly developed and much of the formation is but little removed in alteration from a slate. In many places the bedding planes are distinct and indicate a formation originally not finely laminated nor yet very heavily bedded.

Another area of this formation occurs on the east side of the great serpentine area of the Sierra Costa mountains, on Rush creek several miles north of Weaverville.

We may now take a broader view of the schist series. The members are everywhere perfectly conformable to each other and evidently represent continuous sedimentation. At the base was an argillaceous sandstone with certain single heavy strata of nearly pure quartz sand. Following that was deposited a thin stratum of highly carbonaceous and siliceous shale. Another change in conditions brought in a more argillaceous and calcareous sediment and then followed a long period of remarkably uniform deposition of shale, sandy layers being few and fine in texture. All members of the series have been subjected to the same degree of metamorphism. Without shearing except locally, the first member was recrystallized into micaceous quartz schist, the second into graphite schist, the third into actinolite schist and the last seems to have passed through a slaty stage into hornblende schist.

The discussion of the age of this Klamath schist series will be reserved for the close of the paper.

The Lower Slate series.—This is made up of a succession of black slates, quartzytes and limestone. The slates nearly always have a schistose structure due to shearing. The quartzytes make up a large part of the series and are fine-grained and often regularly and thinly bedded. The granular structure and detrital origin are quite apparent to the unaided eye. The beds of quartzyte alternate rapidly with the schistose slates. The limestones occur in long narrow dike-like masses which are often repeated three or four times in parallel lines within several miles transverse to the strike of the slates, apparently as the result of folds or faults. Some of these "lime dikes" have a width of several hundred feet and stand out boldly above the surrounding slates. The limestone is usually massive and crystalline in character. Generally the metamorphism has proceeded to such an extent as to have completely destroyed the fossils, but near the Sacramento and McCloud rivers this is not the case, and there the limestones furnish the material for the determination of the age of this series.

The areas of the Lower Shale series are characterized:—

1. By the peculiar outcrop of the quartzyte; the surface of the hills abounds in fragments of cherty quartz either stained to light tints of red, yellow or brown or having a whitish, bleached appearance. It is difficult to convey an accurate impression of what is here meant, but it is a feature universally present in all the areas of this series no matter how widely separated or whether representing its upper or lower members. No other formation outcrops in quite the same way although internally it may resemble this.

2. By abundant dikes of greenstone intruded into the series and cutting across the stratification.

3. By the belts of limestone. Limestone and marble occur in the earlier schists but are insignificant in development in comparison with those of the Lower Slate series.

4. By a certain degree of dynamo-metamorphism which is comparatively uniform throughout the series and is of the nature of regional and not local or contact metamorphism.

The formation is commonly contorted, faulted and sheared throughout. Much of the argillaceous material has been converted into hornblende and micaceous minerals, but this is not macroscopically prominent. The sandstones have been partially recrystallized and thoroughly lithified. The limestone has usually been altered to a distinct crystalline aggregate presenting little evidence of its original condition. The general appearance of the series is one of practically the same age throughout, and as a whole much older than the Mesozoic slates, to be described later, and much newer than the schist series, discussed in preceding pages.

In Trinity county, the Lower Slate series is chiefly developed in a belt lying just west of the hornblende schist, trending from southeast to northwest from the vicinity of Harrison Gulch in Shasta county, across the Hay Fork country and the Lower Trinity basin, and crossing the divide into Siskiyou county in the New River mountains. It is traversed by the south fork of Salmon river below Cecilville, where much of the country over a width of ten or fifteen miles belongs to this series. The belt probably averages about five miles in width.

The next principal area is in the Scott Valley region, between Fort Jones and Callahan, and extending thence east to Shasta valley near Gazelle. The Sacramento cañon cuts a number of small areas of this formation between Castella and Delta, and it largely occupies the country east of the river to and beyond the McCloud river.

The age of the series is pretty definitely known through fossils occurring in it near the Sacramento and McCloud rivers and studied by Trask,* Walcott, Smith,† Diller, Schuchert,‡ Anderson and others. A small area near Kennett is considered Devonian in age, and in limestone near Gazelle has been found a fossil fauna indicating still lower Devonian. I understand, also, the Devonian fauna occurs in the series in the Scott Valley region. On the McCloud river a Lower Carboniferous fauna is found in the Baird shales and an Upper Carboniferous in the McCloud limestone. Prof. J. P. Smith has informed me that farther up the McCloud river there are fossils of a Permian facies. Hence, it appears, that the Lower Slate series ranges in age from the Lower Devonian to Permian, and as there is no known stratigraphic break in the series, sedimentation was probably continuous throughout Devonian and Carboniferous time. Metamorphism in the McCloud region has been somewhat less in intensity than in the southwestern Siskiyou and Trinity areas. It is to be noted, however, that the small Devonian area near Kennett more closely resembles the series in Trinity county than the Carboniferous area in the McCloud, and the more aged appearance of the western areas may be due not alone to their different situation in the range

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* *Report on the Geology of the Coast Mountains*, 1855.

† "The Metamorphic Series of Shasta county, California," *Jour. of Geol.*, vol. ii, pp. 588-612.

‡ "Discovery of Devonian Rocks in California," *Am. Jour. Sci*, III Series, vol. xlvii, pp. 416-422.

but also to their representing the older or Devonian portion of the series.

This series of slates, quartzytes and limestones certainly represents in part the Calaveras formation of the Sierra Nevada region, but also seems to include strata of the same age as the Arlington and Robinson formations. The Devonian portion of the series is not well represented in the Sierra Nevada region, but strata of that age have been discriminated there. I should be inclined to extend the term Calaveras in its original significance to the Klamath region if it had not come to be restricted to a particular portion of the Devono-Carboniferous series. It is doubtful if we shall be able to separate the Devonian and Carboniferous components of the series in the southwestern Siskiyon and Trinity areas, and we may be obliged to adopt a collective name synonymous with that which I have used, the Lower Slate series.

The thickness of the series in any one section is not known to me. Usually the succession of strata is repeated several times in a single area by faulting and folding. It appears to be considerably thicker than the schist series and than the later Mesozoic slates, and an estimated average for the entire territory of 5,000 feet is probably sufficiently accurate for the present.

The Clear Creek greenstone.—Southeast of the high rugged peaks constituting the Sierra Costa range, there is a much lower mountain country constituting the basin of Trinity river between Trinity Center and Lewiston, the Trinity mountain and the ridges eastward to the Sacramento river. The geology of this extensive territory is comparatively simple and entirely unlike that of the country to the west. Aside from the intrusive granites and porphyries, the mountains are made up of two formations, the Clear creek greenstone and the Bragdon slates. The former is the foundation rock of the region and upon it the slates have been deposited.

In general, the slate formation remains practically in its original horizontal position except that it has been thrown into a broad, shallow syncline, with an axis a few miles east of the summit of the Trinity range; but, considered in detail, it is much disturbed by faults and folds of small dimensions so that locally it presents dips of high degree, in not a few cases vertical and even overturned. This folding somewhat obscures the fact that the greenstone is always under the slates and never intruded into them.

The whole black slate country between Trinity Center and Lewiston has been thrown into a series of about ten anticlinal folds, striking east to west through the Trinity mountain and across the courses of Trinity river and Clear creek. Near the center of the series the folds are closely oppressed and the slates along the sides vertical. Now, if we follow the contact between the greenstone and slates up the limb of the anticlinal we do not have to climb more than 500, or at most 1,000, feet above the Trinity river until we find the slates curving up over the greenstone, and the mountains above are entirely of slate. The maximum vertical range of the folding is probably 2,000 feet, and the more open folds may be included within 1,000 feet. Thus the greenstone rises into view in the axis of each anticline, and sinks beneath the valley under each syncline.

The greenstone formation is made up of a variety of deposits of a volcanic nature, but all having something in common so that it appears over wide areas as a massive, fine-grained dull green rock, outcropping in ragged cliffs and weathering down into a reddish clay soil. Much of it is of a detrital character, chiefly diabasic tuffs and ashes, although in places it is brecciated and occasionally it has a conglomerate structure. This latter is peculiar. It consists of rounded pebbles of diabase cemented by similar material. Among the diabasic tuffs are undoubtedly sheets of lava, in places containing amygdaloids. The formation has been much altered and abounds in secondary minerals of which epidote is macroscopically the most prominent.

Running through the greenstone areas are long broad belts of a fine-grained white rock resembling certain quartzytes, but apparently a felsyte or a devitrified rhyolyte. Commonly associated with them are zones of impregnation of iron and copper pyrites, the sulphides sometimes concentrating into large solid bodies, such as the Iron mountain and Copper city deposits.

Along certain zones of shearing which trend usually east-west and have a width of ten to hundreds of feet, the diabase has been converted into a light-greenish schistose rock which appears to me to answer the description of certain phases of the amphibolyte schist of the Sierra Nevada region. Bands of impregnation of sulphides are also commonly associated with these shear zones.

Another modification of the diabase quite common along Trinity river is into a very hard, fine-grained, purplish flinty rock, perhaps due to silicification of the greenstone. In the same region occur dikes of quartz-porphyry which cut the greenstone but terminate abruptly at the base of the overlying slates. In fact, the whole greenstone formation appears to be a series of diabasic tuffs and lavas bound together by a variety of intrusive porphyries and diabase.

This greenstone in large part is beyond doubt extrusive in character; in other words, it is a formation of surface volcanic material. It has its counterpart in the Neocene tuffs and lavas spread widely over the older formations in the Cascade region. On the isthmus of Panama, I have studied a great Neocene volcanic formation of precisely the same character, except that the tuffs are mainly rhyolitic and the lavas basaltic. The internal structure of these formations is characteristically alike.

The origin of the material of the greenstone has not yet certainly been discovered. The Lower Slate series is particularly abundantly supplied with dikes of greenstone scarcely distinguishable from the main body of the diabase and in places these intrusive diabases seem to pass into the extrusive formation. In the Cinnabar synclinal between the gabbro ridges of northeastern Trinity county, great dikes of greenstone are intruded into the serpentine and form extensive bodies along the axis of the trough. The entire region from the Sacramento river southwestward to the Hay Fork country and northwestward to the lower Salmon river country appears to have been overspread by this greenstone, for wherever its proper horizon is exposed, viz., between the Lower Slate series and the Bragdon slates, heavy bodies of diabase occur as a stratigraphic unit and not as intrusions.

Tuffs imply volcanoes and not mere fissure eruption. The volcanoes of this period have disappeared, but I think they occurred along a belt lying just west of the Sacramento river and including the sites of, say, Kennett, Keswick, Shasta and Centerville. Here the formation is very thick and its fragmental character is most apparent. Toward the westward it appears to thin and become more uniformly a diabase similar to the dikes in older formations. Its thickness is unknown, but in Trinity valley it is at least 1,000 feet, as that thickness is exposed and the bottom not seen.

The Clear Creek greenstone was deposited on land. At the close of the epoch it suffered erosion and was levelled off either by the sea, during the progress of the submergence to which the slates are due, or by sub-aerial erosion, probably as the result of both. This interval of erosion does not appear to have been a long one.

The Bragdon slate.—This has its heaviest development in the Trinity mountain (the bulk of which it forms) between the high mountains east of Trinity Center and the vicinity of Lewiston. It is cut off on the west at the foot of the high Sierra Costa mountains by a sharp monocline or a fault. On the east it thins out because of erosion and has been completely removed from over the greenstone formation along a broad belt lying just west of the Sacramento river.

It is a series of alternating thin-bedded black slates and thick-bedded blue quartzytes. As doubts have been expressed that this formation is distinct from the Devono-Carboniferous I will lay special stress upon the points of difference. In the lower slates, the quartzytes are white and weather red, yellow, brown or a bleached white; in the Bragdon slates, the quartzytes are blue and weather gray. The former formation is schistose throughout the argillaceous portion because of regional shearing; the Bragdon slates have only been sheared along certain zones, and most of the formation is merely a well lithified or silicified shale and sandstone, without shearing. The Lower Slate areas have limestone; the Bragdon slate areas none. The former series abounds in intrusive diabase; the latter has no dikes of this eruptive and all the diabase in its vicinity is under it. Conglomerates are rare in the Devono-Carboniferous; in the Bragdon slates thin sheets of well-lithified, moderately fine conglomerate are rather common, particularly in Hay gulch, three miles north of Bragdon, and near French gulch. The pebbles are of blue, black, red, yellow, brown and white quartz and appear to have been formed principally from the quartzytes, cherts and phthanytes of the Devono-Carboniferous.

Along the Sacramento river, near Elmore and thence eastward toward the McCloud river, there is a deposit of the Bragdon slate. It contains conglomerates which on outcrop have a singular-vesicular character, like an amygdaloid. Now there are Devonian and Carboniferous limestones pretty strongly developed in that vicinity and I explain the rounded cavities in the conglomerate by supposing that they represent pebbles of limestone which have been dissolved out in the process of weathering.

The conglomerates are most abundant toward the northeast, and the whole formation seems to thin toward the southwest, implying that the shore-line and source of the sediments were somewhere on the northeast. In the Hay Fork country, lying west of the Devono-Carboniferous, there is a narrow belt of this formation. Here also it is closely associated with greenstone, as in Trinity mountain. The two are folded into each other and are separated by a sharp even line, with the greenstone always stratigraphically under. Both greenstone and slates are thinner than in the Trinity mountain area and the latter average finer sediments.

The Bragdon slates were probably developed over the greater portion of the Klamath region, but through the vicissitudes of elevation, folding and erosion, have been mostly destroyed. This is the latest of the formations included in the "Auriferous Slate series" of northwestern California and probably the upper limit of the original deposit nowhere remains. There are yet over 2,000 feet in thickness of it in the Trinity mountain country.

The age of the Bragdon slates is as yet somewhat uncertain, as the formation has nowhere yielded any determinable fossils. Along the road between French gulch and Trinity Center, near Whitney's ranch, there are traces of organic remains, apparently impressions of plants. However, no paleontological evidence is available and I can only indicate what correlations are probable from the standpoint of lithology, stratigraphy and structure.

In the Pitt River region, Prof. J. P. Smith has discriminated* a thick series of Mesozoic sediments included in part in his Pitt formation and the Cedar and Bend formations, the latter of Jurassic age. There appears to have been essentially

***Jour. of Geol.*, vol. ii, pp. 558-612.

continuous deposition from the Carboniferous through the Triassic into the Jurassic. My acquaintance with that region is slight, but when I visited it I could not so clearly separate the Carboniferous and Mesozoic slates as in Trinity county. My impression is that the latter formations are entirely unrepresented in Trinity county, their place being taken by a marked interval of erosion. In the Pitt river valley I found the slates grading into the greenstone by interstratification, while in Trinity county they are distinct and a short interval of erosion belongs between them. My studies lead me to think that throughout the Klamath region west of the Sacramento river, sedimentation ceased at the close of the Paleozoic era and the Devono-Carboniferous series was elevated into dry land, somewhat folded and metamorphosed and then greatly eroded, while sedimentation continued through the Triassic and Jurassic periods in the region of the McCloud and Pitt rivers, and thence northeastward through an undetermined area. Sedimentation in the country west of the Sacramento river was only resumed well on in the Mesozoic era, after the Clear Creek volcanic period, and hence the greenstone and Bragdon slates (which rightfully belong together as a series) came to rest unconformably upon the Devono-Carboniferous.

Now, there is a remarkable resemblance in the lithology and structure of the Clear Creek greenstone and the main diabase and porphyryte formation of the Sierra Nevada region. Both seem to represent a time when diabasic tuffs and lavas spread over wide areas much as the Neocene volcanoes cover the older formations in the Cascade region. In the Sierra Nevada region also this extrusive series of eruptives is intimately associated with a black slate formation—the Mariposa slates of late Jurassic age. Not only are the Bragdon slates lithologically similar to the Mariposa slates, but the general make-up of the two series is identical. This parallelism of conditions on opposite sides of the comparatively narrow Sacramento valley is too remarkable to be ignored. It seems to warrant the correlation in a general way of the two series. As the Mariposa slates with their associated diabase and porphyryte are considered late Jurassic in age, I shall provisionally class the Clear Creek greenstone and the Bragdon slate as also Jurassic.

DISCUSSION OF THE AGE OF THE KLAMATH SCHIST SERIES.

The common association of serpentine with the Abrams formation suggests that the peridotyte was intruded into the slates and that the schists represent contact zones of metamorphism about it, and are merely altered portions of the Devono-Carboniferous series or the Bragdon slates. To this hypothesis there are two fatal objections.

1. The original or unaltered sedimentary formations of the schist series, the Devono-Carboniferous series and the Bragdon slate series were of a similar character petrographically (and might be expected to yield like products under like conditions of metamorphism) *but the sequence of the strata was different.* No amount of metamorphism could have converted the Bragdon slates or any portion of the known Devono-Carboniferous into a series as the mica, graphite and hornblende schists. That layer of graphitic schist is extremely important in this connection. By means of it and the nearly purely siliceous layers outcropping as apparent large glassy quartz veins, we are able to determine that the mica schist everywhere in the Klamath region represents the same portion of the original sedimentary series, and the hornblende schist always a certain higher portion while the recognized Devono-Carboniferous nowhere contains representatives of this portion of the original sediments and the Bragdon series is so very different as to be quite out of the question.

2. Along several lines in the Klamath region the Devono-Carboniferous and the schist series are in contact and "dikes" or narrow belts of serpentine appear along these lines. On Hay Fork mountain in southern Trinity county, a narrow belt of the serpentine is bounded on the west as usual by mica schist, followed by the graphite and hornblende schists. On the east it is bounded by a belt of the characteristic schistose slate (cut by greenstone dikes) of the Devono-Carboniferous. Now, if the mica schist is an altered portion of the Devono-Carboniferous and due to the intrusion of peridotyte, why was the metamorphic action so very much more intense on one side of the dike than on the other? These conditions are exactly repeated along the boundary between the undoubted Devono-Carboniferous and the schist series in the vicinity of Cecilville and the King Solomon mine in southwestern Siskiyon county, except

that here the schists are on the east and the slates, quartzytes and limestone on the west of the serpentine.

The serpentine is mainly confined to low levels, and higher the slates and quartzytes rest directly on the mica schist and the contact appears to be unconformable. It seems that the schist series was tilted to the eastward at a considerable angle and the Devono-Carboniferous laid down arcoss the beveled edges of its strata. Similar evidence of non-conformity was obtained on Hay Fork mountain. If the serpentine is older than the schists there will not be any difficulty in demonstrating an unconformity indicating an immense erosion of the schists previous to the deposition of the Devono-Carboniferous sediments, but if the peridotyte was intruded into schists and slates, the unconformity rests upon less definite evidence and more work will be required to establish the fact beyond the possibility of doubt. However, it is a fact that the typical Devono-Carboniferous comes close up to the typical schists and they are separated by a sharp line, not the least evidence of one grading into the other having ever been found.

Throughout the Devono-Carboniferous areas, narrow belts or so-called "dikes" of serpentine are rather common. They usually outcrop at lower levels, the schistose slates and quartzytes apparently curving up over them as does the Bragdon slate over the Clear Creek greenstone in the folds of Trinity valley. One such strip of serpentine forming the axis of a narrow fold occurs in Bridge gulch in the Hay Fork section. The typical schistose slate and quartzyte of the Devono-Carboniferous overlie it and may be traced to the very contact practically unchanged. In the Scott valley region south of Fort Jones in Siskiyou county, a sheet of serpentine appears to underlie the Devono-Carboniferous over at least several square miles. In no instance have I observed the development in these Devono-Carboniferous areas of a mica schist or a graphite schist or a hornblende schist along the contact, such as constitute the Abrams and Salmon formations. It would be too remarkable a case of selection to suppose that the peridotyte converted thousands of feet of strata into mica and hornblende schists in one area, and that in an immediately adjoining area, equally as large masses of peridotyte failed to develop in the same strata even a narrow contact zone of similar schist. The inference is unavoidable that the schists are a distinct series, as a whole much more highly metamorphosed than the Devono-Carboniferous, and that at least to the extent that their alteration exceeds that of the other series, the metamorphism is not due to the intrusion of peridotyte.

In the Coast Range region the serpentine areas are commonly bounded by narrow zones of contact metamorphism, the product of which is in places a schist as thoroughly crystallized as any part of these Klamath schists. These metamorphic zones are nowhere of great extent and cannot be used as an argument in support of the hypothesis that to the intrusion of the peridotyte is due the high degree of metamorphism of the Abrams and Salmon formations which are developed over hundreds of square miles without an outcrop of serpentine. Moreover, serpentine areas five to ten miles in width adjoin the Clear Creek greenstone and the Bragdon slates, as in the Hay Fork section of Trinity county, without the presence of a prominent schist belt if, indeed, there is any contact thermo-metamorphism apparent at all.

It has been suggested that the schists represent contact metamorphic zones due to the intrusion of a granitic batholith. Where these batholiths rise through the hornblende schist as near the head of the south fork of Salmon river, there is often a narrow belt of schist next to the granite. However, this is always merely a portion of the Abrams formation normally underlying the hornblende schist and thrust up along the granite contact *as the presence of the graphitic layer proves.* Large batholiths of granite, quartz-mica-dioryte and intermediate types occur in the areas of the Devono-Carboniferous and of the Bragdon slates and in no case are they surrounded by schist zones such as the Abrams and Salmon formations. In fact, the only sort of contact metamorphism that I have observed in the Klamath region about the granitic batholiths is that the schists and slates near the border have often been contorted by the pressure of the intruded magma, and impregnated with sulphide of iron and in general their metamorphism somewhat intensified but not materially changed in character.

Another suggestion is that the metamorphism of the rocks of the Klamath region is due to the action of a great magma of fluid granitic material underlying the whole territory and deeply buried beneath the present surface level but exerting its influence high in the overlying strata to a degree which the comparatively small batholithic arms could not. This would imply that in any given area, there was a maximum of intensity of alteration in the deepest portion of the strata near the granitic mass and the degree of metamorphism decreased upward toward the surface. The oldest sediments would naturally be buried deepest and be the most altered. Afterwards elevation and folding would bring the deeper strata to the surface and belts of schists would come to outcrop parallel with the belts of but slightly altered slates. As applied to the Klamath region I have the following objection to make to this hypothesis:

No fluid granite magma existed under the Klamath region until after the Jurassic period of eruption of greenstone. During the deposition of the Bragdon slates or immediately after, such a granitic magma may have formed under the region, and when, just at the close of the Jurassic period, the entire territory was uplifted, folded, faulted and extensively fractured, the strata subsided on this fluid magma and the batholiths and acid dikes were formed. Now, did the metamorphism of the schists and slates date entirely from this period, there should be a gradual transition in the degree of alteration from the oldest and lowest to the newest, which certainly is not the case.

I want to particularly emphasize the facts that the schist series is about equally metamorphosed from bottom to top and throughout its extent over hundreds of square miles, that then occurs a break, so to say, and the Devono-Carboniferous series although showing some variation, as a whole is altered to practically the same degree, but *much* less than the schists although the two are in contact in places, while then occurs another "break" and the Jurassic series although showing little variation in metamorphism throughout its extent either vertically or horizontally, as a whole is much less altered than the Devono-Carboniferous. Taken in connection with the evidence of unconformity between the three series the only reasonable explanation is this:

After the sediments of the schist series were deposited, they uplifted, tilted, *to a certain degree metamorphosed,* and then eroded. This land was depressed beneath the sea and the Devono-Carboniferous sediments deposited. At the close of the

Paleozoic era, there occurred another uplift and tilting of the strata. The Devono-Carboniferous formations *were metamorphosed to nearly their present degree*, while in the earlier series which had previously been converted into schists, *there was an intensifying of the metamorphism.* In the Jurassic there came another submergence with the deposition of the Bragdon slates, followed by the uplift, folding, faulting and fracturing of the strata to which the present Klamath mountains structurally are due. During this orogenic disturbance, the Clear Creek greenstone and Bragdon slates were well lithified, partially silicified, and a schistose structure developed along certain limited shear zones; in other words, the Jurassic series *was slightly metamorphosed.* At the same time *there was another intensification of the alteration* of the schists and Devono-Carboniferous series. This theory so well explains the facts observed in the mountains that it is hardly necessary to call into play possibilities which are not strong probabilities.

It is true that there are throughout the Klamath region certain narrow zones of metamorphism due to the intrusion of various acidic and basic dikes, and they have produced even in the Jurassic slates, schists of somewhat similar mineralogical composition to the Klamath series, but the local character of the former is always manifest and there is no reason for confusion. In this paper I am considering only the alteration that is regional in character, affecting entire formations over many hundred square miles. In the case of the Klamath schists this was probably due to their having been deeply buried under other sediments and brought under the influence of the internal heat of the earth. The regional alteration of the Devono-Carboniferous and Jurassic series is mainly of a dynamical character. Upon this is locally superimposed the thermo-metamorphism of the central zones.

We are now ready to consider the question of the age of the schists. They contain no fossils and manifestly our conclusion must be provisional and subject to modification at any time.

I feel safe in asserting that they are considerably older than the Devono-Carboniferous series. They seem to be separated from the latter by a non-conformity of no mean value and certainly by a great difference in degree of metamorphism. The relation in point of metamorphism between the Jurassic, Devono-Carboniferous and schist series of the Klamath region is similar to that between the Carboniferous, Cambrian and Archæan of the Appalachian region. Upon a superficial survey the Abrams mica schist might be classed as Archæan in age. However, I do not think it is that old, for the following reasons: The Archæan complexes of the eastern states are almost invariably highly contorted and their original clastic nature totally destroyed, if, indeed, any parts of them are metamorphosed sedimentaries. As we approach the Pacific coast, the supposed Archæan terranes are less contorted, but the original planes of deposition are usually not apparent. The series contains granites, gneisses and schists, but never, so far as I know, such an assemblage of formations as the mica, graphite and hornblende schists of the Klamath region, and so perfectly preserving in considerable areas their original stratified structure.

The general appearance of the series is similar to that of the Algonkian formations in the Appalachians, lake Superior region and the Black Hills of South Dakota. These Algonkian terranes frequently are but little contorted, lie at comparatively low angles, display evidence of their clastic nature and original stratification, and yet are highly crystalline in character. The same is true of the Klamath schist series.

Opposed to the idea of a Cambro-Silurian age for the Klamath schists is the presence in different parts of California of known Silurian and Cambrian strata much less metamorphic in character. About the northern end of the Sierra Nevada mountains Diller has found strata whose fossils indicate a Silurian age.* From the description, these do not appear to be greatly more altered than the Carboniferous of the same region or the Devono-Carboniferous of the Klamath region. In Inyo county, there have been found Lower Cambrian strata, also not more metamorphic in character than the Devono-Carboniferous of the northern part of the state.†

Yet, in other parts of the Sierra Nevada region there are schists very similar in character to those discussed in this paper, notably in the Big Trees area.‡ It is usually implied that these schists are only more altered portions of the Car-

* Descriptive text of the Lassen peak folio, *U. S. Geol. Atlas.*

† *Am. Jour. Sci.*, vol. xlix, 2395, p. 141.

‡ *Seventeenth Annual Report, U. S. Geol. Sur.*, p. 536. *Am. Geol.* vol. xiii, 1894, p. 229.

boniferous or Jurassic slates, and this is probably true of them in large part. Some of them are referred to as possible representatives of pre-Cambrian formations. As the Klamath region is merely a sort of outlier of the Sierra Nevada, so far as its stratigraphical and earlier dynamical geology is concerned, it is probable that in time a part of the Sierra Nevada schists will be definitely separated from the Carboniferous and Jurassic series and correlated with the Klamath schists.

On the whole, it seems impracticable to fix upon any particular part of the time between the Archæan and the the Devonian as the period of deposition of the Klamath schists, but I believe the evidence favors the earlier or Algonkian portion rather than the Cambrian or Silurian, although I should not like to be placed on record as correlating these schists with the Algonkian in any other than an extremely problematical way.

Berkeley, Cal., Jan. 3, 1901.

ON THE HELDERBERGIAN FOSSILS NEAR MONTREAL, CANADA.*

By CHARLES SCHUCHERT, Washington.

St. Helen's Island in the St. Lawrence river, opposite Montreal, and now one of the public parks and fortifications of that city, furnishes an interesting bit of geology. At the upper extremity of the island, close to the ferry landing, is seen the Utica shale cut by dikes of a highly altered basic rock and an intrusive sheet of dioryte lamphrophyr (=camptonyte), and overlain by agglomerate which covers almost the entire island. Around the island to the southeast are occasionally found small blocks of limestone containing Trentonian fossils, such as *Plectambonites sericeus, Strophomena incurvata*, and monticuliporoid Bryozoa. Towards the southeastern end of the island, along the water front, occurs the Helderbergian exposure. Logan† describes the latter as follows: "There occur two masses of dark gray fossiliferous limestone, weathering to a light gray; which are not magnesian. These are included in a length of about forty yards, and are limited on the east side by the water of the river; they have a breadth of scarcely

* Published by permission of the Secretary of the Smithsonian Institution.
† *Geology of Canada*, 1863, pp. 356-358.

more than ten feet, and appear to run under the dolomitic conglomerate [agglomerate] on the west side. They present, in section, the appearance of two small arches of about four feet in hight, separated from one another by a few feet of the [agglomerate], and sinking under the same rock on the north and south. * * * The dolomite [of the agglomerate] and the limestone seem to pass into one another for a few inches, and show no tendency to separate at the junction. * * *

"As none of this limestone comes from beneath the [agglomerate], where this reposes upon the Utica fromation, it is supposed to belong to a small disturbed lenticular portion, lying in or under the [agglomerate]. Smaller patches of the same limestone, a few feet in diameter, are seen in the forty yards north of the two chief masses; and the whole may be connected beneath. There are other masses of similar limestone, only a few inches in diameter, which are completely enveloped in the conglomerate."

The writer made two visits to this locality in August, 1900. He found the Helderbergian limestone considerably broken and disturbed, with all the crevices filled up by the dolomitic paste of the agglomerate which covers the island. The amount of this limestone exposed is too great to warrant any assumption other than that it represents an outlier *in situ* above the Utica, having been subjected to seismic action shortly before the deposition of the agglomerate. The stratification of the limestone, as seen by the lines of fossils, is too irregular to make out the general lay of the mass.

In the grassy slope but a few feet away from the Helderbergian, there is a large block of a slightly granular siliceous limestone involved in, and forming a part of, the agglomerate. A number of fossils have been collected from this block and mixed up with some from the Helderbergian. These specimens, however, by their color and preservation, can be readily distinguished from those of the Helderbergian limestone, and have nothing in common with the latter. They will be mentioned again later on.

THE HELDERBERGIAN FAUNA.

In the Geology of Canada cited, Logan lists 9 species determined by Billings. It is not necessary to reproduce this list, as *Strophonella punctulifera* and *Rhipidomella oblata* correctly indicate "the existence of the Lower Helderbergian group in two or three small outliers in the great western basin near to Montreal."

Subsequently, J. T. Donald* published a list of 35 species, among which are *Orthis hipparionyx, O. oblata, O. tubulostriata, Strophomena punctulifera, S. profunda, Spirifer concinnus, S. cyclopterus, Stricklandinia gaspensis, Pentamerus verneuili, P. galeatus,* and *P. pseudogaleatus.* Here are forms characterizing the Niagaran, Helderbergian, and Oriskanian formations, an assemblage never met with in America.

In 1890, Mr. William Deeks† restudied these fossils and extended the list to 44 species. Here again appears the same remarkable assemblage first noted by Donald. In 1896, the fossils of Donald and Deeks, now in the Peter Redpath Museum, were re-examined by Dr. Ami, who published a list of 45 species.‡ This list differs greatly from those previously given, and is far more satisfactory, as the species included are apparently of the Helderbergian or Oriskanian age, excepting a Spirifer "very much like *S. pennatus* (=*S. mucronatus*)." In the writer's resumé of the American Lower Devonic faunas§, it is stated that one specimen of *Spirifer concinnus,* as identified by Donald, "is more like *S. cumberlandiae,* but the bilobed fold of the dorsal shell is a character which associates his species with *S. mucronatus* Conrad, of the Hamilton." Assuming at that time that all the St. Helen's Island fossils are from the "conglomerate," and as *Spirifer mucronatus* and "Spirifer apparently near *S. granulosus* Conrad" indicate a Middle Devonic formation, that age was accepted for the "conglomerate" and Dr. Whiteaves was so informed. The latter, in his presidential address before section E of the American Association for the Advancement of Science||, stated, with the permission of the present writer, that the St. Helen's Island fossils "are probably the equivalent of part of the Hamilton formation of Ontario and New York, and not of the Lower Helderberg." It is true that Dr. Ami was the first to notice the Spirifer "very much like *S. pennatus*" but he made no correla-

* *Canadian Naturalist*, n. ser., ix, 1881, pp. 302-304.
† *Canadian Record of Science*, iv, 1890, pp. 104-109.
‡ *Ann. Rept. Geol. Surv. Canada*, n. ser. vii, 1896, pp. 155J-156J.
§ *Bull. Geol. Soc. America*, 1900, p. 332.
|| *The Devonian System in Canada*, 1896, p. 16.

tion from it. Finally, in the paper cited above, the writer stated —"Under these circumstances, judgment is deferred as to the age of the conglomerate on Saint Helen's Island."

After an examination of the fossils in the Peter Redpath Museum and of their mode of occurrence on the island, the evidence seemed conclusive that true Helderbergian rocks *in situ* do occur in this locality, and that some of the identifications of Donald and Deeks need rectification. Mr. E. Ardley of the Redpath Museum also showed the present writer a small slab broken from the siliceous limestone block in the agglomerate, which contains several well-preserved, long-winged Spirifers, like *S. pennatus.* Other specimens of a Spirifer from the same rock were also shown, all of which proved that these fossils have nothing in common with the adjacent Helderbergian fauna, but belong to one of Middle Devonic age. The collections in the U. S. National Museum are too meager for detailed comparison, and in this article the writer cannot do more than correct some of the identifications of Donald and Deeks, while pointing out the probable correlations of the Saint Helen's Island fossil faunas with those of New York.

"*Heliolites,*" Deeks.

This seems to be based on a *Striatopora.* There is no *Heliolites* in the locality.

"*Orthis hippariony**," Donald and Deeks.

This identification is an error. The specimen pertains to the same form as the "Spirifer allied to *S. arenosus.*" Both these identifications are based on a Spirifer apparently near *S. granulosus* Conrad, and *S. eurytienes* Owen, of the Middle Devonic. The specimens are from the block in the agglomerate, and have no connection with Helderbergian fossils.

Rhipidomella cfr. musculosa Hall?

In the U. S. National Museum collection, there is a fragment of a large *Orthis,* or rather, *Rhipidomella,* from the Helderbergian, which may be this species.

Rhipidomella cfr. *musculosa* Hall?

These specimens are usually smaller than those from New York, otherwise they are alike for both regions.

"*Strophomena profunda* Donald, *Strophodonta profunda*" Deeks.

This Niagaran species was not present in the Redpath collection last summer, nor is it listed by Dr. Ami. *Strophomena profunda* must therefore be removed from the Saint Helen's Island Helderbergian.

Stropheodonta varistriata var. *arata* Hall.

The National Museum specimens of this form are poor, but seem to agree with the New Scotland variety of the species, as found at Becraft Mt., near Hudson, New York.

Strophonella punctulifera (Conrad).

The specimens thus labeled in the Redpath Museum belong to an *Orthis* near *oblata* and a *Stropheodonta*, probabaly *S. varistriata* var. *arata.* However, the species doubtless occurs on the island, since Dr. Ami has it in his list.

Spirifer concinnus Hall.

This is one of the common species and appears in its typical form.

Spirifer murchisoni Castelnau, early variety.

This is the commonest fossil of St. Helen's Island, and in the Montreal collections is usually found labeled as *S. cyclopterus.* It has, however, the general expression of a somewhat under-sized *S. murchisoni* from Cumberland, Maryland. It differs from the former species in being, as a rule, more alate, with fewer and more prominent plications. Tracing these early departures from *S. cyclopterus*, the progression terminates in the Upper Oriskanian in the typical *S. murchisoni* of large size, extreme inflation, angulation of the plications, fold, and sinus, and great lingulate extension of the ventral shell.

"*Spirifer allied to arenosus*" Donald, Deeks, and Amo.

This is apparently the earliest form of the *S. arenosus* type. However, it is not that species, since when small it is much like *S. concinnus,* but towards maturity the fold and sinus become plicated. Hall and Clarke figure a similar specimen as *S. concinnus* (Pal. N. Y., VIII, Pt. II, pl. 30, fig. 1). In *S. arenosus* of the Oriskanian, the horizon for this species, the plication of the fold and sinus is not a recently acquired character for it appears in the shell when quite small.

"*Stricklandinia gaspensis*" Donald and Deeks.

The specimen in the Redpath Museum has nothing in common with this species. It is one of those large rhynchonelloids now referred to *Camarothoechia (Pletharhyncha)*, nearest to *C. (P.) pleiopleura* Hall. This is one of the interesting representatives of the Saint Helen's Island Helderbergian fauna in that it shows transition into Oriskanian forms. Dr. Ami has likewise noted this species.

"Pentamerus verneuili" Donald and Deeks.

If based on the specimen thus labeled in the Redpath Museum, this identification is an error for *Spirifer concinnus.*

Gypidula pseudogalcata (Hall)?

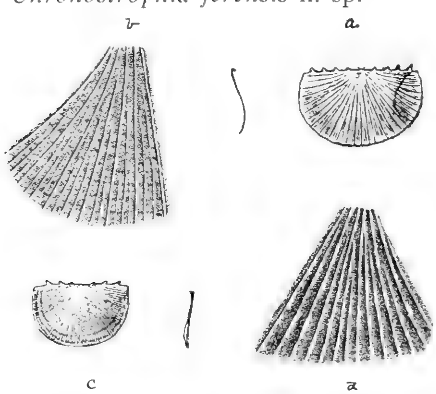
The material in the National Museum representing this species is very imperfect, but it shows that the form is a *Gypidula* without plications. Since *G. pseudogaleata* is the only Helderbergian species of this type, the St. Helen's Island specimens are provisionally identified with Hall's species so characteristic of the Becraft limestone.

Rensselaeria aequiradiata Hall.

The single ventral valve of this species agrees very well with the New York specimens of the large Helderbergian (Becraft) *Rensselaeria.*

Chonostrophia montrealensis n. sp.

Chronostrophia jervensis n. sp.



EXPLANATION OF FIGURES.

Figs. *a* and *b*, *C. montrealensis*; *a*, ventral aspect, *b*, surface x5.

Figs. *c* and *d*, *C. jervensis*, *c*, ventral aspect, *d*, surface x5. The lines between the figures illustrate the curvature of the valves.

Of the first species, there are two good ventral valves which agree well with small *C. complanata* as determined by Clarke.* The Canadian specimens, however, agree best in size and form, with an undescribed species of the Helderbergian (Becraft limestone) of Port Jervis, New York, but differ in the far fainter thread-like striæ which are arranged as in *Rafinesquina alternata* yet not so distinctly bundled as in *Chonostrophia reversa* Whitfield, of the Onondaga. The Port Jervis species may be known as *C. jervensis,* and is distinguished by its size and flatness, but particularly by the equal, sharply elevated, somewhat undulating, and regularly disposed striæ. It generally has three prominent, slightly diverging, cardinal spines on each side of the ventral beak, but there are also specimens with four spines, and others apparently with but the two lateral ones prominently developed. In *C. montrealensis,* there appear to be four similar cardinal spines.

Chonostrophia begins in the New Scotland zone of the Helderbergian in *C. helderbergiae,* and continues upwards as follows: *C. jervensis* in the Becraft limestone, *C. montrealensis* in the higher Helderbergian, *C. complanata* throughout the Oriskany, *C. complanata dawsoni* in the Gaspé sandstone of Quebec, and *C. reversa* in the Ohio Onondaga (Corniferous).

MIDDLE DEVONIC FAUNA.

It has been stated (p. 248) that in the grassy slope and above the Helderbergian rocks in the agglomerate of Saint Helen's island, there is a large block of a slightly granular siliceous limestone containing a few species of brachiopods usually preserved as natural moulds. These fossils were heretofore regarded as of Helderbergian age, but the species are different and indicate a more recent formation. The National Museum collection includes the following forms:

Dalmanella planiconvexa Hall?

There are three specimens of a *Dalmanella* present, which seem to be much like the Oriskanian variety of *D. planiconvexa.* These orthoids, of the group *D. testudinaria,* are difficult to distinguish unless the material is good, and in the present case, therefore, only the general aspect can be indicated.

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* *Memo. N. Y. State Mus.*, iii, no. 3, 1900, pl. 7, fig. 7.

Spirifer macra Hall.

This is the shell referred to by Dr. Ami and the writer as like *S. pennatus*=*S. mucronatus.* The best specimens were collected by Mr. E. Ardley, and are now in the Redpath Museum. The shell differs from the long-hinged Marcellus variety of *S. pennatus* in having a wider ventral hinge area and no distinct bilobation of the ventral medial fold, characters in harmony with *S. macra.* It is closely related to *S. pennatus,* but more directly with *S. macra,* and is considerably removed from *S. cumberlandiae,* of the Oriskanian. There is no shell in the Helderbergian with which it can be compared.

Spirifer cfr. *granulosus* (*Conrad*).

Associated with *S. macra,* there is a more rotund species, with high, slightly incurved ventral area, angular sinus, and prominent dental plates. These are characters associated with *S. granulosus.* At present none of the specimens of this species are at hand, and no identification can be made. However, it undoubtedly belongs to a species in the Middle Devonic.

CONCLUSION.

The foregoing evidence shows clearly that two distinct faunas are represented on Saint Helen's island,—one, the Helderbergian, older than the agglomerate, and another, from a block in the agglomerate, of Middle Devonic age.

The Helderbergian fauna is apparently related with that of New York, and belongs to the facies occurring on the western side of the Appalachian folds. The writer has collected this fauna at Dalhousie, New Brunswick, and from the Gaspé region, Quebec, and both are of another facies and belong to another basin.

The presence of *Rhipidomella* recalling *R. musculosa; Spirifer concinnus;* an early variety of *S. murchisoni; Spirifer* n. sp., connecting phylogenetically *S. concinnus* and *S. arenosus; Camarotoechid pleiopleura; Gypidula pseudogaleata, and Rensselaeria aequiradiata,* show that the Saint Helen's Island Helderbergian is not as old as the New Scotland zone. *Spirifer concinnus,* and especially *G. pseudogaleata* and *R. aequiradiata,* are characteristic Becraft zonal species. However, the

Oriskanian reminders, like, *R.* near *musculosa, S. murchison, S.* near *arenosus,* prove that the Saint Helen's Island Helderbergian is pretty well up towards the top of the New York section, and may represent both the Becraft and Kingston zones.

Spirifer macra and *S. granulosus* establish the fact that, in the region of Montreal, there was once a formation of marine origin later than the Helderbergian and as recent as the Onondaga* (Corniferous); further, that the agglomerate of Saint Helen's Island and other places about Montreal is not older than late Middle Devonic time. Its age is probably more recent, and there may be further paleontologic evidence in the agglomerate.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Calcareous Concretions of Kettle Point, Lambton County, Ontario. By Reginald A. Daly. *(Jour. Geol., 8,* 135-150.)

The concretions occur in a horizontally bedded, fissile, black, bituminous shale of middle Devonian age. They are approximately spherical; one to three feet in diameter, and possess a radial crystalline structure. An analysis of one of the concretions shows 88.42 per cent. of calcium carbonate, only 2.99 per cent. of magnesium carbonate, and the remainder consists of iron oxide, insoluble residue, hydrocarbons and water. The most remarkable feature is the mechanical displacement and deformation of the enclosing shales which the growth of the concretions has involved. The pressure or "live force" of the growing concretions or aggregate of spherical radiating crystals has even been sufficient to induce a true slaty cleavage in the shale at some points. The main thesis of the author is to demonstrate that this great centrifugal pressure is compatible with the persistence of the capillary film investing the growing crystal or concretion and without which its continued growth would be impossible. The explanation, which, it would seem, must be generally accepted, is based upon the experiments of Jamin leading to the conclusion that equilibrium may exist between two unequal pressures affecting the ends of a capillary tube, provided a column of liquid occupying the tube be interrupted by bubbles of air. The presence of the latter excites capillary attraction which is so strong as to take up several atmospheres of pressure applied at one end of the tube. The force so expended is represented in the compression of the air bubbles and in changing the form of the air menisci; surface tension is thus overcome. The movement of the bubbles progressively decreases in the direction of the greater pressure until one is reached which is not disturbed at all so long as the pressure remains constant. The bubbles act like so many buffers. Any capillary tube filled with water interrupted by any insoluble gas or liquid possessing a lower surface tension than water, will exhibit the same phenomenon. W. O. C.

The Granitic Rocks of the Pike's Peak Quadrangle. By EDWARD B. MATHEWS. *(Jour. Geol., 8,* 214-240.)

The granites are regarded as of late Algonkian age; and four types are recognized, differing markedly in texture but agreeing closely in mineral and chemical composition. They are typical biotite granites, in which hornblende rarely occurs; and a mechanical analysis of the coarse Pike's peak type gave: quartz 33.4 per cent; microcline, 53-3; biotite and all minerals with specific gravity above 3.0, 10.7; and oligoclase, 2.6; total, 100.00. The petrographic descriptions are accompanied by tables showing for the different types the relative abundance of the sixteen component minerals, and the relative size and development of the three essential constituents. Strangely enough, fluorite, which occurs in three of the four types and is very marked in the Summit type, is not mentioned as a constituent of the Cripple Creek type, notwithstanding its prominence as a feature of the Cripple Creek ore deposits. Another table gives the chemical composition of all but the Cripple Creek type, in four of Hillebrand's complete and careful analyses, with determinations of seventeen constituents. When the individual analyses and their average are reduced to molecular proportions and compared with analyses of other granites, the Pike's Peak granites are seen to be exceptionally rich in silica and potassium, as well as in fluorine; and the family likeness of these types suggests their origin in a common magma relatively rich in the elements named. Although this tends to make the relative ages of the types of little moment, it may be noted that on page 223 the Pike's Peak type is described as clearly the oldest; while on page 228 this distinction is assigned to the Summit type. The reviewer's observations in this field suggest the advisability of regarding the Pike's Peak type as the normal granite of the batholith; the Summit type and the Cripple Creek types as representing a once-continuous contact zone of the batholith, in which the remnants of the Algonkian cover chiefly occur; and the fine-grained type, which occurs only as dikes in the other types, representing residual magma intrusive in shrinkage and other cracks. According to this view the contact-zone types are the oldest and the fine-grained or dike types the youngest, while the Pike's Peak or normal type is intermediate, having solidified after the contact zone by which it is covered and before the dikes by which both it and the contact zone are intersected. As might be expected, the gneissoid phase is chiefly characteristic of the outer or border portions of the massif.

W. O. C.

Geology of the Little Belt Mountains, Montana, with notes on the Mineral Deposits of the Neihart, Barker, Yogo and other Districts. By WALTER HARVEY WEED. *Accompanied by a Report of the Petrography of the Igneous Rocks of the District.* By L V. PIRSSON.

(*Twentieth Annual Report U. S. Geol. Survey.* Part III pp. 257-581. With 42 plates and 43 figures.)

The stratigraphy represents the same general conditions that are found in the rest of the eastern part of the Rocky mountain area of this state. One feature of especial importance is shown in the Little Belt area, namely, the overlap of the Cambrian beds from the Algonkian in the south to the Archean in the north.

The present structure and altitude of the Little Belt mountains are due to an uplift and folding of the range as a whole, accompanied by a contemporaneous intrusion of large igneous masses producing minor folding and faulting. The principal peaks are igneous and present a variety of types. Sheets, laccoliths, and bysmaliths are found, all three forms grading into one another. Mr. Weed discusses at some length the origin of such intrusions, concluding that in this region the form is a function of viscosity of lava, of resistance of overlying beds, and of the ascensive force.

At least two periods of igneous activity preceded the uplift of the range. The uplift was accompanied by a third period of activity, which was immediately followed by the formation of fissure veins in which the ore deposits occur. Inferentially these ores are believed to be post-cretaceous. Secondary enrichment has played an unusually important part in the development of some of the ores.

Professor Pirsson's report embraces a detailed description of the petrography of the region, and a discussion of analysis and of estimated mineralogical composition. He classifies the igneous rocks into four groups:

a. Granular nonporphyritic rocks, of plutonic origin, including syenites, monzonites, diorites and shonkinites. Yogo peak shows, as part of a single geologic mass, monzonite grading into syenites on the one hand and into shonkinite on the other. This connection is interesting in that it exhibits in the field the grouping which Brögger has suggested on theoretic grounds. Monzonite is not uncommon in the west, appearing in company with either more feldspar or more basic types, and represents the portion of mean composition in a differentiated complex.

b. Acid feldspathic porphyries, the predominant rock of the laccoliths and of a considerable portion of the dikes and sheets. These rocks present many transitions, the transitional masses being often of more importance locally than the commonly known types.

c. Lamprophyres, occurring in small dikes and sheets, and including minettes, vogesites, and analcite basalts. Variolitic facies, shown by some of the minettes of this region, is described as of a spherulitic nature. In this interpretation the author agrees with that of Pohlmann for the variolitic facies of the kersantites of Thuringia, and differs from the general explanation of the structure offered by Rosenbusch in his text-book. These minettes afford no evidence of the action of absorbed aqueous vapors, as described by Cross and by Iddings for spherulites in acid glassy rocks.

d. Effusive rocks, consisting of two flows of basalt.

The average composition of all the rocks described is calculated to be that of an acid syenite approaching a monzonite in character. The rocks of the laccoliths here, as nearly everywhere in the Rocky mountain region, are usually porphyritic and acid. They are typical examples of Rosenbusch's granitic porphyritic dike rocks, which are here typically laccolithic. The phenocysts appear to have been formed where they now are, and in no case to have been brought up from greater depths. No differentiation has been noted in the laccoliths. Yogo peak and the porphyries east of it are examples of differentiation in place, the centre of the mass being acid and the periphery basic. The tendency is here shown for acid rocks to be porphyritic, and basic rocks under the same conditions, granular. Chemical composition, not depth of intrusion, is seen to be the determining factor of granularity.

Numerous small syenite-aplite dikes cut the Yogo mass. They represent the acid residuum forced up into the fracture planes of the upper and previously solidified rock.

The report closes with a discussion of magmas by graphic methods, and of absorption of sediments by magmas. The chemical compositions of the Yogo peak rocks are shown to bear a mathematical relation to one another, which points to a common origin.

This area presents no facts in favor of the view that large amounts of sediments may be absorbed by magmas and produce alterations in composition of igneous rocks. I. H. O.

Notes on the Limestones and General Geology of the Fiji Islands, with special reference to the Taw Group. Based upon surveys made for Alexander Agassiz. By E. C. ANDREWS. (*Bull. Mus. Comp. Zool. of Harvard College. Geol. Survey,* vol. v, No. 1. Pp. 1-46; with 40 plates.)

This paper represents a more careful examination of some of the problems suggested to Mr. Agassiz in his exploration of Fiji in the winter of 1897-8. Further results brought in by the W. S. F. C. S. "Albatros," yet remain to be worked up. Mr. Agassiz expects shortly to publish a final report upon the islands.

The present paper consists of careful descriptions of the different beds accompanied by excellent illustrations and maps. The islands are a group of atolls which in Tertiary, and again in recent time, were subject to volcanic activity. The limestones are indurated in some localities and soapstone is found. There is a decided excess of igneous over calcareous rock. I. H. O.

Contributions to the Geology of Maine. By H. S. WILLIAMS and H. E. GREGORY. (*Bul. U. S. G. S.* No. 165.)

A report upon the fauna of Maine was greatly to be desired for purposes of comparison between the typical forms of New York and of Canada, and also as a basis of correlation between American and European Paleozoic phases. This paper deals with sedimentary areas in Somerset and Aroostook counties, and with the Aroostook volcanic area.

Part I, by Dr. Williams, deals with the Paleozoic fauna. He describes the fossils from various formations, giving good illustrations, but reserves more detailed descriptions for future publication. In this paper he discusses especially phylogeny and variation. The boundary between Silurian and Devonian was first described in the Welsh series in which transition was from calcareous sediments with a marine fauna to sandstone with brackish fauna. Dr. Williams now determines this boundary for America. The Lower Helderberg in the interior is closely related to the succeeding fauna, because there was no radical disturbance in the marine conditions. It is the Oriskany fauna that shows evidences of a disturbance which ended in uplifting large areas of marine surface; and this formation is to be correlated with the Gedennian of the Rhenish provinces, and with the base of the Old Red sandstone of Great Britain. Thus the Lower Helderberg is to be located positively as Silurian, in spite of the Devonian relationships of its New York fauna. The Gaspé and Square Lake limestones of Maine both contained evidence of New York Lower Helderberg fauna, and both occur below the Devonian boundary line.

It is to be regretted that Dr. Williams does not institute a comparison between the Upper Helderberg fauna and that of the Ludlow beds of England, which represent the typical Upper Silurian as defined by Murchison and Sedgwick. Since the Siluro-Devonian boundary may now be regarded as established for both countries, a comparison between the faunas of equivalent beds would be of interest.

Part II, by Dr. Gregory, deals with the volcanics and clastics of the Aroostook country. Northeastern Maine is essentially a region of sedimentary rocks, yet such igneous rocks as there are, present a number of well defined types, and considerable variation in character. Dr. Gregory discusses fully the general nature, field relations, petrography, and chemical composition of the volcanics. The clastics are classified on a petrographic basis and mapped from this standpoint, their stratigraphic relationships being left until further evidence is obtained. The structure and history of the region as a whole are not touched upon.

Part III consists of a list of localities where outcrops were found, and is a most useful addition to a work of this sort. I. H. O.

Geology in its Relations to Topography. By T. C. BRANNER. With Discussion and Correspondence, *Trans. Amer. Soc. of Civil Engineers,* XXXIX., pp. 54-95.

Complaints are often heard from geologists of the inaccuracy of maps. Mr. Branner strikes at the root of this matter in showing the necessity of geological knowledge for a successful topographer. There is at present no physiographical text book adapted to the needs of engineers and it is to be hoped that some expert in geology or geography will soon meet this demand. Mr. Branner's paper contains a short account of some of the simplest physiographic features and supplies in untechnical language valuable information in regard to a few of the problems which confront engineers. I. H. O.

Researches on the Visual Organs of the Trilobites. By G. LINDSTROM. Six Plates. (*Kongl. Svenska Vetenskaps Akad. Handl., Bd.* 34, *No.* 8.)

This is a most important contribution to the biology of the trilobites. First, because it challenges proof of the presence of eyes in many species that are supposed to have had visual organs, denying that the structures that have been taken as such are eyes. And secondly because it announces the discovery of true eyes on the hypostonæ of many species.

Lindström claims that the assumption that because a trilobite had an "eye lobe" it therefore had eyes is quite without foundation, for he teaches that this "eye lobe" is due to the impact of the free-cheek at this point with the inner cheek, and he states that in a number of species which he has examined there is no space for an eye between the two pieces of the head shield which there come in contact. The oldest genera with true eyes on the cephalic shield, which he recognizes, are such of the Upper Cambrian, as Petiera Sphœrophthalmus and Ctinopyge. In the Ordovician, Silurian and Devonian, the genera in which true eyes exist on the head shield, are multiplied. There is an interesting discussion on the origin of the facial suture with applications in Olenellus, Paradoxides, Liostraeus, Solmopleura, etc. He does not recognize the presence of eyes or a suture in Agnostus.

Most interesting to palæontologists is the announcement that the tubercles or, as Mr. Lindström calls them, the "maculæ" in the anterior furrow of the hypostome, as seen in many species, had ocular properties. Not only by the thinness of the skin over these spots, but by the actual presence of lenses in them, has he proved that the maculæ in many species possess this office. This discovery of this condition of the maculæ was made by his draftsman and assistant, Herr G. Liljevall. Many trilobites, it would thus appear, had eyes below as well as on the upper side of the headshield.

This important memoir is fully illustrated with six admirable plates and several text figures; in the former the admirable handiwork of Herr Liljevall is patent.

That this work is founded on abundant material may be assumed when it is stated the hypostomes of thirty-six species of trilobites have been sectioned for investigation. These range from the Cambrian to the Devonian.

Herr Lindström considers that the trilobite eye is best represented in that of Apus and the Isopod. G. F. M.

CORRESPONDENCE.

ON THE AGE OF CERTAIN GRANITES IN THE KLAMATH MOUNTAINS. [Abstract.] Small batholyths and dikes of granite, quartz-mica-dioryte and intermediate types are shown to occur at various places in the Klamath region, but in areas quite subordinate in extent to those of the metamorphic rocks in which they have been intruded. The same region contains extensive areas of serpentine, and instances are given of the granitic rocks having been intruded into the serpentine to prove that the granites are newer, in accordance with the determined relations of these rock types in the Sierra Nevada region, and the reverse of the supposed relation between the granite and serpentine of the Coast ranges.

The black slates of the Klamath region are divided into two distinct series, referred to as the lower slates and the upper slates. The former are considered Devono-Carboniferous in age, being in part equivalent to the Calaveras formation. The latter are correlated, on the evidence of their lithology and their structural relations, to the lower slates and to a certain extrusive greenstone formation of the Sierra Nevada region, with the Mariposa formation of late Jurassic age. The intrusion of granite occurred later than the deposition of these upper slates. Also it is shown that the granites are much older than the Chico formation resting on them as they must have suffered much erosion prior to the Chico epoch.

It is finally concluded that the weight of evidence places the granitic intrusion just about at the close of the Jurassic period. The effect of the agreement is to show that there is a sound basis for the inference heretofore entertained that the Klamath mountains belong rather to the same system as the Sierra Nevada instead of the Coast ranges, and may be considered a sort of out-lier to the former.

Berkeley, Cal. OSCAR H. HERSHEY.

A NATIONAL MUSEUM FOR CANADA. The growth and progress of the work done by the staff of the Geological survey of Canada have reached that point in the history of this classic state institution, which dates from 1842, when the headquarters and museum on Sussex street have become not only over-crowded and limited in accommodation, but also positively unsafe. The mass of specimens displayed has long ago reached its crisis, and special orders from the Honorable the Minister of Public Works have compelled the Museum proper to be lightened as far as possible. Besides this, a large series of wooden posts—in the neighborhood of sixty—have been placed at proper intervals on three floors to act as so many props and supports for the collections of ores, minerals and rocks of economic value, etc., in the Dominion of Canada. The building now occupied by the Staff and Museum is totally inadequate for the requirements of the times. It is practically impossible and unsafe to exhibit any discovery made or record the numerous finds and donations received in a tangible or accessible manner. There are thousands of specimens in the possession of the Geological Department which are rendered quite inaccessible, owing to lack of space, and an effort is now being put forth towards obtaining a suitable and fireproof building in which the products of the earth in Canada, whether as regards its mines, forests, and waters, will be exhibited to advantage.

In looking over the Report of the U. S. National Museum, drawn up by the Acting Assistant Secretary, the Hon. C. D. Walcott, the various divisions and subdivisions of work are given in such a manner as to indicate clearly the line in which it is confidently expected that, at no distant date, the politicians of Canada will see to it that a National Museum will be established at Ottawa, properly equipped, manned and maintained.

It is an urgent necessity that a Central Bureau of *scientific,* in other words, *exact* information exist, where not only reports upon all kinds of subjects can be obtained from specialists, but where a record is kept of information gathered and specimens obtained during explorations, researches, and studies, in connection with the natural resources of half a continent.

The incalculable value of the National Museum to the United States has been recognized by Congress, and it is hoped that Canadian statesmen will see that before long a suitable office and museum buildings be erected, and a thoroughly equipped and efficient staff established, so that the wonderful natural resources of Canada may be exhibited to advantage and carefully published for the information of all.

H. M. Ami.

Geological Survey of Canada, Ottawa, Feb., 1901.

MONTHLY AUTHOR'S CATALOGUE

OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

Adams, Frank D.

Memoir of Sir J. William Dawson. (Bull. Geol. Soc. Am., vol. 11, 1899.)

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Adams, Frank D.

On the probable occurrence of a large area of Nephaline-bearing rocks on the northeast coast of lake Superior. (Jour. Geol., vol 8, No. 4, May-June, 1900.)

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An experimental investigation into the flow of marble. (Proc. Royal Soc., vol. 67.)

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Some Salient Features in the Geology of Arizona, with Evidences of shallow seas in Paleozoic time. (Am. Geol., vol. 27, pp. 160-167, March, 1901.)

Claypole, E. W.

Notes on Petroleum in California. (Am. Geol., vol. 27, pp. 150-160, March 1901.)

Cummings, E. R.

Orthotetes Minutus, n. sp., from the Salem limestone of Harrodsburg, Ind. (Am. Geol., vol. 27, pp. 147-150, pl. 15. March, 1901.)

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Geological report on Sanilac county, Michigan, accompanied by 5 plates, 2 figures and one colored map. (Geol. Sur. Mich., vol. 7, part 3, pp. 34.)

Gould, Chas. N.

Notes on the Geology of parts of the Seminole, Creek, Cherokee and Osage Nations. (Am. Jour. Sci., vol. 2, p. 185, March, 1901.)

Gratacap, L. P.

Note on an interesting specimen of Calcite from Joplin, Mo. (Bull. Am. Mus. Nat. Hist., vol. 13, 1900, p. 95, pl. 6.)

Gregory, J. W.

The plan of the earth and its causes. (II.) (Am. Geol., vol. 27, pp. 134-147, March, 1901.)

Hatcher, J. B.

The lake systems of southern Patagonia. (Am. Geol., vol. 27, pp. 167-174, pl. 17, March, 1901.)

Heilprin, Angelo.

The shrinkage of lake Nicaragua. (Bull. Geog. Soc. Philadelphia, vol. 3, Jan., 1901, pp. 1-12.)

Heilprin, Angelo.

Volcanic phenomena of Hawaii. (Bull. Geol. Soc. Am., vol. 12, pp. 45-56, pls. 2-5.)

Hitchcock, C. H.

The water supply of lake Nicaragua. (Bull. Geographical Soc. Philadelphia, vol. 3, Jan., 1901, pp. 12-20.)

Hollick, Arthur.

A reconnoissance of the Elizabeth Islands. (Annals New York Acad. Sci.'s vol. 13, No. 5, pp. 387-418, pls. 8-15.)

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The relation between forestry and geology in New Jersey. (Ann. Rep. State Geologist of N. J., 1899.)

Hollick, Arthur.

Fossil plants from Louisiana. (Contributions Geol. Dept., Col. University, vol. 9, No. 67.)

Kemp, J. F.

The re-calculation of the chemical analyses of rocks. (School of Mines Quarterly, No. 1, vol. 22.)

Kemp, J. F.

Pre-Cambrian sediments in the Adirondacks. (Annual address of Pres. Sec. E. Am. Association for the Adv. Sci., vol. 49, 1900.)

Lane, Alfred C.

Geological report on Huron county, Michigan, accompanied by 11 plates and 12 figures including two colored maps. (Geol. Sur. Mich., vol. 7, part 2, pp. 330.)

McCallie, S. W.

Preliminary report on a part of Iron Ores of Georgia, Polk, Barton and Floyd counties. (Bull. No. 10-A, Geol. Sur. of Georgia, pp. 190, map and 6 plates.)

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Some notes on the Trap Dikes of Georgia. (Am. Geol., vol. 27, pp. 133-134, pls 12-14, March, 1901.)

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An experimental investigation into the flow of marble. (Proc. Royal Soc., vol. 67.)

Prosser, Chas. S.

Sections of the formations along the northern end of the Helderberg plateau. (From the 18th annual report of the State Geologist of New York.)

Prosser, Chas. S.

Names for the formations of the Ohio Coal measures. (Am. Jour. Sci., vol. 11, p. 191, Mar., 1901.)

Sherzer, W. H.

Geological report on Monroe Co., Michigan, accompanied by 17 plates and 8 figures including 3 colored maps. (Geol. Sur. Mich., vol. 7 part 1, pp. 240.)

White, Theodore G.

Report on the relations of the Ordovician and Eo-Silurian rocks in portions of Herkimer, Oneida and Lewis counties. (Contributions from Geolog. Dept. Col. Univ., vol. 9, No. 66.)

White, Theodore G.

Upper Ordovician faunas in Lake Champlain valley. (Bull. Geol. Soc. of America, vol. 10, pp. 452-462.)

Whitfield, R. P.

Observations on and descriptions of Arctic fossils. (Bull. Am. Mus. Nat. Hist., vol. 13, 1900, No. 19, plates 1 and 2.)

Whitfield, R. P.

Description of a new Crinoid from Indiana. (Bull. Am. Mus. Nat. Hist., vol. 13, 1900, pl. 3, p. 23.)

Winchell, N. H.

Glacial lakes of Minnesota. (Bull. Geolog. Soc. Am., vol. 12, pp. 109-128, pl. 12.)

PERSONAL AND SCIENTIFIC NEWS.

Mr. H. E. Gregory has been promoted to be assistant professor of physical geography at Yale University.

Dr. W. B. Scott, professor of geology in Princeton University, expects to leave for South America, especially for Patagonia, in May.

Mr. E. J. Garwood has been appointed to the Yates Goldsmid chair of geology and mineralogy at University College, London, to succeed Prof. T. G. Barney.

Geological Society of Washington. At the meeting of March 13th, the following was the program: "The Soil Survey of Cecil county, Maryland," by C. W. Dorsey; "Discussion of geologic units: formation, stage and age," by Bailey Willis, H. S. Williams and others.

Geological Society of Washington. At the meeting of March 27th the program consisted of the conclusion of the discussion of geological units, by Messrs. H. S. Williams, C. R. Van Hise, T. C. Chamberlain and others.

Mr. James Bennie, formerly of the Geological Survey of Scotland, died on January 28th. He contributed papers to the Transactions of the Geological Societies of Edinburgh and Glasgow, and two years ago was awarded the Murchison fund by the Geological Society of London.

Geological Survey of Great Britain and Ireland. Mr. J. J. H. Teall, president of of the Geological Society of London, has been appointed director to succeed Sir Archibald Geikie, who retired on February 28th after 46 years of service on the Survey.

School Science is the title of a new journal devoted to science teaching in secondary schools. It is edited by C. E. Linebarger and published at Unity building, Chicago. There is a corps of associate editors, among whom are E. C. Case (Geology) and Wm. H. Snyder (Geography).

Thomas Benton Brooks died on Nov. 22, 1900. Major Brooks was a well-known worker in American geology, and the work for which he will be most frequently praised is that which he did in the iron districts south of lake Superior. In *Science* for March 22nd Mr. Bailey Willis gives a sketch of Major Brooks.

Dr. Robert Bell, M. D., L.L. D., F. R. S., F. G. S. has been appointed director of the Geological Survey of Canada, *vice* G. M. Dawson, deceased. It is understood that Dr. Bell will soon be officially gazetted as "director" of the Canadian

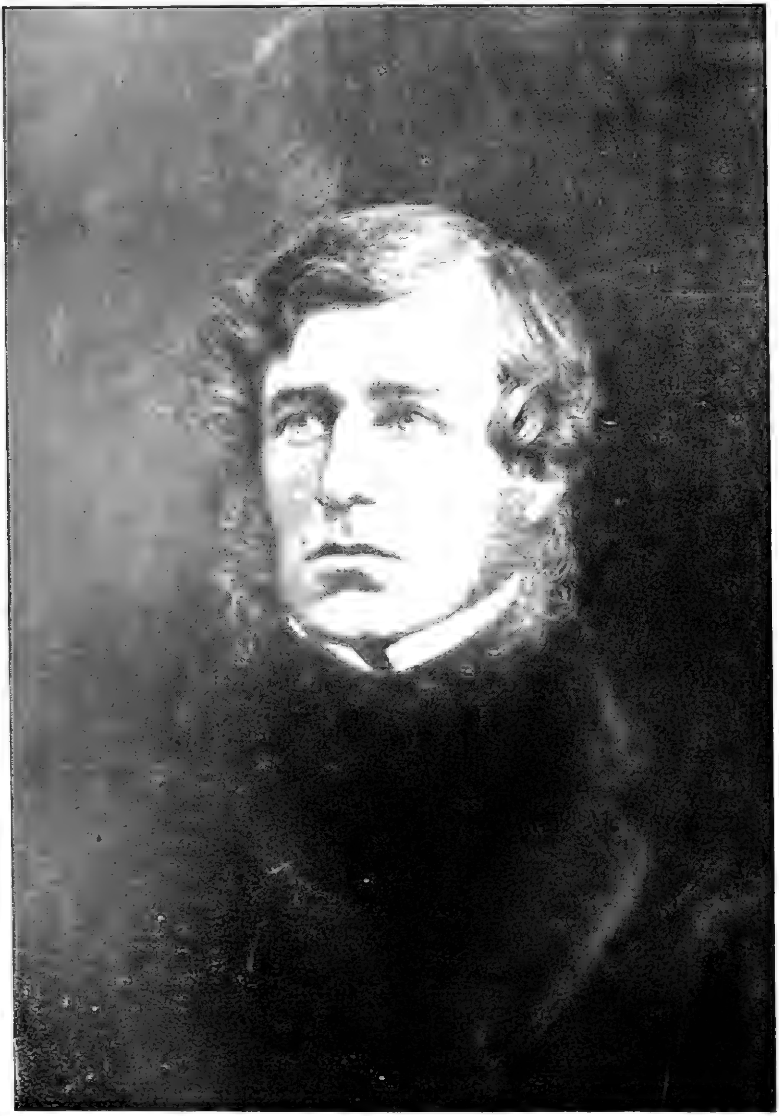
Survey, on which staff he has been engaged for upwards of forty years.

On Saturday, March, 2d, 1901, at the hour of 6:05 P. M., Dr. George M. Dawson, C. M. G., F. R. S., F. G. S., etc., member of the Geological Survey of Canada since 1875, and its able and distinguished director since 1895, died of capillary bronchitis, resulting from a slight cold. He had been attending to his official duties with the usual vigour and enthusiasm up to a late hour Thursday, Feb. 28th, only one day of twenty-four hours intervening before death came. A notice of his life and works will appear later.

THE CERRILLOS ANTHRACITE MINES.—We have, or are supposed to have, so little anthracite coal in the West that a veritable anthracite coal mine is a novelty of especial interest. Such we heard of being near Cerrillos Station in New Mexico, and in a recent visit to that country we stopped off to examine it. We were surprised to find not only a well and deeply developed mine, but a coal village around the works of many substantial houses and numbering some 500 to 800 inhabitants, with an extensive plant and a large coal breaker of thoroughly eastern or Pennsylvania pattern.

The Cerrillos mountains are a small group of hills some 50 miles north of Albuquerque city, New Mexico. They are formed of a central core of eruptive porphyritic rock surrounded by a series of uptilted sandstones of the Laramie Cretaceous coal-bearing series. Into these strata many dikes and intrusive sheets of porphyryte have been intruded, emanating from the parent core. The heat from these eruptive sheets, when they have come near enough to the coal, has metamorphosed the coal into anthracite. Coal beds not so influenced in the same region remain unchanged as bituminous coal, consequently there are two classes of coal worked near one another. One a four foot six inches seam of bituminous coal and another, some 50 to 75 feet below, of three feet six inches to four feet of anthracite overlain by a thick intrusive sheet of eruptive porphyrytes.—*(Mines and Minerals.)*

THE PALAEONTOGRAPHICAL SOCIETY announces that monographs of the following groups of fossils are in course of preparation, and will be published by the Society: the Carboniferous Lepidodendra, by Dr. D. H. Scott; the Cycadeæ, by Mr. A. C. Seward; the Graptolites, by Prof. Lapworth, assisted by Miss Elles and Miss Wood; the Fishes of the Chalk, by Dr. A. S. Woodward; the Reptilia of the Oxford Clay, by Dr. C. W. Andrews; and the Cave Hyæna, by Mr. S. H. Reynolds. The volume issued by the Society for 1900 contains the Cretaceous Lamellibranchs, by Mr. H. Woods; the Carboniferous Lamellibranchs, by Dr. W. Hind; and the Carboniferous Cephalopods of Ireland, by Dr. A. H. Ford. *(Nature.)*



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BRIEF BIOGRAPHICAL SKETCH OF ELKANAH BILLINGS.

Palaeontologist to the Geological Survey of Canada from 1856 to 1876.

By HENRY M. AMI, Ottawa, Canada.

The late Elkanah Billings, who for twenty years was paleontologist to the Geological Survey of Canada, and was the founder of the Canadian Naturalist and Geologist, was born in the township of Gloucester, along the right bank of the Rideau river in the old, and now demolished Billings homestead situated a few yards below the present bridge which spans that river at the little village of Billings' Bridge. He was the second son of Mr. Bradish Billings, whose ancestors came from England, while those on his mother's side came from Wales. His grandfather was a Brockville physician, Dr. Elkanah Billings, after whom the subject of this sketch was named. Both his parents, however, were born in the United States, his father in Massachusetts, and his mother in New York state.

From Dr. Whiteaves' obituary notice of Elkanah Billings the following extracts are made:

"Elkanah Billings, our esteemed associate for so many years, was born at the family homestead on the 5th of May, 1820. His first teacher was a governess (Miss Burrit), his next a family tutor named Maitland, and he afterwards went to three small schools in the neighborhood, kept respectively by Messrs. Colquhoun, Collins and Fairfield. In 1832 the youth was placed at Rev. D. Turner's school in Bytown, as a day pupil and after four years' interval, during which he remained at home on the farm, his parents sent him, in 1837, to the St. Lawrence Academy at Potsdam, in the state of New York, of which the Rev. Asa Brainard was principal.

On leaving this institution Mr. Billings entered the Law Society of Upper Canada as a student in 1839, and was articled to Mr. James McIntosh, a barrister in Bytown. Mr. McIntosh died in the same year and was succeeded by Mr. Augustus Keefer, with whom Mr. Billings remained for nearly four years; and it appears that he was for a short time also in the office of the late Mr. George Byron Lyon Fellowes in the same town. In 1843 he went to Toronto, and studied for a twelve-month longer with the legal firm of Baldwin & Wilson, and was admitted to practice as an attorney in the fall of 1844. Soon after this he returned to Bytown and entered into partnership with Mr. Christopher Armstrong, who was then one of the judges of the county court, but a law having been passed prohibiting judges from pleading, the partnership was dissolved after having lasted only six months."

In 1845 Mr. Billings married a Toronto lady, a sister of the Hon. Judge Adam Wilson. Between 1845 and 1848, he practiced law in Bytown, having been called to the bar in 1845; in 1849, however, he removed to Renfrew where he practiced his profession until June, 1852, when he returned to Bytown, where most of his time was engaged in journalistic and scientific pursuits. He occupied the editorial chair of *The Citizen* from the fall of 1852 until late in 1855. Many of Mr. Billings' leading articles in the *Citizen* of those days comprised popular disquisitions on geological topics and natural history subjects, which served to indicate the trend of thought of the man whose subsequent life led him into inquiries of the highest scientific type, whose writings are now held in highest esteem and well known the whole scientific world over. It was during these years of his residence in Bytown that he began the systematic study of the fossiliferous rocks which are so extensively developed along the banks of the Ottawa river in the vicinity of our city.

Probably at first entered upon more as a pastime and relaxation from his journalistic duties these researches culminated in his final adoption of geological studies, especially in the department of fossil organic remains, for the remainder of his life.

The magnificent collections of Crinoidea, Cystoidea and Asteroidea from the Trenton limestone of Ottawa, that are now exhibited in the museum of the Geological Survey of Canada, testify to his remarkable success and energies in these researches, for it must be remarked that these organisms are exceedingly rare and great diligence as well as patience must be exercised if satisfactory results are to be obtained.

Early in 1856 Mr. Billings issued the first number of the *Canadian Naturalist* of which, and the succeeding numbers of the first volume, he was practically the sole contributor. The production of this number marks an epoch in the history of the progress of scientific research and discussion in Canada. The articles contained in the first volume of the *Canadian Naturalist and Geologist* at once stamp Mr. Billings as a master in description both of fossil organic remains and of recent natural history objects.

Previous to the issue of this magazine, Mr. Billings had been brought into direct communication with Sir William Logan, then director of the Geological Survey of Canada, and it was not long, yea, but few months elapsed, until the latter with his usual clearsightedness engaged the services of Mr. Billings, his friend, as paleontologist to the Geological Survey of Canada. It was in August, 1856, that Mr. Billings entered upon his duties as government paleontologist and, until his death, which took place June 14, 1876, a period of nearly twenty years elapsed in which he worked ceaselessly in the domain of paleontology, and in assisting his chief and director in assigning geological outcrops to the various geological horizons of eastern Canada, involving numerous and difficult problems which made it a task of no mean importance.

His first geological paper was published in April, 1854, and was entitled "On Some New Genera and Species of Cystidea from the Trenton Limestone." It was published in the Canadian Journal, Toronto, page 215. On removing to Montreal in 1856, Mr. Billings removed also the headquarters of his magazine. *The Canadian Naturalist and Geologist*, from that date on was published in Montreal under the same designation and under the name of *Canadian Naturalist and Q. J. So.*, until 1883, when it was superceded by the *Canadian Record of Science*, and became the recognized official organ of the Natural History Society of Montreal. Of this society he was regularly elected a vice president for 14 years, having declined the office of president, proffered to him on many occasions.

In 1858 Mr. Billings made a visit to Europe, where he came in contact with leading geologists of the time and examined various collections in geology in Great Britain. These he studied most zealously and made a comparison of the Silurian (including both the lower and upper Silurian of Murchison) and Devonian fossils of western Europe, with those of Canada, and arrived at the conclusion that there were but few species identical with those of Canada. In April, 1858, when in London, he was elected a fellow of the Geological Society of London; Sir Roderick Murchison, Professor A. Ramsay and Professor T. H. Huxley, having nominated him. He visited Paris where he met a number of distinguished men, amongst others the great Bohemian paleontologist, the Abbe Joachim Barrande, with whom and in conjunction with Sir William Logan, a most interesting discussion arose regarding the age of several rock formations occurring in the province of Quebec, to which Sir William Logan gave the name "Quebec Group"—a controversy which included many difficult problems of which the "Taconic Question" was a conspicuous factor.

The term "Quebec Group" will invariably be associated with the excellent work performed by Sir William Logan and Mr. E. Billings.

In 1854, two years before his appointment on the Geological Survey staff, Mr. Billings accompanied Mr. James Richardson in an examination of the fossiliferous rocks of Point Levis, Que.; in the following year he also accompanied the same field geologist in his explorations at Point Levis, Que., and Thetford, in the township of Bosanquet, County of Lambton, Ontario.

Of Mr. Billings' work prior to 1863, Sir William Logan gives the following succinct account on page 7 of the "Preface" in his "Geology of Canada," published in 1863:

"Mr. Billings was appointed paleontologist to the survey in 1856 and since then his unremitting attention has been devoted to the study of the palaeozoic fossils of Canada, of which very considerable collections have been made in our various explorations.

"Of these fossils he has described in the publications of the survey and in the scientific journals of the province; 526 species, of which 395 are Lower Silurian, 67 Middle and Upper Silurian, and 64 Devonian.

"He has thus greatly facilitated the means of determining with precision the limits and distribution of our geological formations, and of the economic substances which they contain. In order to insure uniformity in the paleontological part of this work, all the palaeozoic fossils mentioned in it have been submitted to the inspection of Mr. Billings, and the species are therefore all given on his authority. Of the described Lower Silurian species found in Canada, not including those of the Quebec group, he has prepared a catalogue, showing their vertical distribution, and referring to the publications in which the descriptions and figures will be found. This catalogue has been introduced into the appendix to this volume."

Then after a brief sketch of the early studies made by himself in the "Quebec Group" of rocks, Sir William points out what part Billings played in the unravelling of that interesting succession of palaeozoic sediment. He goes on to say: "But the discovery in May, 1860, of the Point Levis fossils at once enabled Mr. Billings to conclude that the rocks of the Quebec group must be placed near the base of the second fauna of Barrande or about the horizon of the Calciferous and Chazy formation. This opinion, our subsequent investigations in the neighborhood of Lake Champlain, and of the Strait of Belle Isle, have completely borne out, and there now remains little doubt that the attitude of the rocks in question in the vicinity of Quebec is due to a great overlap, which runs from southwest to northeast through the whole length of the eastern part of the province, and extends in both directions far beyond it."

The above serves to show clearly the remarkable work done by Billings in that most difficult field east of the great Champlain, St. Lawrence or Appalachian fault.

His critical eye detected differences where they had not been seen and by his knowledge the vertical range of fossil remains was firmly established.

Notwithstanding all the attacks that have been made upon the validity of the term "Quebec Group," and the discussions on its significance, it is as truly a natural group or division in the succession of paleozoic sediments in eastern Canada today as it was in the 50's and 60's, and the chapters devoted to this most important study in the "Geology of Canada" for 1863, are replete with wisdom and forethought.

On several occasions Mr. Billings made extensive collections in the Silurian as well as in the Devonian formations of Ontario and in the vicinity of Montreal, as can be seen from the collections now in the geological department, but the bulk of his time was devoted to the determination of geological horizons for mapping purposes and the description of new genera and species brought in to the department by the various field-geologists. Of genera new to science, Mr. Billings described no less than 61 and in all described 1,065 new species of fossil organic remains from various horizons in the paleozoic of Canada. He also contributed many papers on natural history and zoology.

He did much in assisting Sir William Logan to establish and build up the geological museum, for, besides the large number of new species which he described, he identified as many more, from Canada, with forms previously described by Conrad, Hall, Emmons, Vanuxem and Sowerby, and other paleontologists of America and Europe.

His writings indicate a clear and precise mind, coupled with a rare judgment; they are couched in a phraseology simple but to the point. He published upwards of 170 distinct papers, memoirs or reports, many of which are now very difficult to obtain or entirely out of print. The bulk of his writings are embodied in the reports of the Geological Survey of Canada, comprising the figures and descriptions of "Canadian Fossil Organic Remains," or Decades 1, 3 and 4; the "Paleozoic Fossils," Vol. 1, parts 1 to 5; Pal. fos., Vol. 2, part 1; part 2 of which last is still unpublished. While residing in Montreal he was a constant contributor to the Canadian Naturalist, he also wrote important papers for the *American Journal of Science and Arts,* New Haven, the *Geological Magazine,* London, and the *Journal of the Canadian Institute,* Toronto.

He was an indefatigable worker; from early morning till late at night he was at his desk, and later at home into the hours of night he carried on his studies, and thus accomplished much in those twenty years of official connection with the Geological Survey of Canada.

Billings left behind him a large amount of unfinished work, numerous and important lists of organic remains bearing upon the geology of the older provinces. Many of these lists would form most important contributions to Canadian geology, should they ever be published. As noted by Dr. Whiteaves in his obituary sketch and *In Memoriam* paper, Vol. 8, No. 5, *Canadian Naturalist and Quarterly Journal of Science*, p. 261, "Mr. Billings died before he could describe the whole of the material he had studied and carefully examined, including collections by Sir William E. Logan and Professor (now) Dr. Robert Bell, in Gaspe, by Mr. T. C. Weston, at Arisaig; T. Curry, at Port Daniel and Bay of Chaleurs. The whole of the material from these localities had been carefully examined, and it only remained to write the descriptions of the different species, but this, alas, he was not destined to accomplish." Those who had the pleasure and privilege to know Mr. Billings, state that he was characterized "by great firmness and decision and an unswerving love of truth and justice, and by an unaffected and winning modesty of demeanor."

During his lifetime Mr. Billings received many tokens of appreciation. In 1867 the Natural History Society voted him its silver medal for "his life-long efforts for the promotion of science in Canada." He was awarded a bronze medal (in Class I.) by the jurors of the International Exhibition of London in 1862, and a similar one at the Paris Exposition of 1867.

To do him honor and indicate to the world of science what Billings did for Canadian geology, many a paleontologist in America and Europe has described genera and species after him. The genera Billingsia, Billingsite, Billingsella and Elkania have been erected by Walcott, Hall, Ford and Hyatt, whilst upwards of thirty species of corals, crinoids, brachiopods, lamellibranchs, molluscs, cephalopods, ostracods, trilobites and other fossil organic remains bear his name.

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ORIGINAL MICACEOUS CROSS-BANDING OF STRATA BY CURRENT ACTION.

By J. B. Woodworth, Cambridge, Mass.

The process of sedimentation normally produces layers of uniform texture parallel with the surfaces of the laminae. Bands of different mineralogical and textural characters inclined to the planes of stratification are common in the metamorphic rocks as the result of mineralization of shear zones or of the brecciation and mineralization of shear zones inclined to the original sedimentation planes. The following description relates to a case in which a micaceous banding occurs as an original structure at a high angle with the stratification imitating the dual structure of some metamorphosed sediments.

The Fitchburg railroad one and a half miles east of Concord, Mass., occupies a deep cut through a rude glacial sandplain which encloses lake Walden. In a side cutting in this excavation, the writer observed in 1898 a bed of fine, brown glacial sand about one foot thick sharply demarcated from clays and sands above and below by certain peculiarities of structure and texture. This layer was very regularly beset by current-mark with westward facing steeper fronts, indicating the drifting of the sediment in that direction during deposition. The crests of the ridges were regularly superposed, each successive layer having its crests at regular intervals somewhat advanced to the westward upon the underlying one, giving a crest plane inclination for the series of about 45° east.

The striking feature of the bed was a band of highly micaceous sands forming the frontal slopes of the entire series of crests in the bed as shown in the annexed figure, by the shading.

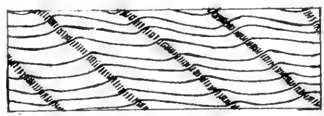

FIG. 1. CROSS-SECTION OF A PORTION OF THE LAKE WALDEN GLACIAL SAND BED, SHOWING A CURRENT MARK WITH MICACEOUS BANDS IN THE FRONTAL SLOPES OF THE CRESTS.

The micaceous bands were about half an inch in width. They dipped 45° east, as stated above, parallel to planes passing through the respective crests. The individual particles of mica lay parallel to the crest slope, producing an obvious false bedding totally distinct from the straticulate structure of normal cross-bedding in relatively homogeneous sands. The micaceous bands were between four and five inches apart.

The type of rippled stratification with which the micaceous banding was associated shows that the banding developed under the action of the vortical movements of the bottom drift of a slowly moving current. In analogy with the observed vortices of a continuous bottom current, my colleague, Dr. Jaggar, suggests the whirling movement of the water must have been as in the annexed figure at the crest of each current mark. (See fig. 2.) In the dead space on the frontal slope, particles of mica which were caught in the bottom movements would come to rest as the deposit grew upward.

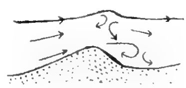

FIG. 2. SCHEME OF VORTICAL MOVEMENTS ABOUT THE CREST OF A CURRENT MARK. THE SHADED SLOPE SHOWS THE AREA ON WHICH THE PARTICLES OF MICA HAVE COME TO REST BENEATH THE NODE JUST IN ADVANCE OF THE CREST. (AFTER SKETCH BY JAGGAR.)

In this connection, it will be recalled that Spurr in this Journal (vol. xiii, 1894, pp. 43-47, 201-206, with discussion by Jaggar, pp. 199-201), described a rhythmic succession in texture parallel to the stratification resembling current or ripple mark, but the textures were pebbly and sandy. In the Minnesota glacial deposit described by Spurr as in this case a cross-banding was produced at about 45° to the true stratification. Of the structure described by Spurr, the writer has seen no examples and is therefore unable to make further comparison of the two cases.

It will be noted that the simulation of the banding of metamorphic schists in the lake Welden case is remarkable, and if the deposit existed as a firmly consolidated, slightly metamorphosed rock, it might be on hasty examination mistaken for an ordinary deposit with its banding induced by the production of new minerals. Where metamorphism and the production of micaceous minerals take place without shearing as in the quartz-albite-biotite rock of the "Devil's foot ledge" in the Carboniferous of Kingstown, Rhode Island, the secondary mica may lie in the original planes of stratification, including those of the cross-bedding. Moreover, it is conceivable that the metamorphism of a bed like that at lake Walden under static conditions without deformation might lead to the retention of the essential arrangement of the original particles. The writer is not aware, however, that any known mica-schists or quartz-mica-schists exhibit evidence of this original distribution of their mineralogical components.

An analogous but not homologous structure exists in the diagonal fissility of Van Hise in certain sheared and mineralized sediments. Thus in the carboniferous gneissoid sandstones of Prudence Island in Narragansett Bay, these bands of compact mineralized layers of arenaceous sediments alternate with thicker layers of finer sediments less mineralized but beset by open planes of diagonal fissility inclined about 45° to the bedding, this secondary structure occupying relatively to the mineral banding the position held by the original bedding planes to the micaceous banding in the glacial deposit above described.

A HISTORICAL OUTLINE OF THE GEOLOGICAL AND AGRICULTURAL SURVEY OF THE STATE OF MISSISSIPPI.*

By E. W. Hilgard,† Late State Geologist, Berkeley, Cal.

The geological and agricultural survey of the state of Mississippi had its origin in an act of the legislature entitled "An Act to further endow the University of Mississippi," approved March 5, 1850, which took effect on the first of June following. This act is worded as follows:

Sec. 1. *Be it enacted, &c.,* that the further sum of three thousand dollars be and the same is hereby semi-annually appropriated, subject to the draft of the President of the Board of Trustees of the University of Mississippi, to be applied by them to the purchasing of books and apparatus, and the payment of the salaries of professors and assistant professors of agricultural and geological sciences in said University; provided that one-half only of the amount of said appropriation shall be from the revenue in the treasury, and the other half shall be made out of the sale of lands belonging to the seminary fund hereafter to be sold as provided by law.

Sec. 2. That the authority required by the State Treasurer for the payment of the trustees, shall be the warrant of the President of the Board of Trustees, drawn in favor of any person whatever.

Sec. 3. That at least one-half of the amount herein appropriated shall be expended in making a general geological and agricultural survey of the State, under the direction of the principal professor to be appointed under the first section of the Act.

* Reprinted from the publications of the Mississippi Historical Society.

†Professor Eugene Woldemar Hilgard was born in Zweibrücken, Rhenish Bavaria, Jan. 5, 1833. He emigrated to America in 1836. After completing his collegiate education at Belleville, Ill., he took the degree of Ph. D., at Heidelberg in 1853. He also studied at Zurich, and at Freiberg, Saxony. The degree of LL. D. has been bestowed upon him by Columbia University, the University of Michigan, and the University of Mississippi. He was state geologist of Mississippi from 1855 to 1873, during which time he filled the chairs of Geology and of Chemistry successively. In 1873 he accepted the professorship of Geology and Natural History in the University of Michigan. After two years' service at this place he went to the University of California as Professor of Agricultural Chemistry and Director of California Agricultural Experiment Station and Dean of the Faculty of Instruction in California. He is at present actively engaged in the discharge of his duty at the University of California, Berkeley, California. In 1860 his *Report on Geology and Agriculture in Mississippi* was published by authority of the State Legislature. This valuable work is still regarded as a standard authority on the geological formations peculiar to Mississippi and the Southwest. In 1880 he directed and edited the work on the report entitled "Cotton Production in the U. S." (10th Census), to which he himself contributed detailed descriptions of the agricultural features of Mississippi, Louisiana and California. In 1894 he received the Liebig medal for distinguished achievements in agricultural science from the Academy of Sciences, Munich, Bavaria.

In 1860 Dr. Hilgard married Miss J. Alexandrina Bello, daughter of Col. Bello, of Madrid, Spain.

In spite of a comparatively feeble body, Mr. Hilgard's vigorous intellect and untiring energy have produced and published a large number of remarkably valuable papers upon topics of scientific interest and relating to a large variety of subjects connected with his wide field of activity.—Editor.

SEC. 4. That the survey herein provided for shall be accompanied with proper maps and diagrams, and furnish full and scientific descriptions of its rocks, soils and geological productions, together with specimens of the same; which maps, diagrams and specimens shall be deposited in the State Library and similar specimens shall be deposited in the State University, and such other literary institutions in the State as the Governor may direct; provided that the survey shall be made in every county in the State.

SEC. 5. That the Trustees of the State University shall cause a report to be made annually to the Governor, to be by him laid before each session of the Legislature, setting forth, generally, the progress made in the survey hereby required.

SEC. 6. That this Act take effect and be in force from and after the first day of June next.

Under the somewhat loose provisions and phraseology of this act Dr. John Millington, at the time professor of chemistry at the University of Mississippi, was in June, 1850, appointed to the position and additional duties provided for by it. No assistant was obtained until July 15, 1851, when Oscar M. Lieber, of South Carolina, was appointed to the position. No record or report of Lieber's work was made; during a portion of his incumbency (presumably in autumn of 1852), he made, on horseback, a reconnoissance of the Yazoo Bottom; but nothing beyond that fact appears from the letters written by him under the regulation defining his duties, which provides that "When not actually engaged in making explorations and surveys, he shall aid the principal professor of geology, agriculture and chemistry in the discharge of his duties; and while engaged in making such surveys, he shall make reports at least monthly to the principal professor, and the salary of said assistant professor shall be $1,000 per annum." Lieber resigned on January 14, 1852.

In January, 1852, the position was accepted by Prof. B. L. C. Wailes, then of the faculty of Jefferson College, near Natchez. This gentleman had already made a collection of rocks and fossils of the southwestern part of the state, and had quite an extended knowledge of the general features of the latter. There was also passed by the legislature, in session at the time, "an act to amend an act to further endow the University of Mississippi, approved March 5, 1850," the provisions of which are as follows:

SEC. 1. That the fourth section of the above recited act be so amended as to read "Zoological" instead of "Gological" productions.

SEC. 2. That the room adjoining the State Library, formerly occupied by the Surveyor-General, be appropriated and set apart for the deposit and safe-keeping of such specimens as may be collected during the progress of the geological survey, provided for in the above recited Act; and that the sum of 200 dollars be appropriated, out of any money in the State Treasury not otherwise appropriated, to defray the expenses of fitting up and preparing said room for the reception of said specimens.

SEC. 3. That the fitting up of said room shall be done under the direction of the Governor, upon whose requisition the auditor shall issue his warrant for the sum herein appropriated, or so much of said sum as may be necessary.

SEC. 4. That the said room after being so fitted up shall be under the charge of the State Geological Society, who shall be authorized to employ the librarian as curator of the same.

SEC. 5. That the said room shall be open to the public during such hours as the State Library is now required by law to keep open, and the librarian shall be allowed an additional compensation of $50 per annum for the services required by the 4th section of this Act.

It will be noted that by the verbal correction made in the first section of this act, the survey was practically made a complete natural history survey; since the only branch not specifically provided for—botany—might be understood to be necessarily included in the provisions for an agricultural survey. The State Society mentioned had but a very ephemeral existence. During the two succeeding years, viz: 1852 and 1853, Mr. Wailes traveled chiefly in the southern and eastern part of the state with his own team and outfit, examining the territory of the cretaceous in northeast Mississippi and the tertiary and quarternary areas in the southern part of the state.

Collections of tertiary fossils, especially from the shell bed at Jackson, were sent by Wailes to Conrad, and mammalian and other bones from the loess to Leidy, for determination and description; and collections of these and other fossils as well as of rocks were by him deposited, both at Oxford and at Jackson.

In January, 1854, Wailes presented to the Board of Trustees of the University of Mississippi the manuscript of his report on the work of the two preceding years, which was transmitted through the governor to the legislature, with the recommendation that it be printed. The legislative committee to whom it was referred reported back the following act, which was passed and under which the survey was thereafter carried on for a number of years:

AN ACT

To authorize the printing of the first annual report of the Agricultural Geological survey of the State.

SEC. 1. *Be it enacted by the Legislature of the State of Mississippi,* That two thousand copies of the report of Professor B. C. L. Wailes, State Geologist, be printed under his supervision, in quarto form, and in such manner, and with such illustrations and plates, as his excellency the Governor shall deem appropriate and necessary for its illustration.

SEC. 2. *Be it further enacted,* That when printed and bound the said report be deposited in the office of the Secretary of State, to be by him distributed as follows: fifty copies to be deposited in the State Library; twenty-five copies to be deposited in the State University; one copy to each state in the Union; one copy to be given to each incorporated college and academy in the State; one copy each to the Governor, Secretary of State, Auditor of Public Accounts, State Treasurer, Adjutant General, the Chancellor and Vice-Chancellors, the Judges of the High Court of Errors and Appeals, the Attorney General, the Judge and District Attorney of each District, each member of the present Senate and House of Representatives, and one hundred copies to the said State Geologist, to be by him exchanged for similar reports from other states, and to furnish to scientific societies and public libraries.

SEC. 3. *Be it further enacted,* That one thousand copies of said report shall be deposited in the office of the Secretary of State, to be sold by any agent or agents to be appointed by the Governor, under such regulations and for such sum as he may deem proper and advisable, for the purpose of reimbursing the State for publishing the same, and the balance to be distributed among the several counties of the State, in proportion to their representation in the Legislature, to be furnished to the people thereof, in such manner as the Boards of Police of the several counties may direct.

SEC. 4. *Be it further enacted,* That previous to the printing of said report, it shall be revised and completed by the said State Geologist; and the portion of it which treats of Zoology, as far as prepared, shall be omitted, and in lieu thereof, a catalogue of the fauna of the State, as far as ascertained, shall be substituted.

SEC. 5. *Be it further enacted,* That for the farther and more efficient prosecution of the survey, analyses of the marls, soils, mineral waters, and the chief agricultural productions of the State, shall be made at the University of Mississippi, as the Trustees may designate; and the State Geologist may, from time to time, furnish such soils, marls and waters as may be required for analysis, and shall receive in return from the chemist full and precise reports of all analyses which may be made; and specimens of soils and marls shall be preserved in convenient glass bottles in the State Cabinet and in the Cabinet of the State University, properly labeled with the chemical character of the substance and the locality from which the same was obtained.

SEC. 6. *And be it further enacted,* That the said Geologist shall make collections of specimens to illustrate the mineral character and paleontology of the State, in addition to the zoological productions which by law he is now required to collect, and to cause them to be suitably arranged and preserved in the State Cabinet, and in that of the University; and any duplicates that remain may be distributed by him among such of the incorporated colleges of the State as may apply for them.

SEC. 7. *And be it further enacted,* That a sum not to exceed two thousand five hundred dollars be appropriated out of any money in the treasury, to be drawn upon the requisition of the Governor, for the purpose of carrying into effect the provisions of this Act.

SEC. 8. *Be it further enacted,* That this Act shall be in force from and after its passage.

Approved March 1, 1854.

Wailes' *Report* (the first of the Mississippi geological reports), of which the publication was provided for by the above act, bears the imprint of "E. Barksdale, State Printer, 1854," but was actually printed at Philadelphia, where Wailes remained during the greater part of 1854 to superintend its passage through the press. The volume is an octavo of 371 pages, with 17 illustrations, partly of a historical character, partly referring to the cotton industry; eight illustrate geological subjects, the most important being four plates of shells from the Jackson shell bed, named and described by Conrad. The report begins with a "historical outline" covering 125 pages; a treatise on the agriculture of the state, partly historical and dealing largely with cotton culture, followed by some analyses of marls, cotton ashes and mineral waters, and covering 81 pages; meteorological data, 12 pp.; lists of fauna and flora, 46 pages; appendices, with documents, 25 pages. This summary is sufficiently indicative of the fact that Wailes was not, and did not write as a specialist in any department. He makes no attempt to classify the rocks he describes otherwise than as Cretaceous, Tertiary and Quarternary, and inferentially classes among the latter the sandstone of the Grand Gulf group, which is mentioned as overlying "diluvial gravel." He traces correctly the northern limit of the Grand Gulf rocks from the Mississippi across Pearl river to Brandon, and describes its occurrence in southwestern Mississippi.

It will be noted that although the act of 1854 designates Wailes as "state geologist," it does not create that office, which still remained an appendage of the chair of geology at the University of Mississippi. It was expected that Wailes would be elected to that chair, which in autumn 1853 had been vacated by Dr. Millington. At an election held in June, 1854, however, the choice for that position fell on Lewis Harper.*

Wailes, thereupon, immediately resigned his position, which remained vacant until September, 1855. Up to the summer of 1855 Harper, bearing the titles of professor of geology and agriculture, and state geologist, had not taken the field himself. He was now by action of the Board of Trustees relieved from a portion of his duties as instructor, and directed to take the field personally, for the purposes provided for in the act. Besides, Dr. F. A. P. Barnard, then professor of physics at the university, was requested to secure a competent assistant geologist at a salary of $1,000 per annum, during a contemplated visit to the North. At the Providence meeting of the Am. Ass'n Adv. of Science, August, 1855, Dr. Barnard fulfilled his mission by tendering the appointment to the writer (then lately returned from Europe), who promptly accepted it, amid the sincere condolence of his scientific friends upon his assignment to so uninteresting a field, where the paleozoic formations (then occupying almost exclusively the minds of American geologists), were unrepresented.

On the way south, a few weeks later, I paid a visit of several days to Dr. David Dale Owen and his assistants, E. T. Cox and S. S. Lyon (then engaged in the work of the Arkansas state geological survey), at New Harmony, with a view of obtaining suggestions for the work before me. This visit was most important and fruitful in giving direction to my subsequent studies and methods.

Reaching Oxford about the middle of September, 1855, I found that Harper had then just returned from a rapid reconnoissance of the cretaceous and tertiary prairie regions in eastern Mississippi; and it was agreed that we should as soon as possible set out on a joint exploration over the same route, to be continued to the Gulf shore; thence across the southern counties of the state to the Mississippi river. The start was made early in October, the outfit consisting of an ambulance

*Properly, Ludwig Hafner, of Hamburg, Germany, originally a student of law, who for political reasons had to leave the country before graduation, and subsequently became interested in natural history; then a teacher of natural science at an academy near Greenville, Alabama.

carrying a camping outfit, and a negro driver, who at the same time performed the office of cook. The cretaceous prairie country on the Tombigby river was reached near Okolona, whence the route lay through Aberdeen to Columbus; thence, leaving the cretaceous territory, through Neshoba and Kemper counties to Enterprise on the Chickasawhay river, and along that stream, crossing all the marine tertiary stages, as far south as Leakville, Green county. It then became apparent that there was not time to reach the coast, as intended, without the risk of being caught in a very remote and thinly settled region, by the early winter. We therefore turned westward at once and reached the Mississippi at Fort Adams, from which point we took steamer passage to Memphis, Tenn.

This expedition was made too rapidly and with too few facilities for making collections, to afford anything more than a very general insight into the character and relations of the several cretaceous and tertiary stages. It was shown conclusively that the dip of all the marine tertiary beds is southward, except only as regards the Grand Gulf rocks, whose relations to the rest we had no opportunity of observing, since they are unrepresented in the Chickasawhay section, save by clays of which the equivalence was not then apparent.

Meanwhile it had become apparent to the University trustees that in its present form the survey was in more than one respect a burden to the University; and, accordingly, at the legislative session of 1855-6, Governor McRae, in transmitting to the legislature the regular report of the trustees of the University of Mississippi, accompanies it by a special message in which occurs the following passage:

"The first portion of the trustees' report relates to the geological survey of the state geologist, and proposes the separation of this survey from the University; and asks that it may be taken charge of by the state, as an independent work under the direction of the governor. The reasons for this are fully set forth in the report, and may be recapitulated in brief as follows:

1. The geological survey does not form a part of the course of instruction in the University, and is not properly connected with the business of the institution.

2. The duties of the State Geologist, under the present arrangement, being partly as professor in the University, partly in the field survey,

neither position can be fully or satisfactorily filled by him. Either the classes in this department must suffer in his absence, or the survey in the field be neglected to give them proper attention.

3. The funds of the University are not sufficient to justify it in bestowing a portion of them on a work, however important and valuable to the State, that is not legitimately a portion of its business.

The appropriation by the State of $3,000 annually for the geological survey, pays no more than the salary of the principal and assistant geologists; and the outfit and traveling expenses, &c., amounting to as much more, have to be provided for out of the college funds. This is unjust to the University, and the divided time of the State Geologist between the University and the field, operates injuriously both to the interests of the University and the State. I would not be understood by this, nor would the Board of Trustees, as casting any reflection upon the learned gentleman who now fills the place of State Geologist, and whom they and myself believe to be well and highly qualified for the duties of that station, nor would we have it understood, and the Board of Trustees would not, that we detract in the slightest measure from the great interest and importance to the State of having a geological survey thoroughly and efficiently prosecuted. The object is to place it in the hands of the State and under the direction of her authority, where it properly belongs, and to have it vigorously prosecuted to completion at the earliest day. I therefore recommend to the Legislature, to place it in this position and to provide the means necessary to accomplish this object. It is believed that an appropriation annually, for three years of $6,000, will be sufficient to complete the entire work within that period.

The report of Professor Harper, herewith submitted, contains much valuable information—shows a high degree of scientific attainment on his part, and gives evidence that when the work is completed, it will be one of great value to the public. The present report is only preliminary and partial and is not designed for publication at this time, but is to be embodied and published in the general report when completed."

The suggestion of the governor was not, however, favorably acted upon by the legislature; the matter was left in *statu quo*, but with the understanding that a vigorous prosecution of the work should pave the way to more satisfactory legislation at a succeeding session.

After passing the winter at Oxford in the arrangement of the collections and preparations for analytical work, I proceeded in April, 1856, to make a detailed exploration of the northeastern portion of the state, where the geological structure seemed most complex and varied. In the course of this expedition, made with the same outfit that had served the year before, I determined the character, stratigraphical relations and limits of the carboniferous, cretaceous and tertiary beds of that part of the state, making extended collections especially of what was afterwards designated as the Ripley Group of the cretaceous by Conrad.*

I also investigated closely the features and geological relations of the "Orange Sand" (now better known as the Lafayette formation of the Southwest), showing its derivation partly from northern sources, partly from the underlying formations of which it contains the fossils; distinctly characterizing it as a quarternary deposit.

It having become clearly apparent to me by this time that the survey would never maintain itself in public esteem on the basis of mineral discoveries, and that it must seek its main support in what services it might render to agriculture, I made a point of paying close attention to and recording the surface features,† vegetation, soils, the quality and supply of water, and especially the marls, which I found to occur in large supply and great variety. I also made a collection of plants, which, although omitted from the subjects mentioned in the act creating the survey, I perceived was essential toward the characterization of soils. In the prosecution of these studies, the close connection between the surface vegetation and the underlying formations became so striking, that I soon largely availed myself of the former in tracing out the limits of adjacent formations, in searching for outcrops, etc.

I also, by current inquiry among the inhabitants, ascertained all that was known regarding the peculiarities, merits and demerits of the several regions or soils, from an agricultural point of view, and studied their practice and its results on the several soils and crops.

During the latter part of the season of 1856, I extended

*A collection of fossils from these beds was sent to Conrad by Dr. Spillman, of Columbus, to whom I had given a list of good fossiliferous localities of that group, of which he promptly availed himself. The same season (1856) in Conrad's published description of these fossils (Jour. Acad. Sci., Philadelphia, Vol. IV, N. S., pp. 275 to 291.) Dr. Spillman is erroneously credited with being the discoverer of the Ripley beds. My original collection, containing a number of species still undescribed, was unfortunately never seen by Conrad, with whom I twice made arrangements for a protracted visit to Oxford for the purpose of studying the collections of the survey. His feeble health and subsequent death prevented the carrying-out of this program.

†No instrumental topographical work was ever done in connection with the Mississippi survey, partly because it was not provided for by law, partly because the continually recurring violent barometric changes during the working season rendered the use of the aneroid, so useful elsewhere, very unsatisfactory. The railroad levelings then available were, however, fully and extensively used by me, and were excluded from the report of 1860, simply by the absolute need of brevity for the sake of reducing the expense of publication.

the detailed survey of the cretaceous area as far south as Columbus; and thence, as the beginning of the rainy season rendered farther field work unprofitable, I drove across the country to Tuskaloosa, Ala., in order to compare notes and consult with Tuomey, then state geologist of Alabama, and to gain an insight into the works of reference for cretaceous and tertiary paleontology; of which not one had been provided by Harper, although at his request the costly illustrated works of Goldfuss, d'Ordigny and others, treating of European paleontology, had been placed in the University library. As these works did not furnish us with the means of identifying the fossils of the Mississippi formations, Harper seriously proposed to confer on them all, names of our own making, irrespective of previous observers. Upon my suggestion that this was rather an unusual mode of proceeding and might at the very least give rise to some confusion, he agreed that I might try to obtain from Tuomey the necessary information as to the possibility of procuring the existing American works, of which he, however, expressed a very low opinion. Hence my excursion to Tuskaloosa, in which I reaped the benefit of Tuomey's previous labors, and came to an understanding with him in respect to the subdivisions of the cretaceous, recognized by him. It happened that he had just returned from an excursion to the (Ripley) cretaceous area of Chunnenugga Ridge, which was entirely new to him, and the relations of which to the other groups he had not yet made out. Recognizing the characteristic fossils and marlstones of the Ripley group, I was enabled to clear up that point as well as the relations of the "Tombigby Sand" fossils (which had been sent to him from Columbus by Dr. Spillman) to the "Rotten Limestone," which we had thus far designated as "Upper," but agreed henceforth to consider as middle cretaceous. I then learned for the first time that he had found fossils,—well preserved ammonites and several gasteropods, silicified, in the lower cretaceous clays near Eutaw (or rather Finch's Ferry), Alabama; and we agreed to designate this lower clayey stage, which in Mississippi I had found entirely barren of fossils, as the "Eutaw" group. Subsequently, prior publication gave precedence to Safford's name of "Coffee group" for the lower clays, and similarly my "Tippah group" received from Conrad the prior name of "Ripley" for the uppermost cretaceous. Tuomey had at that time a portion of his second report in manuscript; and as unfortunately he died six months after our conference, after a protracted illness, that report, which was posthumously edited by J. W. Mallet, does not show the latest phase of Tuomey's knowledge of the cretaceous stages. As his collections were mostly destroyed during the war, it is of interest to record here, from my personal observation, that almost all the cretaceous fossils marked "Miss." in list "A," p. 257, of that report, were from the "Tombigby Sand" and the immediately overlying portion of the "Rotten Limestone," in Lowndes county, Miss.; the "Ammonites Binodosus," recorded in the same list, from Eutaw, Ala., was considered by him as a "leading fossil" of the lower cretaceous clays; the specimens were all silicified and in excellent preservation.

As regards the tertiary formations, Tuomey was strongly impressed with the fact that the older stages reappear above the drainage level to the southward, after sinking out of view at the St. Stephens bluff; and he suggested to me then that what I subsequently named the "Grand Gulf rocks" might be equivalents of the "Burstone" sandstones of South Carolina. So far as this point is concerned I was therefore strongly impressed with the same ideas that have been so persistently set forth by Otto Meyer. Having obtained from Tuomey references to all publications then extant on the cretaceous and tertiary of the south and west, I returned to Oxford in November, across a country rendered almost impassable by copious rains.

I found matters rapidly coming to a crisis at the University. Harper had been provided with a separate ambulance outfit, and had taken the field for a few weeks during the season of 1856 in the northwestern counties; but he seemed to be unable to keep away from Oxford for any length of time. Finally, the dissatisfaction of the board of trustees with his personal acts, in relation both to the survey and to the University, came to a head in November, 1856, when he was forced to resign. I was continued as assistant, with compensation increased to $1,500 per annum, and was for the time being placed in charge of the survey, the office work of which I continued during the winter.

At the legislative session of 1856-'7, however, Harper, by strenuous effort, procured the passage of an act entitled "An Act to provide for the printing of the Second Annual Report of the Agricultural and Geological Survey of the State, and for other purposes," approved January 31, 1857. The substantial provisions of this act were, first, the complete separation of the survey from all connection with the State University; second, that the survey should be prosecuted to completion according to the provisions of the previous act, "by a state geologist, to be appointed by the governor, and to receive a salary of two thousand dollars per annum, to be furnished with such an outfit as may be necessary, to be provided under the direction of the governor; he shall also keep an exact account of his expenses in making said survey, and submit the same to the examination of the governor, who shall issue his requisition upon the treasury for the amount, provided the sum shall not exceed one thousand dollars per annum." An appropriation of twelve hundred dollars was also made for the purchase of chemical apparatus for making analyses, and the state geologist was authorized (as a measure of economy suggested by himself), to "occupy as a laboratory the two front rooms in the second story of the penitentiary building; and he shall be allowed the assistance of one convict, to be named by the inspectors, to aid him in keeping his apparatus in good order." It was also ordered "that five thousand copies of Professor Harper's report be printed," and thereafter distributed in accordance with the provisions of the former act. The sum of thirty-five hundred dollars was appropriated for this publication, and Harper entered upon the office on March 1, 1857, but was voted compensation from the date of his resignation, in November preceding. The only work performed by him during his tenure of office under this act, was the writing and publication of his report, which was done under his personal supervision at New York, although, like the former report, it bears the imprint of the state printer at Jackson.

Of this report it need only be said that it is a literary, linguistic and scientific curiosity, and probably unique in official publications of its kind. It is the labored attempt of a sciolist to show erudition, and to compass the impossible feat of interpreting and discussing intelligently a considerable mass of observations mostly recorded by another working on a totally different plan from himself. In making use of my field notes, which of course passed into his hands, the facts as well as the conclusions suffered such distortion that but for the introduction of all the figures and diagrams given in my manuscript, I sould have been unable in many cases to recognize my own work. It is thus that the "Orange Sand" becomes in his hands "The Miocene Formation;" while what he saw of the Port Hudson beds, as well as the quarternary gravels, are referred to the eocene. Shortly after the publication of the book, I publicly disclaimed all responsibility for either facts or conclusions pretended to be based upon my work, since, although my name is nowhere mentioned in the volume, the innumerable errors would, in the course of time, be likely to be laid at my door. The circulation of the report through the state soon produced the inevitable result of discrediting its author to such extent that toward the end of the year 1857 he was obliged to resign his office.

Shortly afterwards the appointment was tendered to me (then acting as chemist to the Smithsonian Institution), and accepted; and I entered upon its duties early in 1858. At Jackson I found in the "two front rooms in the second story of the penitentiary," under the charge of the convict assistant, the outcome of the purchases made by Harper under the provision for the outfitting of an analytical laboratory. It consisted essentially of apparatus for elementary lectures in chemistry, and an expensive microscope; the analytical balance was represented by a pair of apothecary's scales, etc. Under authority of the governor, a portion of the useless articles were sold, and the proceeds applied to the purchase of necessaries for analytical work, and under the same authority and by permission of the Board of Trustees of the State University, I transferred the whole to a front room in the University building at Oxford, which I fitted up as a laboratory, at a personal expense of $600, for the time being. By this evasion of the law, framed under Harper's auspices (which was mandatory only in respect to the location of the "office," but not of the laboratory), the survey was again practically restored to its original connection with the University, without which the work could not be successfully carried on under so small an appropriation.

I took the field again in April, with the same outfit, an ambulance with two mules and a negro driver, and starting at the Ripley cretaceous, I devoted the season to the verification ot a full section across the tertiary area, from north to south; including also the detailed examination of the fossiliferous localities of the "Jackson" and "Vicksburg" stages in their most characteristic development. Contrary to my first impressions, I found the Vicksburg beds everywhere along their southern limit of outcrops, dipping southward *under* the lignito-gypseous and sandstone strata of the "Grand Gulf" group, which rise abruptly and sometimes in steep escarpments from the low rolling or prairie country of the Vicksburg area; and being thus led to consider the Grand Gulf rocks as belonging to a miocene or possibly pleiocene epoch, I devoted considerable time to the study of its features and to the search for fossils. That this search was unavailing so far as the finding of definite animal forms is concerned, and that a subsequent continuation of the search over the rest of its area in Mississippi and Louisiana has led to no better results, I have stated and discussed in later publications.*

The fundamental fact of the infra-position of the Vicksburg beds to those of the Grand Gulf group that has been called in question by Otto Meyer, can easily be verified by any one understanding the logic of stratigraphical and hypsometrical facts in numerous localities along the belt of contact. I mention especially the outcrops at Mississippi Springs on Pearl river below Byram; on Richland creek, Rankin county; on the Brandon and Byram road; north of Raleigh, Smith county, and at numerous other points, both in Mississippi and Louisiana. No other interpretation of the stratigraphical facts is possible in a region where disturbances (apart from small local faults), are unknown, and where the broad facts are identical from the Chickasawhay to the Sabine.

In passing through the state I became painfully conscious of the fact that the survey had become extremely unpopular, as a consequence of Harper's incumbency and report; so much so that it was often very difficult to obtain information, or even civil answers to inquiries. I felt that it would be neces-

*See my *Mississippi Report of* 1860, p. 147. *Am. Jour. Sci.*, 1887; *Ibid.*, Nov., 1869; *Ibid.*, Dec., 1871; *Ibid.*, July, 1881; also *Smith. Contr. Sci. Memoir*, No. 248.

sary to throw off, and purge myself completely, of the obnoxious antecedents, if the survey appropriation was to be sustained at the coming session of the legislature. I therefore, after consulting with Governor McWillie, wrote a short *Report upon the Condition of the Geological and Agricultural Survey of the State of Mississippi,* of 22 pages, 8vo., which was printed by executive order and circulated prior to the session of the legislature in the winter of 1858-'9. In this report I discussed, first, the need and advantages of a thorough geological and agricultural survey of the state; recited the causes of the slow progress and failure to satisfy the public, chief among which were inadequate appropriations and the incompetency of the late incumbent; also gave examples of what had been done in the matter in other states, and closed with a recommendation for the repeal of the law locating the headquarters of the survey in the state penitentiary, and for the restoration of the geological assistantship, in connection with a more reasonably adequate appropriation.

The storm, however, broke loose when the legislature assembled. Those who had been instrumental in passing Harper's bill in 1857, were now most eager to have the survey "wiped out" to allay their soreness. A special committee was appointed to investigate the subject, and without even giving me a hearing, that committee promptly reported a "bill to abolish the geological and agricultural survey of the state." In presenting this report the chairman inveighed fiercely against the insolence exhibited in my report, above alluded to, and my attempt to "coerce the legislature by forestalling public opinion." The report to abolish would undoubtedly have been promptly adopted, but for my forcing a personal conference with the chairman; in which I presented to him the documents in the case, and exhorted him to abolish *me,* if he thought there was cause, but not the *survey,* the revival of which would only be a question of time. After this, the "bill to abolish" was not called up, and the survey remained in *statu quo* during 1859.

The previous season's work having settled conclusively the succession of the several stages of the tertiary, and their prominent stratigraphical, lithological and paleontological features, I devoted the season of 1859 to the filling-in of details. I went more leisurely over the ground intended to have been covered by the previous joint expedition of Harper and myself in 1855, viz: from the southern border of the cretaceous area, near Columbus, down the Chickasawhay and Pascagoula valleys to the sea coast; along the coast to Pearl river, up that river to Columbia, Marion county, and thence across to the Mississippi; thence northward along the eastern border of the loess region to the belt of marine tertiary, which I also examined more in detail between Jackson and Vicksburg. All these observations only served to confirm and complete my previous conclusions; the onlv new point being the examination of the perplexing aspects under which the "Port Hudson group" (then provisionally designated by me as "Coast Pliocene"), appears on the shores of Mississippi Sound. I was not long in rejecting all ideas of its direct connection with the Grand Gulf strata; but its true character of a littoral member of the deposits of the loess epoch did not become apparent to me until, later on, I had the opportunity of studying, connectedly, the geology of southern Louisiana.*

Returning from the field somewhat earlier than usual I began the arrangement of materials for a report, to be presented at the legislative session of 1859-'60, with a view to its publication and the procurement of a better endowment for the survey.

As an earnest of the work done, I put up a collection of soils and marls, gathered during the three years' work, and had it on exhibition at the State Fair held at Jackson in November. It excited a good deal of attention and newspaper comment, and gave a favorable turn to public opinion, previously aroused by frequent communications of results made by me to agricultural and other papers of the state. Outside of the fair week I carried on the work of analysis and writing, simultaneously and unremittingly; the only assistance received being that of the legislature convened in December, 1859. But there was cataloguing of the tertiary fossils by Prof. W. D. Moore, then holding the chair of English literature at the University of Mississippi. The manuscript was not nearly completed when enough to satisfy a special committee that it should be printed, and that the working facilities should be enlarged.

The bill reported by that committee and afterwards passed with little difficulty by the legislature, makes no radical changes

*See *Smith's Contra. Sci., Memoir No. 248*, above referred to.

in the previous act defining the objects of the survey; but provides for the appointment of an assistant geologist at a salary of $1,500; enlarging the limits of the annual "expenses necessarily incurred in fitting up a chemical laboratory," and repealing the provision for keeping an office at Jackson; permitting the alternative of having it at Oxford. An appropriation of three thousand five hundred dollars is made for printing the report, "with such diagrams and maps as the governor shall deem necessary for its illustration; and it is hereby especially enjoined upon his excellency, in the publication of said book, to have the same performed at the South, if the same can be done at an advance of ten per cent. upon the cost of its publication at the North."

The latter clause was a charactertistic sign of the times. The act was approved by the governor, February 10, 1860. It was soon and easily ascertained that the five thousand copies of the volume could not be printed anywhere at the South at an advance of ten per cent. on New York prices; but Governor Pettus declared that he would not allow it to go North under any circumstances, even if it had to remain unprinted. Estimates prepared by Mr. E. Barksdale, the state printer, showed that to do the work in his office would cost over $4,000, at the lowest estimate I placed upon the uncompleted manuscript. Finally, Mr. Barksdale proposed that if I should be personally responsible for $250 of the excess of cost over the amount allowed by the state, he would cover the rest; and I accepted the proposition. The governor relented so far as to allow the map, which could not be furnished by any Southern establishment, to be prepared by the Coltons, at New York; the other plates were prepared at New Orleans. The printing was begun at Jackson in May, 1860; the latter parts of the report were largely written while the first portions were passing through the press. But several forms were not yet in print when in August imperative matters called me to Europe, and Prof. W. D. Moore, who had previously aided me in working up the lists of fossils, undertook to see the remainder of the work through the press. Hence there remain in the latter part of the book a number of uncorrected errata, of which none, however, are of material consequence.

In this report (which except as otherwise credited in the text, represents my personal field, office and laboratory work during four years), I undertook to separate as far as possible, the purely scientific part from that bearing directly upon practical points, in order to render the latter acessible to unscientific readers as the nature of the case permitted; while at the same time giving scientific discussion full swing in its proper place. This was the more necessary, as my predecessor's reports had been sharply criticised in this respect; and I think the result has justified my judgment in the premises. The volume is thus divided nearly evenly between a "geological" and "agricultural" portion; the former giving under the special heading of "useful materials" the technically important features of each formation, after its geological characters have been discussed. In the agricultural portion, it seemed needful at the time to give, by way of introduction, a brief discussion of the principles of agricultural chemistry, then but little understood by the general public; and, accordingly, fifty pages are given to this subject and are discussed with reference to the agricultural practice of the State. In the special or descriptive portion of the agricultural report, the State is divided into "regions" characterized by more or less uniformity of soil and surface features; and each is considered in detail with respect to all natural features bearing on agricultural pursuits; special attention being given to the nature of the soils, as shown by their vegetation and analysis. In the latter respect I departed pointedly from the then prevailing opinions, by which soil analysis was held to be practically useless. My exploration of the State had shown me such intimate connection between the natural vegetation and the varying chemical nature of the underlying strata that have contributed to soil formation, as to greatly encourage the belief that definite results could be eliminated from the discussion of a considerable number of analyses, of soils carefully observed and classified with respect both to their origin and their natural vegetation, and a comparison of these data with the results of cultivation; and that thus it would become possible, after all, to do what Liebig originally expected could be done, viz: to predict measurably the behavior of soils in cultivation from their chemical composition. To what extent this expectation has been fulfilled, is hardly apparent from the very limited number of analyses which my unaided work was able to furnish for the report of 1860. But the lights then obtained encouraged me to persevere in the same line of investigation, in the face of much adverse criticism, when wider opportunities presented themselves afterwards. By the aid of these I think I may fairly claim, that the right of soil analysis to be considered as an essential and often decisive factor in the *a priori* estimation of the cultural value of virgin soils, has been well established alongside of the limitations imposed by physical and climatic conditions, and by previous intervention of culture.*

With the recognition of these facts, the importance of agricultural surveys to the population of especially the newer states and territories becomes sufficiently obvious to command at least the same attention as those investigations directed specially to the recognition of the geological and mineral resources of the same regions; and the "classification of lands," provided for under the law creating the United States Geological Survey, assumes a new and more pressing significance. Even apart from any special investigations of soil composition, the right of the agricultural interests to at least a good, intelligent and intelligible description of the surface features of a region, given with respect to its agricultural capabilities and its attractions for settlers, can hardly be denied. With the additional possibilities opened by the intelligent application of soil investigation, there is no excuse for the neglect, sometimes almost absolute, with which this branch of the public surveys has thus far mostly been treated by those charged with their execution.

Dr. David Dale Owen was, among the older American geologists, the one who most steadily kept the agricultural interests in view, and gave them prominence in his researches and reports. While my personal intercourse with him predisposed me to follow his example in this respect, my further experience has only served to strengthen my conviction that a reasonable proportion of attention given to agricultural work would effectually smooth the path of our state surveys, whose fate is forever trembling in the balance at each reassembling of the legislative bodies upon which their continued endowment depends, and by whose country members their utility is constantly called

*For a more extended exemplification and discussion of the nature and utility of such work, see the "Report on Cotton Production in the United States" Vols. 5 and 6 of the *Reports of the 10th Census*; also *Am. Jour. Sci.*, Dec., 1872, p. 434; *Ibid.*, Sept., p. 183.

in question. No such question was raised in Mississippi after the publication of my report of 1860; and the legislative appropriations for substantially similar work done by me on behalf of agriculture have since been liberally maintained in California, despite the conspicuous disfavor with which the geological survey of that state has for many years past been regarded by the public. Had that survey been adapted to the legitimate needs of the state, by proper diligence in the pursuit of its agricultural side, the discontinuance of the work could never have been carried through the legislature.

As a striking exemplification of the change wrought in public sentiment by the energetic prosecution of agricultural survey work, I may quote the action taken at the called session of the legislature of Missisippi in August, 1861. Under the terrible stress brought to bear on the state even then by the impending conflict, it would have been natural to expect the complete extinction of the appropriation for the survey work. Instead of this, an act was passed suspending the appropriation for the geological survey "until the close of the war, and for twelve months thereafter; except the sum of $1,250 per annum, which shall be applied to the payment of the salary of the state geologist, and the purchase of such chemicals as may be necessary to carry on the analysis of soils, minerals and mineral waters and to enable him to preserve the apparatus, analyses and other property of the state connected with said survey." This appropriation was actually maintained during the entire struggle of the confederacy; and so far as the vicissitudes of war permitted, the chemical work (and even some field work) was continued by me during the same time. The scarcity of salt suggested a utilization of some of the saline waters and efflorescences so common in the southern part of the state, and some forty (unpublished) analyses of such saline mixtures are on record. I made an official report on the subject to Governor Pettus, dated June 9, 1862. I also made a special exploration on the several limestone caves of the state, with a view to the discovery of nitrous earths; but from the fact that these caves are all traversed by lively streams, I found nowhere a sufficient accumulation of nitrates to render exploration useful.

Soon after the beginning of active hostilities in Tennessee, the University faculty having been dissolved, I was detailed by the governor, as commander of the state militia, to take charge of the state property at the University during the war; and this, as well as a subsequent appointment by the confederate authorities as an agent of the "Nitre Bureau," prevented my being called into active service; except on the occasion of the siege of Vicksburg, when, toward the end of that memorable epoch, I was ordered to erect "calcium lights" on the bluffs above the city, for the illumination of the Federal gunboats when attempting to run the gauntlet of the batteries. The difficulties of construction and procuring of the necessary materials delayed the completion of the arrangements, so that on the occasion of the final passage of the fleet no adequate light could be given. From a hospital at Jackson, where I was a patient at the time of its first capture, I soon afterwards made my way to my post at Oxford, where I remained on duty during the rest of the war. This duty was oftentimes a very arduous one, Oxford being then within the "belt of desolation" between the two armies, which swept back and forth over it. The survey collections had several very narrow escapes from destruction when the buildings were hastily occupied for hospital purposes; they were several times transferred on hospital cots from one building to another, but finally escaped without any material injury. Not so the collections at the capitol at Jackson, where the shelves and cases seem to have been swept with the butts of muskets, and the floor was strewn with broken specimens and shattered glass jars. About one-third of the collections stored there was entirely ruined, and of the remainder nearly all the labels were lost.

On my return from Europe in November, 1860, I found my report in print, and shortly afterwards it was shipped to St. Louis for binding. The political events which soon afterward convulsed the country, prevented the return of the bound edition to Mississippi. It remained warehoused in the binder's hands during the entire war between the states, and it was not until 1865 that measures were taken for its recovery. The war and the "twelve months thereafter" having expired, the survey was revived *ipso facto* on the basis of the act of 1860; and I found the state printer of that time, Mr. E. Barksdale, determined to carry out to the letter his agreement in respect to the publication of the report; thus likewise reviving my obligation to contribute $250 toward the payment of its cost, which under the conditions then existing was a heavy tax. The edition was received at Jackson early in 1866, and thence distributed according to law.

The mule team of the survey had been sold by authority from the governor, soon after the passage of the act of suspension. There being no legal mode of turning the proceeds into the state treasury, they remained in my custody in the form of "Cotton Money" (notes issued by the state upon "cotton pledged" for their redemption) during the war; and as at its end these notes had become worthless, the survey was left without means for repurchase. Subsequently, however, a suitable team was procured out of the appropriations for current expenditures.

Dr. George Little, formerly professor of natural sciences at Oakland College, near Rodney, Miss., was appointed assistant geologist in July, 1866, and shortly thereafter took the field for detailed exploration of the loess region from Rodney to its fartherest point in Louisiana; the special object being to ascertain its relation to the "Coast Pliocene" or Port Hudson beds on the one hand, and to the southern equivalent of the "Yellow Loam" of Mississippi and Tennessee on the other. The general results of this exploration are briefly stated in Memoir No. 248 of the Smithsonian Contributions, p. 4, viz: That the loess material gradually changes toward that of a non-calcareous and non-fossiliferous hardpan or indurated loam, from a point about eight miles below the Louisiana line, and seems also to thin out. No detailed report of field notes of this trip are on record.

In view of the difficulties and insecurity besetting the office of state geologist under the *regime* then existing in the state of Mississippi, in October, 1866, I accepted permanently the chair of chemistry at the University; and Dr. Little was then, upon my recommendation, appointed state geologist. He took the field in autumn of 1867, in order to re-explore the section of the tertiary strata afforded by the Chickasawhay river, between Enterprise and Winchester. He descended the stream in a canoe, making numerous portages over shallow stretches. The result of this re-examination was simply a confirmation of the observations previously made by myself, going by land, in 1859. Of this exploration, also, no detailed record or report is on file.

No field work was done by Dr. Little in 1868, partly because by consent of the governor he was acting as professor of geology and mineralogy at the University in addition to the survey work in the laboratory and collection rooms. In October, 1870, however, he definitely resigned the state geologistship for the professorship of geology and natural history in the University, and in order to prevent the survey from being either abolished or falling into the wrong hands, I again assumed its direction without additional compensation; it being understood that I should be under no obligation to take the field personally. In November, 1868, the assistantship had been most fortunately filled by the appointment of Dr. Eugene A. Smith, of Alabama, then just returned from his studies in Europe. Dr. Smith took hold of the work with his characteristic energy, although the first work in order was not of the most interesting character; namely, the farther prosecution of the analyses of soils and marls selected so as to cover as nearly as possible all parts of the state. This work was carried on by him through the year 1869 and a portion of 1870. In September of that year he took the field, with the usual outfit of a two-mule ambulance and driver. There were then two regions in the state that had not been at all satisfactorily explored: one the belt northward of the Jackson area, of which only the portions lying in Neshoba and Lauderdale counties on the eastern border of the state, and a small area in Attala county, near the Central railroad, had been somewhat minutely examined by me. This being the connecting link between the "northern lignitic" and calcareous marine stages, its examination was of special interest, but at the same time a difficult task on account of the extreme variability of its materials and fossils, and the scarcity of outcrops. The other comparatively unknown region was the great "Yazoo bottom," the geological exploration of which had become of especial interest in connection with the question of the age of the formation of the gulf coast and delta.

While the Bottom region was to be the chief objective point of the first expedition, Dr. Smith availed himself of the opportunity of observing a section across the older tertiary in passing from Oxford to Yazoo City via the Pontotoc, "Flatwoods," Kosciusko and Jackson.

He then descended into the Yazoo bottom and traversed it, zigzagging from the river to the bluff from near Vicksburg to its head near Memphis. In this laborious and insalubrious trip he studied carefully both the surface features of the great alluvial plain, and the geological features of the deposits that form its substrata. A summary report of this important exploration was given by him at the Indianapolis meeting of the A. A. A. S., and was published in the volume of *Proceedings* of 1871, p. 252. The outcome of these observations is there summarily stated to have been that "the true river deposits, of any considerable thickness, are mostly confined to narrow strips of land lying on both sides of the Mississippi and of the bayous and creeks, and to ancient channels since filled up; while a large proportion of the superficial area of the bottom, including some of the most fertile lands, is derived from the clays of older formations into which these beds have been excavated." The equivalence of this older clay formation with that of the Port Hudson profile, already suggested by me, was thus fully verified.

Returning to Oxford early in December, Dr. Smith carried on the chemical work until the end of May, 1871, when he took the field again in order to trace across the state the "Siliceous Claiborne" belt, referred to. His route lay from Leake county southeastward to the Alabama line, along the northern contact of the problematic "Red Hills" and yellow standstones with the lignitic formation; then westward again in the more southerly portion of the belt, to the border of the Yazoo bottom (the "Mississippi bluff"). In this trip he traced the connection and established the equivalence of the ferruginous formation as a local feature, with the sandstones of Neshoba and Newton counties; which connect unequivocally with the characteristic "burstones" of Lauderdale.* The beds of the Jackson group were then traced by him, down the edge of the bluff to Yazoo City and Vicksburg, forming the third complete section across the eocene observed in Mississippi.

*The more extended development of the ferruginous feature in northern Louisiana was afterwards observed and described by myself. *Am. Jour. Sci.*, Nov., 1869, p. 341; *Supplementary and final report of a geological reconnoisance of Louisiana*, p. 22. Also Rep. on the cotton production and agricultural features of Louisiana, in *Report of the 10th Census U. S.*, Vol. 5, pp. 112, 132.

In September, 1871, Dr. Smith resigned the assistantship to take the chair of geology and mineralogy in the University of Alabama, with which, through his efforts, the state geologistship of that state was afterward connected.

His successor in the assistantship of the Mississippi survey was Mr. R. H. Loughridge,* of Texas, who had for some time previously acted as my assistant in the chemical laboratory, and subsequently as instructor in general chemistry. Mr. Loughridge prosecuted the chemical work of the survey during a part of the year 1872, and was preparing for the elaboration of another report covering the work done since the publication of the report of 1860; when by an arbitrary ruling of the state auditor of public accounts the survey appropriation was withheld; and thus in the autumn of 1872 the work was peremptorily stopped.

It has not been revived since, although so far as I am aware the act of 1860 has never been legally rescinded. No provision for the publication of the unpublished results has ever been made by the state; the records and collections of the survey remain in the custody of the University of Mississippi, and were left by me fully labeled as to locality and time of collection, with reference to the field notes, and to the name or designation under which the specimens of fossils appeared in my report of 1860.

When I took charge of the Tenth Census report on cotton production, and at my suggestion it was determined by Superintendent Walker that agricultural descriptions of the cotton states should be embodied in the report, I requested of President A. P. Stewart, of the University of Mississippi, permission to use the records of the survey in the elaboration of the report on that state. Permission was promptly given and the papers forwarded to Berkeley, Calif.; and they were used by me as intended, in the composition of the monograph on the agricultural features and cotton production of Mississippi, which forms part of Volume 5 of the Census Reports for 1880. This paper embraces 164 quarto pages, and is accompanied by a col-

*Mr. Loughridge subsequently received from the University of Mississippi the degree of Ph. D., and served for several years as assistant to Dr. Little in the geological survey of Georgia. Subsequently, acting under my direction as special agent of the 10th Census, he made a reconnoissance of Texas, and wrote the monographs on that State, Arkansas, Indian Territory, Georgia and Mississippi for the report on Cotton Production. Later he served on the Geol. survey of Ky., with Prof. Proctor; and is now connected with the Agr. College of California.

ored map of the state; showing the several soil regions, which in this case largely coincide with the geological subdivisions as given on the map accompanying the report of 1860. While the surface features of the state are given very much in detail, the geological description is considerably condensed, into one and a quarter pages; since greater minuteness of description would have lain outside of the objects of the report. Hence, except as casually mentioned in connection with the surfaces, the geological observations made by Dr. Smith in 1870 and 1871 remain unpublished, save as regards the abstract of his observations in the Yazoo bottom, given in the paper referred to before.

A revised edition of the report of 1860 would, without additional field work, form a pretty complete account of the geological and agricultural features of the state.

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EDITORIAL COMMENT.

PLEISTOCENE GEOLOGY OF NORTHERN AND CENTRAL ASIA.

Prof. George Frederick Wright, of Oberlin, Ohio, and his son, Fred B. Wright, returned home about April 1st from a journey around the world, chiefly for geological observation, which occupied somewhat more than a year. Their route was by the Southern Pacific railway to California; thence to Hawaii, Japan, and China, leaving the city of Peking after the beginning of the Boxer massacres, from which they encountered much delay and peril, by the Siberian railway, passing lake Baikal, and traveling the vast Russian empire to St. Petersburg; thence through the region of the Volga, and of the Black and Caspian seas, to Armenia and Palestine; thence by the Mediterranean and southern Europe to England; and thence by Boston and New York to Oberlin. Attention was given principally to Pleistocene geology, and to the absence or presence of evidences of glaciation. Professor Wright on March 6th, at a meeting of the Geological society of London, presented a paper on "Recent Geological Changes in Northern and Central Asia," from which the more important of his observations are summarized as follows in an abstract published in the Proceedings of that society.

"The result of six weeks spent in Japan was to show that there are no signs of general glaciation in Nippon or Yesso.

Neither is there any sign of glaciation along the border of the Mongolian plateau, where the general elevation is 5,000 ft. but the whole region is covered with loess. This has usually accumulated like immense snow-drifts on the southeastern, or lee side of the mountains, and in it houses and villages are excavated. In the mountainous region, strata of gravel and pebbles are so frequent in the loess that it is necessary to invoke both wind and water in order to explain fully the origin of the deposit. At the present time the loess in the interior is being washed away by the streams much faster than it is being deposited by the wind. The journey across Manchuria from Port Arthur along the Loo-Ho and Sungari rivers was through valleys choked with alluvium, and there was no evidence that the drainage of the Amur had ever been reversed by ice, like that of the St. Lawrence; nor was there any other evidence of glaciation. The lower course of the Amur indicates subsidence. Again, there are no signs of glaciation on the Vitim plateau.

"Lake Baikal appears to be of recent origin; it is 4,500 feet deep, and has not been filled by the great quantities of sediment brought down by the Selenga and other rivers. Although glaciers could frequently be seen on the mountains which border the Central Asiatic plateau on the northwest, there was no evidence that the glaciers had ever deployed on the plain. The loess region of Turkestan, and indeed the whole area from the sea of Aral to the Black sea, appears to have been recently elevated, in some places as much as 3,000 feet. Desiccation took place at the same time, so that the larger lakes are only brackish or still fresh. Direct evidence of this in the form of deposits is given. The author thinks it likely that the absence of glaciation in northern Asia may have been due to the rainlessness of the region, and that, while America was elevated, Asia was depressed during the Glacial epoch."

In connection with the discussion of this paper, Prof. Wright disclaimed any intention to imply an eolian origin for the loess of the Mississippi valley, but attributed its deposition there to annual river floods, mostly of short duration, followed generally during a greater part of each year by aerial exposure of the flood plain, permitting it to be occupied by vegetation and land shells. W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Was Mount Royal an Active Volcano? By J. S. Buchan, *K. C., B. C. L.* Canadian Record of Science, Vol. VIII, No. 5, pp. 321, 328.)

It is well known that the broad and nearly level valley of the St. Lawrence, which is underlain with paleozoic strata, has suffered enormous denudation, unique evidence of which is furnished by the interesting series of intrusive hills which crosses the valley from Montreal to Shefford. These, owing to their greater resistance to erosion, stand out in bold relief, rising to hights of seven hundred to twelve hundred feet above the plain, while high up on their slopes, sedimentary fragments are often found *in situ,* giving unmistakable evidence of the once greater thickness of the sedimentary deposits.

In the above mentioned paper, these and other phenomena are discussed in support of the hypothesis that Mount Royal is an uncovered laccolite instead of a once active volcano. Mount Royal rises seven hundred and forty-four feet above the St. Lawrence river at Montreal and sedimentary patches occur on it nearly at the top. As corroborative evidence the plutonic character of the igneous rocks together with the absence of tuff or effusive material is cited, as well as a slight uplift of the strata in some places.

Since the absence of any but deep-seated rocks seems to be sufficiently accounted for by the extent of the erosion already referred to, and as the uplifting of the strata is not very pronounced, Mr. Buchan is probably prudent in expressing his conviction very reservedly. The generally little disturbed position of the surrounding strata is certainly unfavorable to the theory of a laccolitic structure, which seems less likely to occur here than in the eastern part of the St. Lawrence valley within the influence of the Appalachian uplift.

J. A. D.

The Summary Report of the Geological Survey of Canada for the Year 1900. (203 pages, 1901.)

In this report special prominence is given to the results of field-work accomplished during the past summer, thus affording an early publication of a preliminary kind for any new facts obtained, whether of economic or scientific importance.

Thirteen parties were in the field for the greater part of the summer and carried on observations from the Yukon district and British Columbia to Nova Scotia.

The report states that several mineral products have been obtained and sent out as samples or for examination by experts, among which may be mentioned, amlar mica, or phlogopite, which was sent to the director of the Scientific and Technical Department of the Im perial Institute, London, and was pronounced by experts to be of exceptionally high value for electrical purposes. Molybdenite from Quebec and Ontario was tested in the laboratory of McGill university and samples of auriferous black sands from the Atlin district were also examined. These samples varied from 0.5 oz. gold per ton to 5.985 oz. gold per ton. Mention is made of the discovery of anthracite coal in the region about the headwaters of the Sheena and Slikine rivers. It is estimated there are 22,000,000,000 tons of possibly workable coal in the Crow's Nest Pass coal fields. Coal has also been found in the Klondike region but so far possesses only a medium economic value.

Reference is made to the collection sent to the Paris exposition. This collection weighed about 70 tons, and comprised over 1,200 separate exhibits and was much larger than any shown by Canada at any previous international exposition. The awards actually awarded to the Canadian mineral exhibits comprise six grand prizes, ten gold medals, eighteen silver medals, nine bronze medals and four honorable mentions.

The most important facts of economic value are contained in the descriptions of the following: The placer mines (estimated to produce over $16,000,000 this year), the lignite area and the White Horse copper deposits in the Yukon district, the Atlin and West Kootenay gold fields and the extensive coal area of the Crow's Nest pass, in British Columbia, the iron bearing rocks of the Michipicoten district including the Helen mine, which from definite measurements contains 26,000,000 tons of ore and possibly a much larger quantity; the alluvial gold deposits of New Brunswick, and the extensive and important coal deposits of Springhill and Cape Breton in Nova Scotia. A large amount of work was done by all the field parties in mapping out the geological formations, and in making surveys and collecting facts about the regions traversed so that the report contains valuable information about the physiography and natural history of large areas in the older provinces as well as in outlying districts including Great Bear lake.

The work done in chemistry and mineralogy, mineral statistics, petrography, palaeontology and zoology, botany and mapping is fully set forth by the gentlemen in charge of these branches. W. J. W.

Analysis of Emery from Virginia. By W. W. MILLER, JR. *Am. Chem. Jour., 22*, 212-213.

The emery occurs in a heavy ledge near Whittle's on the line of the Southern railroad in Pittsylvania county. It is described as a black, crystalline mass; magnetic; polar; with specific gravity 4.205; and hardness, 8. The analysis shows:—alumina, 56.74; ferric oxide, 15.50; ferrous oxide, 20.77; silica, 0.68; titanic oxide, 1.86; soda, 3.95. The ferrous oxide in excess of that required to form magnetite, is supposed to be present as hercynite, $Fe\,Al_2O_4$; and the soda is considered to take the place of the ferrous oxide in forming additional hercynite, thus greatly reducing the amount of alumina which can exist as corundum.

The large amount of hercynite reduces the erosive power and makes the mixture of no value as emery. W. O. C.

On the Constitution of Barytocelestite. By C. W. Volney. *J. Am. Chem. Soc., 21,* 386-388.

Although previous work had discredited the existence of a true bariumstrontium sulphate, showing only barites containing a trace of strontium or celestites containing a trace of barium, the author finds this mineral from eastern Ontario to yield: $BaSO_4$, 30.850 and $SrSO_4$, 70.010. A previous analysis by the author had given: $BaSO_4$, 39.850 and $SrSO_4$ 58.200. These results correspond very closely to the formulas $(BaSr_2)$ $(SO_4)3$ and $(BaSr_3$ $SO_4)4$. These two types of barytocelestites have distinct habits of crystallization which remain to be investigated. W. O. C.

Examination of Sandstone from Augusta county, Virginia. By W. W. Miller, Jr. *Am. Chem. Jour., 22,* 216-217.

This sandstone is a disintegrated quartzite, occurring in the vicinity of Basic City, and found to be valuable for ballast and road metal. The analysis shows large proportions of alumina and alkalies, indicating partially kaolinized feldspar which is regarded as explaining the packing of the material in use. W. O. C.

Analysis of Smithsonite from Arkansas. By W. W. Miller, Jr. *Am. Chem. Jour., 22,* 218-219.

The smithsonite from the Morning Star mine in Searcy county, is the usual botryoidal variety, and encloses layers of zinc blende from which, probably, it has been derived. The analysis shows it to be nearly pure; but with a little cadmium, copper and iron replacing zinc. W. O. C.

Some Principles of Rock Analysis. By William F. Hillebrand. *(Bull. No. 176, U. S. Geol. Surv.)*

While this is primarily a description of the analytical methods followed in making rock and mineral analyses by the chemists of the U. S. Geol. Survey at the Washington laboratory, the author has included so much that is valuable in the way of general discussion of the problems involved that the bulletin practically amounts to a very complete treatise on the subject of rock analysis. Particular emphasis is laid on the importance of thoroughness of analytic work, especially as regards the detection and estimation of the rarer rock-forming elements. The value of many of the older analyses was greatly lessened and often wholly destroyed by failure in this respect, and many erroneous conclusions concerning mineral composition resulted. The introduction of improved analytical methods has not only made greater accuracy possible but has brought to light many interesting facts about the occurrence, relative distribution and associations of the rarer elements. In the descriptive parts we find the methods of procedure which experience has shown to yield the most satisfactory results outlined in such a manner as to be of service to any having occasion to make rock or mineral analyses. Alternate methods are also given in many instances and their advantages and disadvantages considered. In a few cases apparatus of especially desirable pattern have been figured in the text. Chemists will find the parts devoted to the estimation of small quantities of the rarer rock-forming elements, titanium, zirconium, chromium, vanadium, molybdenum, barium, and strontium of particular interest; also those devoted to ferrous iron. The author finds in the strong reducing action which sulphides even in small amounts have on ferric salts, an explanation of the fact that ferrous iron estimations by the sealed tube method of Mitscherlick give higher results, as a rule, than those obtained by other methods, this difference becoming more marked as the percentage of iron increases. All rocks contain sulphur, at least in traces, and the more highly ferruginous ones not only commonly carry higher percentages of ferric iron, but considerable quantities of iron sulphides, conditions exactly calculated to produce the results obtained. During the heating of the rock powder with sulphuric acid in the sealed tube the sulphur of the sulphides is oxidized to sulphuric acid at the expense of the ferric iron. In this way as little as 0.10% of sulphur increases the ferrous iron by an error of 1.35%. This seems to furnish a correct and interesting explanation of a long unsolved problem. The wide experience and established reputation of the author make this carefully prepared bulletin a most valuable addition to the literature of analytical chemistry and it will find wide use by geologists and petrographers interested in rock analysis. W. O. C.

Analyses of Rocks, Laboratory of the U. S. Geological Survey. Tabulated by F. W. CLARK. (*Bull. No.* 168, *U. S. Geol. Sur.*)

In this bulletin are tabulated the results of 1,404 analyses of rocks, minerals, clays, etc., which have been made between the years 1880 and 1889, by the chemists connected with the U. S. Geological Survey. The analyses are arranged in groups according to the geographical location of their respective rocks, and with each one are such notes and references as are necessary for the proper identification and study of the rocks. A table, showing the average composition of the earth's crust as calculated by F. W. Clark from some eight hundred carefully selected rock analyses, is an interesting and valuable part of the introduction. Every geologist will appreciate the high value of this bulletin. W. O. C.

An Experimental Investigation into the Flow of Marble. BY FRANK DAWSON ADAMS and JOHN THOMAS NICHOLSON. (*Phil. Trans. Roy. Soc. London, Vol. 195*, pp. 363-401, pls. 22-25. 1901.)

The artificial production of structures found in nature is a department of investigation capable of yielding data on many problems of a theoretical nature. The folding and flowage of rocks in the deeper part of the earth's crust are commonly supposed to be due to the interaction of three factors;—great pressure, high temperature, and percolating water. In the experiments here described carrara marble is placed in specially constructed cylinders and subjected to differential pressure under varying conditions. Dry marble at ordinary temperatures developed a cataclastic structure, exhibiting an anastomosing network of calcite granules with marked shearing lines. Macroscopically the marble thus treated assumed a chalky appearance, which was found to be due to the destruction by polysynthetic twinning of the continuity of the reflecting cleavage surfaces of calcite. Dry deformation at 400°C. produced foliation without any trace of cataclastic structure. As in ice, the higher temperature produced a greater plasticity of the grains and hence the ability to flow around each other. The addition of percolating water made no difference in the resulting structure. The cataclastic structure was found to have weakened the crushing strength of the marble; foliation to have weakened it very slightly; but foliation produced with the accompaniment of percolating water strengthened the stone.

These deformations are found to be similar to those produced upon metals, and analogous structures are found in certain highly contorted limestones. It is interesting to note that the presence or absence of water made no difference in the structure, but it is possible that the pressure was so great as to mask or prevent the possible effects of water. These experiments were admirably planned and executed, and they throw a little light on the difficult problem of the conditions which obtain in the deeper zones of the earth's crust. I. H. O.

The Physiography of Acadia. By REGINALD A. DALY. *(Bull. Mus. Comp. zool., Vol. XXXVIII. Geol. ser., Vol. V, No. 5, pp.* 73-104, 11 pls.)

This is the first coherent and serious presentation of the physiography of Nova Scotia and adjacent regions. One might wish that it were based upon a longer field study than a few days by rail and boat; but it is founded also upon an extensive knowledge of physiographic forms, and a close study of such maps as have been available. Further research will probably not alter the main thesis of the paper. It will, however, fill in many gaps: for the present study is only in outline, and of necessity treats of the broader features of the country. It is to be hoped that it will be followed by more detailed work in the same area, and an extension to peripheral regions.

The country is divided into the southern plateau, the Cobequid plateau, the New Brunswick highlands, and the Triassic lava plateau embracing North Mountain, Digby Neck and Long Island—all parts of a well made peneplain of probable Cretaceous age; the Triassic lowlands, of Tertiary age; and the Carboniferous lowlands, also of Tertiary age as regards denudation. The denudation is thought to have been subaërial, although other theories are carefully considered.

The southern plateau is composed of the metamorphic gold-bearing series (Algonkian?) and Siluria and Devonian strata. The author omits a series of Cambro-Silurian rocks which are found in the eastern half of Nova Scotia. It is stated that each of these has been involved in a late Devonian mountain building. As it seems to the reviewer, field evidence has not yet shown that the Silurian and Devonian are structural units with the gold series, or that the main mountain building was Devonian. On the contrary, before the end of the Devonian, the auriferous veins had been injected into the lower member of the series, the whole had been folded in two directions and extensively faulted and eroded; and at some times before this, enormous masses of granite had been intruded, cutting the veins and folds. These granites are not all of the same age, but range from pre-Silurian, when some of it in the east probably cooled, to Devonian, which is the age of the large mass in the western half of the province, if it be one intrusion as seems likely. It is probable that the mountain building was pre-Silurian. Before lower Carboniferous times, three-fourths of the whole gold series had been eroded from some regions.

Dr. Daly has done well to emphasize the real lack of mountainous projections in this part of Nova Scotia. Transportation companies' prospectuses, with the too vivid descriptions of untrained travelers, have given a prevailing impression of ruggedness where none exists. For this there is excuse; but there is none for the statements on the subject which have appeared in some geological articles.

The structure and history of the Triassic area and the history of the Bay of Fundy trough are reviewed at length, from the literature. The main peneplain has been affected by two warps, one in the direction about S. 30° E., east of Digby; the second transverse to it, affecting the western part. These are believed to have aided in the formation of the Tertiary lowland on the Trias, by reviving subaërial work. The Carboniferous areas are referred to the same age as regards their denudation, from similarity of hight and topographic form. The dates of the two peneplains have been placed as Cretaceous and Tertiary, on account of similarity with corresponding ones along our own Atlantic coast. At the close of the paper, (p. 98), a table of homologous forms, expressed in terms of history is presented, comparing New England and Acadia; and the general resemblance is certainly striking.

Shore and stream development are not considered; but, especially with no topographic maps for the area, this would require a large amount of field work, and doubtless will be given to us in time. Cape Breton is entirely left out of the problem; and perhaps this is well, for it requires special study, being largely a topographic and geologic unit of itself. It may be said, however, that it has had a somewhat similar development in outline.

The gelatine plates are for the most part excellent, and give very vividly, especially to one who knows the structure of the country, some of the chief topographic phases. The map leaves something to be desired, in that it is too light; and it might better have occupied the whole page, the legend being placed on a separate sheet.

On the whole, any criticisms of this first study must be of a minor nature; and we owe much to Dr. Daly for being the first to give us an intelligent idea of the topographic development of a country hitherto rather neglected. The recent tendency of American students to invade Canada deserves a passing notice. Within a year, for instance, two more studies, of a quite detailed nature, will be published from Harvard University, dealing with problems which, from the nature of the work, have been largely overlooked by previous observers. J. E. W.

The Structural Relations of the Amygdaloidal Melaphyr in Brookline, Newton, and Brighton, Mass. By H. T. Burr. (Bull. Mus. Comp. Zoöl., vol. xxxviii. Geol. Ser., vol. v., no. 2, pp. 53-69, 2 pls.)

In earlier years, the melaphyrs of the Boston basin have been considered as contemporaneous flows by some writers. The present paper appears to prove beyond doubt that those of the western portion, included in the above-mentioned territory, are entirely intrusive. We have no fossiliferous horizon to use as a key to structure; and the presence of contemporaneous flows would be welcome. Their proved absence in the western areas removes that aid, as far as those areas are concerned. Readers who are familiar with the geological literature of the region know the general relations of the rocks as regards position, and it is not necessary to state them here.

A word may not be out of place, concerning the methods used in this study, which was an incidental one; for they illustrate the careful approach which is now employed in the problems in this difficult field. A detailed outcrop map was plotted on a very large scale, made possible by the aid of city engineers. This gave the exact location of every exposure of melaphyr, and of the other rocks as well. Detailed observations were recorded for each outcrop, and specimens collected when necessary, for petrographic work. The result appears in the character of Mr. Burr's paper, which is a mass of clearly presented evidence, with the inevitable conclusions drawn from it. The former is so stated that the precise outcrops are indicated, and one can without difficulty prove the worth of the observations for himself. This is as it should be.

The evidence is of three kinds: lack of melaphyr pebbles in the overlying conglomerate, negative but confirmatory; character of the upper contacts of the melaphyr; and structural relations. The summary is worth giving in full. "(1) The melaphyr, in the region discussed, is intrusive in the sediments. (2) The melaphyr is not associated with any definite horizon, and is therefore of no value as a guide to the interpretation of the structure. The first conclusion depends upon the following facts: 1. The conglomerate, associated with the melaphyr, contains no fragments of it. 2. The contacts, wherever found, are igneous in character. 3. The melaphyr is seen in contact with sediments, varying from the coarsest of the conglomerates to the finest of slate. 4. The distribution of the melaphyr shows it to be discordant with the structure of the sediments under any interpretation of the latter that has been offered. The second conclusion follows directly upon the first."

While these problems occupy most of the paper, space is given to a new interpretation of the structure of the Chestnut Hill slates and the northern conglomerate, which harmonizes with the field evidence better than any of the earlier views. J. E. W.

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CORRESPONDENCE.

ARE THE AMYGDALOIDAL MELAPHYRS OF THE BOSTON BASIN INTRUSIVE OR CONTEMPORANEOUS?—The recent paper by my friend, Henry T. Burr on the "Structural Relations of the Amygdaloidal Melaphyrs in Brookline, Newton and Brighton, Mass.,"* is, in the main, a criticism of my view that the melaphyrs of this area, as of the other parts of the Boston Basin, are chiefly contemporaneous, and of an unpublished map by Woodward in which that view is embodied. I have not claimed that the melaphyrs are wholly contemporaneous, recognizing that they must be intrusive at some points, since the magma necessarily reached the earth's surface before it could play the role of an effusive; but in the area which he has studied, Mr. Burr finds all the melaphyrs to be intrusive. His argument rests largely upon the evidence of the contacts, which are found to be, without exception, where clearly exposed, igneous. Details which appear to support this thesis are made the most of; but broad, fundamental facts which tell strongly against it have not been duly considered. No attempt is made to show that none of the irregular contacts supposed to be igneous could be as well explained as due to the covering by sediments of the cracked and scoriaceous surface of a submarine flow; or that the supposed baking of these overlying sediments is never silicification accompanying the chloritization of the melaphyr. The orientation of feldspars in conformity with the contact is emphasized, although this feature belongs also to the free surface of a flow, and not alone to its igneous contact with another rock. Notwithstanding the title of his paper, as quoted above, our author takes absolutely no account of the very prevalent amygdaloidal and scoriaceous textures of the melaphyr and his sections show dykes of melaphyr from 500 to more than 3,000 feet in width. He starts out by noting that the melaphyr and the trap dikes of the district are, petrographically, hardly distinguishable; but does not attempt to show why, if the trap and the melaphyr are both intrusive, a three-thousand-foot dike of the melaphyr should be throughout amygdaloidal, scoriaceous or aphanitic, while a three-foot dike of trap is holocrystalline and homogeneous. If these masses of melaphyr really are dikes from 500 to 3,000 feet wide, it would be very interesting to know where and how they terminate; and certainly a fissure 3,000 feet wide filled with basic magma at a level in the crust permitting it to solidify with aphanitic and vesicular textures could not have failed to gush effusively at the surface; but no suggestion is offered as to what has become of this effu-

* Bull. Mus. Comp. Zool., Geol. Series, 5, 53-69.

sive material. These supposed dikes are represented as transverse to the dip of the enclosing strata; but their close conformity with the strike of the sediments is not explained.

Another fundamental fact which is overlooked is the occurrence in this area, and in intimate association with the melaphyr, of important beds of melaphyr tuff. The genetic relations of the tuff to the melaphyr cannot be questioned; and the existence of the former should be regarded as conclusive as to the contemporaneous origin of a part at least of the latter. Much is made of the supposed absence of melaphyr pebbles in the overlying conglomerates. These are not, however, wholly wanting; and at some points they are a very striking and significant feature of the contact. For instance, between Newton Upper Falls and Newton Highlands, in the western part of Mr. Burr's field, a north-south section shows, if there be no repetition of the strata by strike faulting, four heavy beds of conglomerate and sandstone, all dipping in a general northerly direction at angles of twenty to forty degrees, separated by three broad bands of melaphyr. The most clearly exposed contact in this series is the uppermost, or that between the northern band of melaphyr and the overlying conglomerate. This melaphyr is, in the southern (lower) part of the band, a solid and homogeneous rock of approximately holocrystalline aspect; but northward it becomes more slaty, in part amygdaloidal, brecciated and scoriaceous; and at last is decidedly shaly in structure, looking more like a tuff than a flow. It is covered by the conglomerate with apparent conformity; and the conglomerate is, on and near the contact, not injected by the melaphyr, but crowded with angular fragments of precisely similar melaphyr. Within a yard above the contact the melaphyr detritus begins to die out; and at a distance of two yards an occasional fragment only is to be found. The melaphyr in the conglomerate is clearly a contact feature; and it can not be doubted that this body of melaphyr was in existence as a surface formation when the deposition of the conglomerate began. Everything goes to indicate that these effusive eruptions were submarine; and at Nantasket, as also in Brighton, we have conclusive proof, in the well preserved wavy and ropy surfaces of the flows, that in some instances they were covered without suffering erosion.

The main bodies of melaphyr, throughout the Boston basin, have all the characters of lava flows and are essentially unlike any known dikes or sills. In other words they are masses which fundamental and indisputable facts indicate to be contemporaneous. And yet, because of certain minor irregularities of contact and appearance of baking, etc., they are described as intrusive; and highly improbable sections, with transverse dikes thousands of feet wide, are constructed to explain their structural relations. Apparently, every irregular or transverse contact is to be regarded as igneous, ignoring all the raggedness of a normal lava flow, to say nothing of subsequent faulting and crushing, and ignoring the almost inevitable induration by silicification, of a sediment in contact with such a prolific source of free silica as these basic lavas were during the process of chloritization; and certainly nothing is more normal than the impregnation of sediments in contact with a basic eruptive by ferruginous minerals, thus readily explaining directly or by subsequent oxidation the very local reddening of the sediments, extending commonly less than an inch from the contact, to which Mr. Burr attaches much importance. Of the excess of free silica during the alteration of the melaphyr we have substantial evidence in the quartz and jasper amygdules and segregations which often crowd the melaphyr and the numerous veinlets of quartz frequently to be observed in the immediately bordering sediments.

Mr. Burr then discusses the structure of the region, to show that the melaphyrs are not confined to a particular horizon or limited part of the sedimentary series and that they are not continuous at any horizon. These contentions must be conceded, and so far as I know have never been questioned; but they are certainly, to say the least, very inconclusive as arguments against the contemporaneous origin of the melaphyrs; for there is no apparent reason why the volcanic activity should have been sharply localized in time, and certainly aerial continuity is no more essential to effusives than to intrusives.

The account of the structure of this area on pages 61 to 66 fails to indicate that the main features had been previously described. Reference may be made especially to the detailed account of the thrust fault between the slate and the northern conglomerate. This is fully described and figured in my Contributions to the Geology of Eastern Massachusetts, published in 1880. I described it again, and with additional emphasis upon its structural importance in 1884 (Proc. Bost. Soc. Nat. Hist., 23, 24-27); and still again in 1889, in my lectures on the Physical History of the Boston Basin.

So much it has seemed necessary to write in the interest of truth; but it is only fair to add that the impetuous following of a narrow line of argument to its logical conclusion, regardless of obvious and important counter arguments, which Mr. Burr's paper illustrates, is the more surprising since the author has previously done most excellent geological work; and the explanation is undoubtedly to be found in a hasty study, under unfavorable conditions by a mind of more than ordinary energy, directness and influence. As an example of Mr. Burr's better work, and as an indication of what may be hoped from him in the future, I may mention his brilliant paper of a year ago on a new Lower Cambrian fauna from Eastern Massachusetts, which I have elsewhere described as unquestionably the most important contribution to the paleontology of the Boston Basin since the discovery of Paradoxides by professor W. B Rogers, nearly fifty years ago. W. O. CROSBY.

Institute of Technology, Boston, April, 1901.

PERSONAL AND SCIENTIFIC NEWS.

DR. H. E. GREGORY has been promoted professor of physical geography at Yale University.

PROF. G. H. BARTON, of the Massachusetts Institute of Technology, plans to spend the summer in Europe.

PROF. S. CALVIN, of IOWA CITY, recently visited Montana for the purpose of making a special examination of the Great Falls coal basin.

DR. T. NELSON DALE has resigned as instructor in geology and botany at Williams College, and will leave Williamstown during the summer.

MR. W. S. GRESLEY, of Eria, Pa., sailed for England on April 17th, where he is to take up professional work in connection with mining and geology.

THE OFFICE OF THE STATE GEOLOGICAL SURVEY OF MISSOURI has been moved from Jefferson City, the capital, to Rolla, where the State Mining School is situated.

RICHARD P. ROTHWELL, founder and editor of the *Engineering and Mining Journal,* and editor of the yearly volumes of *The Mineral Industry,* died at his home in New York City on April 18th.

AT A RECENT MEETING OF THE BOARD OF TRUSTEES of the Ohio State University John A. Bownocker was promoted to be professor of inorganic geology and Charles S. Prosser to be professor of geology and head of the department.

IT IS SAID THAT FOR THE FEW OPEN POSITIONS on the Geological Survey of Canada, a hundred applications have been received. This competition is due in part to the interest in geology awakened by recent developments of an economic nature in the Dominion.

MR. THOMAS W. ALLEN, St. Joseph, Mo., reports the discovery of a very fossiliferous stratum of gray sandstone about 60 feet above the bed of the Missouri river at that place, 12 to 14 inches thick. The rock is a mass of fossil plants consisting of ferns, calamites, Lepidodendrons, Sigillaria, broad-leaved plants, nuts, fruits, seeds etc. many varieties.

GEOLOGICAL SOCIETY OF WASHINGTON.—The program for the meeting of April 3d, was as follows: "The priceite of Lone ranch, Curry Co., Oregon," J. S. Diller; "The problem of Archean," C. R. Van Hise. At the meeting of April 10th the following was the program: "The Philadelphia gneisses," Miss F. Bascom; "Possible Pre-Wisconsin tills of Massachusetts," M. L. Fuller; "The Waverly group of Ohio," G. H. Girty.

NATIONAL MUSEUM FOR CANADA.—In the supplementary estimates to be laid before parliament in the course of a few days there will be included a substantial sum of money to be devoted toward the erection of a national museum of geology and natural history for the magnificent collection now accommodated in the Geological Survey building, Sussex street. The edifice will be of sufficient size and in design worthy of the purpose to which it is to be put.

DR. R. A. F. PENROSE of the *Journal of Geology* editorial staff, is about to undertake a journey around the world for the purpose of visiting the mines and mineral deposits of greatest interest. It is his intention to begin with the older Cornish tin mines and the chief mineral localities of England. Thence he intends to pass to Sweden and after visiting her principal objects of interest, to proceed by steamer from Stockholm to St. Petersburg. When he has completed his tour of observation of the mines and minerals of Russia he will go via the trans-Siberian railway to the Pacific and back to the diamond and gold fields of South Africa. Ceylon and Burmah will be visited, if possible, and he will return to California in a year or more.

J. PIERPONT MORGAN, the financier of New York City, one of the trustees of the American Museum of Natural History, was the donor of the Bement collection to that institution. This is probably the finest donation of minerals ever made to any institution. It is valued at from $150,000 to $200,000, and was called after Clarence S. Bement, of Philadelphia, who began the collection 35 years ago, and kept adding to it until it passed from his possession. Neither time nor money was spared in gathering desirable specimens, and in 1884 the Bement collection was looked upon as so important as to call for a special report in the interest of the National Museum, Washington. It was expected at one time that this collection would become the property of the government. A curator of a foreign museum, after seeing the Bement collection went to Europe. He cabled that he would purchase the specimens, but did not succeed in raising the necessary money. Since 1884 the Bement collection has increased over 50 per cent.

These accessions to the collection raise the American Museum of Natural History to rank among the museums of the world like that of the British Museum, heretofore, by common consent, considered as rich beyond comparison in rare specimens.

NEUTACONKANUT'S GREAT BOULDER.—This was described bv Dr. C. T. Jackson in his report on the Geological and Agricultural survey of Rhode Island in 1840. It is in Johnson, near Providence. It is shown in a halftone cut in the *Providence Journal* of March 24. The boulder still rests where it did in 1840 and for centuries previous. The traveler in passing still takes a second look to see if it is really about to topple over and roll down the hill into the highway. It is a striking feature of the landscape, and will ever remain as an object lesson to the geologist, and a topic of interest to the casual observer.

Following is Dr. Jackson's description: "The rocks on Neutaconkanut Hill are alternate strata of micaceous and hornblende slate, the former being very much contorted. On the south side of the hill there may be seen a huge boulder of hornblende rock poised upon the mica slate. This rock must have originated elsewhere, and it now rests in an accidental position, as will be evident to anyone who examines the situation in which it is placed. Since hornblende rocks do occur at the northward, and not to the southward of the place where this block is now found, we feel confident that this immense rock has been removed southwardly from its parent ledge and deposited on the rocky strata where we now find it."

FIELD WORK METHODS IN GEOLOGY AT HARVARD.—The elementary laboratory and field course at Harvard this year has enrolled about 190 men. The class is divided into three sections and each section into three companies for field work. The following memorandum has been issued to each student as a reminder of what he may expect to find in the field excursions. The assistants in charge of each company follow up this outline with questions and remarks called out by the particular locality. The students' results are handed in at the close in the form of a brief report with maps and sections.

Geology 5. Field Season of 1901. Brief Synopsis of Queries Answerable by Personal Observation.—Ask yourself on arriving at a locality selected for study whether it is an area of *erosion* or *deposition.* If an area of *erosion,*—what agent or agents are now at work or have been at work in the immediate past? Waves, currents, rivers; winds; ice or glaciers; life; weathering, disintegration, decomposition? What land forms have resulted from erosion? What new deposits have been made?

If an area of *decomposition.*—what materials are accumulating? What is their form? What is their structure?

In the case of a *rock in situ,*—what kind of rock is it? *If*—(a) *an igneous rock,*—What is its form? Batholith, laccolith, dike, sill, lava-flow, volcanic neck? What is the country rock? Where are the contacts? Is it intrusive? What is the mineralogical composition of the rock? What is the structure of the rock? Crystalline, porphyritic, glassy or devitrified? Has it flow structure? Is it vesicular, amygdaloidal, spherulitic?

(b) *A veinstone.*—What mineral or minerals compose it? What has been the order of their growth or genesis? What is the country rock? Did it furnish the substances in the vein? What is the nature of the cavity in which the vein is deposited? What rock movements are shown? Is there any volcanic breccia? When did the vein form in relation to other structures or rocks?

(c) *A clastic rock.*—What is it? A conglomerate? If so, what rocks form the pebbles? What is the cement? How was the conglomerate formed? If a sandstone, what is it composed of? What is the cement? If a pelite, what is its structure, lamination, banding, or stratification? Are there fossils?

(d) *A metamorphic rock.*—What is its structure, composition? What was it originally? What has produced the metamorphism?

In any case, what is the attitude of the rock? strike, dip? Has it been jointed, folded, faulted, tilted, metamorphosed? Has it slaty cleavage? dip and strike of same? What is the age of the rock relative to others of different kind? In what order do the secondary structures intersect?

What has been the succession of events in the area studied?

THE SPENDIAROFF PRIZE.—The following letter may perhaps explain itself: Le Congrès géologique international, dans sa séance générale du 25 Août 1900, a nommé membres de la Commission du prix international Spendiaroff: MM. Albert Gaudry, président; Marcel Bertrand, Sir Archibald Geikie, Karpinsky, Tscherneyschew, Zirkel et Von Zittel. Cette Commission propose comme sujet de prix pour 1903:

Revue critique es methodes de classification des roches.

Dans la séance du 20 Août 1900, le Conseil du Congrés avait décidé que les ouvrages présentés pour le concours seront envoyés au Secrétaire général du dernier Congrès au nombre deux exemplaires au moins, et que l'envoi sera fait au plus tard une année avant la session suivante. Le Conseil a décidé aussi que le droit de priorité pour obtenir le prix appartiendra aux œuvres traitant les sujets proposés par le Congrès.

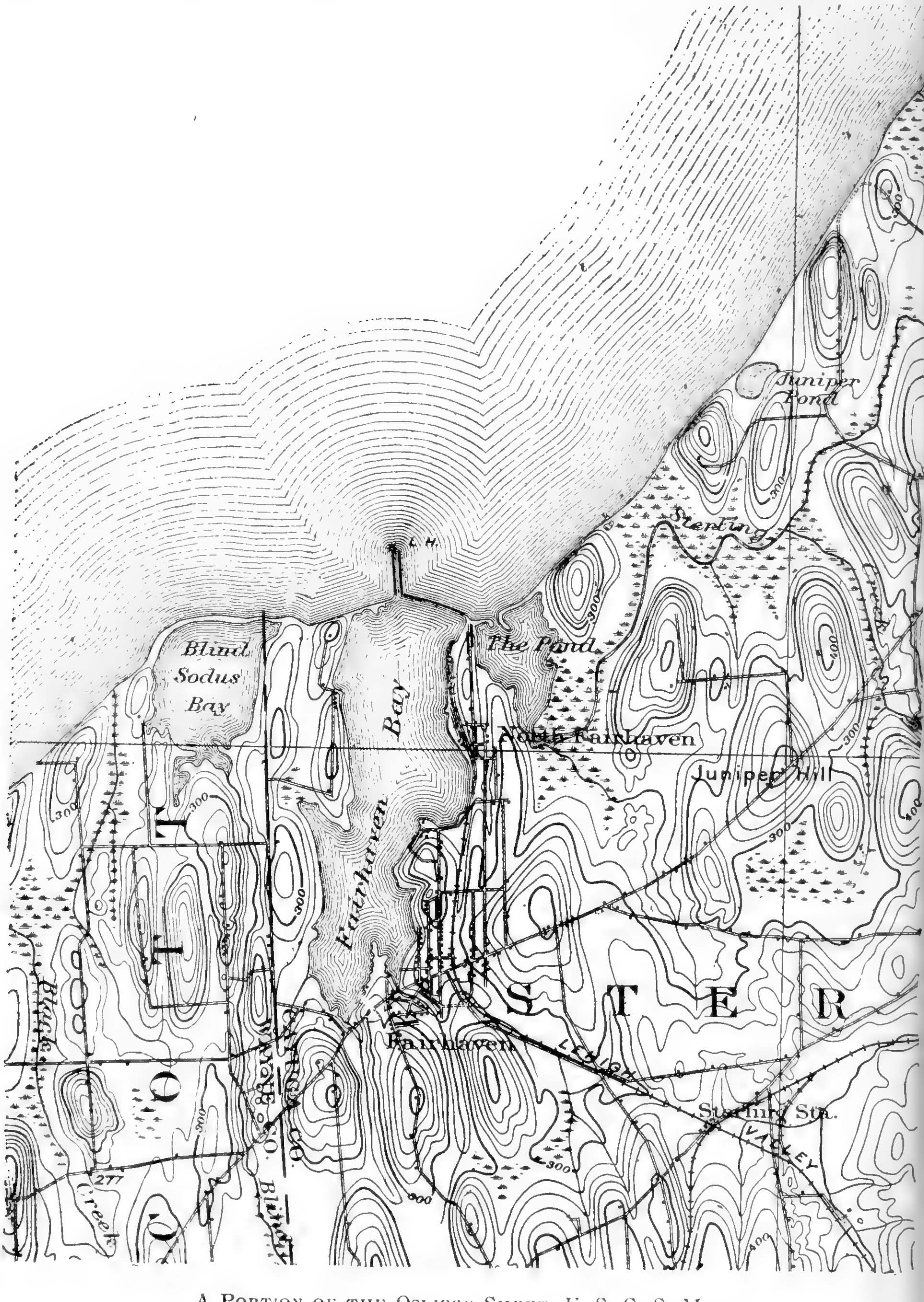
Les envois doivent être addressés à M. Charles Barrois, Secrétaire Général du Congrès géologique international, 62 boulevard Saint-Michel, Paris.

La valeur du prix est de 456 roubles, c'est-à-dire environ 1.200 francs, d'après l'indication de M. Karpinsky.

En vous communiquant ces renseignements, nous avons l'honneur de vous prier d'en faire part aux savants qu'ils pourraient intéresser.

Veuillez, Monsieur, agréer l'expression de nos sentiments les plus distingués.

ALBERT GAUDRY, Le Président du Congrès.
CHARLES BARROIS, Le Secrétaire général.



A PORTION OF THE OSWEGO SHEET, U. S. G. S. MAP.

THE
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THE ONTARIO COAST BETWEEN FAIRHAVEN AND SODUS BAYS, NEW YORK.

By J. O. MARTIN, Cornell University, Ithaca, N. Y.

PLATES XXVI and XXVII.

During the summer of 1900, while engaged in a study of the New York state drumlin area, I became interested in the peculiar shore phenomena of that part of the Ontario coast lying between Fairhaven and Sodus bays. The drumlins which so thickly beset the south-lying plain are here brought to an abrupt termination by the erosive action of the lake. The resulting coast line, being of an unusual type, has seemed to me worthy of a brief description.

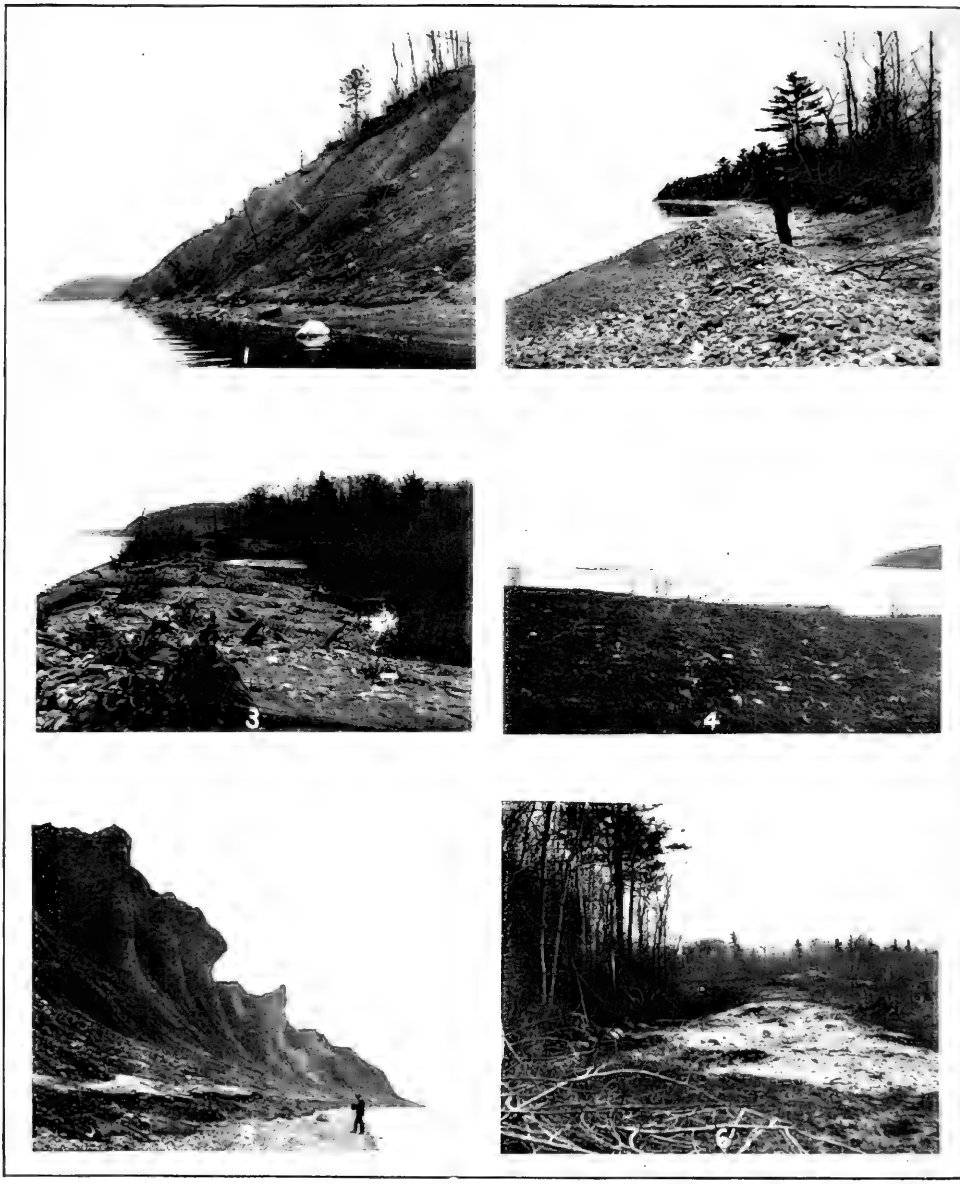
Viewed from a boat passing along shore, this coast presents a series of semi-elliptical bluffs which are wave-cut drumlin sections and these bluffs are connected, one to another, by low-lying beaches. A closer inspection of these drumlin cuts shows them to be composed of the usual stiff boulder clay, which, in this case, contains a very large percentage of Medina sandstone. The intervening beaches are composed of the coarser gravel and boulders of this drumlin till with little or no sand. Between the drumlins and behind their connecting beaches, lies a series of more or less extensive ponds and swamps. The above features are well shown on the accompanying map, (pl. XXVI), which is a part of the "Oswego Sheet" of the United States Geological Survey map and may be taken as typical of the whole stretch of coast under consideration.

At the close of the Glacial period when lake Ontario had assumed its present level, the drumlins extended out into the lake, forming a quite continuous series of islands. The general northeast and southwest trend of this coast exposed it to the most violent and frequent winds of our northern climate; consequently and because of the absence of bed-rock its development has been quite rapid. When wave erosion first began to cut into the drumlins, sea cliffs were formed on all sides of the drumlin islands and traces of these cliffs still exist, in some cases with large trees growing thereon.

As a result of their more exposed position, however, the northern ends were cut back most rapidly and then began the growth of the connecting beaches. The waves loosened from the drumlins more material than they could grind up and this material began to travel along shore, moved by the diagonally approaching waves, now in one direction, now in the other, but always gaining in the direction away from the most frequent winds. Slowly beach-bars grew out from each end of the sea-cliffs on the northern end of the drumlins, and these joined with those of the neighboring drumlins, tying them together and producing a continuous coast line.

On the drumlins where wave erosion is most rapid, nearly vertical cliffs are formed and the stiff drumlin till exposed to the combined action of weathering and erosion assumes the most fantastic forms. Buttress-like projections stand out from the cliff face, their upper edges reduced by rain erosion to sharp, thin, knife-like edges. Between these buttresses are ditch-like depressions down which streams of mud flow during wet weather. On such of the drumlins as are tree-covered there is a continual down-sliding of undermined trees and the farmers of this region, well knowing how rapidly their land is disappearing, place only temporary fences along the cliff edges. The very steepness of the cliffs of boulder clay shows how rapid this wearing back must be.

As the drumlin cliffs are cut back by wave erosion, the beaches are constantly changing their form and moving shoreward. From the data obtained from the farmers who note the necessary moving of fences and the shrinking of their fields, I have estimated that the cuts are moving backward from a few inches to ten feet a year where cutting is most rapid. Since the retreat of both the sea cliffs and beaches depends upon the rapidity with which the waves grind up and carry away the material loosened from the drumlins it is interesting to note the following fact which indicates, in a way, how rapid this process is.



1. Drumlin Cut showing Down-sliding of trees.
2. View along an Inter-drumlin Beach.
3. Inter-drumlin beach and enclosed pond.
4. Beach bar nearly enclosing "The Pond."
5. Steep Faced, Drumlin Cut.
6. Old Beach at Base of Old Sea Cliff.

THE ONTARIO COAST BETWEEN FAIRHAVEN AND SODUS BAYS, NEW YORK.

My first visit to this coast was in the spring. At this time, owing to thawing and to the great quantities of water in the drumlin till large masses of clay were constantly sliding down to the waves. As a consequence of this rapid supply the beaches in front of the cuts had large numbers of the characteristic angular and striated pebbles so abundant in drumlin till. A visit three weeks later to the same point showed very few angular pebbles and these few had evidently just fallen down. In the short period of three weeks, then, the hard Medina sandstone pebbles had been so worn down as to have lost all traces of their angularity.

The ponds and lagoons in the rear of the beaches receive the whole of the land drainage and consequently the sediment which the streams are bringing down. The sediment is deposited in the ponds while the water flows into the lake, either by filtering through the porous gravel beaches, or, as in the case of "The Pond" (see map), by keeping for itself an open passage through the beach. Sediment and abundant aquatic vegetation are rapidly filling these ponds and in some cases have completed their task.

By a reconstruction of the truncate drumlins (see map), one can see that there has been a retreat of the off-shore beaches and drumlins of from a fourth to half a mile. As to how much farther north these drumlins extended we have no certain data; but the presence of several boulder pavements at a considerable distance off shore, having the basal outline of drumlins, seems to indicate the former positions of drumlins which have been completely cut away. These boulder pavements are of very large boulders, such as the waves would have been unable to remove. Just such boulders are now to be seen off the northern ends of the existing truncated drumlins.

We have in the formation of the above described inter-drumlin beaches a striking illustration of the power of waves as a transporting agent and proof of their importance in shore phenomena. Professor Tarr, in a paper on "Wave Formed Cuspate Forelands,"* calls attention to the importance of wave transportation as a cause for many cuspate forelands; and since waves seem to me the most important along-shore agents, I have made some observations which show in a definite man-

* *American Geologist*, vol. xxii, 1898, p. 1.

ner how rapidly the material of these beaches is moving. In order to test the rapidity of this movement, I selected from the beach two pebbles which were striking enough to be easily distinguished from the others. One of these pebbles was spherical in form, the other had a roughly triangular outline with two flattened faces. The first of these, (weighing half an ounce), was thrown into the zone of wave action at a time when the waves were breaking at an average hight of six inches and at an angle of fifty degrees with the shore. It immediately began to move in a zigzag course along the beach, now washed diagonally upward upon the beach, now rolling backward with the returning wave. The two motions thus described were at an angle with each other and the apex of this angle pointed shoreward. Frequently the along-shore shove resulting from these two motions was as much as two feet, though its general average was sixteen inches. At one time this pebble moved three yards in nine minutes, at other times, however, the specimen became buried by the rolling mass of pebbles and it would be some time before the waves would uncover it and start it along again. The larger of the two specimens weighed seven ounces and this when the waves were breaking at a hight of twelve inches, gave as a result of three trials, a linear motion of sixteen yards in ten minutes. With stronger winds, observations were impossible for the waves then became so muddy that one could not follow the movements of the specimen.

At the entrance to "The Pond" (see map), there is a curious hook on the end of the eastern beach, which is kept from growing across this entrance by the outflow of the land drainage and also by the piling up of the water in "The Pond" during stormy weather. During a strong on-shore wind the water backs up into this bay until the level of the water in "The Pond" is higher than that of the lake. When the wind subsides the water runs toward the lake again with a considerable current. This current, however, is not able to carry back the materials washed in by the more powerful waves. Here again the waves are the most important factor and the current, though stronger than most currents in the lake, is capable of moving little else than sand and clay.

EIGHTH SESSION OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS, PARIS, 1900.

ITS PROCÈS VERBAUX WITH RUNNING COMMENTS.

PERSIFOR FRAZER, Philadelphia, Pa.

A volume, royal 8vo of 62 pp. has been issued by the French ministry of commerce, trade, post and telegraph giving the procès verbaux of the eighth session, held at Paris last year from the 16th to the 27th of August. The promptness with which all the publications of the last Congress have been issued, is an unmistakable indication of the directing power of Charles Barrois, the able general secretary.

After an enumeration of the twenty-five excursions, follow the more or less formal addresses of the retiring president, Karpinski (who was re-called to Russia a few days afterwards by a death) and of the incoming president, Gaudry. The announcement by the latter of the deaths of the former members of the Council, Lieut. General de Tillo, Hauchecorne, Janettaz, James Hall and Marsh seems to have been erroneously printed "since 1878" (the date of the first meeting of the Congress in Paris). In point of fact all these eminent men appear to have died since the St. Petersburg session of 1897. In Barrois' report the happy solution of a difficulty which threatened the success of these International Congresses is announced. It was to organize two sets of excursions, the first open to practically any one who cared to take part, but the second restricted to professional and practising geologists. For several sessions the local committees have staggered under the increasing burden of providing for the transportation and maintenance at a minimum price of great numbers of persons, chiefly foreigners to the country where the session was held, who read in the newspapers of the excursions planned for the geologists, and determined to profit by them as personally conducted tours to which the payment of an entrance fee of twenty-five francs, entitled the payer. This imposition was most severely felt at the St. Petersburg session in 1897.

Six months before the opening of the session, the newspapers throughout the world had announced the generous plans of the Russian local committee to carry two or three hundred members of the Congress in special trains, steamers, and coaches over the Urals and Caucasus. The benefits to be enjoyed by such excursions appealed to many persons who knew little of Russia and nothing of geology, but who could easily spare five dollars to become a "member" of the Congress, and the necessary traveling expenses to bring them within the vortex of Russian hospitality. One gentleman of general but not geological attainments expressed to the writer his ability to "hand a grand duchess into the supper room as well as the best geologist." In consequence of the extreme good nature of the Russians, and the selfishness of the non-geological travelers who desired to take "everything in" the great Ural expedition occupying about a month and employing about thirty sleeping and dining cars carried 253 passengers of which it was said fully one-third were not geologists, nor capable of profiting geologically by what they saw; but kept fully seventy or eighty deserving geologists from taking part.

Unfortunately the United States had a larger misrepresentation, both male and female, in this fraudulent practice of ride stealing than any other country. The debates upon the subject were warm, but without result. The method of M. Barrois, which might be compared to a lightning arrester, solves the the difficulty with least friction.

The following reports of committees were presented:

1. On geological nomenclature by M. Tschernyschew.

2. On the map of Europe by G. Capellini on behalf of the directors.

3. On petrography by M. Zirkel.

4. On glaciers by M. Richter.

5. Proposition of Sir Archibald Geikie on international coöperation in geological investigations.

6. Proposition of M. Oehlert on the reproduction of types.

The jury on the Spendiaroff prize was as follows. Gaudry (President), Marcel Bertrand, Sir Archibald Geikie, Karpinsky, Tschernyschew, Zirkel and v. Zittel.

The committee on Spendiaroff award was also happy in preventing the generosity of M. Spendiaroff from becoming a bad precedent in the administration of the Congress.

The history of this foundation is peculiar.

During the month of excursions prior to the St. Petersburg Congress, a young man was noticed by all participants, and especially by the foreigners, for his grace and courtesy in assisting them, and his intelligence and zeal in the science of geology. During the beautiful Volga steamboat excursions he will ever be remembered by those who were present for his delightful singing of the Russian folk songs, both alone and in chorus. One day in St. Petersburg at the morning session of the Congress, after the Ural and other ante-session excursions had finally come to a close, the members were shocked to learn of the sudden death of young Spendiaroff. A few days afterwards the president, M. Karpinsky, announced the donation of his father to found a prize in memory of his son. The object was most laudable, but many of the members, including Hæckel, feared lest the precedent should be abused by persons desirous of securing international notice.

The committee appointed to determine the method of applying this fund has placed it in the Russian treasury to the credit of the Russian Geological Survey, and the minister of agriculture and domains has offered the interest of the 4,000 Rubles to the International Geological Congress for a prize to be offered under such conditions as the congress may choose.

This relieves the difficulty of any direct dealings between the congress and individuals, and avoids the necessity for such an organization of the former as would enable it to hold and administer funds. On the whole, in its present shape the donation may prove beneficial.

It is amusing to note that Karpinsky, without whom the Spendiaroff prize would never have been attached to the International Congress of Geologists, was the first to receive it nolens volens, although two sessions of the council were occupied with his efforts to avoid this honor.

Vienna was named as the place of the meeting in 1903.

On Archibald Geikie's motion, a committee (Geikie chairman, Horne, Dawson, Tschernyschew, Sederholm, Ramsay, Chamberlin, Brögger, Reusch, de Geer, Högrom, Barrois,) was appointed to secure more uniformity in the relative studies of the coast lines of the northern hemisphere—and another (Credner and v. Zittel, Mojsisovics, von Mojsvar, Tietze, Geikie, Teall, Renard, Walcott, Chamberlin, Barrois, de Lapperent, Capellini, Karpinsky, Alexis, Pavlow, Brögger, Renevier,) to ascertain in what direction international coöperation in geological investigations is most required.

Karpinsky and Stefanescu report for Russia and Roumania respectively that these countries have accepted the suggestion of the previous congress in reference to instruction in geology in the public schools.

M. Karpinsky reports as to the creation of a floating institute which has presented such great difficulties. It was referred to the Geikie committee on international coöperation.

M. Oehlert's committee to procure photographic representations of types of fossil species consists of Bather, Woodward, Frech, von Zittel chairman, Mojsisovics, v. Mojsvar, Uhlig, v. d. Broeck, Fraipont, Walcott, Williams, Alcmera, Gaudry, Oehlert secretary, Canavari, Kjöer, Stefanescu, Pavlow, and Tschernyschew, Choffat, Lindström, Lorriol. It was pointed out that the commission should hasten its work in order to show a commencement in 1903 at Vienna.

The council legalized by vote the practice which has hitherto always obtained of relegating to the management of each council the execution of the work of a congress until the next session of the congress.

The Meetings of the Sections.

I. *General Geology and Tectonic.*

Archibald Geikie the president of the section delivered his address on international coöperation, etc. (Note.—It were greatly to be desired that James Geikie, the president's talented and learned brother, took a more active part in these congresses. Especially would his assistance be of value in the section presided over by his ex-official brother.

The papers were:

M. J. Joly, 1) Geological age of the earth determined by the content of sodium in the ocean;. 2) Experiments concerning denudation by fresh and by salt water. 3) Order of formation of silicates in igneous rocks 4) Internal mechanism of marine sedimentation.

M. de Lapparent. On the limit of geological stages.

M. Stanislas Meunier. Subterranean denudation.

M. Bleicher. The denudation of the Vosges.

M. Richter. Report on the works of the Glacial Commission.

H. F. Reid. On the movement of glaciers.

M. Arctowski. The former extension of glaciers in the regions discovered by the Belgian antarctic expedition.

M. Popovici-Hatzeg. The new geological map of Roumania.

M. Vorwerg. Proposition tending to simplify the notation of dip and strike of beds.

The abbe Parat. The grottoes of La Cure.

II. *Section of Stratigraphy and Paleontology.*

V. Zittel presiding in place of Renevier detained by illness.

The suggestions of the committee have only moderate interest or novelty.

One is to substitute "Eo" for "Paleo," but it has not occurred to the proposer of the change what would be the fate of *"Eozoic"* and *"Paleo-zoic,"* both terms of great value. As to eras, Gaudry prefers the terms primary, secondary, and tertiary.

Prof. Scott presents to the section the fauna of Patagonia, through the studies of J. B. Hatcher. The series of beds is thus arranged:

Gault; containing Ammonites resembling entirely the synchronous fauna of the South of Africa.

Magellian; a terrane of Eocene or Oligocene age.

Patagonian; very fossiliferous Miocene of which the fossils are closely allied to those of Australia and New Zealand.

Santa Cruz; beds fossiliferous fresh-water Miocene with mammifers of which the fauna is more closely related to the southern Australian fauna of Africa than to the northern of America.

Beds of Cape Fairweather; Pliocene age.

M. Bertrand by "gelosic and humic coals," comprehends the boghead coals and bituminous schists. His paper is original and interesting.

M. Grand Eury. On the rooted stems of the Carbonic terranes.

M. Lemeire. Methodical connection explanatory of the chemical formation of various fossil combustibles.

M. H. F. Osborn. 1) "Progress of methods in Paleontology." 2) "Correlation between the mammiferous faunæ and the Tertiary horizons of Europe and America."

The conclusion of this last study is that in these two regions of the northern hemisphere the paleontology and stratigraphy accord; that the progress of evolution is parallel if not identical; and that the same divisions into stages may be permitted.

M. Ficheur presented the third edition of the geological map of Algeria on a scale of 1 : 800,000.

M. Flamand. "Geology of South Algeria, high plateaux and mountains of Ksour, and the regions of Sahara."

M. Donville. 1) "The Jurassic terrane of Madagascar." 2) "The geological results of the exploration of M. Morgan in Persia."

M. Zeiller. "The fossil plants of Tonkin."

M. Malaise. "The Cambric and Siluric in Belgium."

M. Oehlert, proposed the foundation of an international publication for the purpose of re-editing the types of described species anterior to a certain determined epoch. This proposition was referred to the Council.

M. F. Hume. 1) "The rift valleys of Sinai." 2) "Notes on the geology of the eastern desert of Egypt." 3) "The valleys of eastern Sinai."

III. *Section of Mineralogy and Petrography.*

M. Michel-Lévy, as president of the international committee on petrography, read the following suggestions which the foreign scientific members expressed.

First suggestion. The names of the authors shall always be placed after the names of the rocks as is the custom in zoology and botany.

Second suggestion. That the congress name an international committee to publish the new names of rocks with as precise a description as possible, with their chemical analyses, and, if necessary, with an illustration reproducing their structure. This publication will take place in the transactions of the congress.

The committee appointed consists of: Rosenbusch, Weinschenk, Zirkel,, Boecke, Dolter, Tschermak, A. Geikie, Judd, Teall, Twelvetrees, Renard, Hussak, Adams, Ussing, Calderon, Hague, Iddings, Pirsson, Fouqué, Lacroix, Michel Lévy, Barrois, Ramsay, Sederholm, Sabatini, Strüver, Viola, Koto, Brögger, Reusch, Wichmann, Mrazec, Karpinsky, Lagorio, Loewinson-Lessing, Zujovic, Duparc, Schmidt, Backström, Törneböhm. This committee has the right to add to its number.

Third suggestion. It is desirable to regulate the nomenclature of the eruptive rocks, where the lack of unity is particularly felt. Different authors attribute different significations and senses to one and the same name, and conversely different denominations are employed to designate the same rock, the same group of rocks, or the same structure. All these inconveniences of nomenclature can and ought to be abolished. At least for the great groups.

Fourth suggestion. The characteristic of the great group (for example, families) should be based upon the mineralogical composition, supported by chemical composition and structure.

This request was adopted with 19 dissenting votes. Löwinson-Lessing's motion that chemical composition shall be the characteristic of first importance in the great groups, received nine votes.

Fifth suggestion. The great groups can be determined at once, without interfering with the ultimate development of the classification and dismemberment of these groups in subdivisions. Adopted.

Seventh suggestion. It is desirable to designate the principal types of structure by special names. Adopted.

Ninth suggestion. It is necessary to avoid the employment of the same denomination (of identical term) in different senses. Adopted.

Tenth suggestion. The employment and creation of different terms to designate the same idea, the same rock, or the same group of rocks, should be avoided wherever possible. Adopted.

Thirteenth suggestion. The employment of pre-existing names, or the assignment to them of a new meaning, by restricting or enlarging their significations, should be avoided wherever possible.

The secretary exhibited the proof of the petrographic lexicon of M. Loewinson-Lessing.

M. Zirkel was elected president of the commission of Petrography. An executive committee of the petrographic committee was chosen, consisting of Becke, Barrois, Brögger, Loewinson-Lessing, Pirsson.

IV. *Section of Applied Geology.*

M. Mourlon. "The new paths of Belgian geology."

M. Gosselet. "The salt waters met in the aquiferous areas in northern France.

M. Van der Veur. "The enlargement of the Kingdom of the Netherlands by the drawing of the Zyderzée."

M. Thevenni. "The plateaux of the Hautes Pyrénées and the dunes of Gascony."

v. d. Broeck. "The applications of geology."

M. Kunz. "The progress of the production of precious stones in the United States."

M. L. Janet. "The enclosing and protection of the springs of potable water."

M. de Richard (read by the president). "The origin of petroleum.".

Final General Session.

M. Matthew, Jr., presented in the name of his father a note, printed by the congress, on "The most ancient paleozoic faunæ."

An interesting episode was the reading by the secretary-general, M. Barrois, of a passage from a note by M. Walcott, director of the U. S. Geol. Survey, on "Fossiliferous pre-Cambric formation," in which, relying on the testimony of M. Rauff, he doubts the existence of the organisms described by M. Cayeux in the pre-Cambric of Brittany. After the reading, M. Rothpletz stated that with M. Renard he had seen the sections described by M. Cayeux and considered the existence of the Radiolaria in these preparations indubitable.

M. Pavlow. 1.) "The Portlandian of Russia compared to that of the Boulonnaise." 2) "Some methods which might contribute to the elaboration of a genetic classification of fossils."

M. V. de Broeck. "On the Bernissartian."

M. A. Guebhard. "Tectonic phenomena of the Alpes maritimes."

The president announced the receipt of a written communication from MM. Lohest and Forir on "The method of numbered notation of terranes."

M. Stanislas Meunier. "The structure of the diluvium of the Seine."

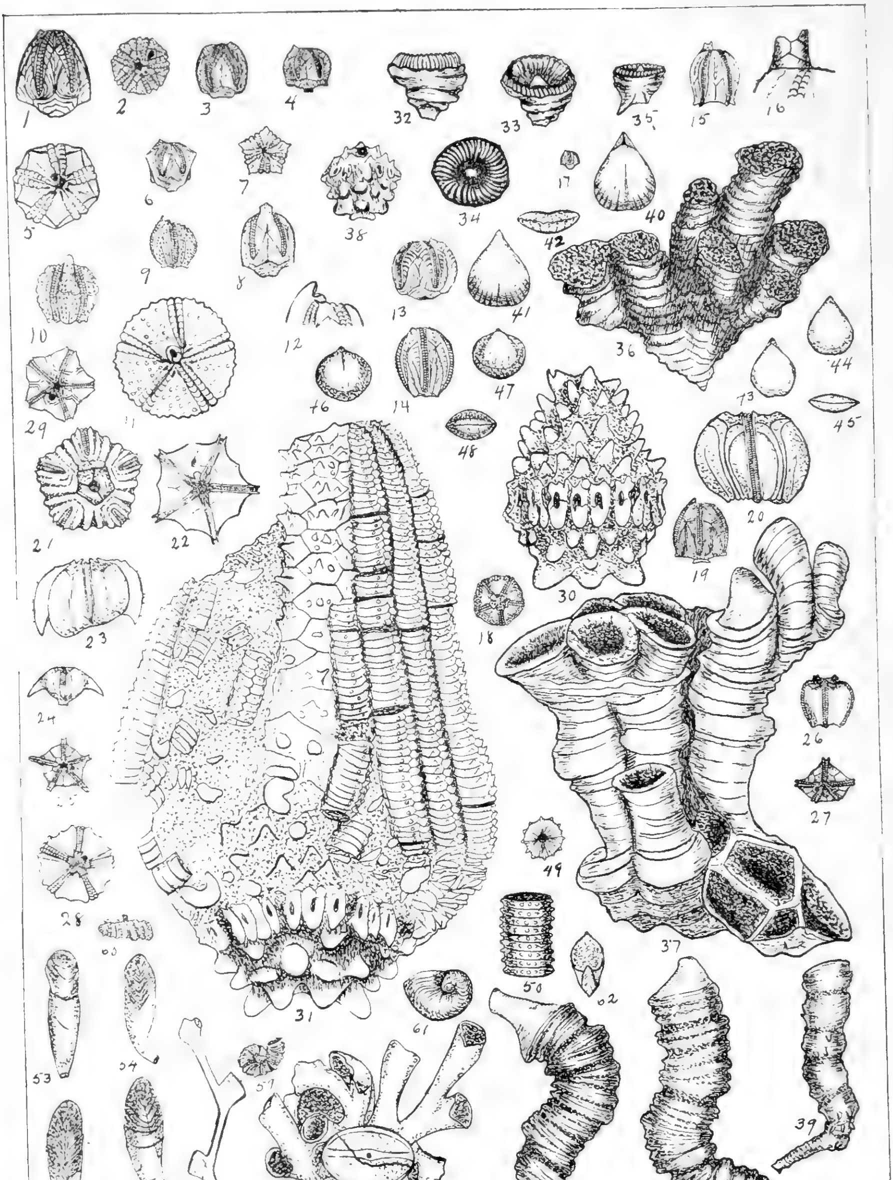
The Secretary-General resuméd a note from *M. Hull* on "Suboceanic terraces and valleys of the western rivers of Europe." Also a note from

M. Huddleston, on "The eastern border of the Atlantic."

M. E. A. Martel. "The general geological and hydrological results of the subterranean explorations which the author has undertaken since 1888."

M. G. Dollfus. "The last geological phenomena of which the Seine and Loire have been the theater."

The late congress is pledged to publish before the expiration of the year a volume containing not only the transactions but important memoirs accompanied by fine illustrations.



FOSSILS FROM THE UPPER PALEOZOIC OF MISSOURI.

TWO NEW GENERA AND SOME NEW SPECIES OF FOSSILS FROM THE UPPER PALAEOZOIC ROCKS OF MISSOURI.

By R. R. ROWLEY, Louisiana, Mo.

PLATE XXVIII.

It is our purpose here first to discuss two little groups of blastoids of which scarcely anything is known to the general student of this class of organisms, since they are not only very limited in their distribution, but even locally reckoned among the rarities.

Of group one, the first mention is probably to be found in Dr. Shumard's description of *Pentremites roemeri* in the old "Missouri Geological Survey, I and II Reports, 1855." Imperfect as the description is and poor as the figures are, the author had before him a specimen of what has since been described as *Granatocrinus sampsoni.* It was hardly a medium sized individual and without surface markings, but with the rather large interradial (deltoid) and distinctly convex base. (I refer to his figure 2a. Figs. 2b, 2c and 2d represent another and quite distinct thing.)

Along with his figure of *Granatocrinus sampsoni,* Dr. Hambach figures one of Dr. Shumard's specimens, but it is certainly specimen no. 2 (2b, 2c, 2d as above) and can hardly stand for *G. roemeri.*

The type of the latter species came from the Chouteau limestone of Providence, Boone Co. Later collectors have found this form near Sedalia, Pettis Co., and in the Kinderhook beds at Osceola and Cedar Gap. The author of this paper has found it at both of the latter places and has obtained specimens of it from the other places mentioned.

The next species of the group brought to the notice of naturalists is the *Codonites inopinatus,* passing over the problematical *Pentremites neglectus,* too poorly defined and ill figured to be able to be identified even generically.

Codonites inopinatus was figured and described in the Kansas City *Scientist,* July, 1891.

In the August number of the same journal and same year the third species was defined and figured as *Granatocrinus aplatus.* Two more species will follow the generic description here.

This group of blastoids presents some striking characteristics, and is further removed from Orbitremites (Granatocrinus) than Cryptobastus is. The base is either level with the lower ends of the ambulacra or decidedly convex. The basal plates form a low broad cup, thus separating widely the lower ends of the ambulacra. The interradials (deltoids) are rather large, often quite a third of the length of the fossil, while the anal plate is sometimes extravagantly produced upward to form a hood over the anal opening and pushing out towards the center so as to reduce the usual star-shaped central opening to a lunule. The spiracles are small and, although known for some time in *Granatocrinus aplatus,* have been discovered but recently in *Codonites inopinatus.* They are hardly round in any of the species and decidedly elongate in the last two mentioned species, thus approaching, as we have always suspected, the slits of *Orophocrinus.*

The prominence of the radial or fork pieces along the sutures, gives rise to elongate depressed triangles bordering the ambulacra, and across these triangles the lines of ornamentation run as on the deltoids, or interradials, recalling the side-plate areas on Orophocrinus. The ambulacra are either even with the surface of the radials and interradials or stand out bead-like above them.

The tops of the radials at the common suture are generally prominent and sometimes so much so as to give a strongly pentagonal cross section and a decidedly Codaster-like appearance to the specimen.

The ornamentation is either linear, sometimes very fine and again cord-like in its coarseness, or toothed-linear and possibly granulo-linear.

We propose for this little group the generic name of *Lophoblastus* in allusion to the crest-like hood over the anal opening, and make *Codonites inopinatus* the type species of the genus. We offer the following generic diagnosis: Body conoidal, elliptical or quite globose; ventral side generally convex, but sometimes flat; base large, flat or decidedly convex; deltoids or interradials large, sometimes a third of the entire body length; radials or fork pieces from one-half to nearly three-fourths the length of the whole body; ambulacra even with the radial lips or above them; Spiracles ten in number and vary from punctures to slits; anal opening surrounded by an elevated rim and often strong hood-like upper prolongation of the anal deltoid or interradius; ornamentation, fine lines, coarse cord-like folds, or crenulated lines; columnar cicatrix rather large, but the column is unknown, so also the pinules. The central opening above (ventral) confined to a lunular area and, in perfect specimens, covered by an integument of small plates.

The genus begins in the Kinderhook or the so-called Lower Chouteau beds and extends through the Lower Burlington.

Lophoblastus conoideus, n. sp.

PLATE XXVIII.

Fig. 1.—Side view, two diameters, of a large specimen.

Fig. 2.—Ventral view, two diameters, of another specimen.

Fig. 3.—Side view of a large elliptical specimen, natural size.

Fig. 4.—Side view of a specimen, probably of a different species.

Body small, conoidal or elliptical. Base large, convex and composed of the usual three plates. Columnar scar medium in size and excavated. Interradials from one-fourth to one-fifth the length of the body. Radials more than half the length of the body. The lower ends of the ambulacra project outward. The spiracles are round or slightly elongate openings and the anal opening is rather large and with a less pronounced hood than any of the other species, excepting *Lophoblastus roemeri*. The ornamentation is fine or coarse lines parallel with the plate sutures. The elongate triangular areas bounding the ambulacra as marginal parts of the radials are less pronounced than in the type species.

The specimens of this species were collected from Upper Chouteau beds, two and one-half miles northeast of Curryville, Mo.

This fossil was figured along with *Granatocrinus mutabilis* under the impression that it belonged to the same species, but better specimens lately obtained show the greatest difference between them.

Lophoblastus marginulus, n. sp.

PLATE XXVIII.

Fig. 18.—Ventral view of a specimen with the central opening covered by an arch of minute plates extending a little way over the ambulacra.

Fig. 19.—Side view of the body of the type specimen, showing the character of ornamentation and the little rim around the stem base.

The collection contains four of these little blastoids. The base is flat or a very little convex. The lower ends of the ambulacra are separated by a rather broad base made up of the usual three pieces. The columnar base is surrounded by a distinct rim, giving a slightly concave surface for attachment. The radials (fork pieces) are hardly more than half the greatest length of the body. The interradials (deltoids) are more than a third of the length of the body. The ambulacra are more convex than the radial and interradial borders and the interambulacral areas are flat or concave and three of the four specimens are decidedly pentangular in cross section but this may be due in part to the fact that the test is very thin and the three specimens in question may be a little misshapen, due to pressure.

There are ten elongate or slit-like spiracles and an anal opening with a hood but less prominent than in *L. aplatus*.

There is no elevation above the general surface at the tops of the radials as in *L. opinatus* but the ornamentation is the same as in that species (fine longitudinal lines), the cross lines of the deltoids continuing down the sides of the ambulacra as elongate triangles on the radials to the very end of the ambulacra. The mid-interambulacral triangular areas of the radials are crossed longitudinally by fine lines. The type specimen is 7½ mm. long and about 7 mm. wide. The basal rim is a little over 2 mm. wide.

This blastoid comes from the brown, earthy layer just over the top of the fifth division of the Lower Burlington limestone and is associated with *L. aplatus, Aorocrinus wachsmuthi, Agaricocrinus planoconversus* and *Cactocrinus springeri.* Hart's and Pratt's Quarries, Louisiana, Mo.

An average specimen of Lophoblastus conoideus is about 4 mm. in length by 4 mm in breadth. A large specimen 6mm. in length by 4½mm. in breadth. A small specimen 2½mm. in length by 3mm. in breadth.

The species of this genus at present known are,

Lophoblastus inopinatus, Lower Burlington limestone.

Lophoblastus aplatus, near top of Lower Burlington limestone.

Lophoblastus conoideus, top of Choteau limestone.

Lophoblastus marginulus, top of Lower Burlington limestone.

Lophoblastus roemeri, Kinderhook or Lower Chouteau limestone.

Lophoblastus (?) *neglectus,* Lower Burlington limestone.

The other group embraces three already described species and a new one here figured and described for the first time. *Granatocrinus magnibasis* was defined in the October, 1895 number of the AMERICAN GEOLOGIST, *G. piriformis* in the August, 1891, number of the Kansas City *Scientist,* and *G. stella* in the February, 1900, number of the AMERICAN GEOLOGIST,

We propose for this group the generic name *Carpentereblastus,* as a slight tribute to our friend the late Dr. P. Herbert Carpenter, of Eton College, England, and take for the type species *Granatocrinus magnibasis.* The distinguishing characters of the new genus are sunken ventral surface; narrow, elevated ambulacra; broad, convex basal disk; coarse, cord-like ornamentation, and usually distorted appearance; rather small deltoids, eight small rounded spiracles (two more are probably confluent with the anal opening), and a small anal opening. None but the young of *C. magnibasis* have symmetrical shapes, while most of the specimens of *C. stella* are similarly and singularly misshapen, the only one preserving the test, however, is quite regular in outline. *C. stella* differs much from the other species in the free ends of the ambulacra and consequent great prominence of the base. The new species is represented by a single specimen and that is in a crushed condition. It will be known as,

Carpenteroblastus pentagonus, n. sp.

PLATE XXVIII.

Figs. 26 and 27.—Side and ventral views of the type specimen. This little blastoid is about 6 mm. long by 5½ mm. broad: has small deltoids, long fork pieces and a flat, not large base; the ventral side is concave. The spiracles are small, round and the anal opening is inconspicuous. The ambulacra are narrow and convex beyond the radial edges. The interambulacral areas are flat. The ornamentation is hardly noticeable on the type specimen.

This rare bastoid comes from the same horizon as *Lophoblastus aplatus* and *L. marginulus* (top of the fifth division of the Lower Burlington limestone) at Louisiana, Mo.

The species of this genus at present known are,

Carpenteroblastus magnibasis, base of Upper Burlington limestone.

Carpenteroblastus piriformis, Upper Burlington limestone.

Carpenteroblastus stella, base of Upper Burlington limestone.

Carpenteroblastus pentagonus, top of fifth division Lower Burlington limestone.

Aorocrinus wachsmuthi, n. sp.

PLATE XXVIII.

Fig. 38.—Side view of the type specimen, natural size.

This little crinoid has nodose calyx plates and blunt spinose ventral plates. The central dome spine, so conspicuous in Dorycrinus is represented by a nodose plate in this species. The basal plates form a low rim about the top of the column. The first radials are very nodose and about as long as wide. The second radials are smaller, quadrangular pieces. The third plate in the radial series is a bifurcating piece and five-sided, and a little smaller than the second radial. The interradials consist of one large noduse plate, upon which rest two flattened plates above. The anal interradial area is filled by a large plate in line with the first radials and a little larger than them, supporting three smaller nodose plates above and resting on the latter in turn are three smaller flat plates. The anal opening is on a wart-like prominence. Three of the arm lobes give off two arms each while the right and left anal lobes give off three each, making 12 arms in all. The stem base is very small and round.

We are glad to name this pretty little species for the late Charles Wachsmuth of Burlington, joint author with Mr. Frank Springer of the genus *Aorocrinus.*

This crinoid is found associated with Lophoblastus aplatus and another Aorocrinus, apparently a variety of *A. parva,* near the top of the fifth division of the Lower Burlington limestone at Louisiana, Mo.

In our notes on the "Fauna of the Burlington Limestone at Louisiana, Mo.," AMERICAN GEOLOGIST, Vol. XXVI, October, 1900, page 247, we mentioned a specimen of Schizoblastus sayi with a short proboscis. We here figure this little specimen to show this feature. Another specimen has since been found showing the same structure. Figs. 15 and 16; the latter is an enlarged view.

Fig. 30 is a side view of a splendid body of *Cactocrinus springeri,* a crinoid figured and described by the author in the February, 1900, AMERICAN GEOLOGIST, as *Batocrinus springeri.*

Fig. 31 is a large body, somewhat crushed, with three entire arms and parts of three others. The great ventral tube is preserved to the arm tips and furnished with spines. The arms are traversed longitudinally by short spiny nodes in rows. Associated with these crinoids are spiny stems which, doubtless, belonged to this species.

Axophyllum ? alleni, n. sp.

PLATE XXVIII.

Figs. 32, 33, 34.—Side and ventral views of the largest specimen
Fig. 35.—Side view of a smaller specimen from Weston, Mo.
All drawn natural size.

The specimens of this species are short and broad, with the top of the lamellae arched and above the epithecal covering of the outside, even more pronounced than in Microcyclus. The lamellae or septa number about sixty (60) and are rather crowded. The central boss or columella of the shallow cup is strong, rounded and low, or triangular, and is formed of the upturned inner edges of the lamellae or septa. The cups show no other feature than those mentioned. The outer surface or epithecal covering is considerably wrinkled and folded. The base is acute and with or without radicular appendages.

Its distinguishing characters are the shallow cup, upper edges of the septa arched above the outer epithecal covering, shallow almost discoidal outline, short but stout columella.

It comes from the Upper Coal Measures of Northwestern Missouri. Specimen, figure 35, is from Weston.

The specific name is in honor of Mr. Thomas W. Allen, of St. Joseph, Mo., an excellent collector in the Upper Coal Measures of western Missouri and one to whom the author is indebted for many favors.

Leptopora ramosa, n. sp.

PLATE XXVIII.

Fig. 36.—Side view of the type specimen, natural size.

Two specimens of this peculiar coral are in the author's collection and both are pointed below and expand above by the multiplication of stems from the parent stalk, due to lateral gemmation. The coralites are more or less round, very rugose and irregular in shape. The cups are very shallow and where the sides and bottoms are weathered, appear cellular. No septa are visible and are probably wanting, but placenta are probably present as in *L. placenta*, although not seen in the types.

This species occurs in the Chouteau limestone, east of Curryville, Mo., associated with Leptopora placenta and other corals.

Leptopora procera, n. sp.

PLATE XXVIII.

Fig. 37.—Side view of the type specimen, natural size.

The base of this coral differs but little from Leptopora placenta, being flattened and with large shallow cups and a very wrinkled and rugose epithecal under surface but in producing tall crowded stems above by calicular budding, it differs from all the species of Leptopora with which the author is acquainted. The stems spring from the shallow cups below, are more or less round, very rugose and distorted and, crowding together at the top, the otherwise round cups become polygonal. From the calyx of one of the stems three small stems arise. No septa are observable nor are placenta, but the latter are surely present. The cups are shallow and are pitted or cellular in appearance.

The fine specimen figured was obtained from the Chouteau limestone at Annada, Mo.

Trigeria? curriei, n. sp.

Plate XXVIII.

Figs. 40, 41, 42.—Views of the brachial and ventral valves and the front of the shell, respectively, twice natural size or two diameters.

Shell longer than wide, plicated but with the plications more or less obsolete, except near the front of the shell. Young individuals, however, are plicate throughout. The beak of the pedical valve is rather long and pointed with a triangular area beneath it and a delicate triangular foramen. Nothing is known of the inside of the shell. The shells vary from 1½mm. to 6 mm. in length and from 1 mm. to 6 mm. in width. The specimen figured is 5 mm. by 4 mm. (length and breadth.) There is a slight sinus at the front margin of the brachial valve and sometimes one on the pedicel valve also. It is rather a rare form in the Louisiana (Lithographic) limestone at Louisiana, Mo. It is obtained, among other small forms, by washing the clay from between the limestone layers.

This little brachiopod is named specifically for Rev. H. Currie, of Thedford, Ontario, an excellent collector in the Hamilton group and a most obliging scientist.

Dielasma? pediculus, n. sp.

Plate XXVIII.

Figs. 43, 44, 45.—Brachial, pedicel and front views of a large specimen, two diameters.

Length of a large specimen 4½, width 3½ mm.

This little shell is smooth, rather flat, elongate, with a rather long pedicel beak, the end of which is perforate. It occurs abundantly in the clay seams of the limestone and is obtained by washing the soft material. It is found associated with the above species, Ambocoelia minuta and Chonetes geniculata in the Louisiana limestone at Louisiana, Mo.

Nucleospira barrisi? (white.)

Plate XXVIII.

Figs. 46, 47, 48.—Three views of the brachiopod, natural size, as it occurs in the Louisiana (Lithographic) limestone at Louisiana, Mo.

It is not plentiful. There is some doubt as to the correctness of the specific reference.

Cyrtolites bennetti, n. sp.

PLATE XXVIII.

Figs. 61 and 62.—Front and side views of the type, natural size.

The aperture of this shell is elongate, heart shaped. There is a mid-dorsal fold and the strong lateral lines of ornamentation curve sharply toward this fold. The inner whorls are hidden by the outer. This shell is 7½ mm. wide and is very rare. It is named for my friend, Rev. John Bennett, of Kansas City, Kan.

It occurs about the middle of the Lower Burlington limestone at Louisiana, Mo.

Spirorbis? dubius, n. sp.

PLATE XXVIII.

Figs. 59, 60.—Two views of the type specimen, natural size.

This little shell was free and has no appearance of ever having been attached.

It is composed of three irregular whorls, more or less distorted and crossed by sharp ridge-like lines. It coils loosely. This species is almost certainly not Spirorbis but its generic relations are doubtful and for the present we leave it under Spirorbis. It is 5 mm. wide.

It comes from near the middle of the Lower Burlington limestone at Louisiana, Mo.

Amplexus vermicularis, n. sp.

PLATE XXVIII.

Fig. 51.—Side view showing nearly the entire length, natural size.

Fig. 52.—Another view showing the contracted cup, natural size.

This peculiar fossil has the external appearance of Amplexus but despite the excellent preservation of the type specimen, the septa are not visible through the epithecal covering and are to be seen only on a weathered spot, and, doubtless, are merely raised lines along the inner side of the outer wall.

The external surface is beautifully ornamented by irregular cross ridges and crowded lines of growth. Placenta are, doubtless, present but not seen in the type specimen.

The example figured is entire, rather elongate, distorted and contracted in places, yet gradually enlarging toward the front. The strangest feature of the type specimen is its contracted calix, giving the appearance of a second end for attachment and no open cup. The contraction begins about 1-3 of an inch from the anterior end and is almost closed at the front. Were it entirely closed the question might be asked, can this be an opercutate coral? Other specimens apparently of the same species but less robust and more elongate, have fine crowded septa but hardly developed beyond the appearance of raised lines and with placenta crossing the central open space at irregular intervals without curvature. This fine coral is from the third division of the Lower Burlington limestone at Louisiana, Mo.

Amplexus radigerus, n. sp.

PLATE XXVIII.

Fig. 39.—Side view of the type, natural size.

Coral elongate, differing little in cross diameter, except where the stem makes rapid contractions.

Shape irregular, often abruptly bending to the right or left. The cup is not clean in the type specimen, but is apparently deep and the septa poorly developed, but seen on the surface as fine crowded lines. On the inner side of the surface wall they are more pronounced than in *A. vermicularis.* Cross lines of growth and ridges of distortion gird the exterior. Tabulae at irregular intervals cross the central area. A few short radicular appendages occur along the lower half of the coral.

Another Amplexus, probably distinct, with little greater diameter than this form, is often found several inches long and apparently incomplete, alternately contracted and exponded, but without radicular appendages.

This coral comes from the third division of the Lower Burlington limestone at Louisiana, Mo.

Coleophyllum? greeni, n. sp.

PLATE XXVIII.

Fig. 53.—Side view of a nearly perfect coral, natural size.

Figs. 54, 55, 56.—Side views of other specimens, weathered in such a way as to show structural features, natural size.

This coral is elongated, curved and without septa (lamellae). The cup is shallow. The entire fossil is made up of a series of invaginated tabulae, as seen on the weathered specimens. The outer surface is comparatively smooth except near the calix where the edges of the tabulae remind one somewhat of Cystiphyllum.

The specimens are from the Upper Chouteau limestone, three miles northeast of Curryville, Mo.

Aulopora longi, n. sp.

PLATE XXVIII.

Fig. 57.—Side view of a large stem, natural size.

This is a slender, elongate species. The tubules are very long with the oral portion rapidly expanding. Each coralite comes off from the one below it in such a way as to give a zigzag appearance to the stem. This species is probably attached at the base but never along the side.

It occurs both in the Lower and the Upper Burlington limestones at Louisiana. Some specimens are quite two inches long. The specimen figured is from the base of the Upper Burlington limestone. It is a much more delicate species than *A. gracilis.* We are glad to name this coral for Mr. F. R. Long, of Louisiana, Mo.

Aulopora amplexa, n. sp.

PLATE XXVIII.

Fig. 58.—View of a colony surrounding joints of a Platycrinus stem, natural size.

This is a much stouter coral than either *A. longi* or *A. gracilis* but near to the latter, except in its manner of growth. The colonies are always found surrounding stem joints of crinoids, especially Platycrinus and, sometimes, as in the type specimen, between two stem joints, pushing them apart and surrounding them. The tubules are rather large, short and little expanded at the orifices.

Stem joints of Platycrinus are often found in the Burlington limestone with from two to four or five conical holes reaching almost or quite to the center of the stem and sometimes showing remnants of a tubular form filling each hole. Is this our Aulopora?

This species comes from the base of the Upper Burlington limestone, at Louisiana, Mo.

EXPLANATION OF PLATE XXVIII.

Lophoblastus conoïdeus, n. sp.

Fig. 1. Type specimen. Side view x2.

Fig. 2. Ventral view of another specimen, showing the anal opening and the ten small, round spiracles x2.

Fig. 3. Side view of a specimen, more globose and with finer ornamentation x1.

Fig. 4. Side view of a broad specimen apparently granulo-striate x1.

Fig. 17. Side view of a young specimen, natural size.

Lophoblastus inopinatus Rowley & Hare.

Fig. 5. Ventral view of a specimen showing the anal opening and the short slit-like spiracles x2.

Figs. 6 and 7. Side and ventral views of a specimen with a strong pentagonal outline at the top of the radials, natural size.

Fig. 8. An elongate specimen, side view, showing the shape and great hight of the anal hood. Natural size.

Lophoblastus aplatus Rowley & Hare.

Fig. 9. Side view of a medium sized specimen, natural size.

Fig. 10. Side view of a larger specimen, showing ornamentation and the hight and shape of the anal hood, natural size.

Fig. 11. Ventral view of a specimen to show the anal opening and elongate spiracles, x2.

Fig. 12. Side view of the top of a specimen to show the hood and anal opening, x2.

Lophoblastus roemeri Shumard.

Fig. 13. Side view of a medium sized specimen, showing the coarse character of ornamentation, natural size.

Fig. 14. Side view of an elongate specimen with flat base, natural size.

Lophoblastus marginulus, n. sp.

Fig. 18. Ventral view of a plump specimen, showing the central opening closed by a covering of small plates that extend out for a short distance over the ambulacra. Natural size.

Fig. 19. Side view of the type to show the beautiful ornamentation, broad base and the expanded columnar disk or rim. Natural size.

Carpenteroblastus magnibasis Rowley.

Fig. 20. Side view of a specimen to show the character of ornamentation, x1.

Fig. 21. Basal view of the same, natural size.

Figs. 22 and 23. Ventral and side views of a natural cast from chert to show the great thickness of the test about the ambulacra and the usual unsymmetrical character of the species. Natural size.

Fig. 29. Ventral view of a smaller specimen, preserving the test and showing the spiracles and anal opening, natural size.

Carpenteroblastus stella Rowley.

Fig. 24. Side view of the type, showing specific characters, natural size.

Fig. 25. Ventral view to show the anal opening and spiracles, natural size.

Carpenteroblastus pentalobus, n. sp.

Figs. 26 and 27. Side and ventral views of the type, natural size. (Specimen somewhat crushed.)

Schizoblastus sayi Shumard.

Fig. 15. Side view of an undersized specimen, preserving the base of a little ventral tube. Natural size.

Fig. 16. Top of the same specimen, enlarged to four diameters, to show the plates in the tube.

Fig. 28. Ventral view of a somewhat larger specimen, having the central opening closed by a covering of minute plates, passing out over the ambulacra for a short distance. Natural size.

Aorocrinus wachsmuthi, n. sp.

Fig. 38. Side view of the type specimen. Natural size.

Cactocrinus springeri Rowley.

Fig. 30. Side view of a fine body, natural size.

Fig. 31. A specimen showing the heavy spinose ventral tube and the heavy nodose arms, x1.

Figs. 49 and 50. The column of this crinoid, end and side views, natural size.

Leptopora ramosa, n. sp.

Fig. 36. Side view of the type specimen, natural size.

Leptopora procera, n. sp.

Fig. 37. Side view of the type specimen, natural size.

Axophyllum ? alleni, n. sp.

Fig. 32. Side view of the largest specimen, natural size.

Fig. 33. Same with the calix turned a little toward the observer.

Fig. 34. Same, calix view.

Fig. 35. Side view of a smaller specimen. All figures of this species, natural size.

Amplexus radigerus, n. sp.

Fig. 39. Side view of the type specimen, natural size.

Amplexus vermicularis, n. sp.

Fig. 51. Side view, natural size, showing nearly the entire length.
Fig. 52. Another view showing the contracted cup, natural size.

Chonophyllum greenei, n. sp.

Fig. 53. Side view of an unworn and nearly entire specimen, natural size.
Figs. 54, 55, 56. Side views of worn specimens, showing the invaginated tabulæ.

Aulopora longi, n. sp.

Fig. 57. Side view of the type specimen, natural size.

Aulopora amplexa, n. sp.

Fig. 58. A specimen surrounding a platycrinus stem joint, natural size.

Spirorbis? dubius, n. sp.

Figs. 59 and 60. Two views of this peculiar fossil, natural size.

Cyrtolites bennetti, n. sp.

Figs. 61 and 62. Front and side views of the type specimen, natural size.

Trigeria ? curricі, n. sp.

Figs. 40, 41, 42. Brachial, pedicel, and front views of a large specimen. x2.

Dielasma ? pediculus, n. sp.

Figs. 43, 44, 45. Brachial, pedicel and front views, x2.

Nucleospira barrisi? White.

Figs. 46, 47, 48. Pedicel, brachial and front views, natural size.

ORE FORMATION ON THE HYPOTHESIS OF CONCENTRATION THROUGH SURFACE DECOMPOSITION.

By CHARLES R. KEYES, Des Moines, Iowa.

In seeking a suitable explanation for the localization of ore materials from an assumed generally diffused condition in the country rock, a number of recent writers have leaned towards the idea that through the surface decomposition and degradation of the land the heavy materials in large part remain behind and tend to concentrate into ore deposits, the extent of which in any particular instance is to be regarded in a measure proportional to the amount of general erosion which that region has undergone.

This hypothesis has received special attention in the consideration of the lead and zinc deposits of the Mississippi valley.

Its application, however, has not been confined to this region. It has been extended to other mining districts, even those in which typical fissure veins abound.

Since the most advanced conceptions regarding the nature of erosion have gained such wide hold among geologists, ore students have seized with avidity upon some of these principles as furnishing a long sought for solution to the manner of many concentrations of ore bodies. The attractive features of the hypothesis are many. But objections have not been so obvious, and have not generally presented themselves. These last mentioned phases of the subject have entirely escaped the notice of mining engineers and special students of ores from the mining side. To geologists who have given geographic development special attention, the objections appear formidable, and in many instances unsurmountable.

Winslow* formally states the hypothesis when he says that it "starts with the proposition that the metalliferous minerals originally existed in the Archean rocks, either in a disseminated condition or in veins. With the decay of these early rocks, the minerals became diffused through later-formed sediments, this diffusion being quite uniform over contiguous areas. Successive decaying of successively formed rocks simply resulted in a transfer of these minerals." Accordingly, the concentration process was entirely subsequent to the period of rock formation. "It is, primarily, a result of great and long-continued surface decay of the rocks; and, secondarily, the result of the presence of local favorable physical and chemical conditions."

This general statement presents numerous slight modifications with different writers. Its advocates agree that the diffused ore-materials are, as degradation of the land goes on, carried downward to lower and lower levels, the metal-accumulating zone retaining always a constant relation to the ground surface. From this proposition two main phases proceed. One would retain the ore materials in a diffused condition; the other in a concentrated form, or as an enrichment of the lower zones.

The principles of geologic geography demonstrate beyond all doubt that lands elevated are worn down to near sea-level with far greater rapidity than has been generally supposed.

* *Missouri Geol. Sur.*, vol. vii, p. 477, 1894.

The fact that in many localities enormous denudation has taken place in the past, has been for a long time widely recognized. But that profound erosion, thousands of feet in depth, may easily take place in a single geological epoch or period, instead of during one or several long geological eras is a proposition which has not been so universally appreciated.

If we apply to any particular locality either phase of the hypothesis that generally diffused ore materials are concentrated through surface decomposition of the country rocks, we should expect to readily find abundant facts in substantiation. Either the ore materials of a region should give evidence of unusual original accumulation through the phenomena of local sedimentation; or the concentration should be about proportional to the amount of erosion.

With regard to the first of these propositions, students of ores are now pretty well in agreement that such factors as oceanic currents can no longer be considered as appreciable factors directly affecting the localization of ore deposition through solution. Besides, there are so many secondary factors entering into the problem, that even if the truth of the proposition be assumed, it would be utterly impossible to adduce proofs, so completely would they be obscured by attendant features. In the light of recent geographic and geologic research, all theoretical deductions appear to militate against the possibility of such conditions.

The second proposition presents some objections not met with in the first. The theoretical deductions are conclusive. The practical demonstrations present no very great difficulties. In the case of the Ozark region, of which a special example has been made, the facts are singularly against the hypothesis advanced.

The analyses made by Robertson* of Missouri rocks, show the presence of lead, zinc and copper in minute quantities. While the number of determinations made is far too small to enable any broad generalizations to be stated, it is significant that those rocks taken from the mining localities contain a very much higher percentage of metallic contents than those collected from localities remote from ore bodies. The inference would naturally be that the present difference in the amounts of the

* *Missouri Geol. Sur.*, vol. vii, p. 479, 1894.

metals in these rocks is due largely to the same concentration which produced the existing ore bodies.

The analyses mentioned were made for the express purpose of supplying evidence to the theory of the general diffusion of metals in rock masses. Winslow's hypothesis* is that in the Ozark region the rocks have suffered enormous denudation, and consequently the metallic substances that were diffused through the portion eroded have settled down, and have been redeposited in the constantly lowering zone at or near the ground surface.

Curiously enough for this hypothesis, along the summit of the Ozark dome, where decomposition and denudation have been greatest (by some 4,000 feet or more than at the margins) there are practically no ore bodies of consequence. The richest and most extensive deposits are at the very base of the uplift, in a district which has not only suffered a minimum amount of denudation, but which has not been removed more than the northern part of the state of Missouri, where no deposits whatever occur.

In a very localized form the same hypothesis is claimed to be applicable to true fissure veins. This phase of the subject has been lately emphasized by Weed† in the consideration of the gold and silver deposits of Montana. This author also calls special attention to the ore bodies of the Australian Broken Hill Consol mine of New South Wales, as described by Smith,‡ and to the Aspen district of Colorado, described by Spurr. § He says: "Active degradation favors the accumulation of enrichments, while prolonged degradation of a region, resulting from physiographic revolutions, may result in successive migrations of material and the accumulation in a relatively shallow zone of the metals derived from many hundreds, and possibly thousands, of feet of the vein worn away in the degradation of the land. Climatic conditions, rainfall or aridity, warmth and rapid alteration of vein fracture are agents affecting surface weathering, and hence, also, enrichment.

"Active degradation of a region, that is, rapid weathering, favors enrichment by the quickness with which it removes the upper already leached part of the vein, so that a large amount

* *Missouri Geol. Sur.*, vol. vii, p. 469, 1894.
† *Trans. American Inst. Min. Eng.*, vol. xxx, 1900.
‡ *Trans. American Inst. Min. Eng.*, vol. xxvii p. 69, 1896.
§ *U. S. Geol. Surv.*, Mon. xxxi, 1898.

of the vein matter is lixiviated in a given time than would result from slower wasting of the land. Such enrichments are favored by high altitudes. Moreover, the mountainous regions are those in which secondary fractures are most apt to be found."

Blake's observations* on the formation of the lead and zinc deposits of the Wisconsin district have an import similar to that of Winslow's for Missouri.

Of like suggestion is Winchell's view† regarding the Wisconsin lead deposits and the Minnesota iron ores. This author regards the Cretaceous strata as having extended over the whole of the upper Mississippi valley region and in their removal to have allowed the ore materials to lodge in the porous and gashed Silurian rocks beneath.

These special examples have been noted in this connection for the reason that in all there is the same effort to seek an adequate and direct source for the ore bodies. All start with the assumption that the present ore bodies were derived from the ore materials that had settled downward as the great rock masses above were removed through erosion. In other words, the existing ore bodies of the region mentioned are claimed to be deposits the formation of which has depended wholly or largely upon the general metallic content of the country rock once existing above the present ground surface of the respective districts.

In none of these cases is it believed that the conclusions reached regarding the local source of the ore materials are either warranted by the arguments adduced, the facts as they are presented in the field, or the general geological conditions known to be prevalent in ore-producing regions.

In the case of the Ozark region, we have unusually complete data regarding the geological times of rapid erosion and the periods of peneplanation. There is abundant evidence showing that immediately after the deposition of the Lower Carboniferous rocks—the country rock of the southwest Missouri zinc district—the Ozark region was not the highland it now is. Between the time when the last Lower Carboniferous limestones were deposited and that when the first Coal Measures of Missouri were laid down, the strata were tilted and so

* *Trans. American Inst. Min. Eng.*, vol. xxii, p. 628, 1894.
† *Minnesota Geol. Sur.*, Bull. 6, p. 153, 1891.

profoundly eroded as to expose all formations down to the Cambrian; while in the south, in Arkansas, where sedimentation went on uninterruptedly, strata to a thickness of 20,000 feet accumulated. Along the horizon of this peneplain there is no evidence of notable deposits of ores of any kind.

Beds belonging to the upper part of the Coal Measures are now known to occur on the highest parts of the present Ozark dome. Small doubt therefore exists as to the extension of the Coal Measures (Des Moines and Missouri series) entirely over the region occupied by the great uplift. This is also, according to our best knowledge on the subject, probably true of the Cretaceous strata. Before, however, the deposits of the latter were formed another long period of erosion intervened. Yet in the known remnants of the peneplain which was formed at that time no signs of the existence of ore bodies are found.

Again, when the Ozark region was bowed up and planed off in Tertiary time down to the pre-Cambrian basement, no indications are presented that the peneplain which is the present general upland surface of the dome, is a horizon that is a special ore-bearing level. As already stated, it is in the central part where degradation has been greatest that ore deposition has been least.

We are forced to the conclusion, at least so far as the Ozark region is concerned, that degradation and surface decomposition even though so profound as to remove thousands of feet of rock, do not tend to concentrate whatever diffused metallic content the strata may contain. While profound surface decomposition is an important factor in the formation of ore deposits, by itself it produces no effect in this direction. There must also be special geological structures and special geological conditions always present before the localization of ore material is possible.

Without attempting to discuss or furnish detailed evidence at this time, it may be in this connection granted that most rocks actually do at all time contain in a diffused condition ample supplies of most common metals to furnish materials for the richest of ore deposits, that subterranean waters are constantly transferring laterally from one point to another metallic substances along with many others which are not ore-forming, and that the leached substances from near the ground surface are being carried through faults, joints and cracks downward to lower levels. In addition to all this there must be special local geological conditions to be satisfied before ore bodies can begin to form.

There is a parallel example in the case of petroleum. Next to water, we now know that rock-oil is perhaps the most abundant substance circulating in the earth's crust. The Waterlime formation of Ohio and certain dolomytes of the Mississippi valley contain in each 500 feet of thickness upwards of 2,500,000 barrels of oil to the square mile. The oil contained in only three townships would thus be more than the total amount which has up to the present time been taken out of Pennsylvania and New York fields. In order to have an area economically productive a peculiar association of geological structures and conditions must exist. There must be a reservoir in the form of a porous or cavernous bed, a non-porous cover as afforded by a shale stratum, and a bowing up of the strata such as is presented by an anticline. The absence of any one of these precludes the accumulation of oil bodies. So in connection with the ores the conditions and structures may all be present but one and yet there will be a failure of ore bodies.

In the more special case, in which a concentration has already well progressed, as presented by a mineral vein or a lean ore vein, where enrichment has taken place below the zone of weathering through downward flowing currents, it does not appear probable that the ores from the upper part of a vein can be considered as furnishing the enriching materials for the lower portion. As openings, fissures of any kind are at best very ephemeral in character. In no instance can they be regarded as forming open water passages for any considerable period of time. They must be completely closed up long before surface degradation has advanced to any appreciable extent.

New fissures may open up in the rock, new fault movements may take place, new cracks may be formed, through which metalliferous solutions may find access to the old mineral vein or lean ore sheet, but only in exceptional cases would material from the upper part of a vein find lodgement lower down in the same vein. The waters affecting the surface of an ore sheet would ordinarily carry the decomposed materials far from the neighborhood.

The general metallic content carried by circulating waters would doubtless accomplish the same result of secondary enrichment of lean veins, but it would certainly be through other openings than that in which the original vein was formed.

In the particular examples cited by Weed* of the Mollie Gibson and Smuggler ore bodies and bonanzas, the enrichments are along the lines of secondary faulting and the alterations are only in the immediate vicinity of these later fractures. Many other similar examples might be mentioned.

The immediate practical importance of the distinction is perhaps not so great at the present time as is the fact that the plausibility of the hypothesis at first glance being so evident is likely to lead often to untrustworthy conclusions.

The conclusion seems inevitable that with the exception of possibly a few isolated unimportant instances ore concentration does not generally take place through surface decomposition of rock masses, in areas such as the Ozark lead and zinc region. As in the case of petroleum, if it be assumed that all rocks at all times contain ample supplies of metallic salts in a diffused condition sufficient for the most extensive ore deposits, and that the circulatory waters hold them at all times in solution to a greater or less but adequate extent, these must be regarded general, always present conditions. But concentration of metallic salts into ore bodies must be admitted to be accomplished under special local conditions of geological structure, quite independent of all rock decomposition and land degradation.

* *Trans. American Inst. Min. Eng.*, vol. xxx, 1900.

CONCERNING THE OCCURRENCE OF GOLD AND SOME OTHER MINERAL PRODUCTS IN IOWA.*

By Samuel Calvin, Iowa City, Iowa.

It is a source of constant wonder and surprise that, notwithstanding all that has been said and written, there are yet persons of influence, intelligent beyond the average in all other respects, who entertain the crudest conceivable notions concerning the facts of geology and the distribution of mineral resources. The highest natural gifts and the broadest scholarly training and business experience seem to be altogether ineffectual, in the absence of some training in the principles of geology, to protect men from the most amazing fallacies as to what may or may not be found below the surface of the ground. Samples of yellow mica from decayed Kansan bowlders, or iron pyrites from shales or limestones, are received almost weekly from persons who imagine they have discovered gold in Iowa. Small flakes of brass worn from the working parts of pumps or other farm machinery, are among the causes which have led to repeated reports of discoveries of gold in a region where not a single condition favorable to the presence of the precious metal exists. Probably the most wild and unjustifiable of all the crude beliefs respecting geological resources is that which holds to the conviction that by going deep enough the drill is sure to find something of value, no matter at what point the work of boring is commenced. There are numerous wise persons in every community, estimable, influential and in the highest degree public spirited, who are convinced that the question, for example, of finding coal in their special locality is simply a matter of the depth to which the explorations are carried. Rock oil and natural gas are recognized as desirable products in every progressive community, and every such community contains persons, in other respects intelligent, who are ready to stake their own fortune and that of their nearest friends on the belief that oil and gas are everywhere underneath the surface, and that their sources can be tapped with the drill, provided only there is sufficient capital to keep up the process of drilling long enough.

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*Advance sheets from the Reports of the Iowa Geological Survey, Vol. XI, pp. 17-27.

But is there no gold in Iowa? Men certainly have found some. Coal occurs in certain localities in the state, why are the chances not equally good for finding it in all other localites? Why is it not a good business venture in Iowa to explore the depths of the earth for gas and oil, when fortunes are made and cities are boomed by the discovery of these desirable products in other states? Why is it not a proper function of the Geological Survey to bore test holes in different localities in order to settle the question of the presence of oil and gas beneath the surface? To answer these questions fully would require much space and would involve a discussion of some of the most elementary principles of geology. Let me try as briefly as possible to present the facts necessary to an understanding of these subjects for the benefit of the non-geological reader.

Native gold, metallic gold, free gold—by whatever name it may be designated—occurs chiefly under two conditions. First, it is found in veins in the crystalline rocks. Such rocks are generally very old; they are fundamental; they occur at the surface in a broad belt around Hudson Bay—none of the newer or later formed rocks being present in that locality—and they extend down into northern Michigan, northern Wisconsin and northern Minnesota. They have been forced up near the surface and have been subsequently exposed by erosion in all mountain regions. As a rule, it is in mountain regions that gold is associated with them, for it is here that they have been fissured by the strains and movements which gave rise to the mountains. Various minerals have been concentrated in the fissures by circulating waters—the waters being more efficient if warm and alkaline—and among the minerals so concentrated we sometimes find gold. Gold-bearing veins in the crystalline rocks are the basis of all the lode mining; but it must be kept in mind that only a very small proportion of all the veins referred to carry gold. Now there are no true crystalline rocks anywhere near the surface in Iowa. All such rocks here are deeply covered with newer rocks of sedimentary origin. These sediments were laid down, one on the other, in slow and orderly succession, on ancient sea bottoms, in precisely the same way, and of precisely the same materials as the beds of mud and sand and limy ooze which are to-day accumulating on the marginal bottoms of the modern seas. Such rocks contain no gold-bearing veins, and hence it must be obvious that there can be no lode mining for gold in Iowa. In the second place, free gold occurs in placer mines. Placer mines are simply sheets of disintegrated rock material which has been strewn over the surface, usually along river valleys, by the action of flowing water. The rocks of mountains decay and are worn away by air, storm waters, frosts and other agents; the gold-bearing veins, if there are any, decay with the rest; the gold is freed from the matrix in which it was embedded, and the loose materials, gold and all, are gradually washed down to lower levels. The placer miner simply separates—by some convenient device—the gold from the loose clay and sand and gravel with which it is accidentally associated. It must again be obvious that, except in regions where there are gold-bearing veins, there can be no placer mines worth considering. From all this it will be easy for any-one to estimate the probability of finding gold in such a state as Iowa.

In apparent contradiction of all that has just been said it must be acknowledged that gold is occasionally washed out of the sand banks and river gravels within the limits of our state. Spread over the sedimentary rocks and forming our soils and subsoils, are sheets of drift which were transported and distributed by glaciers coming from the north. Some of the materials forming the drift at any given point were carried long distances, from away beyond the national boundary. In northern Minnesota and on the other side of the boundary line, in the Rainy Lake region, are quartz lodes carrying free gold. The ice sheets brought disintegrated materials from this region, as they did from all others over which they passed, and spread them out as part of the drift of Iowa. Some particles of gold came with the rest, and it is possible occasionally to discover some of them by panning carefully the loose surface materials. A resolute, industrious man, working persistently year by year, might possibly accumulate one or two dollars' worth in the course of a lifetime; but the business cannot be recommended as a profitable means of employing one's time. The resident of Iowa who imagines he has discovered a gold mine on his home farm is certainly basing his judgment on deceptive appearances of some kind.

To understand the situation in respect to coal a few things must be kept in mind. First, as every miner knows, the coal is interbedded with sedimentary rocks, usually with sandstones and shales. Second, sedimentary rocks were laid down, one on the other, one after the other, in slow succession; and so the history of rock deposition in Iowa embraces a very long period of time. This history is almost complete from a period earlier than the introduction of life on the globe to times when land plants and animals were well developed. Third, coal was formed from land plants of certain types, the plants being preserved so as to be transformed into coal only under peculiar and favoring conditions. Fourth, coal plants did not come into existence until long after the beginning of the record preserved in the geological strata of Iowa. The older rocks, therefore, can contain no coal, because they were laid down long before any coal plants grew. All the rocks indicated on the geological map, Plate II, in Volume X, as Algonkian, Cambrian, Ordovician, Silurian, Devonian, and Mississippian, are older than any coal. The coal of Iowa occurs chiefly in the Des Moines formation; a little is found in the Missourian. It was while these two formations were in process of accumulation, not before, that coal plants of sufficiently luxuriant growth to count for anything existed in Iowa; and though these plants were abundant, it was only in certain favored and comparatively limited localities that the preservation of the plants took place so as to form coal. The geological formations of Iowa lie one on the other somewhat like the shingles on a roof, except that the oldest and first laid formations extend underneath the rest all the way across the state. The older formations appear successively from beneath the latter in going from the southwest toward the northeast. The Cambrian sandstones that are found in the sides of the valleys near Lansing, lie far below the surface at Des Moines. A well bored at Des Moines would pass, in the reverse order of their formation, through all the older beds, and would finally reach the Cambrian at a depth of about 1,600 feet. All these older beds, and all the individual layers of them, are seen in order, one after the other, between Des Moines and Lansing; and so a drill hole at Des Moines could reveal nothing of consequence that might not be learned by careful investigation of the natural surface exposures in the region between Des Moines and the northeast corner of the state.* Explorations for coal in the Mississippian, Devonian, Silurian, or older systems of rocks are foredoomed to failure for the simple reason that these rocks were all completed before a single workable coal seam was deposited, some of them before a single coal plant, or any terrestrial forms of vegetation from which coal might be formed, had come into existence. These formations all lie geologically below the coal. If one could begin in the Mississippian or lower formations underneath Des Moines or in that vicinity, and bore upwards he might have some chance of striking coal. But boring downwards in any of the formations referred to, whether under Des Moines or at points where the older beds come to the surface in the eastern part of the state, is going in the wrong direction; and the farther the boring is carried, the more hopeless, becomes the search. There is positively no coal in any parts of Iowa, which have formations older than the Des Moines shales and sandstones as the surface rock. The finding of coal is not a question of deep drill holes, but is one of intelligent and thorough prospecting of geological deposits of a particular age. If the operation is begun in any formation older than the Des Moines, the drill may go through to Australia or anywhere else without finding a speck of coal.

Petroleum and natural gas are like coal in one particular—they are derived from organic products. They are known to have their origin in dark bituminous shale, in limestones, which are in general of organic origin, in quantities of vegetable matter included in sandstones, in remains of forests buried in the drift, in any accumulations of organic matter which have undergone or are undergoing decay while hermetically sealed from the atmosphere. The marsh gas, which is annually produced by the decay of vegetation at the bottom of ponds, affords an illustration of the origin of one of the products we are considering, familiar to almost every observant person. It need scarcely be said, therefore, that rocks which are older than

*The Greenwood Park well at Des Moines has penetrated to the Cambrian and has put to actual test the statements which any competent geologist would have made in advance. All the broad details of that boring could have been written out beforehand. The full record of the well, to the minutest details, is given in Norton's *Artesian Wells of Iowa*, Iowa Geol. Sur., Vol. VI, p. 294 *et seq.* Scores of other deep wells scattered throughout Iowa and confirming all that would be inferred from studies of the superficial exposures, are described in the same volume.

the introduction of life on the globe can furnish neither gas nor oil; and the fact that such rocks may be reached in Iowa at no great depth makes it possible to explore the whole of the possibly productive series with comparative ease. Owing to their low specific gravity, oil and gas are displaced by descending waters and tend to rise toward the surface. They may, therefore, be found at some distance above the beds in which they are generated, but it would be very unusual to find them lower down.

The seas were practically destitute of life when the Algonkian quartzytes at the base of the Iowa geological column were laid down, and all rocks older than the quartzytes were formed under conditions even less favorable. It may be very positively affirmed that explorations for oil or gas below the top of the Algonkian are certain to be fruitless. Above the Algonkian lies a body of Cambrian sediments—mostly sandstones—1,000 feet in thickness. Life was far from abundant in Iowa during the deposition of the Cambrian, though even if it had been never so prolific, it would have counted for little, since sandstone is not a good conservator of the organic matter present in the seas at the time of its accumulation. Sandstones are good reservoirs for the storage of gas and oil after these products have been generated from some underlying productive rock. But there is nothing below our Cambrian from which gas or oil could be derived, and so the probability of finding either below the top of the Cambrian sandstones is so small as to be unworthy of consideration. Overlying the Cambrian are two formations, the Oneota and the Saint Peter, equally as barren as anything below them. When the drill reaches the top of the Saint Peter sandstone, it has practically passed through and beyond all formations in which there is any possible hope of finding the products under discussion. Next in ascending order comes the Trenton limestone, a formation that was laid down on a sea bottom fairly crowded with swarming forms of life. This limestone is impure; it contains a large amount of clay mixed either with the materials forming the layers of stone or laid down as beds of shale between the more stony layers. The Trenton formation was deposited under exceedingly favorable conditions for making it a productive source of gas and oil. It still contains large quantities of bituminous matter which by the slow distillation always going on must yield annually considerable volumes of gaseous or liquid hydrocarbons. At all the exposures of the lower Trenton, from Dubuque northward, the dry shaly partings between the ledges of limestone afford material so rich in bitumen that it is easily lighted with a match; it burns freely and emits a strong oily odor. Bituminous shale, precisely like that seen in the natural exposures, was brought up from the horizon of the Trenton in the deep well at Washington, Iowa; it has been recognized in other deep wells; the same shales, rich in bitumen, probably underlies the greater part of the state.

If then a great amount of bitumen is stored up in the Trenton limestone and is constantly evolving gas and oil by slow distillation, why are not gas and oil wells as common in Iowa as in the productive regions of Ohio and Indiana? Let it be answered that something more than petroleum-bearing rock is needed in order that oil may be obtained in quantities of commercial importance. It has been estimated by professor Orton that the rocks beneath the surface over a very large part of Ohio contain at least 3,000,000 barrels of oil to the square mile, and yet not one gallon of this can be secured by the drill without the concurrence of at least two other conditions: (1) There must be a porous reservoir—sandstone or porous limestone—in which the oil or gas may accumulate, and this must be covered with shale or other impervious deposit to prevent the hydrocarbons from escaping to the surface and becoming lost as fast as they are generated. But reservoir and cover alone will not insure a supply. So long as the rocks lie flat or have a uniform dip there will be no accumulations of any importance. (2) The reservoir and cover must present a series of folds beneath the arches of which the oil and gas are entrapped and accumulated under high pressure. Three conditions, therefore, must exist conjointly—the source of supply in some form of organic matter, the porous reservoir and impervious cover, and the arched or folded condition of the beds. It is the last of these conditions that is wanting in Iowa. Our stratified rocks are not folded to any noteworthy extent. The compression and crushing which gave rise to the Appalachian mountains produced folds as far west as Indiana, and then the effects fade out. Iowa is too far away from other centers of crustal disturbance, such as the Ozark region of Missouri or the great mountain axes of the west; and so the rocks are without the folds which are so essential to the accumulation of the fluent hydrocarbons. Besides the Trenton limestone there are petroleum-bearing rocks in other formations in Iowa, notably in the Carboniferous; but so far as discovery has gone, some of the conditions on which accumulation in commercial quantities depends, are always absent. Usable quantities of gas have been found at a few places in Iowa in the drift. This gas has its origin in the buried forests; beds of sand and gravel constitute the reservoir; and overlying bowlder clay is the impervious layer. Near Herndon and Letts are wells of this kind. The volume of gas is small; its source is near the surface; nothing would be gained, but much might be lost, by deeper borings. If either oil or gas is ever found in Iowa in usable quantities, outside the drift, it will be found either in or above the Trenton. There is no possibility of its occurring below that formation. Now, remember that deep wells which have penetrated the whole thickness of the Trenton and gone hundreds of feet below it, are scattered all over Iowa. Every one of these wells, no matter for what purpose it was made, is, in effect, a test hole for gas and oil; and every one of them answers the question of the occurernce of these products in a way that might be inferred from what is known of the geological structure—namely, in the negative. The state has been very thoroughly explored beyond the deepest point at which there is the slightest hope of success, and a thousand other test holes would not make the situation any clearer or the results more decisive. There is always the very remote possibility that there may be a small arch somewhere which has not been pierced by the drill, but the chances of its existence are so few, that if the object is simply to test for gas or oil, it would be an unjustifiable waste of money to search for it even if holes could be bored everywhere down into the Trenton limestone at the rate of one dollar apiece. The geological structure of the state, in its broader features, is now thoroughly known. The records of the many deep wells, so fully and accurately described by Norton in Volume VI of the Iowa Reports, reveal that structure in scores of places down to the Algonkian; and from the base of the Algonkian to the earth's center, there is nothing but barren, igneous rocks in which drills might be worked eternally without the remotest prospect of finding even so much as a trace of gas or oil.

There is another fallacy which should be disposed of, if it is ever possible to dispose of any of the popular and deep-rooted fallacies concerning what is hidden from ordinary observation beneath the surface of the ground. However it has arisen, there is a wide-spread belief that experts in some way are able to judge of the presence or absence of valuable products by an examination of the topography and general characteristics of the surface of any given region. Unscrupulous persons, taking advantage of this belief, have robbed some Iowa communities unmercifully. Such persons usually own an elaborate outfit for drilling, and naturally they want to keep themselves and their machines employed. The community to be victimized is easily selected. With specious claims of expert knowledge and glib assurance that this hill and that ravine and the relations of the level plain all bear unmistakable evidence of underlying wealth of the very kind that the community for the moment most desires, the requisite amount of money is quickly coaxed from the pockets of the public spirited subscribers, the hole is bored, the driller gets his pay, and the community is left to repent its folly at its leisure. Not infrequently it is the public spirited men of the community who take the initiative, and, without knowledge of their own and asking no advice, but firm in the belief that the earth will yield anything desired if we only go deep enough, they proceed with the drilling of test holes on a scale involving the expenditure of thousands of dollars. The end is inevitable. It is that which invariably follows every ill-advised enterprise in which ascertained facts are ignored. The disappointment may be all the keener when the promoters realize that the facts bearing on the case were easily ascertainable.

The highest living authority on the distribution of oil and gas, the man who has done more than any one else for the successful and profitable development of all the interests related to these two products, declares that the most valuable service which science has been able to render in this connection has been the determination of the fields wherein exploration is hopeless. Iowans will do well to remember that, even in a state as munificently endowed as theirs, there are some things and some favoring conditions which Nature has failed to provide, there are some drafts on Nature's apparently limitless bounty which must go unhonored, there are some enterprises looking to the development of natural resources which in the very condition and structure of things are absolutely hopeless. Let them rather reserve all of their capital and energies for the development of the splendid resources which do exist and not waste any in the useless search for geological products which all enlightened experience shows could not, by any known possibility, be developed in the state.

EDITORIAL COMMENT.

Museum Catalogues.—Two catalogues of museums lie on our table, the first by Prof. Renevier, and the second from the Smithsonian Institution, which illustrate among other things the difference in the support to Science which is afforded in Switzerland and the U. S. respectively. The first is entitled "*Notice sur l'origine et l'installation du Musee geologique de Lausanne.* (*Lausanne,* 1895.) *Par Prof. E. Renevier.*

In spite of its title but little more than half a page is devoted to the origin and installation of the collections. The remaining ten pages are dedicated to a description of the collections and their classification. The collection is not a large one, but some points are of interest.

Room I. The *first* collection is of general stratigraphy, three glass cases exposing the principal classic fossils from the earliest to the Cretacic.

The *second* is the petrogenic collection of 1,500 specimens intended to teach the mode of formation of the rocks which compose the terrestrial crust on a system of Prof. Renevier's as follows:

a) *Deutocogenic* rocks of sedimentary origin by mechanical means.

b) *Organogenic* rocks of sedimentary origin through organic processes.

c) *Hydatogenic* rocks, of chemical origin by means of water.

d) *Pyrogenic* rocks of chemical origin by means of heat.

e) *Crystogenic* or crystalline rocks of doubtful origin on account of their crystallization.

The subdivisions of these groups are, as far as possible, equally based upon their mode of formation.

The *third* division is of the Cretacic fossils of the country.

The *fourth* is the Geotechnical collection, including ornamental marble, slate, etc.

The *fifth* is the Morphological collection (Erosion, actual consolidation, organic perforation, etc.

The *sixth* is of geological maps, profiles, photographs etc.

Room II. The hall of regional geology (collections of the western Alps and of the Southern Jura), etc.

III. Paleontology (Fossil mammals; Birds, Reptiles and Fishes, etc.

IV. Mineralogical hall, etc.

This is an unusal arrangement, especially that of the first division with its miscellaneous department at the end.

Far different is Curator Merrill's "*Guide to the study of the collections in the Section of applied Geology.*"

The non-metallic Minerals by George P. Merrill. (From the report of the Smithsonian Institution for 1899, pp. 155 to 483 with thirty plates. "Washington. Government printing office, 1901."

The 328 pages of this useful catalogue interspersed with plates and cuts follow the general classification of Dana in general in the groups which are I. The Elements. II. Sulphides and arsenides. III. Halides. IV. Oxides. V. Carbonates. IV. Silicates. VII. Niobates and Tantalates. VIII. Phosphates. IX. Nitrates. X. Borates. XI. Uranates. XII. Sulphates. XIII. Hydro-carbon compounds. XIV. Miscellaneous.

Under these latter it is to be regretted that the Mineral Waters are stowed, as if in the way. They deserve a separate chapter like the rest. The lack of a proper bibliography of mineral waters of the United States was felt when Daubrée was writing his great work on Les Eaux Souterraines; and sought in vain for systematic information on the subject in this country. Little more than the advertising sheets of rival mineral springs with analyses by known and unknown persons—principally physicians or druggists of the immediate neighborhood, could be obtained.

The catalogue of the XIII sections is admirably full and contains besides the American and principal foreign localities, of each particular product, a very useful bibliography.

P. F.

CONTRIBUTIONS TO THE LITERATURE OF VOLCANOES.—An interesting review of the great work of Stübel on the volcanoes of Ecuador has appeared in the Bulletin of the Société Belge de Géologie de Paléontologie et d'Hydrologie, by Prof. W. Prinz, of the free University of Brussels. The title is "Les volcanoes de l'Ecuador par Alph Stübel. Resumé des theories d'interet général contenues dans cet ouvrage. par W. Prinz, Professeur à l'Université libre de Bruxelles."

He states that Stübel was of those who seek the remotest regions for new facts with which to enrich science, and that he had remained for nearly ten years in the high region of Columbia and Ecuador to study the volcanoes. His results were six thousand specimens of rocks and the aquarelles, sketches, and even oil paintings of M. Troya, an artist who accompanied him, all of which are in the ethnographic museum at Leipzig. The volume which is reviewed is intended as a descriptive catalogue of these objects. There are 14 cuts in the text and a map on a large scale 1:250,000 by M. Th. Wolf. The measurements on which the map is based are discussed by M. B. Peter of the Observatory of Leipzig.

M. Stübel after much hesitation in grouping the separate cones finally concludes that there are but 41 volcanoes in Ecuador, grouped in two chains which enclose the high plateau to the east and to the west. The object of the study is to seek the connection which still exists between the eruptive manifestations and the part of the globe yet in a state of fusion, or in other words do the modern volcanic phenomena depend on the development of the earth?

The tendency of his reasoning is to the negative, and in support he cites the enormous thickness of the crust (even where supposed to be least so.) What disproportion between the flow of lava and the supposed source! Earthquakes too are from causes not situated very deep.

The distribution of the volcanoes in Ecuador, Columbia, Bolivia, Chili, and Mexico, Central America, and the Aleutian group is very remarkable, for it is evident that a great nucleal centre would not discharge the excess of its igneous fluid by narrow channels, but by great orifices in the regions of flow, which would be kept permanently open during the eruptive period.

He leaves the same dilemma which his object was to solve. Either the earth is surrounded by a thin crust although its interior is in a state of fusion, which is in contradiction with certain geological and astronomical facts, although offering an easy explanation of volcanic action; or the earth is solid to a great depth and contains only a relatively unimportant kernel of igneous materials, which conforms to the astronomical and geological facts but leaves the eruptive phenomena unaccounted for.

P. F.

GILBERT'S SUMMARY HISTORY OF NIAGARA FALLS.

Numerous partial descriptions and discussions of Niagara river and Niagara falls have been published in late years, owing to the rapid growth of the Pleistocene geology of the region of the great lakes. Some views have not been in accord with others, and some geologists have amended their own views. The result is that those who have not closely noted the development of this history find some difficulty in forming a consistent idea of the actual result arrived at by these researches. Below is the summary of this result as given by Mr. G. K. Gilbert in connection with the new map of Niagara river and the Pan-American Exposition, dated May, 1901.

N. H. W.

"The beginning of the river is intimately associated with the Glacial or Pleistocene period. Before that time lake Erie and lake Ontario did not exist and there was a very different system of rivers in the region. In the early part of the period glaciers were formed on the highlands of Canada, and gradually grew and spread until they covered all the region of the great lakes. They eroded the land in places and deposited the eroded material elsewhere in the form of drift. Then they melted back so as to uncover the lake region, making an interglacial epoch, and afterwards they again grew large. These oscillations were several times repeated, so that the Pleistocene period was composed of several glacial epochs separated by interglacial epochs. Each interglacial epoch had its own system of lakes and rivers, and in one of these epochs a great river traversed the Niagara district, crossing the escarpment a few miles west of the mouth of the Niagara gorge. Like the Niagara, it made a gorge, and this gorge was eaten back from the neighborhood of the village of St. Davids to the position of the present Whirlpool. The readvance of the glacier not only abolished this river but filled with drift the gorge it had made, so that one may now cross it on what is known as the Old Portage road without suspecting the existence of a buried valley.

"When the ice for the last time melted from the land, it left a hollow which we know as the basin of lake Erie, and another hollow which contains lake Ontario, and it left the face of the land in such shape that the overflow from one lake to the other could not follow the valley of an earlier stream but sought out a new course. Thus the Niagara river was born; and its cataract has been engaged ever since in the making of the gorge.

"Just before the establishment of lake Ontario there was a greater lake in the same basin, with an outlet to the Mohawk and Hudson rivers instead of the St. Lawrence. The abandoned shore of this greater lake, called by geologists the Iroquois beach, lies close to the escarpment and can be traced out by means of its bluffs and ridges. Its line is followed for many miles in New York by a road called the Ridge road, and this road crosses the map. At Dickersonville it runs on a typical beach ridge of gravel and sand. Near Model City it is on top of the ancient shore bluff, and in Lewiston it is on a gravel ridge which was built as a spit in the old lake.

"After the disappearance of the ice the land it had covered was gradually uplifted, the rate of rising being different in different parts. As a result of this warping of the earth the outlets of certain lakes were changed, and these changes had an important influence on Niagara river. There were two epochs during which most of the water of the great lakes region flowed to the ocean by other routes, leaving to the Niagara only the water from the lake Erie basin. During these epochs the river was much smaller than it now is, probably carrying only one-eighth of the present amount of water, and the cataract was then a less powerful agent of erosion. The deeper parts of the gorge, which now contain pools, were excavated by the cataract when the volume of the river was large. The shallow parts, which now contain rapids, were excavated when the volume was small.

"The determination of the age of the river, or the time which has been consumed in the making of the gorge, is a problem of great interest, to which much attention has been given. As the length of the gorge is known and as the rate at which the cataract now lengthens the gorge is known, it would seem a simple matter to compute the time. Taking the gorge length as a dividend and the annual change in length as a divisor, we obtain 7,000 as a quotient, and this has been assumed by some to represent the number of years occupied by the river in the work. But this computation fails to take account of a number of important considerations. The thickness of the limestone is not the same in all parts of the gorge; the hight of the cataract was not the same through the whole period; and, as just pointed out, the volume of the river was sometimes much less. The last-mentioned qualification is the most important of all, for the diminished river would erode much less rapidly than the full river. If we knew precisely what difference the change of volume would make, a fairly satisfactory result might be obtained, but this we do not know. The smaller of the two divisions of the cataract, known as the American fall, now contains nearly as much water as did the whole river during times of diminished drainage basin. But the crest line of the American fall has not changed its form appreciably since the year 1827, when the first accurate drawings of it were made. Its recession must be many times slower than that of the Horseshoe fall. This fact indicates that the rate of erosion of the narrowest parts of the gorge was exceedingly slow and the time consumed exceedingly long. Its estimation is little better than a guess. One may say with some confidence that 7,000 years is altogether too small an estimate of the age of the river, but whether the real age is expressible in tens of thousands or in hundreds of thousands of years is at present a matter of doubt."

The Term Hudson River.—Dr. Rudolf Ruedemann has reviewed the rather quixotic record of this term in geological literature in a recent publication by the New York State Museum.* He also adds many new facts relating to the geographic and stratigraphic distribution of the fossils. He concludes that the Norman's Kill series of shales represents the most important part of the Hudson River series, but that its fauna is only one of four faunas which are embraced in the Hudson River rocks, and the lowest of the four. He also finds that the Norman's kill shales are in the Trenton, lying immediately on the lower Trenton limestone. His summary conclusion is as follows: N. H. W.

"This paper purports to demonstrate the presence of four zones of shales in the 'Hudson River shales' of the Hudson valley region about Albany. These zones, which extend from N. N. E to S. S. W., consist, going from west to east, of shales containing the Lorraine, Utica, Middle Trenton and Norman's kill graptolite faunas. The shales last named include lower Trenton conglomerate and rest on lower Trenton limestone. This succession of zones places the Norman's kill graptolite beds, which form the mass of the Hudson River shales in the Hudson river valley, between the middle and lower Trenton, and determines, together with other facts, the Lower Trenton age of these shales.

"The beds lie conformably inverted, on account of their being the remnant of the underturned wing of an overturned fold of the Appalachian type. This fold has turned into an overthrust fault which brought the Cambric beds as the next succeeding terrane above the Norman's kill shales.

"On account of the fact that the mass of the beds hitherto called Hudson River shales and correlated with the Lorraine beds of central New York, is composed of terranes ranging from the Lorraine to the lower Trenton, and on account of a lack of a fully representative fauna and of a complete section of the Lorraine portion of these terranes, it is proposed to drop the term Hudson River shales for the uppermost part of the Lower Siluric, and the term Hudson River group for the Utica and Lorraine beds, and to employ the term Norman's Kill shales for the clastic facies of a part of the lower Trenton which is characterized by the graptolite fauna of the Norman's kill."

* The Hudson River beds near Albany and their Taxonomic equivalents, *Bull. No. 42*, vol. viii, April, 1901.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Phylogeny of the Rhinoceroses of Europe. By Henry Fairchild Osborn. (*Bull. Am. Mus. Nat. Hist., vol.* xiii., *article* xix., *pp.* 229-267, 1900.)

Some New and Little Known Fossil Vertebrates. By J. B. Hatcher. (*Annals, Carnegie Museum, vol.* 1, 1901, pl. 1-4.)

The Rhinocerotidæ have hitheto baffled the taxonomist, and their origin, development and migration are still problematic. The phylogeny proposed by Mr. Osborn divides the rhinoceroses into six phyla, having no known relation to each other. The supposed stem forms are traced back to the early Cenozoic, thereby suggesting that the rhinoceroses, like numerous other mammalian phyla, come under the law of early divergence.

Mr. Osborn bases his classification upon the proportions of the skull and correlated proportions of the body and upon the location of the horn cores. He finds these to be the main divergent characters, setting aside several homoplastic characters heretofore employed in classification.

Besides suggesting a hypothesis of descent, Mr. Osborn offers some interesting systematic and comparative descriptions, based upon the study of the collections in various European museums.

Mr. Hatcher's paper is based upon material collected by the paleontological expedition of 1900, for which Mr. Andrew Carnegie supplied the funds. He describes *Trigonias osborni,* a new genus of rhinoceros, from the base of the White River Oligocene. The manus differs from all other known American rhinoceroses in being functionally tetradactyl; it has an unreduced number of superior teeth; and simple structure of the superior premolars. It is therefore of a generalized type, and is the most primitive member of the Rhinocerotedæ at present known.

The comparison with the unreduced teeth of *Trigonias* will make possible the establishment of the homology of the teeth of the modern rhinoceroses. *Trigonias* probably represents the ancestral form of one of Mr. Osborn's six groups, the *Aceratheriinae.* I. H. O.

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CORRESPONDENCE.

Are the St. John Plant Beds Carboniferous? The writer has been urged to take notice of the opinion of Dr. David White, of the United States Geological Survey, expressed as to the age of the St. John plant beds, or "fern ledges," as they were designated by the late professor C. F. Hartt.

As long as Mr. White's statement of the age of these beds was expressed merely as an opinion based on the composition of the flora which these beds contain (which flora he regarded as that of the Pottsville conglomerate of Pennsylvania, or in English parlance the Mill stone grit*), it did not seem to call urgently for reply. But since he has lately written a communication to the Natural History Society of

* U. S. Geol. Surv. 20th Ann. Rep. Part ii, General Geology, &c., page 917.

Montreal, wherein he has stated that the "erroneous reference of this fauna to the Devonian was forced upon Sir William [Dawson] by the findings of the stratigraphers,"† it becomes necessary for the writer to show something of the history of these "findings," since to him and to professor L. W. Bailey is chiefly due the assignment of the age required by the stratigraphy.

With this question is now involved the age of certain plant-bearing terranes in Nova Scotia, surveyed and mapped by Messrs. Hugh Fletcher and R. W. Ells, of the Canadian Geological Survey; but in this communication the writer proposes to confine himself to the New Brunswick areas, and to mention the stratigraphical points bearing on the age of the plant bed as briefly as possible.

The "Millstone grit" is well developed in New Brunswick, with floras at various points; and visibly at almost all points where its borders are exposed, is underlain by red shales and conglomerates with some Lower Carboniferous limestones. The gray rocks (Millstone grit) have been traced and surveyed by Drs. L. W. Bailey and R. W. Ells from a point about 30 miles north of St. John, eastward to the Joggins section in Nova Scotia.

The underlying red shales and conglomerate above mentioned, or to use the Pennsylvania nomenclature, the *Maunch Chunk* shale, comes within three miles of St. John on the north and an outlier is found one mile to the southeast of the city. These rocks are inclined at low angles from the pre-Carboniferous complex on which they rest, and the outlier reposes upon the contact of the Mispec and Little River terranes *unconformably*.

In the valley of the Kennebecasis and the Pettecodiac rivers (which are continuous) extending northeast from St. John about eighty miles there appear at intervals beneath the equivalent of the Maunch Chunk red shales, bodies of gray and dark gray bituminous shale (near St. John mostly gray standstones) and underlying conglomerates, that were much eroded before the deposition of the red shales, etc. These gray shales contain at various points frequent remains of *Ansimites acadica* and *Lepidodendron corrugatum,* and are the equivalent of the *Pocono.*

Down to the base of this series the sandstones are "free stones," that is they have not been filled with a secondary growth of silica between the grains; the plants in the shales retain their bitumen; the limestones are not metamorphosed and the igneous effusives contain zeolites. Below this the sandstones are strongly cemented with silica and some calcite, the shales are converted into slates, the limestones are more crystalline, and the beds are usually tilted at high angles.

The division between the rocks in these two conditions is the line of a great unconformity with discordance of dip, and usually strike as well, between the underlying and overlying measures.

The first terrane below the unconfomity is the *Mispec*—Conglomerate and red slate. As this terrane contains rolled fragments of Silurian corals the whole series below it to the horizon of these corals must have been denuded before or during its formation.

† Can. Rec. Sci. Vol. viii, p. 277.

The next terrane is the *Little River* group which contains the plant beds of the "fern ledges." To the stratigrapher it appears absurd to speak of these being equivalent to the Pottsville conglomerate (i. e., the Millstone grit) in age.

Lest it might be thought that the reference of the plant beds of St. John to this low horizon, rests only on the writers' early determinations, supported later by Drs. L. W. Bailey and R. W. Ells, he may say that Sir William Dawson went over these sections before he wrote his classic papers and reports, wherein he referred them to the Middle Devonian. Dr. T. Sterry Hunt also spent a good part of one season in examining the southern coast region of New Brunswick with Dr. L. W. Bailey and the writer; and Dr. Selwyn when Director of the Canadian Geological Survey, went over the same ground; as he gave the imprimature of the survey report to the view above expressed, it is to be presumed that he was satisfied with the evidence in its favor.

The fact of the matter is that Mr. White has read the biology of the plant bed flora from the wrong end. A few of the ancient types of this flora (Archæopteris) were known when Rogers made the first geological survey of Pennsylvania. And since Dawson studied the flora other types have been gradually gathered from the lower horizons of the Carboniferous: *Megalopteris* for instance was found in several species in Ohio by professor Andrews from the lower coal measures, and later Lesquereux described others, gathered chiefly in the south and the Mississippi states from the equivalent of the Maunch Chunk red shale. It would appear that a number of the species of this flora survived in Pennsylvania until the time of the Pottsville conglomerate.

The reference of these plant beds to the Millstone grit reminds one of the persistency with which Lesquereux some thirty or forty years ago clung to the view that the Lignite beds of the west were of Tertiary age, whereas it has been amply shown by the marine fossils that they are Cretaceous.

Many genera of plants have a wide vertical range; witness the recent genera, Amentaceæ &c., in the Cretaceous, some species of which are very difficult to distinguish from modern forms; is the Cretaceous recent because it contains these? Some species of marine forms (Brachiopods and Trilobites even) range through a whole geological system, why may not some plants?

To recapitulate, the following changes occurred between the deposition of the St. John plant beds and the formation of the Millstone grit.

Erosion of strata to the Niagara horizon with deposition of the Mispec terrane.

Crushing and folding of the unconsolidated terranes from (and including) the Mispec downward. Extrusion of granite.

Deposition of the Albert shale and conglomerate=*Pocono.*

Erosion to the Laurentian or Fundamental complex, with deposition of red slate and conglomerate=*Maunch Chunk.*

Slight deformation of the crust with deposition of the Millstone grit=*Pottsville Conglomerate.* G. F. MATTHEW.

St. John, N. B., April, 1901.

THE STRUCTURE OF DIAMOND HEAD; OAHU.—Two summers ago I made some observations on the structure of the beds at and about Diamond Head, Oahu, Hawaiian Islands. A brief summary of them was printed by Dr. C. H. Hitchcock in his account of the geology of Oahu (Bull. Geol. Soc. of Am., 11 pp. 57-60.) I am not aware that there is anything in these observations to excite emotion, but it resulted in some very emotional newspaper articles, followed in cooler vein by contributions to other periodicals including a paper in the AMERICAN GEOLOGIST for January last, pp. 1-5, by the Rev. Dr. S. E. Bishop, and still others later. I am averse to controversy in matters which can be settled by an appeal to facts, and especially to controversy over a scientific matter with a person not trained in the specialty to which the subject matter belongs: for reasons which are obvious. Moreover, Dr. Bishop is known as an amateur observer who has done service to science in various ways and a most worthy person, individually.

The reiteration of the opinions expressed by the reverend doctor has been so prolonged that it has been suggested to me that further silence on my part might be misunderstood among geologists, and, therefore, I ask space in your journal for a few statements, as follows:

1. The hypothetical cone described at such length by Dr. Bishop. does not, as a matter of fact, exist at Diamond Head.

2. The observations made by me and recorded in Dr. Hitchcock's paper above referred to, are sound; and can be verified by any person with good eyes, reasonable powers of observation, and a moderate familiarity with Tertiary stratigraphic geology.

3. The inferences or hypotheses which I drew from those observations are subject to the criticism of experts in Tertiary geology and will take their chances of acceptance in the usual manner.

4. The old beaches with their corals, sedentary bivalves like *Chama, Ostrea,* etc., and other attached invertebrates, remaining as they grew in life, extend at least two-thirds around the cone, where I traced them (and I have little doubt, entirely around it), and under the tuff and thin sheets of lava of which the lower part of the cone is composed. Every little bluff at Pearl Harbor and sections cut in sewering the city of Honolulu exhibit similar phenomena, which are probably common to the entire periphery of the island where the sea has not eaten them away. The inter-stratification is undeniable except in defiance of the most obvious facts. But the elevation is greater toward Diamond Head and less in the opposite direction, though the difference is not very great. In the middle portions of the cone the beaches are replaced by horizontal layers of compacted coral sand which can be seen half a mile, and which leaches out in the calcareous snowy crusts so conspicuous on the slopes. I did not visit the upper part of the cone, but it presented no external appearances different from that lower down.

5. I do not intend to publish anything further on this subject, in this connection.

I may add that very similar phenomena can be observed on the north shores of Unga and Popoff islands of the Shumagin group, Alaska, where the age is probably Oligocene. WM. H. DALL.

Smithsonian Institution, May 1, 1901.

PERSONAL AND SCIENTIFIC NEWS.

J. W. BEEDE has been appointed instructor in geology at Indiana State University, Bloomington, Ind.

DR. J. B. WOODWORTH has been appointed assistant professor of geology at Harvard University, Cambridge.

MR. WARREN UPHAM will attend the Dartmouth College Commencement, June 23 to 26, the thirtieth anniversary of his graduation.

THE CASCADE TUNNEL, by which the Great Northern railroad passes the Cascade mountains, is three miles long and is cut wholly in granite.

DR. T. C. HOPKINS, professor of geology at Syracuse University, will work on the Geological Survey of Indiana during the present summer. His work will be on the geological map of the state.

PROF. R. P. WHITFIELD has returned from several weeks stay in the Bahamas, where he secured for the American Museum of Natural History a number of remarkable specimens of corals, to be added to the magnificent series which he has obtained on previous visits to the islands and presented to the institution.

THE UNITED STATES GEOLOGICAL SURVEY HAS ISSUED a map of Niagara river and vicinity on a scale of 1:62500, showing the topography and the culture features, which will be of great convenience to all who, visiting the Buffalo Pan-American Exposition, desire to make some examination of the geology of the region.

THE NEXT MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, and of the Geological Society of America, will be held at Denver, Colo., Aug. 24 to Aug. 31. C. D. Walcott is president of the Geological Society and C. R. Van Hise is vice-president in charge of the section of geology and geography of the Association.

MISS L. A. OWEN describes, in *Verhandl. des VII. internat. Geographen-Kongresses, Berlin*, 1899, the discovery of a large stone ax imbedded in the bluff on the west side of the river at Atchison, Kansas, twenty miles south of St. Joseph, Mo. The implement, whose discovery is attested by affidavit taken by an eminent attorney, was found in comparatively undisturbed loess, four feet below the surface.

ERNST HAECKEL writes from Baden Baden, on April 14, 1901, pleasantly to a member of the GEOLOGIST staff:

HIGHLY HONORED FRIEND: I have just returned from an eight months' voyage to Java and Sumatra (of which you will find an account in the Berlin "*Deutscher Rundschau*").

I return to Java on the 28th inst. and re-commence my lectures on the 30th. * * * With best wishes.

ERNST HAECKEL.

THE WARD-COOLEY COLLECTION OF METEORITES, at Chicago, has representatives of 541 falls or finds, being the largest in the world of *number of kinds*, the collection in the British museum being next, according to their last catalogue. Of these 201 are from North America, 23 from South America, 189 from Europe, 58 from Asia, 17 from Africa and 23 from Australia. A new catalogue of this collection has lately been prepared by Prof. H. A. Ward.

ACCORDING TO PROF. H. MCCALLEY, in *Mines and Minerals*, the coke industry in Alabama has grown even faster than coal mining. It was not known until 1876 that the Alabama coals would make good coke, suitable for smelting, and now Alabama ranks third of the states of the Union as a coke-producing state, being surpassed only by Pennsylvania and West Virginia. The coke output of the state for the calendar year 1899 was given by the State Mine Inspectors at 1,798,612 tons.

ACCORDING TO O. D. WHEELER'S WONDERLAND FOR 1901, the first published description of the geysers, and other remarkable features of the Yellowstone National Park, was written by W. A. Ferris, published in the *Western Literary Messenger*, in July, 1842, at Buffalo, N. Y. He visited the park May 19 and 20, 1834. He was a trapper, of more than ordinary education and intelligence, originally a civil engineer, connected with the American Fur Company of St. Louis. He removed to Texas, and died in 1873, near Dallas.

UNDER THE UNITED STATES GEOLOGICAL SURVEY in connection with professor Osborn's monograph on the titanotheres, which is the first of the new series of monographs on fossil vertebrates to be taken up, Mr. N. H. Darton, of the Survey, accompanied by Mr. J. B. Hatcher of the Carnegie Museum in Pittsburg, will make a thorough investigation of the titanothere beds in South Dakota to establish as definitely as possible the stratigraphical relations of the horizons in which such remains have been found.

PROF. C. R. VAN HISE, vice president, section E, Geology and Geography, of the American Association for the Advancement of Science, has announced a plan and program of a proposed excursion for geologists from Aug. 17 to Aug. 26, preceding the Denver meeting of the association, intended to accommodate also the members of the Geological Society of America. The itinerary of the trip, which will be within the state of Colorado, has been arranged with the cooperation of Messrs. S. F. Emmons and Whitman Cross.

EXPLORATIONS IN ALASKA. It is reported that the United States Geological Survey will send three expeditions to Alaska this summer. The first, under J. W. Peters, will start from Bergman, nearly 1,000 miles northwest of Sitka, and proceed to the Arctic ocean. The party hopes to advance eastward as far as the British boundary and will then turn westward again and proceed toward point Barrow. The second party, led by W. C. Mendenhall, will work in the vicinity of Kotzebue sound. The third party, led by M. Gerdine, will continue explorations in the region of Copper river.

THE DEPARTMENT OF VERTEBRATE PALAEONTOLOGY of the American Museum of Natural History will have three parties in the field this season under the general direction of professor H. F. Osborn. One will continue the work in the Pleiocene beds of the Mt. Blanco region in Texas, where so many and such fine remains of mastodons, horses and camels have been found by the museum parties in recent years. The second party will continue the excavation of the celebrated Bone Cabin quarry in the Como district of Wyoming, while the third party will prosecute the collection of dinosaurian remains in the Black Hills region of South Dakota and Wyoming.

LEHIGH UNIVERSITY, at South Bethlehem, Pa., publishes a list of the titles of theses to be presented by candidates for degrees, June, 1901. This list gives sixty-one titles. They are almost wholly scientific. The exceptions are two, one devoted to the modern meaning of socialism and the other to Chaucer's "Prologue." Nine are in the course of mining engineering and the remainder, which is the larger half, are in some line of engineering or in chemistry. Not one is devoted to any phase of geology, nor to mineralogy nor to any question of petrography. It seems anomalous that in a mining state like Pennsylvania, whose geology has furnished many of the important elements of the science in America, a university of such scope and standing could graduate a scientific class of sixty-one without evincing any sign of geology in the final theses.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of this society on April 24, Mr. G. P. Merrill exhibited specimens of the so-called Moldavites from Bohemia and Moravia and gave a brief resumé of the views of various writers as to their supposed meteoric nature. He also exhibited weathered pebbles of obsidian from several localities in the arid west which showed corroded surfaces suggestively similar, and which he regarded as produced by natural temperature variations and the corrosive action of the atmosphere.

At the same meeting was exhibited a preliminary sketch for a geological section entirely across the United States, as compiled by Dr. A. C. Peale, for exhibition in the geological department of the National Museum. The horizontal scale was two miles to the inch and the vertical scale 4000 feet to the inch; the entire length of the section, so far as completed, being upwards of seventy-five feet out of a final approximation of one hundred and twenty (120) feet. As the section is an actual compilation from the various surveys, some very interesting and striking results were brought out.

During the Spring Recess, a party of nine students from Harvard University accompanied Prof. W. M. Davis on a geological and geographical trip into Pennsylvania. On the train from New York to Scranton via Lackawana road, a running cross-section was made of the Triassic lowland and the trap ridges, the highland hills and valleys, and the great Appalachian valley, geological maps in hand. A day was spent on the Susquehanna above Wilkesbarre, to see the meandering valley in the Alleghany plateau; and evidence of at least two cycles of erosion was found. Descending the river, a side trip was made to the coal regions, where the scenes of industrial desolation in the anthracite basins was in marked contrast with the thrifty agricultural landscape prevailing outside the Pottsville and Pocono ridges. A synclinal apex of Pocono was ascended over Herndon, on the Susquehanna, then a train ride through the five water gaps to Harrisburg. A half day was given to the extraordinary meanders of Conedoquinet creek, and a morning to the prong of Archean of South Mountain at Reading. Thence the party returned direct to New York by rail.

Increased Coal Mining in Pennsylvania. In 1891 the number of bituminous coal mines in operation in Pennsylvania was 705, while on January 1st, 1901, the number had increased to 943, an increase of 238, or more than twenty-five per cent. Somerset and Armstrong counties have doubled the number of their mines, and Cambria county almost so. In the past decade Allegheny has gained thirteen; Armstrong, eleven: Beaver, three; Bedford, five; Butler, three; Cambria, fifty-four; Center, twelve; Clearfield, six; Elk, nine; Fayette, thirty-two; Huntingdon, four; Indiana, sixteen; Jefferson, eleven; Somerset, thirty-four; Washington, six, and Westmoreland, twenty-six. The counties showing losses are: Blair, one; Bradford, three; Mercer, five, and Tioga, three. The remarkable increase has been greater during the priod 1899-1900 than in any other year of the decade. Captain Baird Halberstadt, of Pottsville, formerly assistant geologist of the Geological Survey of Pennsylvania, has just completed an elaborate and extremely valuable map of the bituminous coal fields of the state, showing the undeveloped and developed areas with the location of every commercial coal mine of these regions.—*Mines and Minerals.*

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Errata for Volume XXVI

On p. 309, line 9 from bottom instead of "Wachsmuth Collection" read Wachsmuth and Springer Collection.

On p. 310, line 17, instead of "statements" read statement.

Errata for Volume XXVII

On p. 258, for "Petiera" read Peltura.
" line 18, for "Ctinopyge" read Ctenopyge.
" line 22, for "Solmopleura" read Solenopleura.
" line 29, for "this" read the.

On p. 329, line 7 from the bottom, for "decomposition" read deposition.

On p. 330, line 7 from the top, for " volcanic" read vein.