NEW SERIES. VOL. VIII.—No. 6.

THE CANADIAN NATURALIST

AND

Quarterly Journal of Science.

WITH THE

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY OF MONTREAL:

B. J. HARRINGTON, B. A., Ph. D.
J. FRASER TORRANCE, A. B., B. A. Sc. } Editors.

MONTREAL:
DAWSON BROTHERS, Nos. 159 and 161 ST. JAMES STREET.

MITCHELL & WILSON, PRINTERS, 192 ST. PETER STREET.

Price Three Dollars per Volume, in Advance.

CONTENTS OF No. 6, Vol. VIII.

Published December 29th, 1877.

Fig. 1

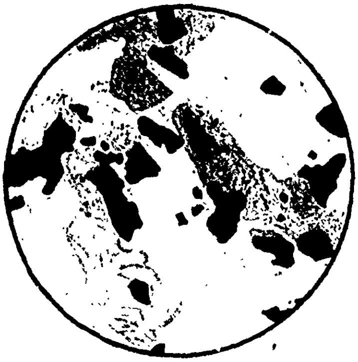


Fig. 2

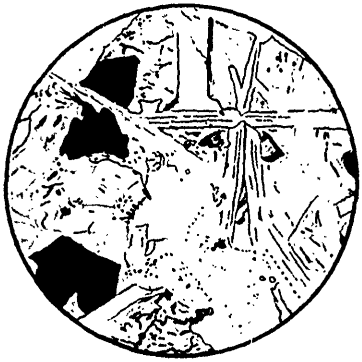
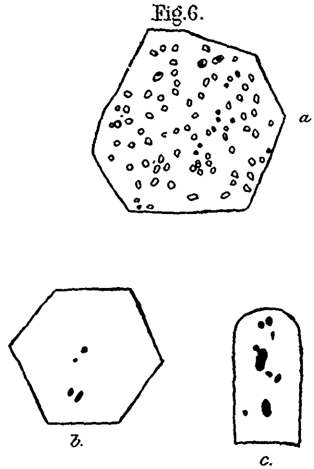


Fig. 3

Fig. 4

Fig. 5

Fig. 6



B. J. H. del. The Burland Desbarats Lith. Co. Montreal.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

NOTES ON A FEW DYKES CUTTING LAURENTIAN ROCKS, MORE ESPECIALLY WITH REFERENCE TO THEIR MICROSCOPIC STRUCTURE.

By B. J. Harrington,

Of the Geological Survey of Canada.

The fact that rocks of Laurentian age are frequently cut by trap dykes, was many years ago noticed by Sir William Logan, who traced out and mapped a number of those found in Grenville and some of the neighbouring townships. Since then other observers have noted their occurrence in widely distant Laurentian areas. Mr. Vennor, for example, observed dykes in Madoc and North Burgess. Mr Macfarlane in his report on Lake Superior * describes dykes which cut the Laurentian rocks at Goulais Bay, Gros Cap, and other localities, and from his descriptions some of them appear to resemble those found in Grenville. At Goulais Bay they are from nine to seventy feet thick, strike N. 72° to 75° W., and are probably doleritic. Others at Gros Cap and the mouth of the Montreal River Macfarlane also considers to be dolerites, but states that near Michipicoten Harbour, and in Bachewahnung Bay, there are dykes of diorite. He further states that at two different points in the Laurentian area examined by him, he observed intrusive rocks of the character of the "newer traps or melaphyres which characterise the upper copper-bearing series."

* Geology of Canada, 1866, p. 120.

Professor Bell, of the Geological Survey, has repeatedly noticed the occurrence of dykes in the regions explored by him north of Lakes Superior and Huron, and states that in some parts of the country they form a conspicuous feature in the geology, and have probably played an important part in producing the present geographical features. One described by him as a diorite in the report of the Survey for 1875–76 (p. 314) is said to be from 300 to 400 feet in width. Its course is N. 12° W., and it cuts a thinly bedded micaceous gneiss nearly at right angles to the strike of the latter.

Mr. G. M. Dawson has also given us a number of facts concerning dykes at the Lake of the Woods, where they are said to be both granitic and dioritic. Some of the latter, which are coarse-grained and apparently have general east and west courses, "may very probably be among the oldest of the intrusions." There are others, however, which are very hard and compact, and have a general bearing of north-east and south-west. These cut not only the intrusive granites of the region, but also the altered Laurentian strata.*

The late Mr. Walter McOuat has mentioned the occurrence of dykes of "diorite" from fifty to one hundred feet thick at several localities between lakes Temiscamang and Abbitibbe, and states that the apparent direction of two large ones on Lac des Quinze (on the Upper Ottawa) is north-by-east and south-by-west. †

It is therefore evident that in almost all parts of the country where the Laurentian rocks have been examined, they have been found to be cut by dykes of various intrusive rocks, few of which have, however, been critically studied as yet.

The intrusive rocks of the Grenville region are of special interest, inasmuch as most of them were shown by Sir William Logan to belong to a date anterior to the deposition of the Lower Silurian. According to the descriptions given in the Geology of Canada, they consist of dolerite, syenite and felsite porphyry. Of these the oldest "are a set of dykes of a rather fine-grained dark greenish-grey greenstone or dolerite, which weathers greyish white." * * * "Their width varies from a few feet to

* See Report on the Geology and Resources of the Region in the vicinity of the Forty-ninth Parallel. 1875. pp. 25, 53.

† Report of Progress, Geol. Survey, 1872-73, pp. 120, 122 and 130.

a hundred yards, and they possess a well marked columnar structure. Their general bearing appears to approach east and west, but the main dykes occasionally divide, a branch striking off at an angle of from twenty to forty degrees." Some of them have been traced for many miles, cutting both the limestones and gneisses, and sometimes forming a ridge across the limestone and a hollow in the gneiss. Whenever they are seen to come into contact with the syenite they are interrupted or cut off by it, being therefore more ancient; and "the relations" Sir William states "of the base of the Lower Silurian group along the foot of the hills composed of the syenite are such as to make it evident that the Silurian beds in some places overlie eroded portions of the intrusive rock." All the intrusive rocks of this region are, however, cut by a set of dykes the relations of which to the Silurian series is not known. They were described in Sir William's original report under the name of melaphyre, but were afterwards designated by Hunt as dolerites, though differing considerably in characters from the older rocks of that name.

The writer regrets that he has not had an opportunity of visiting any of the places mentioned above, or even of seeing authentic specimens of any of the dykes, with the exception of a few from Grenville and two or three other localities. These specimens have, however, been sliced and studied microscopically, and a few notes on their microscopic characters may be of interest.

MICROSCOPIC CHARACTERS.

I. *Grenville, Lot 9, Range IV.* (Plate, fig. 1) The examination of a specimen from this locality shows it to consist of plagioclase feldspar, augite, magnetite, viridite,* apatite, and a little mica and iron pyrites. The plagioclase forms a very considerable proportion of the rock, and although much of it has undergone alteration and lost its transparency, it still shows in places, with polarised light, the banded appearance common in plagioclastic feldspars. It has evidently crystallised before the augite, as blades of it are frequently seen to penetrate the latter mineral. The augite is pale brown or in places pinkish in colour. Its form has, for the most part, been impressed upon it by the

* This useful name is applied to a number of green substances which often result from the decomposition of augite, hornblende and olivine, and which cannot always be "individualised."

other minerals, but here and there a rude crystal may be observed. The mica is present in small quantity, and is brown and strongly dichroic. Magnetite (possibly titano-ferrite) is abundant, occurring chiefly in irregularly shaped grains, but sometimes showing rude octahedral form. Sometimes it is seen in innumerable small grains imbedded in the augite. The viridite is abundant and very bright green. It occurs largely in fibrous or sheaf-like aggregations showing faint dichroism, and with the polariscope changing, on rotation of the analyser, from blue to brown. In all probability it is chlorite. The apatite is found in sharply defined acicular crystals which are hexagonal when seen in cross section. It is most abundant in the feldspar, but is also seen to penetrate the mica, augite, and even the magnetite.

II. *Grenville, Lot 9, Range V.* When examined with the microscope the section of this rock is, like that last described, seen to consist of plagioclase, augite, magnetite, viridite, pyrite and apatite? The feldspar forms a network of blades, and has in places undergone some alteration, although for the most part it appears to be unaltered and with the polariscope becomes beautifully banded. It is distinctly seen to penetrate the magnetite in a number of instances, and must therefore have solidified before, or at least simultaneously with the magnetite. It also contains a good many of what appear to be glass- and stone-cavities. The augite is brownish-grey in colour, traversed by numerous fissures and penetrated in all directions by blades of feldspar. The rock contains a good deal of magnetite, mostly in grains of irregular form, but occasionally in octahedral crystals. When cut across the grains are often seen to contain numerous irregular cavities, and in one case an octahedral crystal was observed which was hollow, or nothing more than a shell. Viridite is present in considerable quantity. It is much duller green than that in the rock last described, and looks more like an alteration product of the augite. It is mostly amorphous, but occasionally occurs in sheaf-like aggregates. Pyrites is present in small irregular grains scattered here and there through the rock.*

* Specimens I and II were many years ago analysed by Dr. Hunt, who described them as follows: "The dykes of this most ancient dolerite or greenstone in Grenville have a well-marked columnar structure at right angles to the plane of the dyke. They are fine-grained, dark greenish-gray in color, and weather grayish-white.

III. *River St. Simon.* (Plate, fig. 2.) This specimen is from a fine-grained, greyish-black dyke which cuts the Green Lake band of crystalline limestone on the St. Simon, a small tributary of the North River, in Terrebonne County east of Grenville. I am indebted for it to the Director of the Geological Survey. The dyke probably belongs to the same set as the Grenville ones just described, its general structure being the same, but it has apparently undergone very little alteration, the section being beautifully clear and transparent. With the microscope it is seen to consist of a network of plagioclase feldspar, with augite, magnetite and apatite (?) and a very little viridite. The feldspar as seen in the section is perfectly transparent and colourless, and with the polariscope shows a beautifully banded structure. In places it contains microlites which are possibly apatite, and also a few vapour- or gas-cavities, generally in groups. The augite is pale greyish-brown frequently penetrated by blades of feldspar and often containing groups of minute grains of magnetite. It appears to constitute about half the rock. The magnetite occurs mostly in irregular grains and masses of most fantastic shape, but now and then in rude crystals and rod-like forms. In some cases it is seen to be penetrated by blades of feldspar. (See figures on next page.)

The viridite is not very abundant and looks as if derived from

---

Under a lens the rock is seen to consist of a greenish-white feldspar with a scaly fracture, mingled with grains of pyroxene, occasional plates of mica, and grains of pyrites. It contains no carbonates. Two analyses of portions of the dolerite from dykes differing a little in texture gave as follows:

Silica	50.35	50.25
Alumina	17.35	32.10
Peroxyd of iron	12.50	
Lime	10.19	9.63
Magnesia	4.93	5.04
Potash	.69	.58
Soda	2.28	2.12
Volatile	.75	1.00
	99.04	100.72

"The iron in these analyses, although given above as peroxyd, exists in the form of protoxyd, and in the second specimen, in part as a sulphuret." (Am. Jour. of Sci., 1864, 2nd Ser., Vol. xxxviii, p. 174.) Which of the analyses applies to the specimen from Range IV and which to that from Range V is not stated.

the augite. It is rather dull green and can scarcely be said to exhibit dichroism. In places it shows numerous fine lines running in several directions.

1 2 3

Figures 1 and 2.—Grains of magnetite penetrated by blades of feldspar. (× 78.)

Figure 3.—Group showing a few of the varied forms which the magnetite assumes. (× 78.)

IV. *River Gagnon, Terrebonne County.* (Plate, fig. 3.) The specimen from this locality is coarser in texture than the last, and of a dark grey colour. Its specific gravity is 3.013. The dyke where observed by Mr. Selwyn (to whom I am indebted for the specimen) cuts a band of gneiss, and is in all probability of the same age as the Grenville ones, though it has not been traced out. The examination of a thin section of the rock shows it to be composed of plagioclase feldspar, augite, magnetite, apatite and a little mica and viridite. The plagioclase shows evidence of but little alteration, and much of it is striated as in the case of the River St. Simon rock, and with polarised light beautifully banded. The blades run in all directions, but do not constitute as continuous a network as in the last specimen, since the augite is much more abundant. Blades of the feldspar frequently penetrate the augite, and occasionally also the magnetite. The augite is pale brown in colour, perfectly fresh, and often dotted with what appear to be gas-or vapour-cavities. Its cleavage is often well-marked and it occasionally shows twinning (see figure). The magnetite is not very abundant and occurs in irregular and often fantastic forms. The apatite and mica are present in very small quantity, as is also the viridite. The latter chiefly accompanies a brown somewhat decomposed mineral which has not been determined. With polarised light the section forms a beautiful object.

V. *Grenville, Lot 4, Range VI.* The specimen from this locality is from one of the newer dykes which, as already stated, cut all the other rocks of the region. It consists of a dark grey fine-grained base (sp. gr. 2.83) with occasional porphyritically imbedded masses of hornblende, which are often accompanied by a plagioclase feldspar. Calcite is also present in white cleavable masses, mostly filling cavities.*

Microscopically this rock is very different from those already described, but it requires much further study. The ground-mass appears to consist of a mixture of plagioclase, biotite (very abundant), and magnetite or titano-ferrite, with a good deal of a green mineral which is probably an alteration product, and is not at all dichroic. Here and there also there are almost colourless crystals, which may prove to be olivine, very much cracked, and often converted along the cracks into a pale green mineral. As stated above, the rock is porphyritic, and a section cut across one of the porphyritic masses shows it to consist of beautifully striated plagioclase with embedded crystals of hornblende and a little pyrite, while all these three minerals contain numerous crystals of apatite, the largest cross sections of which measure about 0.25 mm. Some of the cross sections are perfect hexagons, but none of the crystals when viewed longitudinally show perfect pyramidal terminations, but are generally rounded as seen in figure 6 c of the accompanying plate. When examined with a high power, most of them are seen to contain numerous cavities, which in a few instances have been observed to contain bubbles, although most of them appear to be empty. Almost without exception, too, they contain black globular and sub-globular bodies (see plate), which possibly take the place of the thin nail-like bodies often found in the apatite of basalt. Some of the crystals contain

* An analysis of this rock was published by Dr. Hunt in the Geology of Canada and also in the American Journal of Science (Second Series, Vol. XXXVIII., p. 174) from which the following is extracted: "When in powder the rock effervesces freely in the cold with dilute nitric acid, and the solution evolves red fumes on heating. In this way there were dissolved, lime, equal to 8.70 per cent. of carbonate, 0.50 of magnesia, and 6.50 of alumina and oxyd of iron = 15.70 per cent. The residue dried at 212° F., equalled 83.80 per cent. A portion of aluminous silicate had evidently been attacked by the acid. The dried residue gave on analysis; silica 52.20, alumina 18.50, peroxyd of iron, with some titanic acid, 10.00, lime 7.34 magnesia 4·17, potash 2.14, soda 2.41, volatile 2.50 = 99.26."

only only one or two of these, but as many as nine have been observed in one case. The rude crystals of apatite which are associated with pyrite are cracked across, and the cracks filled with pyrite as shown in figure 5.

The amygdules have a lining of a green structureless mineral (green earth) while the interior is filled with a colourless mineral which appears in most cases to be calcite. In some cases also the cavities contain pyrites, mostly at the junction of the calcite and green earth.

VI. *Madoc, Ontario, lot 24, Range VI.* (Plate, fig. 4.) This rock may be noticed here as a good example of a diorite. It was given to me by Mr. Vennor of the Geological Survey, and stated to have been broken from an undoubted dyke. It was supposed to be a pyroxenic rock, but the microscopic study of a thin section shows it to be a diorite, consisting chiefly of feldspar, hornblende and magnetite, but also containing cubical crystals of iron pyrites and small quantities of a transparent mineral which is probably quartz. The feldspar is a good deal altered, but apparently all plagioclase in the sections examined. The hornblende is of a rich green colour, and much of it shows cleavage lines very distinctly. It is dichroic and polarises beautifully. In places it appears to have undergone some alteration, though not to the same extent as the feldspar.

Conclusions. The first of the rocks just described, on account of the large proportion of viridite which it contains, and the altered state of the feldspar, would be called by German petrographers a diabase. One would also expect to find a larger proportion of water than is indicated by the analysis. In many respects it agrees with Senfter's descriptions of diabase from the Duchy of Nassau in Germany. The alteration which it has undergone, however, is not nearly as marked as in many diabases from much younger formations, as, for example, the Cretaceous of British Columbia. Much of the viridite looks as if it had been one of the original constituents of the rock, but in other places it is pretty evident that it has been derived from the augite.

No. II may perhaps also be called a diabase, although very little removed from such rocks as III and IV. Its general structure is the same, the only important difference being the development of a good deal of viridite. Nos. III and IV are true dolerites or "feldspar basalts," indistinguishable from many of Tertiary age. They are highly crystalline and do not appear to contain any glassy base. As yet no olivine has been observed either in them or the diabases, but very few sections have been examined, and possibly it will be found on further study. In No. I, a mineral has been observed with the characters of sanidin, and no doubt other minerals will yet be detected.

The order in which the different minerals have solidified is a matter of interest, apparently not being that f the fusibilities of the constituent minerals before the blowpipe. In the diabase and dolerite it is evident that the apatite has been the first to solidify; the plagioclase appears to have come next, then the magnetite, and last of all the augite. Mr. J. Clifton Ward gives an interesting example of the apparent order in which the minerals constituting a leucitic basalt near Naples have solidified, which may be noticed in this connection. The minerals are leucite, magnetite, magnesia-mica, feldspar and augite. Of these five minerals the only infusible one is the leucite, and yet Mr. Ward thinks that the last four "were held in solution by leucite in a state of fusion; and that instead of this mineral crystallising out first, it deposited in succession the magnetite, the mica, the feldspar and the augite, and last of all probably solidified quickly, enclosing within its crystals glass- and stone-cavities, and magnetite and feldspar crystals."

It is evident that No. V is a very different rock from any of the others described. In some respects it resembles the so-called melaphyres, but contains much more mica than is found in any of which I have seen descriptions. No. VI is as already stated a diorite and needs no further remark here.

The slight amount of alteration exhibited by some of the ancient dolerites in the Grenville region would no doubt be surprising to some, but is not so much to be wondered at when we consider that they occur in highly crystalline rocks, which would serve to a great extent to protect them from the agencies which have brought about decomposition in dykes cutting the unaltered strata of some more recent formations.

* Quart. Jour. Geol. Soc. 1875, p. 396.

DESCRIPTION OF PLATE III.

FIG. 1. Diabase from Grenville, lot 9, range IV, showing augite plagioclase, magnetite and viridite (magnified 28 diameters).

FIG. 2. Dolerite (Feldspar Basalt) from River St. Simon, showing augite, plagioclase, magnetite and a little viridite. The cruciform group in the right hand upper corner is plagioclase. (x 78).

FIG. 3. Dolerite from River Gagnon, showing augite (a twin on the left) plagioclase and magnetite. (x 14).

FIG. 4. Diorite from Madoc, Ontario, showing bluish-green hornblende, plagioclase, magnetite, and pyrite (the square crystal in the lower right hand corner). (x 78).

FIG. 5. Apatite in rock from Grenville, lot 4, range VI. The portion of the drawing shaded black, excepting the spots in the apatite crystals, consists of magnetite and pyrite, chiefly the latter. (x 78)

FIG. 6. (*a*). Cross section of apatite crystal with numerous cavities a few of which show bubbles, and are perhaps liquid cavities. (*b*). Cross section of apatite crystal, showing the black bodies referred to in the text. (*c*). Longitudinal section of rounded apatite crystal with black bodies similar to those in *b*. (All x 78.)

NOTES ON THE SURFACE GEOLOGY OF NEW HAMPSHIRE.

By Warren Upham.

The following notes on the Drift or Post-pliocene deposits of New Hampshire, are based upon explorations made in 1875 and 1876 for the State geological survey.

To explain the striæ, till, or boulder-clay, and modified drift, which are found in all northern countries, has been a most difficult task, about which some diversity of opinion still remains. The surface geology of New Hampshire seems to require the bold theory of Agassiz, that an ice-sheet swept over our territory from the North. This continental glacier became sufficiently deep to cover every mountain summit in the State. That it overtopped Mount Washington has been recently discovered by Prof. C. H. Hitchcock, State geologist, who has found transported rocks, and shown that glacial drift or till underlies the angular blocks at the summit.* Its thickness farther to the north was so much greater than in this latitude, that its immense weight caused the ice to flow slowly outward. The direction of its current in New England was between south and south-east. Its terminal front in the United States coincided nearly with the course of the Missouri and Ohio rivers, passing into the ocean south of Long Island. Its greater extent east of the Missouri resulted from the increased snow-fall of this side of the continent.

The conditions which brought on the severe climate of this period have been the subject of much speculation and discussion. Mr. James Croll, with much probability, refers the ice-sheet to an astronomical cause, and claims to determine the date and duration of the glacial period. He supposes that an ice-sheet was produced several times about each pole, a glacial epoch in the northern hemisphere being one of genial climate at the south pole, in which the ice-sheet disappeared.* It is certain that the ice was partially melted at times, and that it afterwards advanced, covering the territory from which it had retreated; but the long period requisite for the formation of the ice-sheet, and the low

*Croll's "Climate and Time," pp. 76-78, etc.

temperature of the altitude to which it reached, render it improbable that it was several times wholly melted away.

Near the end of the glacial period, we have proof that the sea stood 100 to 200 feet higher than now along the coast of New England, and about 500 feet above its present level in the valley of the St. Lawrence. It seems quite probable that this submergence was produced by the attraction of the ice, which, as pointed out by Adhémar, would draw the ocean away from the equator towards the poles. The whole amount of water in the sea was *diminished*; but the accumulation of vast sheets of ice, probably several miles in thickness, would be sufficient to retain the ocean at its present height near their lower limits, while it would rise much higher than now about the poles, and at the equator would sink far below its present level. Such a rise of the sea, increasing in amount in high latitudes, is attested by the modified drift of both America and Europe; and coral islands afford proof of the corresponding depresssion of the ocean, succeeded by a gradual elevation to its present height, over large areas within the tropics. The two great continents appear to have existed, with somewhat the same outlines as now, from a very remote geological epoch. From the Silurian age to the glacial period we have no record that any part of New Hampshire was submerged beneath the ocean. This long stability makes it more probable that these recent changes in the relative heights of land and sea, are due to the cause which we have explained, rather than to any downward and upward movement of the earth's surface.

Three divisions of Post-pliocene time are well marked in New England, and apparently in all countries which have been overspread by ice. They are distinctly characterized as successive periods of glaciation, deposition, and erosion. The first is the *glacial period*, during which the ice-sheet prevailed, moving over New Hampshire towards the south or south-east, as shown by striæ throughout the State. These glacial markings appear to show the last direction in which the ice moved, since the latest wearing necessarily effaced previous striæ. We therefore learn that the ice finally retreated from New Hampshire towards the north-west and north, and from the region of the Great Lakes and along the St. Lawrence valley towards the north-east.

As the ice-sheet slowly advanced during this period, fragments were torn from the ledges, and a large part of these were sooner or later held in the bottom of the ice, and worn to small size by friction upon the surface over which it moved. The resulting mixture formed beneath the ice is variously called the ground-moraine, boulder-clay, or *lower till.* It consists of smoothed and striated stones, with fine detritus, which is usually a gravelly clay of dark bluish color, being always clayey, dark, and very hard and compact. The characteristics of the lower till are due to the mode of its formation. Most of its pebbles and boulders are glaciated, having round edges and smoothly worn sides, which often retain striæ. These show that the finer material in which they occur has been produced by the slow grinding up of these stones under the ice. The dark and frequently bluish color is due to seclusion from air and water during its formation, as pointed out by Torell, leaving its iron principally in the form of ferrous sulphides, silicates, and carbonates. Its compactness and hardness are due to compression under the great weight of ice. Because of this quality, the lower till is commonly known as "hardpan." The same cause has also produced an imperfect cleavage in planes parallel to the surface, noticeable wherever an excavation has been for a short time exposed to the weather.

While this deposit was thus accumulating beneath the ice, great amounts of material, coarse and fine, were swept away from hill-slopes and mountain-sides, and afterwards carried forward in the ice. When this melted, a large portion of the material which it contained fell loosely upon the surface, forming an unstratified deposit of gravelly earth and boulders, which may be called the *upper till.* In New Hampshire there is almost always a definite line of separation, at a depth varying from two or three feet, as is most common, to fifteen or twenty feet, between the upper and lower till. The upper member is the one usually exposed on the surface, and it is often the only one present where only a thin covering of till is found. Its characteristics are the larger size of its boulders, which are mostly angular and unworn; the yellowish or reddish color of its fine detritus, produced by the hydrated ferric oxide to which its iron has been changed by exposure to air and water; and the comparative looseness of its whole mass. This division of the till into two members, which is very well marked throughout New Hampshire, is also conspicuous in Sweden and other parts of Europe; and the peculiar features of each have been recently pointed out by Dr. Otto Torell, of Sweden,* in nearly the same terms here used.

* *American Journal of Science and Arts*, Third Series, Vol. xiii, p. 77.

The boulders which are contained in the upper till, or which lie upon its surface, are of all sizes up to ten feet, or rarely even twenty or thirty feet, in diameter; and in this state, they have nearly all been transported southward from their native ledges. Where an outcrop of rock is so peculiar that its boulders cannot be confounded with those from other ledges, we may trace them southward or south-eastward, but not in other directions. They are abundant near their source, and diminish in numbers and size as we advance. The till of New Hampshire contains boulders which are thus known to have travelled a hundred miles.

The distribution of the till in this State and in eastern Massachusetts is quite irregular. Sometimes no considerable accumulations of it are seen for several miles, and the ledges lie at or near the surface. Elsewhere the till occurs in large amount, covering the ledges, which are scarcely exposed over some whole townships near the coast. Wherever it is found plentifully, it is to a large extent massed in peculiar oblong or sometimes nearly round hills. which usually have quite steep sides and gently sloping rounded tops, presenting a very smooth and regular contour. These hills are of all sizes up to one-third or one-half mile long, with two-thirds as great width; and their longest axis is most frequently north-west to south-east, coinciding nearly with the current of the ice sheet. Their height varies from forty or fifty to two hundred feet. These accumulations of till are very prominent near the coast, where they sometimes occupy nearly the whole territory for many miles, while adjoining areas on each side may be almost destitute of surface deposits, showing only naked, striated ledges.

About Winnipiseogee lake, which is 500 feet above the sea, beds of stratified clay are often found underlain and overlain by till. The clay is free from pebbles, and well suited for brickmaking. It varies from five or ten to thirty feet in thickness, and occurs at various heights from the level of the lake to three hundred feet above it. The overlying till is from two or three to ten or fifteen feet in thickness, wholly unstratified and very coarse, containing numerous boulders, which may be five or six feet in diameter. These remarkable clay beds were probably deposited, where drainage was obstructed, in hollows melted under the margin of the departing ice-sheet. This lake basin lies at the south side of the White Mountains, from which source we might expect a greater depth of ice to move southward and cover its area near the close of the glacial period than would at that time remain in other parts of the State to the east and west. The ice-sheet probably formed a high mountain-like ridge over this lake, after it had disappeared from the basin of Ossipee lake and from the lower part of the Merrimack valley. The ice current was thus changed in direction on the east side of Winnipiseogee lake, and the last striæ marked on the ledges differ much from the prevailing course, being deflected towards the east, or even to the north of east. As the melting continued, drainage was frequently obstructed, because the ice-sheet retreated from the lines of watershed towards the middle of this hydrographic basin. The water seems then to have melted large open spaces beneath the ice, near its margin, in which beds of clay and sand were deposited. This would occur at the various heights and in the situations where these beds are found, and the till which overlies them is shown by its material to be that which was contained in the ice-sheet, and fell upon the surface when its melting was completed.

Near the coast, beds of fine gravel, sand, or clay, sometimes enclosing marine shells, are in several instances overlain by upper till, giving evidence of a retreat and subsequent advance of the ice-sheet. Doubtless the ice resisted the influence of the warmer climate and changed conditions before which it disappeared, continuing late like the snow in spring. Its departure at the last was correspondingly rapid; and was closely followed by the hardier forms of vegetable and animal life.

The abundant deposition of drift, both stratified and unstratified, which took place during the final melting of the ice-sheet, has been brought into due prominence by Prof. James D. Dana, who denominates this the *Champlain period*, deriving the name from the marine beds of this era, which occur on the borders of Lake Champlain. It is probable that this final melting took place mostly upon the surface, which was thus moulded into basins and valleys; and near the terminal front of the ice, these appear to have coincided closely with the contour of the land. At last the surface of the ice became covered with the abraded material which had been contained in its mass, and which was now exposed to the washing of its innumerable streams. Its finer portions would be commonly carried away; and the strong current of the rivers which would be formed near the end of the ice-sheet could transport coarse gravel, or even boulders of considerable size. When the glacial river entered the open valley from which the ice had retreated, or in the lower part of its channel, while still walled on both sides by ice, its current was slackened by the less rapid descent, causing the deposition, first of its coarsest gravel, and afterwards, in succession, of its finer gravel, sand, and fine silt or clay. The valleys were thus filled with extensive and thick deposits of modified drift, which took the same slope with the descending current, and which increased in depth in the same way that additions are now made to the bottom-lands of our large rivers by the annual floods of spring.

The retreat of the ice sheet was towards the north; and wherever the natural drainage was in that direction, it would be for a time obstructed by the ice, forming lakes in which the deposition of modified drift would be much different from that which took place when the slope was to the south. In New Hampshire the portion of the Contoocook valley which extends through Hillsborough county was occupied by a lake during a large portion of the Champlain period.

The oldest of our deposits of modified drift are long ridges or intermixed short ridges and mounds, composed of very coarse water-worn gravel, or of alternate layers of gravel and sand irregularly bedded, a section of which shows an arched or anticlinal stratification. Wherever the ordinary fine alluvium also occurs, it overlies, or in part covers, these deposits. Similar ridges of gravel have been often described by European geologists, under the various names of *kames* in Scotland, *eskers* in Ireland, and *asar* in Sweden. They have also been described by geologists in many portions of the northern United States and Canada. In New Hampshire kames are of frequent occurrence, sometimes a single one extending in a steep, narrow ridge for miles along the lowest portion of a valley, or elsewhere short, and several parallel to each other, or in very irregular mounds and ridges, with hollows enclosing small ponds. Their position is generally along the middle or lowest part of the valleys, which are bordered by high ranges of hills; but in the south-east part of the State, in some parts of Maine, and in Eastern Massachusetts, where there are only scattered hills, with the valleys not much below the general level of the country, these ridges, of smaller size than in the great valleys, are found extending usually north and south, without special regard to the present water-courses. In the valleys of our largest rivers, the Connecticut and Merrimack, they extend long distances, but have heretofore escaped notice, owing to the large amount of levelly stratified drift, forming the conspicuous terraces and plains by which the underlying kames are often nearly concealed.

The origin of the kames has been a question much discussed by European geologists, and the theory commonly accepted on both sides of the Atlantic was, that they were heaped up in these peculiar ridges and mounds through the agency of marine currents during a submergence of the land. Even if such ridges could be formed by this cause, under any circumstances, it seemed impossible to account thus for the kames in the Connecticut and Merrimack valleys, which, being bordered on both sides by high hills, would have been long estuaries, opened to the sea only at their mouths, and therefore not affected by oceanic currents. From the position of these peculiar accumulations of gravel, which are overlain by the horizontally stratified drift, the date of their formation is known to be between the period when the ice-sheet moved over the land and that closely following, in which this more recent stratified drift was deposited in the open valley from the floods that were supplied by the melting ice. We are thus led to an explanation of the kames, which seems to be supported by all the facts observed in New Hampshire, and which appears to apply, also, to the similar deposits which have been described in other parts of the United States and in Europe. During the melting of the ice-sheet, it became moulded upon the surface, by this process of destruction, into great basins and valleys; and at the last, the avenues by which its melting waters escaped came gradually to coincide with the depressions of the land. As the melted area slowly extended into the continental glacier, its vast floods found their outlet at the head of the advancing valley. This often took place by a single channel, bordered by ice walls, as was the case along the whole Connecticut kame; but in the Merrimack valley, and in eastern New Hampshire and Massachusetts, these glacial rivers also frequently had their mouth by numerous channels, which were separated by ridges of ice. In these channels were deposited materials gathered by the streams from the melting glacier. By the low water of winter layers of sand would be formed, and the strong currents of summer, layers of gravel, often very coarse, which would be very irregularly bedded, here sand, and there gravel accumulating, and without much order interstratified with each other. Sometimes the melting may have been so rapid that the entire section of a kame may show only the deposition of a single summer, which would then be very coarse gravel, without layers of sand. When the bordering and separating ice walls disappeared, these deposits remained in the long ridges of the kames, with steep slopes and irregularly arched statification. Very irregular, short ridges, mounds, and enclosed hollows resulted from deposition among irregular masses of ice.

The glacial rivers which we have described appear to have flowed in channels upon the surface of the ice, and the formation of the kames took place at or near their mouths, extending along the valley as fast as the ice-front retreated. Large angular boulders are sometimes, but not frequently, found in the kames or upon their surface. Their rare occurrence forbids the supposition that these deposits were formed in channels beneath the ice-sheet, from which many such blocks would have fallen upon the kames.

The course of the glacial river of Connecticut valley for a distance of twenty-four miles is marked by a single continuous kame, frequently nearly covered by the alluvium of the highest terraces, extending from Lyme, New Hampshire, to Windsor, Vermont. Its height is 150 to 250 feet above the river, by which it has been frequently cut through, as well as by tributary streams. This ridge occupies nearly the middle of the valley, and as the river has cut its channel through the alluvium, this has been often a barrier, rising steeply upon one side and protecting the plains behind it. In one or two placces it has been swept away by the river for a distance of one half mile to one mile, and below these places the terraces show, by their coarseness, that the kame has supplied a portion of their material. Short remnants of similar form and material occur northward at Wells River and Colebrook, the last at an altitude of 1,050 feet above the sea; and southward at Charlestown, Bellows Falls, Dummerston, and Brattleborough. The kame of Connecticut valley is principally gravel, always water-worn, the largest pebbles being one to two feet in diameter, with frequent layers, one or two feet in thickness, of coarse, sharp sand.

In the Merrimack valley, a series of kames, always in ridges, sometimes a single one, but more often with irregular branches or several parellel to each other, extends from Loudon, along

Soucook river and the west side of Merrimack river, to Manchester, a distance of twenty miles. Their height varies from 60 to 125 feet above the river, and they are often nearly covered by the alluvium. Those ridges are coarser than the kame of Connecticut valley, consisting almost wholly of very coarse water-worn gravel, with the largest rocks three to four feet in diameter, and containing fewer and only thin layers of sand.

Another interesting series of kames extends from Saco river to Six mile pond, and from Ossipee lake, south-easterly, along Pine river, and by Pine River and Balch ponds into Maine. The first description of any of these ridges in America appears to have been given by Dr. Edward Hitchcock, in 1842, respecting a series which is well shown in Lawrence and Andover, Massachusetts. This series was at first supposed to be about one and a half miles in length ; but Rev. George F. Wright has recently traced it more than twenty-five miles.

About Dover, and southward, near the sea coast, thick deposits of gravel and sand, sometimes forming extensive plains, are found occupying areas of watershed from one hundred to two hundred feet above the streams, which often flow in wide valleys that are nearly destitute of modified drift. The absence in the valleys of the terraces which mark erosion through modified drift, shows that they were never filled with the same materials, and that these remarkable plains and ridges were deposited in their present isolated position, with wide areas of lower land at each side. How this took place we can only explain by referring the formation of these deposits to the same causes which produced the kames. The ice-sheet still remained unmelted upon each side at the time of their deposition, filling the valleys and wide areas of low land, over which this gravel and sand must otherwise have been spread by the current of the floods on which they were brought. The most extensive of these plains occur about Willand and Barbadoes ponds, near Dover, and in Newington and the north-west part of Portsmouth. Broadly rounded deposits of the same class form the elevations on which the villages of Rye, North Hampton, and Hampton are built. A very interesting ridge of this kind extends from north-west to south-east through the city of Newburyport, Massachusetts.

The extensive level plains and high terraces which border the rivers of New Hampshire, constituting the most conspicuous and by far the largest portion of our modified drift, were also deposited in the Champlain period. The departing ice-sheet was the principal source both of the vast amount of material and of water for transporting it into the valleys, which appear in most cases to have been filled to the level of the highest terraces or plains. The prevailing horizontal stratification of these deposits show that they were spread over large areas by the current of the floods which held them in suspension. The modified drift thus increased in depth in the principal valleys through a long period, which may have continued until the last of the ice at the head of the valley and of its tributaries had disappeared.

During the *recent or terrace period,* the rivers have been at work, excavating deep and wide channels in this alluvium. The terraces mark heights at which, in this work of erosion, they have left portions of their successive flood plains. As soon as the supply of material became insufficient to fill the place of that excavated by the river, a deep channel was gradually formed in the broad flood-plain. The process was very slow, allowing the river to continue for a long time at nearly the same level, undermining and wearing away its bank on one side, and depositing the material on the opposite side, till a wide and nearly level lower flood-plain would be formed, bordered on both sides by steep terraces. When the current became turned, to wear away the bank in the opposite direction, a large portion of this new flood-plain would be undermined and re-deposited at a lower level ; but the direction of the current's wear might be again reversed in season to leave a narrow strip, which would then form a lower terrace. In this way we often see the highest plain on our large rivers, and the lower terraces very frequently, being now undermined by the wear of the current, forming steep bluffs and banks. The fine character of the materials which compose the lowest terraces and the interval, or present flood-plain, is due to this wearing away and re-deposition by the river, which have been many times repeated, till what may have been at first gravel becomes very fine sand or silt.

Neither the deposition nor terracing of the modified drift requires any submergence, as by lakes or the sea. These deposits have the form which they must naturally take, in being rapidly brought into the valley by floods, and in afterward being partly excavated by rivers in the process of deepening their channels.

Along Connecticut river, for a distance of 120 miles south from Fifteen-miles falls, and thence extending south into Massa chusetts, the terraces are very numerous, frequently four or five on a side, and reaching a height of 100 to 200 feet above the stream. In the upper Connecticut valley and along Merrimack river, the alluvium principally consists of the bottom-land or interval, and the high terrace or plain, which averages about 100 feet above the river. Both the terraces and intervals have a slight descent with the valley, that of the highest terrace showing frequently a very regular slope. On the Connecticut river above Fifteen-miles falls, the upper terrace descends with the valley in forty-five miles from 1,100 to 850 feet above the sea, averaging $5\frac{1}{2}$ feet to a mile. For 120 miles south from these falls to Massachusetts line, the slope is less steep and less regular, desceending from 650 to 350 feet above the sea. On the Pemigewasset and Merrimack rivers, for ninety-six miles, this slope of the highest terrace varies from 15 to 5 feet in a mile, descending from 750 to 160 feet above the sea.

Upon entering the large valleys, tributary streams of comparatively narrow channel and rapid descent frequently formed extensive deposits, in the Champlain period, similar in material to the flood-plain of the main valley, but having a greater height. Sometimes upon Connecticut river these deltas, being partially undermined, form conspicuous terraces a hundred feet above the highest normal terrace, which is the remnant of the river's continuous flood-plain.

Before the thick forest, natural to all parts of the State, had sprung up, the strong north-west winds were in many places sweeping the loose sand from the valleys upward along the hillsides. These sand-drifts or dunes are found at heights varying from the level of the highest terrace to two hundred feet above it, along the east side of Connecticut and Merrimack valleys and south-east of Ossipee lake. With the clearing away of the forest, they have become again drifted by the wind.

The greatest widths of modified drift that can be measured in the Connecticut valley, on the west side of New Hampshire, are in Haverhill and Newbury, two miles, and in Hinsdale and Vernon, two and a half miles wide. The average width is fully one mile. The most extensive bottom-lands on this river are the Upper Coös intervals at Lancaster, and between Wells River and Bradford, Vt., the latter being twelve miles long, and one-half to one mile wide, including the Lower Coös intervals of Newbury, Haverhill, and Piermont. The largest plains are expanses of the upper terrace, or of still higher tributary deltas. These areas are generally of a clayey, moist, productive soil, quite in contrast with the dry and sandy "pine-plains" of Merrimack river, Ossipee lake, and other parts of the State. The modified drift of the Merrimack is usually one to two miles wide; its greatest development is in Concord, and in Litchfield and Merrimack, where it has a width of nearly four miles.

Valuable beds of clay, extensively used for brick-making, occur in the highest terrace on the east side of Merrimack river for four miles north from Hooksett. This clay appears to form a nearly continuous stratum, which has a thickness of from 20 to 30 feet, with its top about 100 feet above the river, or 300 feet above the sea. It is overlain by a few feet of sand. The upper part of this stratum consists of a hard and compact *gray clay*. At a depth of 12 to 15 feet, this is usually separated at a definite line from the underlying *blue clay*, which is soft and plastic when dug from the bank. Deposits of the same gray and blue clay, the lätter always below the former, are frequently found in the south-east part of the State, near the coast, and along Hudson river and Lake Champlain. These clays and the overlying sand are probably equivalent to the *Leda clay* and the *Saxicava* sand, distinguished by Principal Dawson in the St. Lawrence valley.

The only marine shells that have been found in New Hampshire, occur in these beds near the coast, and show that the sea stood at least 150 feet higher than now during the deposition of the modified drift. Bones of a seal and shells of *Leda truncata* are found at South Berwick, Maine, 30 feet below the surface, and nearly 100 feet above the sea. The surface here is a few feet of sand, the whole depth below which is clay, the upper portion gray, and the lower blue. *Saxicava rugosa*, *Mytilus edulis*, and *Astarte castanea* occur atseveral places in Kittery, Maine, within 30 feet above the sea. These towns border New Hampshire. The most southern locality at which *Leda truncata* has been found is Portsmouth, New Hampshire, where it occurs 15 feet below the surface, and 30 feet above high tide, in blue plastic clay. This species is now restricted to arctic seas, and its occurrence in Portsmouth and South Berwick shows that an arctic climate prevailed during the deposition of the beds in which it is found; but the presence of *Astarte castanea* at Kittery is proof that the ocean became nearly as warm as now before it sank to its present level.

LOWER CARBONIFEROUS FISHES OF NEW BRUNSWICK.

By Principal Dawson, LL.D., F.R.S.

The recent sinking of a shaft on the property of the Beliveau Albertite and Oil Company on the Petitcodiac River, has exposed a new and interesting deposit of fossil fishes in the rich bituminous shales of that district, which contain the remarkable deposits of Albertite, described in my Acadian Geology, second edition, p. 231 *et seq.* The bed affording these fossils is a dark brown bituminous shale; and I am informed by Mr. E. B. Chandler, to whom I am indebted for an interesting collection of the fish remains, was from four to five feet thick. The specimens thus presented, with those previously in my collection, and one kindly given to me by Mr. F. Adams, of this University, and the valuable memoirs recently published by Dr. Newberry in the Ohio Reports, and by Dr. Traquair in the Journal of the Geological Society, enable me now to give a revision of the fishes of this locality, as described by Dr. Jackson in his Report of 1851 on the Albert mine, which I was unable to do in the second edition of Acadian Geology, owing to the small number of specimens to which at that time I had access.

In the collections in my possession, I recognize, in all, five species, three of them very small, and two of larger size. Of these, one, which is unusually well preserved and is the smallest of the whole, appears to be new, and I shall begin by describing it.

Palæoniscus (Rhadinichthys) Modulus, n. s.—Length, five to six centimetres; greatest breadth, 15 to 17 millimetres—the proportion of length to breadth being about five to one and a half. Head, oval and obtuse; details not preserved, except that the bones are sculptured with fine waving lines. Body gracefully curved, and upper lobe of tail long and slender. Pectoral fins small, with stout, unjointed rays. Ventral not distincly preserved, but apparently small and nearer to pectorals than to anal. Dorsal and anal of moderate size and opposite each other. Caudal very heterocercal, with the lower lobe sharply pointed. Fins with well developed fulcral spines, especially large at the base of the caudal. Scales of the sides rhombic, coarsely toothed on the posterior edges and elaborately sculptured with flat, scaly ridges, corresponding to the teeth of the edge. The ridges are arranged in an upper and lower series, the latter oblique to the former, so that each scale has the appearance of being composed of two distinct portions. Lower surface of scales smooth, with a few furrows corresponding to the ridges above, and the posterior edges similarly serrate. Caudal scales narrowly rhombic, pointed, and with a few central lines. The back is protected with about ten large oval scales between the head and the dorsal. They are sculptured with waving lines, curving with the edges, and are apparently truncate and serrate behind. The fish figured by Jackson, Pl. II, Fig. 5, but not named, probably belongs to the above species.

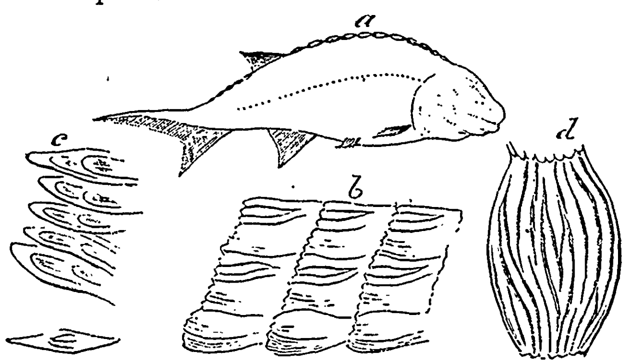


Fig. *Palæoniscus Modulus*, N. S.

(*a*) Outline, natural size.
(*b*) Series of Scales enlarged, seen from inside. The lower row are those on mesial line.
(*c*) Surface of exposed part of scale from side and upper lobe of tail, showing sculpture, enlarged.
(*d*) One of the dorsal scales, enlarged.

This beautiful and elaborately ornamented little fish is a perfect model in miniature of that type of lower carboniferous Palæoniscids to which it belongs, and which has recently been separated by Dr. Traquair in the genus or subgenus Rhadinichthys. For this reason, I have given it the specific name *modulus*. To the same genus belong the two next species, described by Jackson, of which I shall give merely distinctive marks.

P. Alberti, Jackson, is larger than the preceding. The scales have more numerous striæ. The dorsal scales are rounded posteriorly. The posterior edge of the anal fin approaches nearly to the caudal, and extends considerably behind the posterior edge of the dorsal.

P. Cairnsii, Jackson.—About the same size with the last, but more slender, and the head less obtuse in front. Scales think and with few striæ, and less numerous serrations. Dorsal scales pointed posteriorly. Anal fin somewhat remote from caudal and opposite dorsal.

A specimen collected by Mr. Ells, of the Geological Survey, indicates a fish of the same general form with *P. Alberti*, but about six inches long. The outline of this fish is well seen, but the details are not sufficiently clear to show if it differs in these from the smaller species.

The next species and perhaps the following one, belong to the genus *Elonichthys* of Giebel. They are much larger than the preceding.

P. Brownii, Jackson, is deep in form, with large dorsal and anal, the latter reaching almost to base of caudal. Scales of body broad and with numerous fine horizontal striato-punctate furrows, which turn abruptly upward at the anterior side of each scale. A nearly perfect specimen, collected by Mr. Ells, shows that the head was of moderate size, and the body about ten inches long and three and a quarter inches wide, the breadth at the dorsal fin being as great as at the shoulders, giving a sort of rectangular form to the fish, whose breadth suddenly diminishes toward the tail.

The crystalline lens of the eye of Mr. Ells's specimen is preserved in calcite. Under the microscope it shows concentric laminæ and coarse bands or rods with indistinct denticulations; the structure being similar to that in the crystalline lens of the modern ganoid *Amia ocellicauda*. This is the first instance known to me of the preservation of the structure of the crystalline lens in a palæozoic fish.

P. Jacksoni, N. S.—A species figured, but not described, by Jackson, is represented by many fragments in my collection. It is the largest of these fishes, reaching a length of 15 inches. It may be distinguished from the last by its more slender form, its small anal fin, more remote from the caudal, and by the character of the scales, which have many horizontal striæ, and have in the broader ones a few deep and strong serrations posteriorly.

The whole of these fishes have been preserved entire, the body being perfectly flattened and thrown into attitudes which imply that they were imbedded when living or immediately after death. The material in which they are contained is shown, by its microscopical and chemical characters, to have been a vegetable muck or mud, and the fish were either overwhelmed by it in the manner of a bursting bog, or were stifled by the non-oxygenated water mixed with this mud, and suddenly killed and imbedded in the accumulating sediment. That they occur in this perfect state and in a limited thickness of the deposit, may imply that at certain times they were overwhelmed by the irruption of this fetid organic mud into the water in which they lived. The bed is low down in the Lower Carboniferous series, being the equivalent of the Horton series of Nova Scotia; so that these fishes are among the oldest that we know in the Carboniferous period; but we know, from the Horton beds, that many far larger and predaceous ganoids were their contemporaries. No remains of these have however as yet been found in the Albert or Beliveau beds, which were probably deposited in limited fresh-water basins, perhaps not ordinarily accessible to the larger fishes.

Sir Philip Egerton* and Dr. Traquair† have both remarked on the similarity of these fishes to those found in the Lower Carboniferous of Scotland, and Dr. Newberry has described very similar species from the Carboniferous of Illinois and Ohio.‡

NOTE ON A FOSSIL SEAL FROM THE LEDA CLAY OF THE OTTAWA VALLEY.

By Principal Dawson, LL.D., F.R.S.

Read before the Natural History Society, Oct. 29, 1277.

This interesting geological specimen was kindly sent to me, for inspection, by Dr. Grant, of Ottawa. It has an historical as well as scientific interest, which bridges over not the whole history of our Society, but that of its publication, *The Canadian Naturalist.* About twenty years ago, Mr. Billings, then at

* Journal of Geological Society, 1853.
† *ib.* 1877.
‡ Report on Illinois, Vol. II; Palæontology of Ohio, Vol. I.

Ottawa, obtained a nodule with certain bones enclosed in it from the Post-pliocene clays of Green's Creek, on the Ottawa, which have offered so many beautiful specimens of the Capelin and other fishes, and also of marine shells of northern and cold water types. Mr. Billings regarded the bones as those of the limbs of "a small animal of aquatic habit," but, not being able to determine the species, sent the specimen to Dr. Leidy, of Philadelphia. He recognized the bones as those of the hinder extremity of a young seal, but of what species was uncertain. A good figuure and description were published in the first volume of the *Naturalist* in 1856. No further information bearing directly on this fossil was secured until the present year, when the bone now exhibited was obtained by Dr. Grant from a boy who had collected it at the same place and in the same bed in which the first mentioned specimen was found. It is the left ramus of the lower jaw of a young seal, containing a canine and four molar teeth, with an impression of the fifth. It enables us now to affirm that the species is *Phoca Groenlandica*—(*Pagophilus Groenlandicus* of Gray's Catalogue) the common Greenland seal, and it is of such size that it may have belonged to the same individual which furnished the bones described in 1856, or at least to an animal of the same species and of similar age.

Skeletons of larger individuals of this species, which still lives in the Gulf of St. Lawrence, have been found in the Post-pliocene clays near Montreal. Portions of them may be seen in the museums of the Geological Survey and of the University.

This specimen thus carries us back to that glacial period when the valleys of the St. Lawrence and the Ottawa were occupied with the cold ice-laden waters of the Arctic Sea, furnishing a fit habitat for the Greenland seal and the fishes which are its food. It also shows how one discovery in geology serves to throw light upon another, and how our knowledge grows little by little in the lapse of years; and it indicates the value of a society like this, in treasuring up the little instalments of facts accruing from time to time, and so building up the knowledge of the natural history of our country.

The fossil fishes found in the nodules of the clay at Green's Creek, and catalogued in my notes on the Post-pliocene of Canada are, *Mallotus Villosus*, the capelin, *Cyclopterus lumpus*, the lump-sucker, and a species of *Gasterosteus*. I have also fragments that seem to indicate a small *Cottus*.

THE EARTHQUAKE OF NOVEMBER 4, 1877.

(Read at the November Meeting of the Natural History Society, by PRINCIPAL DAWSON, LL.D., F.R.S.)

In the *Canadian Naturalist*, Vol. V., first series, will be found notes on the earthquake of October 17, 1860, with a summary of facts relating to the previous shocks recorded in Canada, and some general remarks on their periods, local peculiarities and probable causes. The subject was continued in Vol. 1. of the new series, in connection with the earthquake of April, 1864, and in Vol. V., new series, in connection with that of October 20th, 1870. I may refer to these notices for what is known on Canadian earthquakes up to that time, and we may now continue the narrative in connection with the somewhat wide-spread disturbances of the earth's crust in the present autumn.

On January 4th, 1871, a shock was experienced at Hawkesbury, Ontario, but was not reported from any other place. A more extensive earthquake occurred on May 22nd, 1871. It prevailed from the city of Quebec to the western part of Ontario. The time for Quebec is stated at ten minutes before two a. m., and there was a second shock at twenty minutes past three. The time for Perth, Ontario, is stated at half-past one. It is noteworthy that this earthquake occurred at nearly the same time with that recently experienced. Since 1871 several minor shocks have been noticed from time to time, but did not attract much attention, and I have preserved no details in relation to them.

That of the present month was probably the most considerable since 1871. It occurred at Montreal, at ten minutes before two on the morning of Sunday, November 4th. At Montreal there was only one distinct shock, preceded by the usual rumbling noise, and sufficiently severe to be distinctly felt, and to shake window-sashes and other loose objects, causing them to vibrate for several seconds. In so far as the published reports give information, the shock would seem to have been limited to the area along the river St. Lawrence, extending from near Three Rivers on the east, to Kingston on the west, and in a direction transverse to the St. Lawrence from Ottawa to the southern part of New England. In a paper prepared for the American Journal of

Science, by Professor Rockwood, of Princeton, he defines the area in question as that of "an irregular trapezium whose angles are marked by Pembroke, Ont., Three Rivers, P.Q., Hartford, Conn., and Auburn, N. Y., and which is some 200 miles on its northern and southern sides, about 300 miles on the eastern side, and 175 on the western." So far as can be learned from the reports, the shock seems to have been most severely felt on the north side of the valley of the St. Lawrence and about Lake Champlain, or may be said to have had its centre in the Adirondack and Green Mountain region.

In the notice of Canadian earthquakes in 1860, I mentioned that it had been observed that the greatest and most frequent shocks have occurred a little after the middle and toward the close of each century. We are now approaching the latter period, so that possibly the last shock may be the beginning of a series of similar phenomena. Since, however, there is no known reason for this periodicity, it may be a merely accidental coincidence, or may depend on some cycle of about half a century.

If we add to the table of earthquakes in Eastern America, given in Vol. V. of the *Naturalist*, the more recent earthquakes observed in Canada, the proportion for the several months will stand as follows:—

January, 9 earthquakes; February, 4; March, 5; April, 5; May, 7; June, 3; July, 4; August, 6; September, 4; October, 8; November, 15; December, 8. Total, 78.

Thus of seventy-eight recorded Canadian and New England earthquakes, fifteen, or nearly one-fifth, occcured in November; forty, or more than half of the total number, in the third of the year, extending from October to January inclusive. The published catalogues show that similar ratios have been observed elsewhere, at least in the Northern hemisphere.

In some earthquakes a low state of the barometer has been observed, as if a diminution of atmospheric pressure was connected with the movements of the crust producing seismic vibrations. This we can readily understand if a low state of the barometer should prevail over an area of the crust tending to rise, simultaneously with a high pressure over a sinking area. In this case a state of previous tension might terminate in a rent of the crust causing vibration. In the present case no very decided indication of such a cause appears, at least in so far as this part of the St Lawrence valley is concerned. Mr. McLeod informs me that the mean barometer for the week preceding the earthquake was 29.7564, and for the following week 30.0864. The barometer on the Friday before the earthquake at 8 p. m. was 29.115, the lowest observed since March last; but at 1.50 a. m. on Saturday it was about 29.967, which is very near the mean of November 1876, and also a little above the mean barometer of the place for the whole year; and on Sunday afternoon it rose to 30.200. It would thus appear that the earthquake was preceded by a low state of the barometer, and followed by one unusually high for the season, and this rapid fluctuation was accompanied with much atmospheric disturbance in the region of the Lakes and the St. Lawrence Valley. The weather map issued by the War Department at Washington for Sunday morning, November 4th, shows a low barometer in the Gulf of St. Lawrence and a high barometer in the Middle States—the area of the earthquake being about half way between the extremes.

In connection with previous earthquakes it has been observed that the greatest intensity of the shocks appeared near the junction of the Laurentian with the Silurian formations. This would be a natural consequence either of the propagation of vibrations upwards from deep underlying regions through the Laurentian rocks, or from the overlying sedimentary rocks towards these older rocks. In the case of the recent earthquake, this appears to have applied chiefly to the border of the Laurentians extending round by the Ottawa and Kingston to the Adirondacks, as if a wave propagated through the Silurian formations had broken against the southern and eastern sides of the Laurentian region, or a shock originating under the Laurentian of these regions had extended itself from them into the Silurian rocks to the south and east. If the prevailing impression stated in the reports, that the vibrations passed from W. to E. or N.W to S.E., is correct, the latter would be the more probable supposition. It is, however, very difficult to attain to any certainty as to the actual direction of the disturbance, and some observers give it as precisely the opposite of that above stated.

In the present year there have been violent earthquake shocks along the chain of the Andes. The latest of these heard of was that of Lima and Callao on the 9th of October. On the west coast of North America, portions of Oregon and Washington

Territories were shaken on the 12th October. On the 14th November a slight shock was felt at Cornwall, Ontario, and on the 15th November earthquake shocks occurred over a wide area in Kansas, Iowa, Dakota and Nebraska.

While the above was in press the following appeared in the daily newspapers:—

"A despatch from Beachburg says:—Two shocks of earthquake were felt here this morning (Dec. 18), the first being between the hours of one and two, and the last between five and six o'clock, the latter being so severe as to shake houses and arouse the inmates from their slumbers."

Beachburg is on the south side of the Ottawa, about twelve miles north-west of Portage du Fort.

ON THE FORMATION OF METALLIC VEINS.

By Fridolin Sandberger.

(Translated from "Die B. & H. Maennische Zeitung," of 2nd and 9th November, 1877.)

Observations on metallic veins and their relations to the country-rock that I have carried on for many years in the Rhenish slate plateau, and in the primordial plateau of the Black Forest, urged me on to researches into the elementary components of the so-called vein-stones, and also of the heavy and precious metals that occur in metallic veins in the form of sulphuric, arsenical and antimonial compounds. These researches, although far from finished yet, have, as I believe, already yielded a number of facts of general interest, which may possibly stimulate others to farther pursuit of the subject. I thought that I should seek the elementary components in the first-formed silicates, which are among the most important ingredients of the oldest crystalline granular and schistose rocks of the gneissose and granitic classes, as also of the eruptive rocks of all geologic ages.

In the first place, I was occupied with the question of the origin of the barium sulphate or heavy-spar, which I had propounded to myself as long ago as 1858. At that time I had always found baryta in a number of the great (Carlsbad) twin-crystals of orthoclase out of the porphyritic granite in the neighbourhood of Achern and Offenburg, but sometimes only in too small a quantity to determine quantitatively. In the crystals of the same rock from Carlsbad there is, according to Redner, only about half a per cent. (0.48 along with 2.41 Na_2O and 15.67 K_2O)*. The orthoclase, rich in potash, of this rock is known to weather but very slowly; as the crystals, loose and comparatively but slightly weathered, can in many places be picked out of the grit into which the rock has crumbled. The baryta separates out only when the crystals are much decomposed, and this seems to take place to any considerable extent only locally. To this corresponds the variety and narrowness of the veins of baryta in the region of porphyritic granite from Achern to the Kinzigthal, where such are observed only on the high Horn near Zell, by Schloss Staufenberg (7 cm), on the Lautenbaechle in the Durbachthal (2½ cm). Others near Gemsbach in the Murgthal exhibit slighter dimensions. The only ores observed in them were spathic iron and a poor limonite.

Otherwise is the behaviour of the non-porphyritic granite that extends from Rippoldsau along the eastern side of the chief gneiss zone of the Black Forest past Schapbach, Wittichen, Alpirsbach, Schiltach, Hornberg and Tryberg towards St. Blasien. In the northern part of this region the orthoclase is poorer in potash (7.81 per cent.) but richer in soda (3.24 per cent.) and contains along with 0.58 lime 0.22 per cent. baryta.† It weathers a good deal more readily than that of the porphyritic granite, probably on account of its greater per centage of lime and soda. Wherever the feldspar is mostly converted into pinite and the rock is much loosened it is traversed by innumerable barytes and metallic veins, which terminate abruptly wherever the fresh granite replaces this porous rock. The veins consist merely of a series of stringers, which quickly unite and attain a width of half an inch to ten inches at the most, only to separate again. Only towards the boundaries of the gneiss, for instance, in the Tiefenbachthal, near Schapbach, does this behaviour change, and the veins become far wider up to five feet; but with merely traces of cobalt *fahlerz*. Only

* The entire composition of the feldspar is: SiO_2 63.02, Al_2O_3 18.28, MgO 0.14, BaO 0.48, Na_2O 2.41, K_2O 15.67.

† Its entire composition, according to Nessler is: SiO_2 65.59, Al_2O_3 20.53, MgO 0.44, CaO 0.58, BaO 0.22, Na_2O 3.24, K_2O 7.81.

their great local richness in silver and cobalt (to which farther reference shall be made) rendered them worth mining near Wittichen, and gave to them a high value. These veins could never have been worked for heavyspar, as this is always coloured flesh-red (and even brick-red in some places) by finely-divided scales of red hematite.

These analyses of the fresh granite by Nessler *a* and of the decomposed by Petersen *b*.

	a Schapbach,	*b* Wittichen (calculated free from water)		
$Si\,O_2$	67.59	70.25	+	2.66
Al_2O_3	18.13	19.18	+	1.05
Fe_2O_3	3.45	2.84	—	0.61
Ca O	1.58	0.32	—	1.26
Ba O	Trace	0.17	+	0.17
K_2O	5.38	5.22	—	0.16
N_2O	2.23	0.65	—	0.58
Mg O	1.65	0.37	—	1.28

prove that the baryta still withstands the attack of waters impregnated with carbonic acid, when no inconsiderable portions of sodic carbonate, potash, lime, magnesia and ferrous oxide have been already carried off. The baryta is therefore not the oldest vein-stone of the Wittichen veins, but is sometimes underlaid by carbonates. The circumstance that it completely coats and covers the older native silver sheds clear light upon its mode of formation, therefore it was in solution as baric sulphate and not as baric sulphide, which cannot be so easily proved in any other place. Since I could extract soluble sulphates (alkalies) from many granites by means of water, the baric carbonate formed by the active decomposition of the feldspar must certainly have come into contact with them in that form and been precipitated. That it can remain partly in solution along with much alkaline carbonates in waters flowing from the granite is proved by the analyses of the Baden mineral waters springing from similar granite, in which Bunsen has found it along with strontic sulphate. The deposition of crystalline baric sulphate in one of the canals of the Carlsbad wells is known.

The orthoclase of the gneiss is the most easily attacked, as it occurs in the larger (Carlsbad) twin-crystals in the porphyritic varieties and the larger granitic bands in the region of the Renchthal, Wolfthal and Kinzigthal. An analysis of the mineral from

Wildschapbach yielded: SiO_2 63.10, Al_2O_3 20.83, MgO 0.52, CaO 2.01, BaO 0.81, Na_2O 9.22, K_2O 2.92.

As the feldspar, in consequence of its greater percentage of lime and soda, weathers far more readily than the orthoclase of the granite and moreover contains more baryta, it might certainly be expected that the largest veins of baryta would occur in the gneiss; which is the case. Thus the vein on the Schottenhoefen near Zell on the Harmersbach reaches a thickness of 25 feet, and the chief vein of the Clara Mine in the Hinterrankach near Schapbach one of forty feet. Heavyspar has played an important part also in the celebrated Wenzel vein near Wittichen. In the Friedrich-Christian and Neu Herrensegen veins in Wildschapbach, which traverse granularly-banded gneiss rich in the above-mentioned orthoclase, only a small part of their contents still consist of heavyspar; although its former abundant distribution in the vein is proved by the structure of the quartz-masses that carry the predominating ore (galena) and have without exception retained the form of the vanished heavyspar. This substitution seems to have occurred only where the feldspar of the country rock has been completely changed to kaolin, *i. e.* has been deprived of all its bases except alumina. Since considerable quantities of silicic acid were separated out in this process, as is proved by the following analyses:

	Sodium-orthoclase from Wildschapbach, containing baryta.	Kaolin, according to Forchhammer, calculated free from water.		
SiO_2	63.10	54.52	—	8.58
Al_2O_3	20.83	45.48	+	24.65
CaO	2.01	0.00	—	2.01
BaO	0.81	0.00	—	0.81
MgO	0.52	0.00	—	0.52
Na_2O	9.22	0.00	—	9.22
K_2O	2.92	0.00	—	2.92

the replacement of the heavyspar is intelligible that has occurred in all cases where the country-rock has not reached the utmost limits of decomposition. In the gneiss there is no lack of sulphates to precipitate the baric carbonate as heavyspar. Apart from my direct solution-experiments, which regularly yielded scuh, Bunsen's analyses of the springs of Griesbach, Freiersbach, Petersthal and Antogast, which do not come from metallic veins, as do those of Rippoldsau, but directly from the gneiss, show very considerable quantities of sodic and potassic sulphate. Whence the sulphates are derived, whether they should be sought for in the numerous fluid-filled cavities of the quartz or where else, has not yet been determined. The southern part of the Black Forest is also rich in veins of baryta; but the feldspars of the local gneisses and granites have not yet been examined for baryta. Therefore the discussion of them must be postponed.

The extremely rare occurrence of heavyspar in the geodes of the phonolite of Oberschaffhausen in the Kaiserstuhl is very easily explained. The presence of baryta, which A. Mitscherlich observed in many sanidines, occurs also in this rock and the decomposed nosean furnishes sulphates in sufficient quantity. Therefore it cannot be wondered at that already in 1829 O. Eisenlohr observed on mesotype wine-yellow heavyspars an inch in size, and Schill repeats this observation. The small quantity of heavyspar that occurs in the geodes of the phonolite proves that for its separation a very active decomposition of the rock is necessary, which a volcanic rock so comparatively new as the phonolite has usually not yet undergone. Where such has occurred, as for instance in the transformation of trachytic rocks into alum-stone in the Hungarian volcanic zone in consequence of the exhalation of sulphurous acid, the small contents of baryta in the original rock has separated out in the form of heavyspar, which is found in several places in the cavities of the alum-stone.

The abundance or the lack of veins of heavyspar in stratified formations will therefore depend on how far the feldspar of the primordial rocks used up in their formation was already decomposed at the time of their deposition. In the Permian and many Triassic sandstones it is often still very fresh, in which case the presence of baryta in the rock can be easily detected, and the occurrence of veins of baryta at a considerable distance from the primordial rocks be easily understood. Where this is not the case the only possible supposition is that it was deposited by springs. The feldspars in the sandstones of the Rhenish slate plateau are very greatly decomposed, therefore veins of heavyspar occur very rarely in them; for instance near Michelbach and Oberrossbach in Nassau, Mittellach in the Bergischen, and in a few Siegener veins. When the rock is lixiviated under an increased pressure and temperature, as by the mineral springs at Ems, the traces of baryta in the water prove that some of this base is always present. More frequently than in the stratified rocks of the Rhenish slate plateau do veins of heavyspar occur in the diabases that intersect them, as for instance in the Ferdinand Mine near Hirzenhain (5 cm.), Rehberg near Merkenbach (3–5 cm.), Theobald, Pallas and Orion near Burg (3–15 cm), and Rundbaum near Dillenburg. As the diabases, according to all examinations hitherto made, contain no orthoclase feldspar, the traces of baryta that the careful researches of Petersen and Senfter have always found in the rock can be contained only in their triclinic feldspars. This is all the more probable since Descloizeaux has very recently discovered a triclinic feldspar that must be regarded as nothing else than a baryta-labradorite.

According to this it would always be the baryta-contents of the feldspars that concentrate themselves in the veins of heavyspar; for the barytic micas have been first discovered by Oellacher in a few places in Tyrol and by me in Salzburg, and therefore cannot yet be taken into consideration here.

A second important veinstone, which usually accompanies the heavyspar in the Black Forest, is fluorspar. Up to the present time, however, I am aware of fluorspar only at one point in the region of the porphyritic granite, viz., in the Hesselbach valley, near Oberkirch, where there is a vein from 4–9 feet wide. The accompanying minerals, which occur in smaller quantity, are heavyspar and limonite; copper pyrites being observed in only one small grain. The country-rock is in a completely decomposed condition. In far smaller quantity has fluorspar occurred in the similar rock at the Hermann mine near Goerwihl, not far from Waldshut.

In the region of non-porphyritic granite the fluorspar is nowhere concentrated in any quantity in the northern Black Forest. Although it occurs in nearly all the metallic veins, the heavyspar always predominates, as in the Neuglueck Mine, King David and Daniel, near Wittichen. In the south it occurs only in association, for instance with copper pyrites at the defunct Hausen iron smelting-works in the Wiesenthal. Direct *points d'appui* for judging of the mode of formation of the fluorspar are not afforded by these veins. But even here it must be carefully noted that the oligoclase and mica of the country-rock of the veins are always equally and much decomposed; and ferric oxyd occurs in quantity, viz., individually in the *Salbaender*, or as the colouring substance of the flesh-red baryta. Similar pho nomena occur in the large pegmatite vein of the Gleisinger Rock in the Fichtelgebirg, in whose fissures violet-blue fluorspar and iron-mica occur together in exact proportion as the dark mica (rich in iron)* and the oligoclase are decomposed. Here, as I already advanced in 1865, there remains no doubt that the origin of the fluorspar depends upon the reaction of the potassic fluoride, that is derived from the mica, with the calcic carbonate from the oligoclase. The spathic iron, which occurs in scales in the fine crevices, is ferric oxyd that separated out of the mica at the same time; and upon the more complete decomposition of the rock it has even concentrated itself into a deposit of schistose very pure spathic iron, which has been worked for some time past. Baryta does not occur here; for the feldspar (completely changed into pinitoid) that furnished the lime is in its fresh condition an oligoclase free from baryta, which contains, according to Gerichten :

$Si\,O_2$	61.36
Al_2O_3	22.25
Fe_2O_3	1.60
$Ca\,O$	1.10
$Mg\,O$	Trace
Na_2O	11.06
K_2O	2.07

The orthoclase of the rock is very much reddened, but not yet changed into pinitoid.

In the Black Forest the veins richest in fluorspar are those in decomposed gneiss, e. g., Friedrich Christian in Schapbach, Teufelsgrund in the Muensterthal, Stephanie near Schoenau, Maus near Todtnau and Neuglueck near St. Blasien; numerous other mines also contain the mineral, although not in such quantity as in the Friedrich Christian, where 714 cwt. were mined in the years 1853–1857 alone. The production continued until 1876 in the so-called Fluorspar Shaft, where it was six feet wide. Fluorspar is one of the minerals that with especial clearness prove the co-operation of organic subtances in the formation of ore-deposits. The crystals are almost always coloured by organic dye-stuffs, sometimes dark violet (Schoenau), pale violet (Muensterthal, Schapbach), light sea-green (Schapbach, Todtnau), and

* The clear potash-mica that is also present undergoes decomposition only much later.

by drying to 100° C. suffer a loss corresponding to the quantity of the dye-stuff. Pale sea-green fluorspar from Friedrich Christian (Sp. gr. 3.169) showed a loss of 0.202 per cent., while pale violet from the same place with sp. gr. 3.184 lost only 0.2005 per cent.

While fluorspar is almost never wanting in the metallic veins that traverse the gneiss of the Black Forest, it is almost entirely unknown in those that similarly carry galena, copper, pyrites and blende in the Rhenish slate plateau. As the sandstones and clayslates of that region are doubtless nothing but the finely triturated *débris* of older rocks, viz., of gneiss and granite, we must assume that the mica of the latter was before its re-deposition very much decomposed and already deprived of its fluorine; as also the feldspar of its baryta.(*vide supra*). It seems to me that in this way a chief difference in the mode of formation of metallic veins in primitive rocks and in sedimentary fragmental rocks would be naturally explained. The occurrence of both minerals in the English Mountain Limestone is quite different; but I do not know the conditions sufficiently to venture to express an opinion.

I come now to the most important part of my task, viz., *the proof of the presence of the heavy and precious metals in silicates.* It was known in this connection that the olivine rock and the serpentine formed from it always contained copper, nickel and cobalt: e.g., according to Stromeyer the olivine from the basalt of Giesen 0.37, that from Kosakow in Bohemia 0.33, and precious chrysolite from Egypt 0.32. I have found that this nickelous oxyd is always accompanied by cobalt, but in far smaller quantity. Herr Geh. Rath Woehler had the kindness to have both metals determined in the olivine from Nauroth near Wiesbaden, furnished by me in 1869. In 100 parts there were 0.307 nickelous oxyd and 0.006 cobaltous oxyd. Still more recently has it been shown that nickelous oxyd occurs very constantly also in the older eruptive lime-olivine rocks—the palaeopikrites: in the palaeopikrite of Dillenburg, 0.162—0.666 per cent., and is accompanied by copper, cobalt and bismuth. The palaeopikrite from Ullitz and other places of the Fichtelgebirg behaves similarly, and the far younger pikrites from Maehren and Austrian Silesia according to my repeated experiments contain the same elements; but no quantitative determinations have yet been made. In the Nassau palaeopikrites it can be proved that the percentage of nickelous oxyd increases in the same ratio as the transformation of the lime-olivine into serpentine progresses. In the stone of the Black Rock near Tringenstein, which contains 20 per cent. lime-olivine to 40 per cent. serpentine, it amounts to 0.162 per cent : but in that of the Huelfe Gottes Mine near Nanzenbach. with only some seven per cent. lime-olivine and 50½ per cent. serpentine, it already reaches 0.666 per cent. In the fresh rocks, so far as known, no nickel deposits occur, but only in the highly decomposed. In the greatly serpentinised palaeopikrite of the Huelfe Gottes such a deposit has been mined for twenty years, whose ore according to Casselmann, is a mixture of bitterspar, ferrous carbonate, copper pyrites (21.98 per cent.=7.60 per cent. copper), millerite (6.68 per cent.=2.64 per cent. nickel), sulphuret of bismuth (2.05 per cent.), iron pyrites (7.72 per cent.) with 0.30 per cent. quartz and red hematite ; but the relative quantities of the sulphurets vary so much that ores occur also with almost equal percentages of nickel (6.13) and copper (5.39). Both here and in the entirely similar ore-deposits of Bellnhausen near Gladenbach (as I have already shown) there is no doubt that the slight percentage of nickel in the palaeopikrite has been concentrated and precipitated by contact with sulphuretted fluids, and in this way has yielded workable quantities of ores of nickel. In the geodes nickel pyrites is always the sulphuret last deposited : a phenomena that recurs in many other metallic veins (Joachimsthal, Andreasberg, Huckelheim and Bieber in the Spessart, etc.) and is connected with the comparatively ready solubility of the sulphuret in sulphide of ammonia and similar soluble sulphur-compounds of alkalies and alkaline earths. It is overlaid only by calcspar, which mineral, moreover, occurs also in small stringers that intersect the ore-deposit and contain arsenical nickel and smaltine. It is a familiar fact that cobalt concentrates itself as an arsenical compound out of ores very poor in this element, everywhere where arsenic is present in any quantity, as, for instance, in the magnetic pyrites of Wiersberg in Oberfranken, as I have already shown, where it forms cobaltous mispickel.

Olivine or chrysolite is a very basic compound (R: Si=2 : 1); but neutral silicates also contain heavy metals, and most prominently hornblende and augite.

Next in regard to *hornblende*, of which I have tested several varieties for heavy metals. By testing samples of 20—40 grammes each—I found along with very much iron :

1. In basaltic (crystalline) hornblende from porphyritic basalt from Liebhards (Rhone)	*Cu not determinable. Co very evident.*
2. In the hornblendic schists from Goldbach near Aschaffenburg	*Copper and cobalt.*
3. Ditto from Oberkotzan near Hof	*Cu faint, Co evident.*
4. Ditto from Albbruck near Waldshut (Baden)	*No Cu, no Co, only Mn.*
5. Ditto from Webicht, near Schmalkalden	*No Cu, Co very evident.*
6. Ditto from Johanngeorgenstadt in the Erzgebirg	*Cu comparatively much, Co less, but very evident.*
7. Dark-black hornblende with olive-green streak from Prackendorf in Hungary	*Cu and Co very evident.*

Up to this time cobalt had been observed in no hornblende, and copper only in the actinolite of Reichenstein (0.40 per cent., Richter) and in the Smaragdite of Corsica (1.5 per cent., Vauquelin). Whereas copper and cobalt in consequence of the intense borax beads that they give before the blowpipe can be easily and surely discovered, even in a very small quantity of the hornblendes that have been so far examined; nickel could but very seldom be discovered accompanying the cobalt, as it usually occurs in still smaller quantity.* Whilst in the olivine of Neurod, the ratio of Ni : Co. was about as 51 : 1, it might probably be reversed in many hornblendes. But considerably larger quantities than hitherto must be operated upon, in order to separate the nickel, when it occurs, from the cobalt, and determine it with certainty. I have not yet examined the hornblendes for bismuth and arsenic. That the latter occurs in hornblendic schists I doubt so much the less from having found it to my very great surprise so long ago as 1862, in its native form, in the quartz stringers of the rock near Maisach, not far from Oppenau. Whenever a violent decomposition of the hornblendic schists occurs, which, however, has but seldom been observed, smaltine

* Certain Scandinavian hornblendic rocks behave evidently quite otherwise in this respect, since they contain highly nickeliferous magnetic pyrites and iron-nickel pyrites.

can separate out from them; and this is certainly the reason why certain cobalt veins at Annaberg always grow considerably richer where they intersect hornblendic schists. Up to the present time I have come to no definite conclusion as to whether the pyrites that occur in quantity in the hornblendic schists (*e. g.* near the Gutach-Muendung, not far from Hausach in the Black Forest), and sometimes in particles as large as peas, separated out immediately on the formation of the rock, or were first formed subsequently, but I am inclined to believe the former, because the pyrites appear firmly grown together with perfectly fresh mica and hornblende. In these pyrites, which consist principally of magnetic pyrites accompanied by only a little iron and copper pyrites, Petersen, who examined them at my request, determined on the average: S 39.93, As 0.15, Pb 0.10, Cu 0.36, Fe 58.31, Ni and Co 0.63, Ti and Mn trace, Bi and Ag slight traces.

The pyrites contain the heavy metals also in much the same ratio in which I have found them in hornblendes free from pyrites.

Several varieties of augite were examined, but naturally only such as form elements of rocks. The following results were obtained:

1. Augite out of a stream of the Somma, near Cisterna.*	*Cu and Co evident.*
2. Augite in the porphyritic basalt from Liebhards intercrystallised with hornblende No. 1: powder dark greenish-gray.	*Cu comparatively much; apparently enough to determine quantatively; Co plain (along with much Mn).*
3. Augite of the porphyritic basalt from Eckardtsberg, near Breisach: * powder light-gray.	*Cu no reaction. Co evident.*
4. Augite of the augite-porphyry of the Fassathal: powder clear greenish-gray.*	*Cu no reaction. Co evident.*

* There were only a few pure crystals to be had.

5. Augite of the granular diabase from Waeschgrund, near Andreasberg (Harz): powder light greenish-gray.	*Cu and Sb little; As still less. Pb much; Co evident. Ni very evident.*
6. Similar augite from Koenigsberg, near Giessen: powder light greenish-gray.	*Cu comparatively much; apparently enough to determine quantitatively. Co evident.*
7. Similar augite from Kroetenmuehle, near Hof (Fichtelgebirg): powder light greenish-gray.	*Cu and Co evident.*

As in the hornblendes, cobalt has been found in very small quantity in all the augites tested, while copper could not be found in every one of them, although in the augite from the diabase of Koenigsberg, near Giessen, and from the porphyritic basalt of Liebhards enough was present to determine quantitatively. Both elements occur in the augites of very ancient and also of very modern eruptive rocks. In the diabases and therewith associated *Schalsteine* of Nassau copper pyrites occurs in direct ratio as the decomposition of the rock has progressed, as is proved by the numerous veins (some thirty) in the neighbourhood of Dillenburg, and some ten in the valleys of the Lahn and Weil near Weilburg, which all contain ore only within this rock and are richest where they intersect beds of red hematite. But on passing into the Cypridina slates, sandstones, etc., the veins become barren. Galena and blende occur but rarely in the Nassau diabases associated with copper pyrites in calcspar fissures or in veins of copper pyrites, as, for instance, in the Fortunatus Mine, Guade Gottes and Gold Mine. Self-evidently the former occurs in the diabase region only in small veinlets (deserted mine Goldgraben near Weinbach, Merkenbach near Herborn) or associated with arsenical tetrahedrite * (Mehlbach

* Tetrahedrite with a maximum of one per cent. siver and galena occurred frequently in separated *Mitteln* at Weyer, the former where *Schalstein*, and the latter where diabase formed the immediate counry rock.

Mine near Weilmuenster, and Weyer near Runkel). Where the diabase became compact and fresh in the depth the veins were compressed into a simple crack, filled with clay and barren of ore. Lead, zinc and arsenic were found by Senfter in Nassau diabases; therefore it cannot be wondered at if, under favourable circumstances, they concentrate themselves into ores. But still more striking is the connection between ore-bearing and the constitution of the neighbouring plutonic rocks at St. Andreasberg in the Harz. Here the clay-slates through which the veins of ore run are bounded on the north by granite and to the south by diabase. The augite of the latter contains, as mentioned above, more lead than copper, more antimony than arsenic, more nickel than cobalt; all of which corresponds to the distribution of these elements in the veins of ore. I have not yet tested this augite for silver and zinc; but I shall repeat my tests as soon as sufficient material reaches me. The latter metal was determined by Marx in 1868 to range from 0.0007–0.0014 per cent. in Central American hornblende-and augite-andesites. The occurrence of zeolites (analcime, chabasite, stilbite, apophyllite), otherwise unusual in metallic veins, but not rare in clefts of diabases, forms an additional and not unimportant argument in favour of the derivation from decomposed diabase of the solutions that are precipitated in metallic veins. The above-cited facts have fully established of what vital importance the contents of the augite in heavy metals are for the explanation of the mode of filling of the metallic veins in diabases and similar rocks.

Not only do the augites of the elder volcanic rocks contain heavy metals, but they have been found by me also in the younger and youngest such rocks; so also for instance the occurrence of cobalt and nickel in the nephelinite of the Katzenbuckel by Rosenbusch, of copper and bismuth in the basalt of the Schiffenberg near Giessen by Winter and Will, of lead in the basalt of Annerod by Engelbach and of arsenic and antimony in that of the Kaiserstuhl by Daubrée.

With time mettallic veins might form themselves also out of such rocks. At the present time in volcanoes also are the contents of augites in heavy metals sometimes very apparent. For the occurrence of copper-and lead-compounds in the lavas and fumaroles of Vesuvius and other volcanoes must always be ascribed to the augite's contents of these metals, which have been changed into compounds with chlorine by long continued exposure to hydrochloric fumes.

The results from the examination of various micas are not less important than those yielded by olivine, hornblende and augite. But these are restricted to dark brown or black micas, which are usually curtly called "magnesia-micas" or "biotites"; but do not include the bright pure potash-micas or "muscovites," as these usually occur in the primordial rocks only as rarities and contain but 3-9 per cent. of iron, in whose company the heavy metals are usually found. After I had once found (in 1870) copper and cobalt in a dark brown mica out of the gneiss from Petersthal in the Renchthal I pursued the subject farther and was encouraged in my researches by Hardman's discovery in Dublin of zinc, copper and lead in micas from the Irish granites In order to obtain a commensurate result from my work I had naurally to separate out and examine as large quantities as possible of fresh micas from the primary rocks of various ranges. Only from a few localities could I obtain some 30 grammes, but from others far less. The entire results are set forth in the following table:—

	Ag	*Pb*	*Zn*	*Cu*	*Co*	*Ni*	*Bi*	*As*
There is contained in mica from gneiss, Petersthal	—	—	—	v. evident	evident	—	evident	—
" " " " " Wildschapbach	—	evident	—	"	"	—	"	—
" " " " garnet gneiss, Wittichen	—	—	—	—	"	evident	"	—
" " " " gneiss, Zindelstein	—	—	—	v. evident	"	—	"	—
" " " " " Rippenweiher (Odenw*)	—	—	—	—	"	—	—	—
" " " " " Damm near Aschaffenburg	—	—	—	v. evident	v. evident	—	evident	—
" " " " decomposed gneiss, Hoerstein	—	—	—	"	"	—	"	evident**
" " " " gneiss, Wenneberg (Rics) *	—	—	—	—	evident	—	—	—
" " " " garnet gneiss, Bodenmais	—	—	—	evident	v. evident	—	—	—
" " " " porphyritic granite, Altenstein, (Thuringian Forest)	—	—	—	"	evident.	—	evident	—
" " " " porphyritic granite, Haeg, (Black Forest)**	—	—	—	—	v. evident	—	—	—
" " " " granite, Schapbach	—	—	—	v. evident	evident	—	—	evident**
" " " " " Tryberg	—	—	evident	evident	"	—	—	—
" " " " " Sulzbaechle near Schiltach (Muendung)	distinct clouding by HCl	—	—	evident	v. evident	—	—	evident**
" " " " vein-granite (pegmatite) Heidelberg.	—	v. evident	—	—	evident!	—	—	—

* Only a small quantity was at my disposal.
** Determined with an improved Marsh's apparatus.

Cobalt, the most easily detected metal, is absent from none of the micas examined by me; most of them contain copper also, often indeed in comparatively large quantity, *e. g.*, that from Petersthal, Zindelstein near Hammereisenbrech and Schapbach in the Black Forest, Damm and Hoerstein in the Spessart, and it is then usually accompanied by bismuth. Nickel is rarer, but it also has been found, for instance, in the mica of the garnet-gneiss from Wittichen and that of the kersantite of Nassau. Arsenic was detected only in that from Schapbach, Schiltach and Hoerstein. The micas from the granitic region of Wittichen and Schapbach contain traces of silver, but no lead. This, however, has been very clearly detected in the mica of the gneiss of Schapbach.

There are in the gneiss, as well as in the region of hornblende-slates, ore-deposits whose sulphurets are so intermingled with silicates, micas, cordierite and feldspars that they can hardly be considered otherwise than as having been separated out at the time of formation of the gneiss. To this class, in my opinion, belong, for instance, those of Bodenmais in Bavaria, Todtmoos in Baden and Orijaerfi in Finnland, which principally contain magnetic pyrites, blende, copper pyrites and galena, and those of Modum in Norway and Tunaberg in Sweden, containing cobaltine and copper pyrites. In these ore-deposits occur again all the heavy metals that were found in the micas of the gneisses. In the case of a great excess of iron and lack of arsenic, only magnetic pyrites occurs, which, however, usually carries with it the remaining metals of the iron group. When, at the same time, as at Bodenmais, it contains but little nickel and cobalt, they can still be detected, and can be quantitatively determined in the pyrites of Kleofa (3.044 Ni, 0.094 Co, *Berzelius*), Todtmoos (Ni 1.82, Co 0.48, *Hilger*) and Horbach near St. Blasien (Ni 3.86, *Rammelsberg*, 11.2, *Knop*); and in this latter case are technically useful. Whenever arsenic occurs in these ore-combinations, the cobalt concentrates itself in the form of cobaltine, while the iron and copper form sulphurets free from arsenic.

The metallic veins in the gneiss region vary greatly in regard to their filling, which I seek to explain only by the chemical composition of the dark mica contained in the gneiss in question. In the gneiss of the Spessart, whose dark mica contains cobalt and arsenic along with copper and bismuth, occur the well-known smaltine veins of Bieber, in many places also (Alzenan, Sommerkal, etc.) stringers of copper ore have been found, which contain principally copper pyrites, but also locally bornite and cobaltous tetrahedrite. The latter mineral, which was first closely examined by me in 1862, occurs evidently in the stringers of those gneisses whose micas contain all the above-mentioned elements—but copper, iron and sulphur in excess over cobalt and arsenic. Galena, as far as I know, has never been found in the Spessart. All the more frequently is it found, either with or without copper pyrites, in the vein-region of the neighbourhood of Schapbach, the mica of whose gneiss contains copper, lead and bismuth. Antimony and arsenic were not discoverable in the mica, and occur only in minimal traces in the veins bearing galena: the former in the very rare antimoniate of lead, the latter in mimetisite, green lead ore (0.61 arsenic acid, Petersen), and in roselite, which was observed only once in very slight quantity. The latter mineral and the equally rare heterogenite seem at the first glance alone in the metallic vein to represent the cobalt repeatedly observed in the mica; but the galena also contains cobalt, nickel and bismuth, which have been precipitated here along with the ore that is present in the greatest quantity, in precisely the same way as elsewhere with magnetic pyrites. A great number of veins of the Black Forest are filled in the same way; but others, viz., those of the region of Geroldseck and of the Muensterthal contain, along with galena, much blende and no copper pyrites; therefore we may infer that they obtained their metals from mica rich in zinc and free from copper. In respect to the veins of Wolfach, Welschensteinach, etc., which are rich in antimony and silver, I must not express any opinions until I have examined the micas of the country-rock: possibly they will give results similar to those from the augite of Andreasberg.

The marked contrast between the ore-districts of the gneiss of Schapbach and the granite of Wittichen, which are scarcely five miles apart, is explained by the composition of their micas. That of Wittichen is free from lead, but contains silver, arsenic, bismuth, cobalt, nickel and a little copper, viz., all the elements that occur in the metallic veins there; towards the west they are united to a cobaltous tetrahedrite, but in the east are separated into native silver, cobalt-nickel ores and copper-bismuth compounds.

As we may observe, these investigations, which could not be continued to the micas of other rocks for want of time, have yielded as striking and important results as those into the olivines, augites and hornblendes; and the theory of the derivation of the ores from the country-rock has been proved for a number of localities. I have not yet been able to obtain mica from the neo-volcanic rocks in sufficient quantity to detect the heavy metals in them, in the same way as in augite and hornblende.

G. Bischof, who is well qualified to express an opinion on the mode of formation of metallic veins and also on chemical geology in general, stated, in the year 1866, in regard to the relations of silicates to the metallic veins: "However likely it may be that the metals of the sulphuretted ores are present as silicates in the country-rock, it is not yet certain." This can no longer be said, at least in the cases described above.

REVIEW.

The Antelope and Deer of America; by John Dean Caton, LL.D.; 8vo., 426 pp.; numerous cuts. New York (Hurd & Houghton). This valuable work has evidently been prepared with care by one who has devoted a great deal of time and study to our Antelopes and Deer. Mr. Caton has kept the American Antelope and several species of Deer in domestication for many years, and had the best of opportunities for observing their habits. His work contains many illustrations, and will, we are sure, be welcomed by both naturalists and sportsmen.

THE ROCKY MOUNTAIN LOCUST.*

By. C. V. Riley, Ph. D.

The subject which you have assigned to me is entitled The Rocky Mountain Locust and the Army Worm. Both these insects are extremely injurious to the agriculture of the United States, and as it would be difficult to do justice to both in the compass of a brief address, I shall confine my remarks at the present time to the first named. So much has been written and said, by myself and others, upon this Rocky Mountain locust during the past two or three years that it would seem difficult indeed to say anything about it that is new or of value. Yet I may safely assert that most of the definite and accurate knowledge regarding its habits and life history was first given to the world during the present year.

Though popularly known as the "grasshopper," yet the term "Rocky Mountain locust," proposed by myself, has been very generally adopted as most appropriate. The insect belongs to the same family as the locusts of Scripture. The term grasshopper is very loosely applied to many insects that hop about in grass, but strictly belongs to the long-legged, long-feelered species. Locusts have short and stout legs, short and stout feelers, and are mute, or, if they stridulate at all, do so by rubbing the hind thighs against the sides of the folded front wings; their prevailing colour is brown; they are gregarious, and they oviposit in the ground by means of short, drilling valves. True grasshoppers have long and slender legs and feelers, and stridulate by vibrating the front wings, which in the males are furnished, generally near the base, with talc-like plates crossed by enlarged and hollow veins; their prevailing colour is green; they are solitary, and they mostly oviposit in different parts of plants, by means either of a sword- or scimeter-shaped ovipositor. It is the grasshoppers, the katydids (which are a tree inhabiting section of them), and the crickets which make field and wood resound with shrill orchestry in autumn; but the locusts take no part in the concert. While our insect belongs,

* Reprinted from the "American Naturalist."

therefore, to the same family as the locusts of Scripture, those people are greatly at sea who imagine it be specifically identical with any of the Asiatic or European species. It is known to entomologists as *Caloptenus spretus,* and is purely American, since it does not inhabit any other continent.

Evolutionists believe—and I am one of them—that existing species are but the modified descendants of pre-existing species. The present species of a genus have at sometime, more or less remote, had a common ancestry. All life exhibits a certain power of adaptation to surrounding conditions, and through what is known as "natural selection" (two words which by Darwin's pregnant pen have come to express volumes of facts and consequences), coupled with other less easily formularized laws, the fauna and flora of the globe have been as profoundly changed as have its physical conditions. The influences that have thus worked in the past are still working at present—less rapidly, perhaps, in the main, but none the less effectually. Among higher and more complex animals, the changes are slow and not very noticeable; the species have become, in most cases, markedly differentiated, and their characters are well fixed. Among lower organisms these changes are more obvious, and naturalists are sorely puzzled in their endeavours to grasp and express them. This is especially the case among insects. We have the simple variation from the typical characters of a species; we have phytophagic varieties, or those departures from the type that result from the kind of food assimilated during growth; we have phytophagic species, or those variations which have become fixed and permanent in the adolescent or immature stages through some peculiar and fixed habit, without having yet modified the imago or mature state; we have geographical variation, increasing—usually with distance—until the separation from the type is sufficient to be indicated by what we call race; we have seasonal variation, sexual variation, and, finally, we have the terms dimorphism, heteromorphism, and many other *isms,* to express still other variations. In short, in the strain, the breed, the sport, the tribe (in the popular sense), the variety, and the race, we have so many terms invented to indicate some of the more patent steps in the evolution of one species from another, and between them all there are so many shades of variation for which no words have yet been coined, that the naturalist who takes a comprehensive view of life upon our planet finds that what we have chosen to call *species* are often with difficulty separated from each other; that they have, in fact, no real existence in nature. All our classificatory divisions are more or less conventional. They are excellent as aids to thought and study, but misleading when believed—as they popularly are—to express absolute creations that have existed for all time.

As with other species, so it is with the locust under consideration. The species is a denizen of the plains regions of the Rocky Mountains to the west and northwest of us. It breeds continuously and comes to perfection only in those high and dry plains and prairies; and though at intervals it overruns much of the lower, moister country to the east and southeast, yet it never extends in a general way to the Mississippi. But there are species east of the Mississippi that are so closely allied to it that the ordinary farmer cannot, without a little special knowledge, appreciate the difference, and entomologists, even, are not of a mind as to whether they should be called species, varieties, or races, etc. The two species most closely allied to the Rocky Mountain locust are the red-legged locust (*Caloptenus femur-rubrum*) and the Atlantic locust (*Caloptenus Atlantis*). Both are wide-spread species, but are either rare or do not occur in the home of *spretus*. The differences between the three species I have elsewhere given in detail; for the present purpose it suffices to say that the distinguishing characters, most easily observed by the non-entomologist, are the relative length of the wing and the structure of the terminal joint of the male abdomen. The Rocky Mountain species has the wings extending, when closed, about one-third their length beyond the tip of the abdomen, and the last or upturned joint of the abdomen narrowing like the prow of a canoe, and notched or produced into two tubercles at top. The wings of the red-legged locust extend, on an average, about one-sixth their length beyond the tip of the abdomen, and the last abdominal joint is shorter, broader, more squarely cut off at top, without terminal tubercles, and looks more like the stern of a barge.

The Atlantic locust, though smaller than either, is in other respects intermediate between the two, but in relative length of wing and structure of the anal joint in the male, most related to *spretus*.

We should encourage the locust's natural enemies. Practically this is not possible with many of the smaller parasitic and predaceous kinds; they are beyond our control. With many of the larger locust enemies, however, as in the case of birds, it is feasible. One of the most effectual ways of accomplishing it is to offer a reward for hawk-heads, as Colorado has done. The introduction of such hardy locust-feeding birds as the grackle and the English rook may be attended with benefit, and the Commission of which I am a member, will try the experiment. The destruction of the eggs is of the utmost importance.

The experience of the present year has proved, what I have always insisted on, that in the more thickly-settled portions of the country, by proper organization and intelligent effort, man may master the young insects. Men of large experience admit that a crop of young insects is not more difficult to cope with than a crop of weeds. It is different with the winged insect, and the question is: "Can anything be done to protect our farmers from the disastrous flying swarms?" At first view it would seem hopeless. Yet there is already a partial answer to the question. There is a popular notion that this pest breeds in and comes from sandy, desert countries. It is a popular error. The insect cannot live on sand, nor does it willingly oviposit in a loose, sandy soil. It does not thrive on cacti and sage bush. It flourishes most on land clothed with grass, in which, when young, it can huddle and shelter. It can multiply prodigiously on those plains only that offer a tolerably rich vegetation,—not rank and humid as in Illinois, but short and dry,—such as is found over much of the plains region of the Northwest, already referred to. Now the destrnction of the eggs, which is so practicable and effectual in settled and cultivated sections, is out of the question in those vast unsettled prairies; but the destruction of the young locusts is possible. Those immense prairies are not only susceptible of easy burning, but it is difficult to prevent the fire from sweeping over them. Now some system of preventing the extensive prairie fires that are common in that country in fall, and then subsequently firing the prairie in the spring, after the bulk of the young hatch, and before the new grass gets too rank, would be of untold value if it could be adopted. At first blush such a proposition seems utopian, but the more I study the question, and the more I learn of these breeding grounds, the more feasible the plan grows to my mind. The Dominion Government has, fortunately, a well-organized mounted police force which constantly patrols through the very regions where the insects breed, north of our line. This force is intended to see that the peace is kept, to watch the Indians, to enforce the laws, and perform other police duties. It could be utilized, without imparing its efficiency as a police force, in the work I have indicated; or it might be augmented for that same work. I have conversed with the Canadian ministers of agriculture and of the interior, and with Governor Morris, on the subject, and they see nothing impracticable in the plan. We have on this side the line a number of signal stations and military posts in the country where the insect breeds. Now, I would have our own military force co-operate with the Dominion police force as a locust vigilance committee. Under the intelligent guidance and direction of some special commissioner or commission, I would have that whole country systematically studied every year by such a force, with reference to the abundance or scarcity of the locusts. I would have such a vigilance force, by a proper system of fire-guards and surveillance, prevent the fall fires in sections where the insects or their eggs were known to abound, in order to burn them at the proper time the following spring; and where such precaution was not possible or had failed, and the winged insects at any season were numerous, I would have their movements carefully watched, and communicated daily to the signal officers, to be by them communicated to the farmers. In this way the latter could be fully forewarned of approaching danger. I would have the Western farmers adopt some general plan of defence against possible invasion. The straw that is now allowed to rot in sightless masses as it comes from the thrasher, and that encumbers the ground unless burned, should be utilized. Let it be stacked in small pyramids at every field corner, and there let it remain until the locusts are descending upon the country. Then let the farmers in a township or a county, or in larger areas, simultaneously fire these pyramids, using whatever else is at hand to slacken combustion and increase the smoke, and the combined fumigation would partially or entirely drive the insects away, according as the swarm was extended or not. In short, not to weary you, I believe, first, that by proper co operation on the part of the two governments interested, the excessive multiplication of this destructive insect may be measurably prevented in its natural breeding-grounds, and that the few thousand dollars that would be necessary to put into operation intelligent co-operative plans were most trifling in view of the vast interests at stake. In fact, with an efficient and properly organized department of agriculture, liberally supported by Congress, and aided by the war department and the signal bureau, the plan could soon be perfected and carried out at minimum expense. I believe, secondly, that where the insect's multiplication cannot be prevented in its natural breeding-grounds our farmers in the more thickly-settled sections may, by the use of smoke, measurably turn the course of invading swarms and protect their crops,—obliging the insects to resort to the uncultivated areas.

Were the injury to continue for another three or four years as it has for the past four, and were the Western farmers to suffer a few more annual losses of forty million dollars, such schemes as I have suggested would soon be carried out. The danger is that during periods of immunity, indifference and forgetfulness intervene until another sweeping disaster takes us by surprise.

Rules greatly assist in the solution of any problem, and in proportion as we get at a knowledge of the laws governing this Rocky Mountain locust shall we be able to overcome it. The country which it devastates is so vast, and the question as to its origin and the causes of its disastrous migrations is so complicated, that a limited study is apt to beget doubt as to whether there are any laws governing the insect or any rules for our guidance. The facts of sociology are so innumerable that the ordinary gleaner of them reaps but confusion. It requires the genius and comprehensiveness of a Herbert Spencer to deduce principles therefrom,—to perceive the laws by which society is moulded. The vain, delusive confidence begot of first study of any difficult subject—that follows superficial knowledge,—reacts in doubt and diffidence upon deeper delving and more thorough study.

"The more I learn the less I know" is a paradoxical but very common remark. It is only after passing through this period of doubt in any inquiry that we can begin to see the light; and in this locust inquiry it is only after accumulating facts and experiences until they almost overwhelm us with their complexity that we can begin to generalize and deduce rules.

The history of this insect east of the Rocky Mountains, when viewed from a comprehensive stand-point, presents certain well-marked features. We have first the migration of winged swarms in autumn from the higher plains of the West and Northwest, into the more fertile country south of the 44th parallel and east of the 100th meridian. It is the more fertile and thickly-settled country south and east of the limits indicated which suffer most, both from the insects which sweep over it and from the young that hatch in its rich soil; and it is principally this country which I have designated as being outside the insects' native home, and in which it can never become a permanent resident. The species does not dwell permanently even in much of the country north and west of those lines, but it flourishes more and more toward the northwest. In short, the vast hot and dry plains and prairies of Wyoming, Dakota, and Montana, and the immense regions of a similar character in British America, comprising what is known as the third prairie plateau or steppe, are congenial breeding-grounds, and supply the more disastrous swarms which devastate the lower Missouri and the Mississippi valleys. That Northwest country may be depicted as a vast undulating prairie sea, now stretching in sandy barren tracts which bring forth little else than the cactus or sage-bush; now rolling for hundreds of miles, and covered with the buffalo grass (*Bucloe dactyloides*) and other short nutritious grasses, and again producing a ranker prairie growth wherever there is increase of moisture. Another peculiarity of that country is that though the spring opens as early, even away up in the valley of the South Saskatchewan, as it does in Chicago, yet the vegetation often becomes parched up and burned out by the early part of July. Now, *Caloptenus spretus*, though coming to perfection in high and dry regions, is nevertheless fond of succulent vegetation, and instinctively seeks fresh pastures whenever those of its own home are dried up. It may sometimes happen, indeed, that the species will die in immense numbers if the scant vegetation where it breeds should dry up before the acquisition of wings, just as another species (*Œdipoda atrox*) has perished in immense numbers the present season in California by the excessive drought that has prevailed there; but ordinarily the insects will be full grown and fledged before the parched season arrives, and the ample wings of the species prove its salvation. Again, it may become so prodigiously multiplied during certain seasons that everything green is devoured by the time its wings are acquired.

"In either case, prompted by that most exigent law of hunger, —spurred on for very life,—it rises in immense clouds in the air to seek for fresh pastures where it may stay its ravenous appetite. Borne along by the prevailing winds that sweep over these immense treeless plains from the northwest, often at the rate of fifty or sixty miles an hour, the darkening locust clouds are soon carried into the moist and fertile country to the southeast, where with sharpened appetites they fall upon the crops, a plague and a blight. Many of the more feeble or of the more recently fledged perish, no doubt, on the way; but the main army succeeds, with favourable wind, in bridging over the parched country which affords no nourishment. The hotter and dryer the season, and the greater the extent of the drought, the earlier will they be prompted to migrate, and the farther will they push on to the east and south."*

We have, second, the return migration toward the northwest from the country south and east of the lines already indicated, of the progeny of invading swarms, as soon as wings are acquired the next summer. Time will not permit me to present the explanation of this return migration. In the work just quoted I have discussed its causes, the reasons why the species cannot permanently thrive in the Mississippi valley, and the conditions which prevent its establishment there.

We have, third, the eastern limit of the insects' spread along a line broadly indicated by the 94th meridian, and the consequent security from serious injury east of that line.

These three features of our disastrous swarms—the return migration from the southeast country (which implies only temporary injury therein), and the eastern limit,—may be stated as laws governing the insect east of the Rocky Mountains. They have constantly been urged by me, and the present year's experience has confirmed and verified them. I think I may safely present a fourth, namely, that the eggs are never laid thickly two successive years in the same regions.

In mapping out the country in Kansas and Missouri in which eggs had been laid most thickly in 1876, I was struck with the fact that the very counties in which the young insects had been most numerous and disastrous in 1875 were passed by or avoided, and had no eggs of any consequence laid in them in 1876. The fact was all the more obvious because the insects did much damage to fall wheat, and laid eggs all around those counties, to the north and south and west. From the exhaustive report on the

* Locust or Grasshopper Plague, page 57. Rand, McNally & Co., Chicago.

insect in Minnesota, made by Mr. Allen Whitman, it was also very obvious that those portions of that State which had been most thickly supplied with eggs in 1875, and most injured by the young insects in 1876, were the freest from eggs laid by the late swarms of the latter year, notwithstanding counties all around them were thickly supplied. I was at first inclined to look upon these facts as singular coincidences only; but instances have multiplied. A remarkable one has been furnished me by Gov. A. Morris, of the northwest territory. You are well aware that in 1875 the locusts hatched out in immense numbers and utterly destroyed the crops in the province of Manitoba. Now, in 1876 they were very numerous over all the third prairie steppe of British America, and largely went to make up the autumn swarms that came into our own country a year ago. Governor Morris started late in July of 1876 from Winnipeg northwest to make a treaty with certain Indians, and during the first five or six days of August he encountered innummerable locust swarms all the way from the forks of the two main trails to Fort Ellice. The wind was blowing strong from the west all the time,—just the very direction to carry the insects straight over into Manitoba. The Governor watched their movements with the greatest anxiety, fearing that the province would again be devastated as it had been the previous year. Yet during all the time he was passing through the immense swarms, they bore doggedly to the south and southeast, either tacking against the wind or *keeping to the ground when unable to do so.* Nothing was more remarkable than the manner in which they persisted in refusing to be carried into Manitoba. A few were blown over, but did not alight, and the province seemed miraculously delivered. Mr. Whitman tells me, again, that in settling the present year the insects avoided those counties in Minnesota in which they had hatched most numerously and done greatest injury, but selected such as had not suffered for some years past.

It is evident that there is more than mere coincidence in these occurrences, and I may say that upon looking more deeply into the matter I cannot find a single instance where eggs have been laid thickly for two successive years in any invaded country. This is a most important fact. During a season of great devastation there is a natural tendency among the more pious portion of the community to beseech the Almighty, by prayer, fasting, and humiliation, for deliverance. How greatly their faith must be strengthened by facts such as I have just stated! As a naturalist it is my province to study the reasons for the facts. Whether what I call the working of natural laws be called by others the instrumentality of Providence is quite immaterial.

To recapitulate, I think we may safely deduce the following four rules as governing the Rocky Mountain locust east of the mountains from which it takes its name:—

(1.) The northwest origin of the more disastrous fall swarms that overrun the more fertile country south of the 44th parallel and east of the 100th meridian.

(2.) The return migration toward the northwest of the insects that hatch in the country named.

(3.) The eastern limit of the insects' spread along the 94th meridian.

(4.) No two successive hatchings of an extensive and disastrous nature can take place in the same region.

The possibility of exception to the rules would be in keeping with the character of all rules; but I am convinced that the exceptions will ever prove most trifling. Now there is a deal of satisfaction to be drawn by our farmers from these rules, which not only limit locust disaster but enable them to anticipate events; and I need hardly state that the accuracy of my own prognostications, repeatedly made during the past three or four years, was in no small degree due to them.

We have had the spectacle of the Rocky Mountain locust, in what I call the return migration, flying over some parts of the vast territory from the 29th parallel to the Dominion boundary line, and from the 94th meridian to the mountains, all along from the end of April till the beginning of August, and with so little injury that, with the exception of the case in Montana, just mentioned,* the question everywhere asked is, Where have the flying 'hoppers gone? What has become of them? I answer that, as in previous years, and as I have always held would be the case, they were, in the main, so diseased and parasitized that they dropped in scattered numbers and mostly perished on their northward and northwestward journey. This is no theory, but known to have been the case in the more thickly-settled parts of Kansas, Nebraska, Iowa, and Minnesota, from which the insects that had dropped have been reported, and in some cases sent to me. But

* Referred to in the portions omitted.—Ed.

as the flight is for the most part over the vast and thinly-settled plains of Indian Territory, Kansas, Nebraska, and Colorado, the number that has dropped and been lost to sight in said plains is infinitely greater than that which has been observed to come down in the more thickly-settled regions to the east.

The more dense and extensive swarms that flew before the 1st of July reached, I have little doubt, the great thinly-settled plains and prairie region of Northwest Minnesota, Dakota, Montana, and British America,—embracing in the latter case most of the country between the projected line of the Canada Pacific and the boundary line, and between Manitoba and the Rocky Mountains. I found the insects sparsely spread over the rank prairies west of Brainerd along the Northern Pacific and along Red River; and by this I mean that a few would hop from the grass at every step, wherever I searched for them. I met with only here and there a straggler in Manitoba; but early in July they flew from the south over the country west of the province, and reached the North Saskatchewan at several points, passing many miles north of Fort Carleton.

The insects that rose after the first week in July (mostly from restricted parts of Minnesota and Dakota) bore for the most part southwardly, while many of those which passed to the northwest earlier in the season returned. Thus, swarms more or less scattering have been passing for the past two months over parts of Iowa, Nebraska, and Kansas, in varying directions, but mainly to the south and southeast. They have lately reached into the Indian Territory. In no instance have they done serious damage, and the reports that come to me are singularly unanimous on this point. The movements of the insects that bred in Minnesota this year were very similar to the movements of those that bred there in 1876. They at first flew to the northwest, but were subsequently brought back, and travelled over parts of Iowa, Nebraska, and Kansas. The difference between the two years is that the flights that thus turned back on the original course in 1876 were recruited and followed by immense and fresh swarms from the northwest plains regions, where, far beyond the boundary line, they hatched and bred innumerably; whereas the Minnesota swarms of 1877 have not been recruited because there were few eggs laid in 1876, and no insects of any consequence reared in 1877 in said northwest country. It is upon this fact that I have founded the belief in no serious devastation in the southeast country this fall

To those who pay little attention to the subject the disappearance of the swarms that left the Mississippi Valley is matter for wonder. "What is hit is history, but what is missed is mystery." Who, at the explanation of some simple trick or piece of legerdemain, has not smiled to think how easily he was baffled! But there are those who prefer the mystery of ignorance, and would much rather believe that the locusts have vanished in the heavens or been swept into the ocean than accept any explanation; and there are others who, from sectional feelings, would much rather believe that the insects have flown to Canada and New England than accept the facts.

MISCELLANEOUS.

ARCHÆAN OF CANADA. (Letter from Mr. Henry G. Vennor, of the Geological Survey of Canada, to J. D. Dana, dated Buckingham, July 10th, 1877.)—I take the liberty of addressing this letter to you, on a subject in which I have for some years been particularly interested, viz: the stratigraphical position of the economic minerals in what we have hitherto called the Lower Laurentian system of rocks.

I may briefly give you the results arrived at, after now some ten years work in Eastern Ontario and the adjoining portion of the Province of Quebec, namely, Pontiac and Ottawa counties. We find that there still exists a great *Azoic* formation, consisting of syenite and gneiss (?) without crystalline limestones. In this there are but little indications of stratification. Occasionally a limited surface presents an approach to an *obscure stratification*, but this does not appear to be due to the deposition of sediment. This rock forms the back-bone of Canada. On it there has been deposited a great series of gneisses, schists, slates, crystalline limestones and dolomites, which, although heretofore grouped with the former, is clearly distinct and unconformable. This second system contains *all of the economics* of any importance; none having been found in the old fundamental red gneiss system. All of these economics are in close proximity and have close relationship to each of the four or five great bands of crystalline limestone.

Eozoon Canadense belongs undoubtedly in the main to the highest band of crystalline limestone yet found, although this fossil may, and indeed has been sparingly found in some of the *lower limestones. The celebrated Petite Nation locality for Eozoon*, has now been proved to be on this highest band of limestone, and in fact in *the most recent portion of my second system;* the zone of limestone in which this fossil occurs is especially characterized by an abundance of serpentine and chrysotile. It is further traversed by veins filled with baryta and galena, and these also extend up through the Potsdam and Calciferous formations, but do not enter far into the crystalline rocks, both minerals rapidly giving out as we descend into these older rocks; while the fissures themselves narrow to threads and bifurcate. *This fact has been proved by a close and careful investigation* in Rossie, N. Y., and Landsdowne, Loughborough, Bedford, Madoc, and Tudor, in Canada.

Immediately beneath the *Eozoon* limestone the apatite-bearing belt of rocks comes in with horizons of both hematitic and magnetic iron ores—chiefly the former; and immediately below these again a great belt of plumbago-bearing rock (extensively wrought for this mineral in Buckingham and Lochaber, Ottawa county), an important volume of crystalline limestone filled with rust-colored lumps and beds. This band of limestone is the second in *descending order. A short distance beneath this last (some* twenty or thirty chains), is an important and well-marked horizon of magnetic iron ore—occasionally with layers of hematite, in which occur a number of promising mines (e. g. the Baldwin and Forsythe mines, Hull, P. Q.; the Christies' Lake and Silver Lake mines in South Sherbrooke, Lanark county, Ontario, etc.)

On a still lower horizon and close to the third belt of limestone, there is another iron ore horizon of coarsely crystalline magnetite with apatite intimately associated, which has now been identified and followed continuously for upwards of one hundred miles.

Lastly, in a *still lower, fourth and last important volume of* limestone, we find some large deposits of hematite iron ore (e.g. the Cowan mine in Dalhousie township, Lanark county), but these, in so far as investigated, are superficial deposits, only penetrating some fifty or eighty feet into the limestone; but the particular layer in which they occur may be followed by its deep hematite red color throughout a great extent of country.

The order then thus given to the economic minerals, just mentioned, is, in ascending order, as follows:—1st, hematitic iron ore;

2nd, magnetite and apatite (unimportant); 3rd, magnetite and hematite (important); 4th, plumbago (very extensive); 5th, phosphate of lime, with iron ores (an important and extensively worked belt): and then, 6th, *Eozoon Canadense*, in abundance, with serpentine, chrysotile and veins of baryta and galena.

You will thus observe that iron ore runs through the series, though most important in one horizon; that plumbago (with a great deal of pyrites cobaltiferous) is toward the upper portion; while the great body of apatite-bearing rock is at the very summit.

* * * * * * * * *

The *Huronian and Hastings series of rocks* I believe to be simply an altered condition, on their western extension, of the lower portion of my *second system;* and this alteration commences as this portion reaches Hastings county, where you will remember Hunt, Macfarlane and others likened them to the Huronian, while Sir William thought they more resembled some portions of the Devonian.—*Am. Journal.*

PREPARATIONS are being made at the Champ de Mars, Paris, for executing Foucault's pendulum experiments on an enlarged scale. His apparatus was suspended in 1851 under the dome of the Pantheon. It was in operation for a long while and removed only when the building was transformed into a church after the *coup d'état* in 1852. The weight of the pendulum will be 300 kilogrammes, and it will oscillate at the end of an iron wire from 65 to 70 metres long. Thus a special construction will be required for its suspension. The pendulum will be suspended above a grooved pipe which will move freely on an axis in its centre. The pendulum in oscillating will displace this pipe, which will remain, like the pendulum itself, fixed in space, in reference to the constellations. Underneath the pendulum will be arranged a large terrestrial globe, from 25 to 30 metres in diameter. This globe, resting on the ground, will necessarily follow with the spectators the movement of the earth. The pipe, on the contrary, supported by a pivot at the extremity of the axis, will carry large indexes, which will appear to be displaced with it. The globe, which will represent the earth, having a considerable volume, the movement of these indexes will be visible; it will render tangible in some degree to the least attentive, the rotation of the planet on its axis.—*Nature.*

An article in the London *Times* describes some experiments which are being made at the Fulham gas-works in the lighting of lamps by electricity. The patent is that of Mr. St. George Lane Fox, the distinctive feature being an electro-magnetic apparatus attached to each lamp, and connected with a central station, at which an electric current is generated. If the experiments prove successful and the apparatus is adopted, a great saving is likely to be effected. All practical difficulties seem, however, to have been solved in America. Electricity has been tried for the purpose of lighting and extinguishing 220 street lamps in Providence, R. I., scattered over a district nine miles long. One man attends to the whole business and does it in fifteen seconds. The method has now been on trial for some months, and a saving of ten dollars per lamp per year is reported. —*Ibid.*

Col. W. H. Reynolds has concluded a contract with the English Government by which the Post Office Department has adopted the Bell telephone as a part of the telegraphic system. In a recent telephonic experiment in connection with the cable 21¾ miles long, between Dover and Calais, there was not the slightest failure during a period of two hours. Though three other wires were busy at the same time, every word was heard through the telephone, and individual voices were distinguished. This important experiment was conducted by Mr. J. Bourdeaux, of the Submarine Telegraph Company. Some very successful experiments were made with the telephone on Saturday night, between Aberdeen and Inverness, a distance of 108 miles. Songs and choruses were distinctly transmitted, and conversation was carried on at times with marvellous distinctness, notwithstanding the weather was unfavourable. The experiments were made with Prof. Bell's instruments. The Berlin correspondent of the *Daily News* states that a Berlin house is making a number of telephones for experimental use in the Russian army. The result is awaited with great curiosity in military circles. The *Cologne Gazette* denies that any telephone is in existence between Varzin and Bismark's office at Berlin. Our contemporary says that the distance, 363 kilometres, is too large for using a telephone with any advantage.—*Ibid.*

The deepest artesian well in the world is being bored at Pesth, and has reached already a depth of 951 metres. The well at Paris, which measures 547 metres, has hitherto been the first. The work is undertaken by the brothers Zsigmondy, partially at the expense of the city, which has granted 40,000*l.* for the purpose, with the intention of obtaining an unlimited supply of warm water for the municipal establishments and public baths. A temperature of 161° F. is shown by the water at present issuing from the well, and the work will be prosecuted until water of 178° is obtained. About 175,000 gallons of warm water stream out daily, rising to a height of 35 feet. This amount will not only supply all the wants of the city, but convert the surrounding region into a tropical garden. Since last June the boring has penetrated through 200 feet of dolomite. The preceding strata have supplied a number of interesting facts to the geologist, which have been recorded from time to time in the Hungarian Academy of Sciences. Among some of the ingenious engineering devices invented during the course of the boring are especially noteworthy the arrangements for driving in nails at the enormous depth mentioned above, for pulling them out (with magnets), for cutting off and pulling up broken tubes, and. above all, a valuable mechanical apparatus by means of which the water rising from the well is used as a motive power, driving the drills at a rate of speed double that previously imparted at the mouth of the well.—*Ibid.*

The preliminary works for boring the British Channel Tunnel are being prosecuted with great activity at Sangate. A shaft has been sunk to a depth of 100 metres, and the experimental gallery has been commenced. It is to be continued for a kilometre under the sea. If no obstacle is met with, the work will be continued without any further delay. Two powerful pumps have been established for elevating the water which, of course, filters in in large quantity.—*Ibid.*

The Rhine Provincial Museum in Bonn has succeded in purchasing the famous collection of prehistoric remains from the Neander Valley, hitherto in the possession of the late Prof. Fuhlrott, of Elberfeld, although a high price has been offered from England.

Published Dec. 29, 1877.

PUBLISHER'S NOTICE

COMMENCING with Volume Seven, the Natural History Society of Montreal has arranged to give to each of its Annual Subscribers a copy of the 'Canadian Naturalist' without additional charge.

The Magazine is issued four times a-year as before, but the parts consist of 60 pages only. The volume of 480 pages will thus spread over two years, and as the former price of three dollars has been retained, it is now quoted "per volume" instead of "per annum." Those who are not members of the Society will thus obtain the Magazine at precisely the same price as heretofore, viz. three dollars for 480 pages.

☞ The Editors of this Journal are responsible only for such communications as bear their names or initials.

Transactions of Learned Societies or other Publications, sent in exchange for this Journal, or Books for the Society's Library (and for review), may be addressed to the

NATURAL HISTORY SOCIETY,
MONTREAL,
CANADA.

And may be sent by mail direct, or to either of the following Agents of the Smithsonian Institution, Washington, U. S. A.:

Dr. Felix Flugel.	Mr. Gustave Bossange,	Mr. Fred. Muller
LEIPSIC.	PARIS.	AMSTERDAM.

Or to the Publishing House of

MESSRS. SAMPSON LOW & CO.,
188 FLEET STREET,
LONDON