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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., EDITOR.
J. T. DONALD, B. A., - ASSISTANT-EDITOR.

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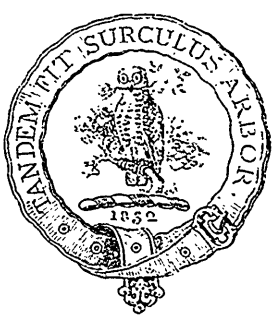

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THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

REMARKS ON RECENT PAPERS ON THE GEOLOGY OF NOVA SCOTIA.

(From a Paper communicated to the Nova Scotian Institute of Natural Science, by J. W. Dawson, LL.D., F.R.S., &c.)

The following remarks have reference to two papers by the Rev. D. Honeyman, D.C.L., Curator of the Provincial Museum, Halifax, published in the Transactions of the Nova Scotian Institute of Natural Science, Vol. iv., Part iv., 1878. These papers are respectively entitled — "Pre carboniferous Formations of Annapolis and King's Counties," and "Nova Scotian Geology, Pre-carboniferous, Lower Carboniferous, &c." Special reference will be made to the following points: (1.) The age assigned by Dr. H. to the fossiliferous rocks of Nictaux and New Canaan and their relation to the intrusive granites of the region. (2.) The Geology of the Pre-carboniferous Rocks of the Eastern part of Nova Scotia and Cape Breton.

1. Nictaux and New Canaan.

In the first of the papers above referred to, Dr. H. very freely criticises my conclusions respecting the age of the rocks of these localities, but does not take the trouble to state what these conclusions are, so that a reader unacquainted with the facts might take it for granted that all these rocks had been referred to the Devonian system, or that no definite idea of their age had previously been given. For this reason I shall take the liberty to quote from a paper on the Silurian and Devonian Rocks of Nova Scotia (April, 1860), my actual results, which are given in nearly the same form in Acadian Geology, 2nd edition, 1868. I may premise that these results were worked out at a time when

there were no railways or county maps to assist the explorer, and when the aids in determination of fossils were much less accessible than at present; and also that I have added some explanatory notes, which are included in brackets.

"The oldest fossiliferous beds seen (at New Canaan) are the fine fawn-coloured and gray clay slates of Beech Hill, in which Dr. Webster, many years since, found a beautiful *Dictyonema*, the only fossil they have hitherto afforded. It is a new species, closely allied to *D. retiformis* and *D. gracilis* of Hall, and will be described by that palæontologist under the name of *D. Websteri*, in honour of its discoverer. In the mean time I may merely state that it is most readily characterised by the cellules, which are very distinctly marked in the manner of *Graptolithus*."

"The Dictyonema slates of Beech Hill are of great thickness, but have in their upper part some hard and coarse beds. They are succeeded to the south by a great series of dark coloured coarse slates, often micaceous, and in some places constituting a slate conglomerate, containing small fragments of older slates, and occasionally pebbles of a gray vesicular rock, apparently a trachyte. In some parts of this series there are bands of a coarse laminated magnesian and ferruginous limestone, containing fossils which, though much distorted, are in parts still distinguishable. They consist of joints of crinoids, casts of brachiopodous shells, trilobites and corals. Among the latter are two species of *Astrocerium*, not distinguishable from *A. pyriforme* and *venustum* of the Niagara group, and a *Heliolites* allied to *H. elegans*, if not a variety of this species.* On the evidence of these fossils and the more obscure remains associated with them, Prof. Hall regards these beds as equivalents of the Niagara formation of the New York geologists, the Wenlock of Murchison. Their general strike is N. E. and S. W.; and to the southward, or in the probable direction of the dip, they are succeeded, about six miles from Beech Hill, by granite. They have in general a slaty structure coinciding with the strike but not with the dip of the beds, and this condition is very prevalent throughout this inland metamorphic district, where also the principal mineral veins usually run with the strike. The beds just described run with S. W. strike for a considerable distance, and are succeeded in ascending order by those next to be described."

* [These corals fortunately show their structure very distinctly when cut and polished, though from the hardness of the rock their external forms are obscure.]

"At Nictaux, 20 miles westward of New Canaan, the first old rocks that are seen to emerge from beneath the New Red Sandstone of the low country, are fine-grained slates, which I believe to be a continuation of the Dictyonema slates of Beech Hill. Their strike is N. 30 to 60 E., and their dip to the S. E. at an angle of 72°. Interstratified with these are hard and coarse beds, some of them having a trappean aspect. In following these rocks to the S.E., or in ascending order, they assume the aspect of the New Canaan beds; but I could find no fossils except in loose pieces of coarse limestone, and these have the aspect rather of the Arisaig series than of that of New Canaan. In these, and in some specimens recently obtained by Mr. Hartt, I observe *Orthoceras elegantulum, Bucania trilobita, Cornulites flexuosus, Spirifer rugæcosta ?* and apparently *Chonetes Nova-scotica*, with a large *Orthoceras*, and several other shells not as yet seen elsewhere. These fossils appear to indicate that there is in this region a continuance of some of the Upper Arisaig species nearly to the base of the Devonian rocks next to be noticed." [Some Lamellibranchiate and Gastropod shells in the limestone above referred to, led me to infer that some member of the Upper Silurian series not seen at Arisaig may occur here, and may represent the Salina formation of the American geologists, just as distinct Niagara fossils, not seen at Arisaig, occur in New Canaan.]

"After a space of nearly a mile, which may represent a great thickness of unseen beds, we reach a band of highly fossiliferous peroxide of iron, with dark coloured coarse slates, dipping S. 30° E. at a very high angle. The iron ore is from 3 to 4½ feet in thickness, and resembles that of the East River of Pictou, except in containing less silicious matter. The fossils of this ironstone and the accompanying beds, so far as they can be identified, are *Spirifer arenosus,** *Strophodonta magnifica, Atrypa unguiformis*

* There is in the iron ore and associated beds, another and smaller *Spirifer*, as yet not identified with any described species, but eminently characteristic of the Nictaux deposits. It is usually seen only in the state of casts, and often strangely distorted by the slaty structure of the beds. The specimens least distorted may be described as follows: General form, semi-circular tending to semi-oval, convexity moderate; hinge line about equal to width of shell; a rounded mesial sinus and elevation with about ten [to twelve] sub-angular plications on each side; a few sharp growth ridges at the margin of the larger valves. Average diameter about one inch; mesial sinus equal in width to about three plications. I shall call this species, in the meantime, *S. Nictavensis*." [It is nearly allied to the well-known *Spirifer mucronatus* of the Hamilton group.]

[now known as *Orthis hipparionyx*], *Strophomena depressa* [now usually known as *S. rhomboidalis*], and species of *Avicula*, *Bellerophon*, *Favosites*, *Zaphrentis*, &c. These Prof. Hall compares with the fauna of the Oriskany sandstone; and they seem to give indubitable testimony that the Nictaux iron ore is of Lower Devonian age.

"To the southward of the ore, the country exhibits a succession of ridges of slate holding similar fossils, and probably representing a thick series of Devonian beds, though it is quite possible that some of them may be repeated by faults or folds. Farther to the south these slates are associated with bands of crystalline greenstone and quartz rock, and are then interrupted by a great mass of white granite, which extends far into the interior and separates these beds from the similar, but non-fossiliferous rocks on the inner side of the metamorphic band of the Atlantic coast. The Devonian beds appear to dip into the granite, which is intrusive and alters the slates near the junction into gneissoid rock holding garnets. The granite sends veins into the slates, and near the junction contains numerous angular fragments of altered slate.

"Westward of the Nictaux River, the granite abruptly crosses the line of strike of the slates, and extends quite to their northern border, cutting them off in the manner of a huge dyke, from their continuation about ten miles further westward. The beds of slate in running against this great dyke of granite, change in strike from south-west to west, near the junction, and become slightly contorted and altered into gneiss, and filled with granite veins; but in some places they retain traces of their fossils to within 200 yards of the granite. The intrusion of this great mass of granite without material disturbance of the strike of the slates, conveys the impression that it has melted quietly through the stratified deposits, or that these have been locally crystallised into granite *in situ*.

"At Moose River, the iron ore and its associated beds recur on the western side of the granite before mentioned, but in a state of greater metamorphism than at Nictaux. The iron is here in the state of magnetic ore, but still holds fossil shells of the same species with those of Nictaux.

"On Bear River, near the bridge by which the main road crosses it, beds equivalent to those of Nictaux occur with a profusion of fossils. The iron ore is not seen, but there are highly

fossiliferous slates and coarse arenaceous limestone, and a bed of gray sandstone with numerous indistinct impressions apparently of plants. In addition to several of the fossils found at Nictaux, these beds afford *Tentaculites*, an *Atrypa*, apparently identical with an undescribed species very characteristic of the Devonian sandstones of Gaspe [this is now known as *Leptocoelia flabellites*], and a coral which Mr. Billings identifies with the *Pleurodictyum problematicum*, Goldfuss, a form which occurs in the Lower Devonian in England, and on the continent of Europe."

It will thus be seen that I recognized, on the evidence of stratigraphy and fossils, in the district extending from New Canaan to Bear River, the following groups of rocks:—

1. The Niagara series, the Wenlock of English geologists, represented by the Dictyonema shales and the coral-bearing rocks of New Canaan. This group may be called either Middle or Upper Silurian, according to different classifications in use.

2. The Upper Arisaig series (of my arrangement, not of that subsequently advocated by Dr. H.) This is the equivalent of the Lower Helderberg series of America, the Ludlow of England, and is the upper member of the Upper Silurian as held at that time.

3. The Oriskany series, represented by iron ores, sandstones or slates. At that time the Oriskany was regarded by all as Lower Devonian. More recently some American geologists have proposed to place it in the upper part of the Upper Silurian, above the Lower Helderberg, with which its fossils have some affinity.

If I understand Dr. H., he admits the ages which I have assigned to Nos. 1 and 2 above mentioned, though, after his usual manner, without giving the slightest credit for the original discovery of the facts, but he assigns No. 3 to the horizon of the Medina sandstone, a formation older than the Niagara, and regarded as an equivalent of the Mayhill sandstone (Llandovery) of Great Britain. The first reason assigned for this opinion is one based on mineral character, "I at once recognized the Mayhill sandstone," &c. On this I may merely remark that any geologist who would profess to distinguish at sight the Oriskany sandstone from the Medina sandstone would be more characterised by boldness than prudence. The stratigraphy of the district is confessedly somewhat obscure, and I fail to find in Dr. H.'s paper any new light tending to the inversion of the section as it

was understood by me many years ago. The fossils must in this matter furnish the most reliable information, and in this department unfortunately Dr. H. merely gives lists of genera, most of which have a very wide range, and which prove nothing, unless the species can be determined with accuracy. In this, however, there is some difficulty. The specimens are usually merely casts, they are much distorted, and from the hardness of the rocks they can usually be procured only in fragments. When in the region, I collected very diligently, and have since carefully studied my collections, and compared them with fossils of various portions of the Upper Silurian and Devonian; but though I have arrived at much more definite determinations than those given by Dr. H., I have hesitated to publish detailed lists. It is now necessary, however, to go into details, and I trust I can show to the satisfaction not only of palæontologists but to that of any student who possesses a geological text-book, that Dr. H.'s conclusions on this subject are wholly illusory.

The following list refers to my collections from the Nictaux ore and the neighbouring beds, and from Moose River and Bear River, on approximately the same horizon :—

1. *Zaphrentis*, a large species with deep calyx; but a cast merely, and therefore not determinable specifically.—Nictaux.

2. *Favosites*. General form and size of cells similar to those of *F. cervicornis*, Ed. and Haime; tabulæ continuous and very close.—Nictaux and Bear River.

3. *Pleurodictyum problematicum*, Goldfuss. Cast of a large specimen.—Bear River.

4. *Stenopora*. A branching species with very fine cells.

[Of the above corals No. 3 is characteristically Devonian. The others are found in association both in the Upper Silurian and Devonian.]

5. *Strophodonta magnifica*, Hall. A large Strophodonta, resembling, as far as the specimens admit comparison, the above species, characteristic of the Oriskany.—Nictaux and Bear River. Dr. H. somewhat disingenuously writes of *Strophodonta* as if it were a characteristically Clinton genus. In point of fact, of 56 species of this genus catalogued by Miller in his American Palæozoic fossils, 43 are found in the Oriskany and overlying formations, and only three as low as the Clinton and Niagara, while no species whatever is known in the Medina.

6. *Strophomena rhomboidalis.* Fragments from Nictaux.

7. *Spirifer arenosus*, Hall. This characteristically Oriskany species is so abundant at Nictaux, that though the specimens are imperfect, I think its recognition certain. It is found also at Bear River.

8. *Spirifer arrectus*, Hall, or allied, also an Oriskany species. —Nictaux.

9. *Spirifer Nictavensis.* This is the most abundant species in the Nictaux ore, some specimens of which are crowded with it, and it is also found at Bear River. It is very nearly allied to the well known *Spirifer mucronatus* of the Devonian. It is perhaps still nearer to *S. Gaspensis* of Billings from the Gaspé sandstone; and no Spirifers of this type are known to extend so low as the Medina.—Nictaux and Bear River.

10. *Orthis hipparionyx*, Hall. A characteristic Oriskany shell, apparently represented by casts of the interior.—Nictaux.

11. *Leptocelia flabellites*, Hall. This little shell is abundant at the base of the Devonian in Gaspe, and the same or a very similar species is found at Nictaux and Bear River.

12. *Rensellœria ovoides*, Eaton. A very characteristic Lower Devonian species at Gaspe and elsewhere.—Nictaux.

13. *Megambonia*, very near to the Oriskany species *M. lamellosa*, Hall.—Nictaux.

14. *Aviculo*, a large species of the type of the Oriskany species *A. textilis*, but too imperfect for determination.—Nictaux.

15. *Tentaculites*, not distinguishable from *T. elongatus*, Hall, of the Lower Helderberg.—Bear River.

16. I group together a *Platyceras* very near to an Oriskany species, a *Bellerophon* and an *Orthoceras*, found at Nictaux.

Fragments in my collection indicate several other species; but the above I hold to be amply sufficient to prove that the beds in which they occur are approximately of the age of the Oriskany sandstone, and cannot possibly be so old as the Clinton formation. I may notice in farther evidence of the facts stated above, that slates very near to the ore-bed hold Upper Arisaig (Helderberg) species, so that there appears to be a passage from the Lower Helderberg to the Oriskany, which would be quite natural; whereas the juxtaposition of Lower Helderberg and Medina fossils could take place only by extensive faulting or the absence of all the intermediate formations. It is also to be observed

that independently of the determination of species, the whole aspect of the fauna of the Nictaux iron bed, in its abundance of large ribbed spirifers, of large strophomenoid shells, and of great lamellibranchiate species, is different from that of the Medina, and on the contrary reminds an observer forcibly of the Oriskany sandstone of Gaspé and of western Canada. I shall show in the sequel that it is also distinct from that of the Upper Silurian red hematite of Pictou.

It should, however, be distinctly understood, that, in so far as I have held Devonian rocks to exist at Nictaux and Bear River, the upward extension of such rocks is limited to the Oriskany sandstone, and should any one hold that this formation may be included in the Upper Silurian, I have no objection; though I think that on physical grounds and by virtue of its close relationship with the overlying formations, it has quite as good claims to be correlated with the Lower Devonian.

The question which has been raised respecting the age of the granite, can only be discussed profitably on the ground. My notes of many years ago assure me, however, that I have traced the Lower Devonian beds into contact with the granite in such circumstances as prove the later date of the latter, and there are now in my collections specimens showing the gradations from the fossiliferous to the altered strata, including some which hold Oriskany fossils, but have assumed an incipient gneissic structure, and were penetrated by granite veins. It is further to be observed that the age assigned by me to these granites accords with the fact that in Nova Scotia the formations older than the Carboniferous are more or less in an altered and disturbed condition, and that granite debris does not occur as a prominent ingredient in our formations till the Lower Carboniferous age. In the district in question, the thick beds of granitic sandstone in the Lower Carboniferous near Wolfville and Lower Horton, afford a good illustration. I hope that this interesting district may soon be surveyed and mapped by the officers of the Geological Survey, when we may expect to have more light thrown on this subject. In the meantime I would caution geologists against accepting the somewhat crude deductions of the paper referred to, more especially as this question affects our conclusions as to the age of the auriferous veins of the Atlantic coast, and as to the correlation of the intrusive granites of Nova Scotia with those of other parts of Eastern America.

2. Pre-carboniferous Rocks of Eastern Nova Scotia.

The second paper, above referred to, is of a character so autobiographical, contains so little that is new in a scientific point of view, and deals so unceremoniously with the reputations of nearly all who have worked in the geology of Nova Scotia, that it is difficult to criticise it without being personal. I shall endeavour, however, to avoid this, and to confine myself to the geological questions involved.

The first attempt, after Dr. Gesner's Geology of 1836, to deal with the complexities of the older rocks in Eastern Nova Scotia, was made nearly thirty years ago, in a paper on the Metamorphic and Metalliferous Rocks of Nova Scotia, published in the Journal of the Geological Society in 1850; a very imperfect attempt, no doubt, but still a step of progress, and one involving much hard labour under very difficult circumstances. Before preparing the paper, I had examined lines of section from Pictou to the Atlantic coast, and had collected fossils at Arisaig and on the East River of Pictou. In this paper, the "shales, slates and thin bedded limestones of Arisaig" were referred to the Silurian system, on the evidence of their fossils, as were also the similar rocks occurring on the east side of the East River of Pictou. I was obliged, however, to add that specimens taken to England by Sir C. Lyell, with whom I had visited the East River in 1842, had been referred by palæontologists there to the Lower or Middle Devonian age, and that Prof. Hall, the best American authority on these fossils, appeared to lean to a similar conclusion.

The cause of this doubtful position of the matter is easily explained, without attaching any blame to the eminent geologists above named. At that time the line of separation of the Devonian and Upper Silurian was not very clearly defined; and indeed it may be said yet to be in some uncertainty, since it is only within a few years that it has been proposed to transfer the Oriskany sandstone to the Upper Silurian, and in the latest classification of the Gaspé series by the Geological Survey of the Dominion,* no less than 880 feet of shales and limestones are designated as "passage beds" between the two. In addition to this, the fossils from the Nova Scotia beds were to a large extent different from those both of the New York series and of England,

* Billing's Palæozoic Fossils, 1874.

so that their general facies only could be compared, many of them were in an imperfect state of preservation, and our whole collections were not large.

Matters remained in this state until the preparation of my Acadian Geology, published in 1855, when it became very desirable to obtain some clearer light on the subject, and accordingly considerable collections of the fossils were made and sent to Prof. Hall, and to palæontological friends in England, in the hope that these difficulties might be cleared up. But up to the time of the publication of the book, and for some time thereafter, no aid came from either quarter. In these circumstances, being convinced that some of the lower fossiliferous beds must be Silurian, and supposing that some of the upper beds were Devonian, but having no means of separating them, I included both under one chapter, and placed over the few fossils I ventured to figure, the title "Devonian and Upper Silurian."

On my removal to Canada in 1855, I at once availed myself of access to the collections of the Geological Survey, and of the advice of Mr. Billings in the arrangement of my collections, and sent further specimens, along with a number of species communicated to me by Dr. Honeyman, the late Dr. Webster of Kentville, the late Dr. Harding of Windsor, and Mr. Hartt of Wolfville,* to Prof. Hall; and in 1859 I received from him the series of descriptions of the Nova Scotia Upper Silurian fossils published in 1860 in the Canadian Naturalist, and which really constituted the "first step" in the palæontology of these difficult rocks. The only credit that the gentlemen above named or the writer can claim is the collection of materials; and Nova Scotia owes a debt of gratitude to the New York Palæontologist for his gratuitous labours in our behalf, at a time when he was pressed with many and engrossing occupations. It was at this time, and while I was in correspondence on the subject with all the friends in Nova Scotia above named, and with Prof. Hall, that, in advance of the latter gentleman's full report, I sent to the Nova Scotia Literary and Scientific Association a communication, in which I referred to the labours of all these gentlemen, and stated the results arrived at as follows:—"At Arisaig and other places in the East, where

* Afterwards Prof. Hartt of Cornell, and the head of the Survey of Brazil; a very able geologist, too early removed by death, and who worked most successfully in the geology of New Brunswick and Nova Scotia.

the older rocks come out from beneath the Carboniferous system, we have a series of shaly and calcareous beds, consisting of two members. The Upper, and more calcareous and fossiliferous of the two, is of the same age with the Lower Helderberg of the New York geologists and the Ludlow of the English geologists. The Lower, more shaly and containing Graptolites, may be as old as the Clinton, the Upper Llandovery of England." In the following sentences the occurrence of similar fossils on the East River and at Earlton is indicated, and the several ages of the New Canaan and Nictaux series already stated are referred to. This paper was written in the summer of 1859, and was published in a Halifax newspaper, I suppose, in the winter of the same year. It appears that Dr. Honeyman had previously, in a paper which he calls his "debut" in writing on Nova Scotia geology, and dates April, 1859, asserted the Upper Silurian age of the Arisaig series, and on this ground has based very large claims with reference to Nova Scotia geology. I have not a copy of this paper, and do not remember its contents, if indeed I ever saw it; but on his testimony I have, both in my paper of 1860 and in the 2nd edition of Acadian Geology (page 566), acknowledged his prior publication, feeling, however, that the credit of establishing the age of these rocks on a firm basis belonged to Hall, and that Dr. H.'s reiterated assertion of his claims, coupled with sneers at my "supposed Devonian age" of these rocks, was, to say the least, in very bad taste. In truth, what we required at that time was not a mere opinion from any local geologist as to the age of these rocks, but a careful comparison by a palæontologist of the wide experience of Hall.

Here intervenes an unfortunate circumstance, on which Dr. H. dilates with evident pleasure, though he perfectly well knows the true explanation of it. In the masterly description of the Pictou coal-field by Logan and Hartley (Reports of Geological Survey, 1869), one of the most thorough geological investigations ever made in Nova Scotia; by some unexplained oversight, these authors referred to the older rocks, east of the East River, as Devonian, and gave my authority for this; although in my paper of 1860 and again in 1868 in Acadian Geology, I had described these rocks as Upper Silurian. Immediately on noticing this error, I mentioned it to Sir William, but this was not till after the publication of the Report. The rocks in question were not within the direct scope of Sir William's work at the time, and

were merely incidentally noticed, but I know that he regretted the error very much, though of course as I had, eight or nine years before, abandoned all idea of these rocks being Devonian, I could not be blamed for it.

Another point raised in the paper now in question, is the use of the terms *Upper Arisaig* and *Lower Arisaig*, a point perhaps of no great geological importance, but of some consequence since the abuse of those names has tended to cause confusion. Dr. H. calls this a "new division introduced in the second edition of the Acadian Geology, 1868," but it was really introduced in my paper of 1859 above quoted, and this Dr. H. has himself admitted in the Journal of the Geological Society, vol. xx, p. 233, though it seems now to have escaped his memory. The reasons for this division were as follows. The term "Arisaig series" is a useful local name for the peculiar development of the Upper Silurian in Eastern Nova Scotia. The results of Prof. Hall showed that the fossils were referable to the Clinton and Lower Helderberg, without the intervention of any distinct representative of the Niagara limestone, and as the lower and upper members were somewhat distinct in mineral character, it seemed the most natural course to divide the series into Lower and Upper. Dr. H., who had an opportunity of showing his fossils to the late eminent palæontologist Mr. Salter, gives on his authority a more minute subdivision into five members. This will be found discussed in Acadian Geology, I trust in a fair spirit, and the relations of the two arrangements pointed out. But more recently Dr. H. has thought proper to change the name of the whole Arisaig series as before understood, to "Upper Arisaig," and to include as "Lower Arisaig" rocks which he regards as Laurentian. This is objectionable, not only as interfering with established and useful names, but as extending local terms to a degree which no other geologist can possibly accept. It amounts in fact to calling the whole Eozoic and Lower Palæozoic by the local name "Arisaig series." For these reasons I shall continue, as heretofore, to use the terms Upper and Lower Arisaig for the subdivisions of the Upper Silurian as represented at that place.

Another question raised in this paper relates to certain rocks at Lochaber, in which Dr. H. affirms that he found fossils of the genus *Petraia*, which I had informed him belonged to the genus *Zaphrentis*, and thereby misled him as to their age. The specimens referred to were sent to Montreal in 1860, along with

a paper by Dr. H., which was read before the Natural History Society, and I was requested by him to give some opinion as to their age and nature, which I did, after consulting the late Mr. Billings, and added a note on the subject to Dr. H.'s paper when it was published. Some time afterwards I was surprised to find Mr. Salter's authority cited in direct opposition to mine, with the usual flourish of trumpets as to a great mistake discovered and exposed. On re-examining the fossils, which still remain in my collection, I could not change my opinion of their nature; and never having had an opportunity to compare notes with my poor friend Salter, one of the soundest palæontologists of our time, and who has on more than one occasion done us good service in determining difficult fossils, as the pages of Acadian Geology show, I have not yet had any solution of the mystery, and have not complained of this, though I felt that I had received a poor return for an intended service. The fossils themselves are however of some interest. They consist of two turbinate corals from Lochaber, one from Marshy Hope, one from Doctor's Brook, and one from French River, with a few other species from Lochaber. These corals are in the form of mere impressions, in which state it is not always easy even to distinguish genera. Still, in the deep fossette, the character of the septa, and the traces of the horizontal tabulæ, they all have the characters of *Zaphrentis* rather than *Petraia;* except one from Lochaber, which which can scarcely be anything other than a *Heliophyllum*. The other fossils from Lochaber are a *Stenopora* similar to one found at Arisaig and East River, *Strophomena rhomboidalis*, an *Orthis* resembling *O. elegantula*, and shells resembling *Pentamerus* and *Atrypa*, but not well preserved. The *Zaphrentis* from Doctor's Brook resembles *Z. Stokesii*, a species of Niagara age. That from Marshy Hope seems different, and in its form and deep cup resembles the *Z. rugulata* of Billings from the Gaspé limestones. These might fairly belong to the Lower Arisaig series, and possibly to the lower part of it. The French River specimen is merely a cast of the exterior and quite undeterminable. But the Lochaber species seems different, having a shallow cup, with deep fossette, and from its association with *Heliophyllum* and the other fossils, I still think it probable that it belongs at least to a higher horizon than that of the Lower Arisaig. Of course as I have not seen the specimens submitted to Salter, I cannot express any opinion as to them; but if similar to mine, I am at a loss to

account for his opinion, and as the specimens in my possession seem to contradict the greater age assigned to the rocks, I have not ventured to adopt that opinion—though, up to this time, without taking any notice of Dr. H.'s references to my supposed mistake.*

Another point in which I find I am at issue with Dr. H. is the age of the great iron ore bed of "Webster's" or "Blanchard's" on the East River of Pictou, and which also has been traced to the eastward in Merigomish. This I have assigned to the Lower Helderberg on the evidence of stratigraphy and fossils. Of the latter large collections have been made by Mr. D. Fraser and myself in connection with the recent explorations of these ores. They appear to be of unequivocal Upper Arisaig facies, but include many new and interesting forms which I had hoped to have described ere this time, but this has proved absolutely impossible from want of leisure. They may represent a special horizon in the Upper Arisaig, or even between the upper and lower members, or their peculiarities may be the result of local conditions of deposit. Dr. H. seems to affirm that this iron ore is of the same age with that of Nictaux, and that both are of the age of the Clinton or Medina sandstone. Neither of these positions can be correct, for the fossils of the East River hematite seem closely related to those of the typical Upper Arisaig series, while those of the Nictaux ores are, as already shewn, newer than the Upper Arisaig. These two great deposits of iron ore are therefore not of the same age, and neither of them can be as old as the Clinton. Dr. H. correlates them with the Clinton ore-beds of the United States, but he omits to notice that there are also ore-beds in the Helderberg series of that country: I should not, indeed, be surprised were some of the newly opened beds at Nictaux, which I have not seen, to prove of Helderberg age, or were beds of Oriskany age to be found at Pictou. It is probable, however, that these ore-beds are less constant than some of the strata associated with them.

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* It is to be observed here that the relations of the genera *Petraia* and *Zaphrentis* are not so clearly defined as they should be. Some palæontologists of eminence reject *Petraia* altogether, and unite these corals with *Cyathophyllum*, and the limits of the genus *Zaphrentis* are differently understood by different authorities. Still there are certain forms, by whatever name known, which are, in our American geology, characteristic of certain formations, and it is by this indication that I have been guided in this case.

The remarks made by Dr. H. on the alleged Lower Silurian of Wentworth, scarcely merit criticism. It is to be regretted, for his own sake, that he has ventured to attack Mr. Billings's determination of the age of the fossils, as he has done (p. 480), and also that he has republished his section of the Wentworth cutting, in which the well-known intrusive dykes of dark diabase, so abundant in the Cobequids, figure as bedded diorites, and swell the thickness of a section which is in many respects truly "remarkable." I have not had an opportunity to examine Dr. Honeyman's collections from Wentworth; but those I have myself made, and those I have seen in the Museum of the Geological Survey, by no means warrant his determination of a Bala or Hudson River age. This subject will be found noticed in the Supplement to Acadian Geology, p. 75.

This review has extended to too great a length; but one is tempted to notice the Laurentian discoveries of the author. Dr. Honeyman, when employed by Sir W. E. Logan in 1868 in exploring at Arisaig, examined the coast east of Malignant cove, and found there the extension to the sea cliff of rocks apparently identical with that old metamorphic series which I have named the Cobequid series. These he has described as Laurentian, and quarrels with Sir W. E. Logan, Dr. Hunt and myself for failing to admit this age. My own justification is,—first, that, as Dr. H. admits, there is no good evidence from stratigraphy or fossils to prove this great age; and secondly, that after somewhat extensive studies of Laurentian rocks, I have been unable to see any resemblance between the typical rocks of this age and the so-called Laurentian of Arisaig, the Cobequids and southern Cape Breton. All these rocks I hold, for reasons stated in the Supplement to Acadian Geology, to be probably either Lower Silurian, Cambrian or Huronian. Dr. H. repeatedly taunts me with affirming these rocks, and even those of St. Anne's in Northern Cape Breton, to be Devonian; and goes so far as to relate an anecdote (p. 453) which would seem to show that so late as 1867 he had retailed this fiction to Sir Wyville Thomson, in connection with specimens of *Eozoon* stated to have been obtained in these rocks. Lest the same practical joke should be played on others, it may be well to say that I have never seen anything resembling *Eozoon* from St. Anne's, and that I am not aware of ever having supposed the crystalline rocks of that promontory to be Devonian. In reality, after much study of specimens, and after revisiting in

1877 some of the most instructive sections in Nova Scotia, I fail to perceive any good lithological evidence for the Laurentian age of any of the older rocks of the Province, except some of those in Northern Cape Breton, and notably those of St. Anne's mountain, which have, apparently on good grounds, been referred to this age by the late Mr. Hartley and Mr. Fletcher.

One word as to the geological map in 'Acadian Geology,' which notwithstanding its imperfections, needs no apology, when its nature as a mere preliminary and imperfect sketch, the result of private effort and not of a regular survey, is fairly considered. The materials do not exist for a detailed map of the older formations of Nova Scotia. They are being slowly accumulated by the labours of the Geological Survey of the Dominion; but I do not expect to live to see them complete. Dr. H.'s criticisms, which are so microscopic as scarcely to allow for the accidents of printing, would be unfair, if applied to a map on this scale, even had I been employed to make a regular survey of the country, and had many years been spent in the work. They are specially objectionable when applied to a work executed without public aid; and when proceeding from a man who has enjoyed opportunities of official employment not accorded to me.

NOTE.—Since writing the above, I have received Volume "F" of the Report of the Second Survey of Pennsylvania, relating to the "Fossil Iron Ore Beds" of Middle Pennsylvania. In this report, bedded iron ore deposits are described as occurring in the Clinton, Lower Helderberg, Oriskany, Corniferous and Marcellus, so that they range, as I believe they do in Nova Scotia, from the Middle of the Upper Silurian to the Lower Devonian inclusive. The principal deposits in Pennsylvania are in the Clinton, Oriskany and Marcellus. In Nova Scotia only small layers are known to me, at Arisaig and East River, so low as the Clinton, and the principal deposits seem to be Lower Helderberg and Oriskany. The analogy is thus sufficiently close, beds of the age of the Marcellus not having been recognised in Nova Scotia.

I have used the term "Devonian" in the above paper; but, owing to the doubts and controversies respecting the Devonian rocks of England, I greatly prefer the term "Erian," derived from the great development of the typical rocks of this age on the shores of Lake Erie.

THE STRATIGRAPHY OF THE QUEBEC GROUP AND THE OLDER CRYSTALLINE ROCKS OF CANADA.

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I propose in this paper to state as briefly as possible the conclusions I have arrived at from examinations made in the field during the seasons of 1876 and 1877 with the object of satisfying myself, before publishing the geological map of the Eastern Townships, respecting the much-discussed questions of the structure and the age of the rocks in the region on the south-east side of the St. Lawrence, extending from the Vermont, New Hampshire and Maine boundaries north-easterly to Gaspé. I shall also make some remarks on the results of the work of the Geological Survey in connection with the stratigraphy of the Laurentian rocks on the north side of the St. Lawrence valley and the conclusions at which they seem to point.

In some respects my views are in accordance with those of others, while as regards some points they are I believe new. Whether they eventually prove correct or otherwise, I can say that they have been arrived at solely upon and after careful consideration of the evidence and the facts collected by myself and colleagues, and without any bias or pre-conceived ideas, which, had I allowed these any weight, would have led to conclusions entirely different.

All who have taken any interest in Canadian geology are aware that the whole of the region referred to has been described by the Canadian Geological Survey as occupied by only four great formations or groups of strata, which in descending order are: —

1. Devonian.
2. Upper Silurian.
3. Lower Silurian.
4. Laurentian.

No. 3 includes:

a. Utica slates.
b. Hudson River or Lorraine Shales.
c. Trenton limestone.
d. Bird's-eye and Black River limestone.
e. The Quebec group and its equivalents, Chazy and Calciferous.
f. Potsdam.

Subdivision *e*, the Quebec group, is the one about which so much discussion has arisen and so many different opinions have been expressed. Indeed so varied have these been that it is now almost impossible to suggest anything which some one has not already suggested, but most of these opinions have been advanced on palæontological, mineralogical or theoretical grounds, without any study of the actual stratigraphy in the field. According to the latest determination, by the geological corps, under my predecessor Sir W. E. Logan, the Quebec group is divided into three conformable formations, viz. in decending order:—

The Sillery.
The Lauzon.
The Lévis.

These have been supposed to occupy the whole of the region lying south of the St. Lawrence between the great St. Lawrence and Champlain fault and the Upper Silurian overlap, notwithstanding the very diverse mineralogical, palæontological, and physical conditions under which they appear in different parts of the area. The base and the summit of the middle division, which was only introduced in 1866, has been supposed to be characterised by copper ores, dolomites and serpentines, and it would really seem that in mapping the structure the presence of any one of these has almost invariably been made to determine the limits of this division. It is not, however, my object now to refer to the past, or to recapitulate the opinions of others, and I shall confine myself as much as possible to a statement of my own views respecting the stratigraphy of the Quebec group.

First, then, I may say that I recognize in it three distinct groups, which in descending order may be enumerated as

1. The Lower Silurian group, Levis formation.
2. The Volcanic group, probably Cambrian.
3. The Crystalline Schist group.

No. 1 consists of a great variety of slates or shales (argillites), red, green and black; limestones, in thin bands; limestone conglomerates, sandstones and quartzites. In every part of their distribution from the Vermont boundary to Gaspé, 500 miles, they hold a large number of genera and species of characteristic Lower Silurian fossils, full descriptions of which have been given in the reports of the Geological Survey. This fossiliferous belt occupies a strip of country on the south side of the St. Lawrence, which in its widest part, in the valleys of the Chaudière and the Etchemin does not exceed twenty-five miles, and in this portion the structure presented is that of a broad crumpled and folded synclinal with prevailing south-easterly dips on the north-western side, and north-westerly dips on the south-eastern side; the characteristic Point Lévis limestone conglomerates coming up near the base on both sides. There are doubtless a number of local and unimportant overturn dips, but there seems to be no evidence whatever of a general inversion of the strata.

On the north-western side this belt is bounded by the St. Lawrence and Champlain fault, or overlap, which brings the even-bedded shales and limestones of the Hudson River or Lorraine Shale group into contact with the crumpled and twisted strata of the Lévis formation. The line of this dislocation, or unconformity—whichever it may be—has been supposed to pass in rear of the Quebec citadel. This I hold to be a mistake, and I think it can be distinctly shewn that it passes from the south-west end of the Island of Orleans under the river and between Point Lévis and Quebec; it appears again on the north shore about one mile north of Point Pizeau, passes north of St. Foy, and thence in a direct course to where it again crosses the river south-west of Cap Rouge. The entire absence of Levis fossils in the Citadel rocks is thus easily explained. I have traced this break carefully from the last-named point on the north shore of the St. Lawrence to the north-east end of the Island of Orleans, where on the beach the actual contact of the two formations is well seen, and a short distance inland we find the characteristic Levis limestone conglomerate. *Salterella* and *Archæocyathus* occur both at Point Lévis and on the Island of Orleans, and the graptolite (*Phylograptus*) shales are interstratified both above and below the limestone conglomerates. *Obolella* occurs also in shales clearly above the conglomerates and below other shales holding graptolites, and in some beds both occur together.

As regards the belt of Potsdam rocks—upper, middle and lower—which have been described in the Geological Survey Report for 1866–69, pp. 119–141, I must state, that after having carefully examined some portions of these supposed Potsdam rocks, I hold that there are no reasons whatever for separating them from the Lévis formation, either stratigraphical or palæontological. Obolella, graptolites, and fragments of other fossils, too indistinct to be determined, have been found in them.

On the south-eastern side, the fossiliferous belt is bounded by a line which, commencing on the United States boundary near St. Armand, runs on a course nearly parallel with the St. Lawrence, passing through the townships of Dunham, Brome, Shefford, Stukeley, Melbourne, Cleveland, Tingwick, Chester, Halifax and Leeds, to the vicinity of St. Marie on the Chaudière. Between St. Marie and St. Claire on the Etchemin River, the strata which I have referred to division 2 increase greatly in width, cropping out, apparently unconformably, from beneath the fossiliferous belt and separating it from division 3. The boundary we have been tracing of the Lévis formation is here suddenly deflected to a course nearly north for some sixteen or eighteen miles, viz. from St. Claire to St. Vallier, where it again turns north-east, and beyond this it has not yet been defined with certainty. It may be that this apparent unconformity is really a fault which running transverse to the strike brings the Lévis black slates and limestone conglomerates into contact with a set of strata which lithologically can not in this part well be distinguished from the typical Sillery sandstones of New Liverpool, Sillery Cove, &c., above Quebec, or from those of Acton, Roxton and Granby, which they still more nearly resemble, and which there are some reasons for supposing may occupy a similar unconformable position beneath the Levis formation. The distribution of these sandstones as indicated on the unpublished map of the Eastern Townships very forcibly suggests this idea.

Division No. 2 embraces a great variety of crystalline and sub-crystalline rocks; coarse, thick bedded, felspathic, chloritic, epidotic and quartzose sandstones, red, grey and greenish siliceous slates and argillites, great masses of dioritic, epidotic and serpentinous breccias and agglomerates, diorites, dolerites, and amygdaloids, holding copper ore; serpentines, felsites, and some fine grained granitic and gneissic rocks, also crystalline dolomites and calcites. Much of the division, especially on the south-

eastern side of the axis, is locally made up of altered volcanic products, both intrusive and interstratified, the latter being clearly of contemporaneous origin with the associated sandstones and slates. The greatest development of these volcanic rocks appears to occur, as above stated, on the south-eastern side of the main axis, to which I shall presently refer, and about the summit of Division 3, of which they may perhaps be only an upward extension, as we have at present no evidence of any unconformity between these two divisions. The rocks composing it have hitherto nearly all been included in the Sillery sandstone formation, and supposed to be everywhere the highest member of the "Quebec group"; represented by a yellow color on the geological map of Canada and on the unpublished map already referred to. It appears to me, however, that neither their true stratigraphical position nor their geological characters have been correctly defined, and they have, regardless of these, been confounded and incorporated with the true Sillery sandstones, which are only a local development of thick sandstones at several horizons in the Quebec group or fossiliferous Lévis formation. At Sillery above Quebec, and at various points thence northeastward to Gaspé, good exposures of these sandstones may be examined, and it has now been shewn that at Little Metis at Ste. Anne (the Pillar sandstones of Mr. Murray's report of 1844) and elsewhere they are characterized by graptolites and other Levis fossils, whereas in the massive red and green sandstones and slates which are associated with the volcanic rocks, and which the stratigraphy, as I think, clearly shews to be a lower unconformable formation, no fossils of any description have yet been found. Certain fucoid markings in slates near Actonvale may perhaps, however, belong to this division. Further examination will probably afford other fossils, but if so I should expect them to indicate a lower horizon than the Lévis formation, probably not far removed from that of the St. John group and the Atlantic coast series of Nova Scotia. In describing this belt of sandstones and slates which extends north-eastward from St. Claire on the Etchemin river, Sir W. Logan writes: "The area over which these strata occur commences in a point near the Chaudiere; it has been traced to the north-eastward across the Seignories of St. Mary and Joliette into St. Gervaise, and it probably extends much further. . . . . The distance between this area and its equivalent to the south is about ten miles."

"The sandstones in the two areas on the opposite sides of the Rivière du Sud are massive; on the northern side they are often very coarse grained, and in general of a green color, while the shales which separate the masses are usually red. Very coarse beds are not so frequent on the south side, and there the red color is not confined to the shales, but characterizes the sandstones also, which are as often red as green."*

There are two other distinctions not pointed out by Sir W. Logan. The one is that fossils, *obolella* and *graptolites*, characterize the northern area, and are apparently absent in the southern area. Another is that the sandstones in the latter frequently present a peculiar schistose structure, not, so far as I know, to be seen in the true Sillery sandstones of the Levis formation, to which the northern of these two sandstone areas clearly belongs.

I shall now pass on to the consideration of Division 3, which, however, as I have already stated, may be intimately related to the preceding. The rocks composing it are chiefly slaty and schistose, and embrace a great variety of chloritic, micaceous, siliceous and magnesian strata with copper ores, also imperfect gneisses, white and gray micaceous dolomites and magnesian limestones. They constitute the main anticlinal axis of the region, which axis may be traced from Sutton Mountain, east of Lake Memphremagog, on a gently curving line, northeastward to the counties of Montmagny and L'Islet—a distance of 150 miles. Between the St. Francis and the townships of Chester and Wolfestown, a very considerable dislocation crosses the axis transversely, and the structure here is exceedingly complicated, and is rendered still more obscure by the overlapping of the Upper Silurian rocks, and by the interposition, in the magnesian belt—by a complication of faulting and unconformable superposition—of a long, narrow band of the black shales and dark earthy limestones of the fossiliferous Levis formation. Further north, however, the magnesian belt again assumes its normal relation to the overlying divisions 1 and 2. And on page 258 of the Geology of Canada, we find its course thus described: "The general course of the magnesian rocks on the south side of the *synclinal* is, however, pretty well determined by a band of dolomite occasionally passing into serpentine, which has been traced from the

* Geology of Canada, p. 258.

13th lot on the line between Chester and Halifax to the Chaudière, near the line between St. Mary and St. Joseph." The synclinal spoken of is a purely theoretical one, and if we lay the above described line down on the map, it will be found to cross diagonally not only this Sillery synclinal, but likewise the Lauzon and the Lévis formations, as shown on the map; while, on the other hand, it runs entirely parallel with the line which, without any previous knowledge of the above quoted description, I had myself carefully traced on the ground, in 1867, as the upper limit of the magnesian belt and division 2, and the unconformably overlying fossiliferous Lévis formation.

The gneissic mica schists of Sutton Mountain are probably the deepest exposed portion of this great anticlinal. To the north-east, between the county of l'Islet and the Trois Pistoles River, the rocks of the anticlinal have not been traced. They will, however, doubtless be found to continue till they pass beneath the overlapping Upper Silurian strata which on the Rimouski River are stated to rest directly on the fossiliferous Levis formation. Rocks which clearly belong to the upper part of the division, with associated traps, emerge from beneath the Upper Silurian all along the northern shore of Matapedia Lake, and I think it will be found that they extend thence into the Shickshock Mountains, which on the north are flanked by the Lévis fossiliferous rocks, and on the south by strata of Upper Silurian age. The investigation of the structure of these mountains presents a fine field for any active and enterprising geologist.

The copper ores of the region under consideration, to which too much importance has, I think, been attached, in determining the limits of the divisions of the Quebec Group, appear to me to belong to two distinct periods, and to occur under conditions almost, if not quite, as distinct as they do in the Huronian and "Upper Copper-bearing" rocks of Lake Superior. Those of the first period belong to the crystalline, magnesian schist group, and occur both in beds and in lenticular layers parallel with the stratification, and also in veins cutting the strata transversely, but in no case accompanied by intrusive crystalline rocks. The Harvey Hill mine, the Viger mine and the Sherbrooke mines are examples of this mode of occurrence. Those of the second period seem to be chiefly confined to the rocks of Division 2, but occur also within the limits of the Lévis fossiliferous belt. They are in almost every instance more or less closely associated with cer-

tain highly crystalline rocks: diorites, dolerites, amygdaloids and volcanic agglomerates, with bands of white, grey and mottled dolomites and calcites which have much more the appearance of great lenticular, vein-like, calcareous masses than of beds belonging to the stratification. No traces of organic forms have been found in them, and yet many of them are scarcely more crystalline than certain Devonian and Carboniferous limestones in which fossils are abundant. The Acton mines, and the numerous openings that have been made in searching for copper ore in that vicinity and in the neighbouring townships of Roxton, Milton, Wickham and Wendover, may be cited as instances of this second class. And it certainly appears as if the copper ore in these upper divisions were in some way connected with the intrusion or segregation of the crystalline rocks which everywhere accompany it. In any case, I think, there are very few who would agree with Dr. Hunt in the general proposition that the diorites and serpentines of the Quebec group are of sedimentary origin, and the amygdaloids altered argillites; and, unless all contemporaneously interbedded volcanic products are to be considered as of sedimentary origin, the Quebec group might be said to present some of the most marvellous instances on record of "*selective metamorphism.*" But whether this is so or not, there seem to be no good grounds for assigning either an age or an origin to the cupriferous diorites, dolerites, and amygdaloids of the Eastern Townships different from that of the almost identical rocks of Lake Superior, which Dr. Hunt* states have been shewn to overlie *unconformably* the Huronian and Montalban series, but which at Keeweenaw Point are stated by Professor Pumpelly† to rest *conformably* on the Huronian; and Prof. Pumpelly justly remarks that "the question would still seem to be an open one, whether the cupriferous series is not more nearly related to the Huronian than to the Silurian." The same may certainly be said of the cupriferous rocks of the Eastern Townships. Brooks does not, in his paper‡ quoted by Dr. Hunt, give any very conclusive reasons for his change of views since 1872, and writes altogether as if the question of the unconformable superposition of the copper-bearing rocks on the Huronian were still undecided; and so late as 1877, Professor

* 2 G. S. of Penn., Special Report on Azoic Rocks and Trap Dykes, §458.

† Geo. Survey of Michigan, Vol. I, 1873.

‡ Am. J. of Sc., Vol. XI, 1876, pp. 206-207.

Roland Irving writes: the unconformity between the Huronian and the upper copper-bearing rocks "*is not certainly proven.*"*

A very considerable amount of careful investigation and laborious work in the field is yet required before the indicated divisions can be correctly delineated on the map. The two maps exhibited shew respectively the supposed distribution of the old divisions of Levis, Lauzon and Sillery, and that of the new divisions (so far as they have been determined), which I now propose to adopt. These latter have at least the advantage of simplicity; they also obviate the necessity of invoking any of the numerous almost impossibilities in physical and dynamical geology which are required to explain the previous theory of the structure, and they are, moreover, very closely in accord with the views entertained by Professor Hitchcock as regards the general succession of the formations in the adjoining States of New Hampshire and Vermont.

Laurentian.—I shall now make some observations on the results of the recent work of the Survey in unravelling the complications of the stratigraphy of the older "*crystallines*" on the north side of the St. Lawrence Valley. Since 1866, Mr. H. G. Vennor, of the Geological Corps, has been occupied in a careful examination of the stratigraphical relations of the Laurentian rocks. His observations, commencing in Hastings county, north of Lake Ontario, have now extended across the Ottawa River, eastward, to Petite Nation and Grenville, embracing a band of country 200 miles in length, with an average breadth of 55–60 miles. Throughout this tract of country, Mr. Vennor has followed and mapped, in all their windings and convolutions, the great series of Laurentian limestone bands first investigated and described by Sir W. E. Logan, in the years from 1853 to 1856, more particularly in the Grenville region, and in 1865, by Mr. Macfarlane, in the Hastings region. The results and conclusions of all these earlier examinations are given in detail in the Geological Survey Reports. And these shew that the classification then adopted by Sir W. E. Logan was regarded by him as provisional. (See Note, p. 93, G. S. R., 1866.)

Thus, at the commencement of Mr. Vennor's investigation in 1866, it was supposed that the limestones and calcareous schists of Tudor and Hastings holding eozoon, together with certain

* Am. J. of Sc., Vol. XIII, 1877.

associated dioritic, micaceous, slaty and conglomerate rocks, were a newer series than those already examined and described by Sir W. E. Logan, and they were accordingly designated, in the report published in 1870, the *Hastings series*, and it was further supposed, from its apparent stratigraphical position and from certain lithological resemblances, that it might be of Huronian age. The gradual progress of the work, however, from west to east has now, I think, conclusively demonstrated that the Hastings group, together with the somewhat more crystalline limestone and gneiss groups above referred to, form one great conformable series, and that this series rests quite unconformably on a massive granitoid gneiss—the gneiss 1*a* of Sir William Logan's Grenville map, published in 1865, in the Atlas to the Geology of Canada. I wish it to be understood that I have not personally examined this region, and I am therefore expressing the views of Mr. Vennor, from which, however, I have no reason to dissent.

Of the actual distribution of this lower or "Ottawa" gneiss very little is at present known with certainty, though it probably occupies very extensive areas from the eastern shores of Lake Winnipeg to Labrador. And between these same localities there will doubtless yet be found many large areas of the so-called Norian System. The first suggestion of this unconformable Upper Laurentian series, which, it seems to me, is intimately connected with the Hastings and Grenville series, appears to occur in the supplementary chapters to The Geology of Canada, 1863, pages 838-839; but the evidence there given by no means proves the subsequent assumption of this unconformity; while the careful descriptions by Sir W. Logan, both in the supplementary chapter above cited and likewise in chapter III, shewing the intimate association and interstratification of the orthoclase gneisses, quartzites and crystalline limestones with these supposed unconformable Upper Laurentian anorthosites, much more strongly favor the supposition that they are part and parcel of the great crystalline limestone series.

The exhaustive History of the labradorite rocks by Dr. Hunt, in the volume already cited,* while giving much valuable and interesting historical information, does not advance us a single step beyond the position taken by Sir W. E. Logan, in 1863, as regards their true stratigraphical relations. In not one of the

* 2nd G. S. of Penn., Special Report on Azoic Rocks and Trap Dykes.

several areas where they are known to occur in Canada, have they yet been mapped in detail, and even their limits, as indicated on the geological map, are more or less conjectural. This appears to be likewise the case as regards the areas where they have been noticed in Essex and adjoining counties in New York State and in New Hampshire, where Professor *Hitchcock* shews that they rest unconformably on the upturned edges of the "Montalban" gneisses,* leading to the conclusion that the gneisses of the White Mountains are older than the "Norian," whereas Dr. Hunt, solely, I believe, on mineralogical considerations, supposes these same "*Montalban*" gneisses to constitute a system newer than the Huronian. Here then, as in the Hastings region, we find theory and experience at variance. But the question suggests itself, may we not have labradorite rocks belonging to systems younger than Laurentian? Dr. Hunt refers (§ 318), to the valuable chemical and microscopic examination of these rocks in Essex county, New York, by Mr. Albert Leeds, the results of which are given in the *American Chemist*, March, 1877; but Mr. Leeds does not appear to have studied the stratigraphy of the region, and his general conclusions are stated as follows:

"That these norites are a stratified rock but have undergone a metamorphosis so profound as to have caused them to be regarded by Emmons and earlier observers as unstratified. The dolerites which are formed of the same constituent minerals, and are of the mean specific gravity of these norites, have probably been formed from a portion of these stratified deposits, by deeply seated metamorphic action and have further modified and greatly tilted the superposed rocks in the course of their extrusion."

Prof. James Hall in 1866† has stated his conclusions that the limestones of Essex and adjoining counties in New York State "do not belong to the Laurentian system either lower or upper." The facts, on which a part of this conclusion is based, viz. the unconformity of the Laurentian limestone series to the lower orthoclase gneisses agree with those of Mr. Vennor, and there is, I think, but little doubt that all these crystalline limestone groups—that is those of Essex and St. Lawrence Counties, U. S.

* Geology of New Hampshire, Vol. II, pp. 217-218.

† A. J. of S. Vol. XII, p. 298.

and Rawdon, Grenville and Hastings in Canada—are parts of one great series, and at present I see no evidence for excluding from this series the associated Norian rocks. Whether the series as a whole will eventually retain the name Upper Laurentian or whether it will be found to be more convenient to designate it Huronian System does not much signify.

We can, however, confidently state that this series occupies an unconformable position between a massive gneiss formation below and unaltered Potsdam or Lower Silurian rocks above, and this may likewise be stated respecting the stratigraphical position of the typical "Huronian series" of the Georgian Bay, which together with its close proximity to the western-most known exposures of the crystalline Laurentian limestone series which we now know, extends from Parry Sound to Lake Nippising, and includes some Labradorite gneiss, renders it very probable that a connection will eventually be traced out between even these supposed greatly different formations, similar to that now, as already stated, proved to exist between the Hastings and Grenville series.

Prof. Hall in his note already referred to, states that the Labradorite formation is "associated" with bands of crystalline limestone, and further on that the limestones do not belong to either the upper or lower Laurentian. He does not however say what the upper Laurentian he alludes to is, though in another paragraph we find it stated that the "lower Laurentians are succeeded by massive beds of Labradorite," which we may infer are considered upper Laurentian, in which case there would seem to be, in New York State two sets of Labradorite rocks, one associated with the limestones which are "altogether newer than Laurentian," and another massive and representing upper Laurentian. There is, however, so far as I am aware, no evidence of this being the case in Canada. If it is admitted—which, in view of the usual associations of Labrador feldspars, is the most probable supposition—that these anorthosite rocks represent the volcanic and intrusive rocks of the Laurentian period then also their often massive and irregular and sometimes bedded character and their occasionally interrupting and cutting off some of the limestone bands as described by Sir W. Logan, is readily understood by any one who has studied the stratigraphical relations of contemporaneous volcanic and sedimentary strata, of palæozoic, mesozoic, tertiary and recent periods. Chemical and microscop-

ical investigation both seem to point very closely to this as the true explanation of their origin. That they are eruptive rocks is held by nearly all geologists who have carefully studied their stratigraphical relations. But I am not aware of any one having suggested that they are the products of volcanic action in the Laurentian or perhaps lower Huronian epoch; doubtless, as Mr. Leeds says "*profoundly metamorphosed*" as of course they would be from having suffered all the physical accidents which have resulted in producing the associated gneisses quartzites, dolomites, serpentines and schists.

When we recall the names of Dahl. Kerulf and Torrell in Norway, Maculloch and Geike in Scotland, Emmons, Kerr, Hitchcock, Arnold Hague, and others in America, all of whom consider these norites as of eruptive origin, we may well pause before accepting Dr. Hunt's conclusions respecting them, and that they should often appear as "bedded metamorphic rocks" (the opinion expressed respecting those of Skye by Prof. Haughton of Dublin) is quite as probable as that we should find the mineralogically similar dolerites occurring in dykes and bosses and in vast beds interstratified with ordinary sedimentary deposits of clay, sand, etc.

In conclusion I may say that I fail to see that any useful purpose is accomplished, in the present stage of our knowledge of the stratigraphical relations of the great groups of rocks which underlie the lowest known Silurian or Cambrian formations, by the introduction of a number of new names such as those proposed by Dr. Hunt for systems which are entirely theoretical, in which category we may in my opinion include the Norian, Montalban, Taconian and Keeweenian. These, one and all, so far as known, are simply groups of strata which occupy the same geological interval, and present no greater differences in their physical and mineralogical characters than are commonly observed to occur both in formations of the same epoch in widely separated regions, and when physical accidents, such as contemporaneous volcanic action or subsequent metamorphism have locally affected the general character and aspect of the formation within limited areas.

No better instances of such differences could be cited than the Mesozoic and Carboniferous formations of British Columbia and those of the same periods in Eastern America, and the Silurian and Cambrian formations of Australia, Europe and America.

It seems to me that the well-known and recognized names

Laurentian
Huronian
Cambrian and Silurian

—with the introduction, where found desirable, to denote some local break, of the terms upper, middle and lower—meet all present requirements so far as systems are concerned.

Unfortunately in Canadian geology, hitherto the stratigraphy has been made subordinate to mineralogy and palæontology, and as the result we find groups of strata which the labours of the field geologist during the past ten years have now shewn all to occupy a place between Laurentian and Cambrian, assigned to Carboniferous and Upper Silurian in New Brunswick and Nova Scotia, to the peculiar palæontological Lévis group and its subdivisions Lauzon and Sillery in the Eastern Townships; and to lower and upper Laurentian, Huronian, lower Silurian and Triassic on the north side of the St. Lawrence valley and around Lake Superior. The same system of mineralogical stratigraphy is now further complicating and confusing the already quite sufficiently intricate problem by the introduction of the new nomenclature I have referred to, and in some cases these names are applied regardless of and in direct opposition to well ascertained stratigraphical facts. A similar unfortunate instance of *palæontological* stratigraphy is found in the history of the Quebec group; and especially in the late introduction in it of the belt of supposed Potsdam rocks, about which I have already stated my opinion.

In the reconstruction of the Geological map of Eastern Canada, —and in this I include the country from Lake Winnipeg to Cape Breton and Labrador—rendered necessary by the present state of our knowledge, I should propose to adopt the following divisions of systems to include the groups enumerated:

I. Laurentian: To be confined to all those clearly lower unconformable granitoid gneisses in which we never find interstratified bands of calcareous, argillaceous, arenaceous and conglomeratic rocks.

II. Huronian: To include 1. The typical or original Huronian of Lake Superior and the conformably—or unconformably as the case may be—overlying upper copper-bearing rocks.
2. The Hastings, Templeton, Buckingham, and Grenville groups.
3. The supposed upper Laurentian or Norian.
4. The altered Quebec group as shewn on the map now exhibited, and certain areas not yet defined between Lake Matapedia and and Cape Maquereau in Gaspé.
5. The Cape Breton, Nova Scotia and New Brunswick, pre-primordial sub-crystalline and gneissoid groups.

III. Cambrian: In many of the areas especially the western ones, the base of this is well-defined by unconformity, but in the Eastern Townships and in some parts of Nova Scotia it has yet to be determined. The limit between it and Lower Silurian is debatable ground upon which we need not enter.

The apparent great unconformity of the Nipigon group to the Huronian around Lake Nipigon may perhaps be explained by our having here the deep-seated parts of an ancient volcanic crateriform vent greatly denuded and the crater now occupied by the waters of the lake. The eruptions from this crater may have commenced in the Huronian epoch and been continued at intervals even up to the Triassic period; but in the meantime we have no evidence of any of the eruptions being newer than Cambrian. One point I wish particularly to insist on is that great local unconformities may exist without indicating any important difference in age, especially in regions of mixed volcanic and sedimentary strata, and that the fact of crystalline rocks (greenstones, diorites, dolerites, felsites, norites, &c.,) appearing as stratified masses and passing into schistose rocks, is no proof of their not being of eruptive or volcanic origin—their present metamorphic character is as the name implies a secondary phase of their existence, and is unconnected with their origin or original formation at the surface.

(Read before the Natural History Society, 24th February, 1879.)

NOTES ON THE GLACIATION OF BRITISH COLUMBIA.

By George M. Dawson, D.S., Assoc. R.S.M., F.G.S.,
of the Geological Survey of Canada.

While engaged in geological work in British Columbia during the seasons of 1875 and 1876 many points bearing on the glacial period, or epoch of extreme cold and great accumulation of ice which immediately preceded the present condition of affairs, came under notice. The regions more particularly examined during these years were in the interior of the province south of the 54th parallel of latitude, and about the Strait of Georgia on on the coast. Journeys of a more hurried character in other parts of the country enabled me, however, to extend the general conclusions arrived at so as to embrace the greater part of the area of the province. These proved to be of considerable interest, and important particularly in doing away with the apparently anomalous absence of traces of general glaciation on the Pacific slope, a hypothseis based on certain statements rather loosely made, which were afterwards extended to an area greater than they were at any time intended to cover. My observations above referred to, were embodied in a communication presented to the Geological Society, forming an extension to the coast of the Pacific of investigations formerly carried, in the vicinity of the 49th parallel, across the width of the great plains from the Laurentian axis to the Rocky Mountains.* This paper has been printed with a map and illustrations in the Quarterly Journal of the Society.†

In a country with such pronounced physical features as British Columbia, the solution of the problems offered by the traces remaining to us of the glacial period, is by no means so simple as in less rugged districts, and it becomes necessary to keep clearly in view the chief outlines of its orography, and to endeavour in the field and at the time of observation to bring before the mind the various possible causes of each particular phenomenon.

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* Quarterly Journal Geological Society, Vol. XXXI, p. 603.

† Ibid, Vol. XXXIV, p. 89.

British Columbia may be described as including the whole width of a certain portion of the Cordillera region of the continent. The Rocky Mountains, properly so called, form the boundary between the belt of the Cordilleras and the great plains to the east. The south-eastern flank of this system is defined by a remarkably deep and straight valley, in which lie considerable portions of the courses of the largest rivers of the country. Beyond this valley to the south-west, is a second and broader mountain region, called by various names in different parts of its length, but which may be designated as the Selkirk or Gold Range. Many of the summits of these mountains are scarcely less in altitude than these of the Rocky Mountains, which frequently surpass 9000 feet. Nearly parallel to these two great ranges is the Coast or Cascade Range, in which the average altitude of the higher peaks may be stated as between 6000 and 7000 feet. A fourth range may be traced in a partially submerged condition, in the mountains of Vancouver and the Queen Charlotte Islands. Between the Coast Range and the Selkirk or Gold Range lies the great Interior Plateau of British Columbia. This represents the interior basin included between the Sierra Nevada and Rocky Mountain ranges in better known regions to the south. It has an average width of 100 miles, and a mean elevation of about 3500 feet. Its height on the whole increases to the south, while northward it falls gradually towards the cluster of great lakes, and the low country of the Peace River Valley. It is now dissected by deep and trough-like river valleys, into most of which water standing at 3000 feet above the present sea-level would penetrate; and though in some places pretty level and uniform, it is generally when broadly viewed only that its true character is apparent. The north-western end of this plateau appears to be blocked by a high mountainous country formed by the coalescence of the three great ranges about latitude 55° 30′; while nearly coincident with the 49th parallel, is a second irregularly transverse mountainous zone, which is however traversed by several great river valleys, of which that of the Okanagan in longitude 119° 30′ is the most important.

The general conclusions arrived at as to the glacial phenomena of the country as quoted from the paper above referred to are as follows :—

1. The character of the rock-striation and fluting on the south-eastern peninsula of Vancouver Island shows that at one time a great glacier swept over it from north to south. The glacier must have filled the Strait of Georgia, with a breadth, in some places, of over 50 miles, and a thickness of ice near Victoria of considerably over 600 feet. Traces of the glacier are also found on San Juan Island and the coast of the mainland.

2. The deposits immediately overlying the glaciated rocks, besides hard material locally developed, and probably representing *moraine profonde*, consist of sandy clays and sands, which have been arranged in water, and in some places contain marine shells. These, or at least their lower beds, were probably formed at the foot of the glacier when retreating, the sea standing considerably higher than at present.

3. Observations in the northern part of the Strait of Georgia, and the fjords opening into it—where the sources of the great glacier must have been—show ice-action to a height of over 3000 feet on the mountain-sides. The fjords north of the Strait of Georgia show similar traces. Terraces along the coast of the mainland are very seldom seen, and have never been observed at great elevations.

4. In the interior plateau of British Columbia, there is a system of glaciation from north to south, of which traces have been observed at several localities above 3000 feet. Subsequent glaciation, radiant from the mountain-ranges, is also found.

5. The superficial deposits of the interior may be classified as unmodified and modified. The former, representing the boulder-clay, hold many water-rounded stones, with some glacier-marked, and occurs at all heights up to over 5000 feet. The latter characterize nearly all localities below 3000 feet, and are most extensively developed in the northern low country, where they appear as a fine white silt or loess.

6. The interior is marked with shore-lines and terraces from the present sea-level up to 5270 feet, at which height a well-marked beach of rolled stones occurs on Il-ga-chuz Mountain.

7. Moraines occur in great numbers. Some of the moraine-like accumulations may have been formed in connexion with the north-to-south glaciation. Most of those now seen, however, mark stages in the retreat of glaciers towards the various mountain-ranges. The material of the moraines resembles that of the boulder-clay, but with water-rounded stones even more abundant.

8. The sequence of events in the interior region has been :—glaciation from north to south, with deposit of boulder-clay; formation of terraces by lowering of water-surface, accompanied or followed by a warm period; short advance of glaciers from the mountains contemporaneously with formation of lower terraces; retreat of glaciers to their present limits. Glaciation of Vancouver Island may have occured during both the first and second cold periods, or during the second only.

9. If the north-to-south glaciation has been produced by glacier-ice, it must have been either (*a*) by the action of a great northern ice cap (against which grave difficulties appear), or (*b*) by the accumulation of ice on the country itself, especially on the mountains to the north. In either case it is probable that the glacier filled the central plateau, and, besides passing southward, passed seaward through the gaps and fjords of the Coast Range. The boulder-clay must have been formed along the front of the glacier during its withdrawal, in water, either that of the sea, or of a great lake produced by the blocking by local glaciers of the whole of the valleys leading from the plateau, to a depth of over 5000 feet.

10. If general submergence to over 5000 feet be admitted, the Japan current would flow strongly through Behring's Strait, and over part of Alaska, while arctic ice-laden water, passing south across the region of the great plains, would also enter the central plateau of British Columbia, accounting for the north-to-south glaciation and simultaneous formation of the boulder-clay.

To these conclusions the facts met with during the continuation of the geological work in 1877 and the past summer, enable some very interesting additions to be made, all which tend to show that the opinions previously formed are in the main correct.

The region examined in 1877 embraced the southern portion of the Interior Plateau, with portions of the Coast and Gold Ranges. Evidence of the north to south glaciation above referred to, were found in a number of additional localities, on the higher parts of the southern portion of the plateau, and traced to a height, on Iron Mountain at the junction of the Rivers Nicola and Coldwater, of 5280 feet. These observations, with those of former years, cover a portion of the Interior Plateau over three hundred miles in length, and show that the ice pressed onward over the southern portion of the plateau to, or even beyond the

line of the 49th parallel, notwithstanding the generally mountainous charaeter of that part of the region. Travelled boulders and stones rounded by water action are found at like heights with the striation, occurring even at the summit of Iron Mountain; and over the greater portion of the region, from the eastern slopes of the elevated land of the coast ranges, is spread a covering of drift material, more or less abundantly charged with erratics, and where not modified by water action subseqnent to its deposition, to be referred to the boulder clay. Terraces, or "benches," are in many places in this part of the province shewn in wonderful perfection, rising tier above tier from the bottoms of the valleys, till they are found in a more or less wasted state encircling the higher portions of the plateau remote from the river-courses. These in several places exceed 3500 feet in altitude above the level of the sea, but none so high as that previously ob rved on Il-ga-chuz Mountain, in the northern part of the province, were found.

In the valleys connected with the Thompson, and especially about Kamloops Lake and the valley of the South Thompson above Kamloops, but also in the great Okanagan Valley, and forming small outlying patches for some distance up the Similkameen, is a remarkable horizontally-stratified deposit of white silt, in the form of terraces. These are evidently remnants of a sheet of similar material, which has at one time formed the floor of these wide trough-like valleys. In composition it resembles the white silts of the Nechacco Basin, but occurs at a different horizon, reaching a maximum height, so far as ascertained, of about 1700 feet above the sea. In origin it is probably like that of the Nechacco, a deposit from the turbid waters of glaciers at a time when the ice still had a considerable extension from the various mountain ranges, and general depression of the land, or the damming up of the valleys gave rise to a system of winding water-ways—lakes or fjords—which occupied the main depressions of the surface. The heads of these valleys, in the flanks of the Gold Range, still hold long and deep lakes, on the banks of which drift deposits appear to be scarce and the white silts are not found. I refer in this connection particularly to the system of valleys occupied by the Shuswap Lakes. It appears not improbable that at the time the white silts were laid down the portions of the valleys now held by these lakes were filled with glacier ice, and that eventually a rather rapid dissolution

tion occurring, the beds of the glaciers were left as hollows to become lakes. Whether any of these are true rock-basins can not be determined, as the material flooring the lower portions of the wide valleys is altogether detrital. A moraine appears to lie across the valley at the lower end of Little Shuswap Lake.

Explorations along the coast of British Columbia, and more especially in the Queen Charlotte Islands, during the past summer, have developed additional interesting details bearing on the glacial period. These have not yet been worked up, but the main points are as follows. The great glacier which filled the Strait of Georgia, overriding the south-eastern extremity of Vancouver Island, may be attributed with greatest probability tr the earlier and more intense period of glaciation. Its motion was from north to south, but whether this indicated a general glaciation of the coast in that direction, or was due entirely to the contour of the land, was not known. It was evident that had any polar ice-cap or southward-moving glaciating ridge of ice been the agent, it must also have followed the wide sound separating the north-western end of Vancouver Island from the mainland, in a south-eastward direction. This has not occurred, but, on the contrary, a glacier equally massive with that of the Strait of Georgia has poured out of this sound north-westward, sweeping over the northern portion of Vancouver and adjacent islands. From a point nearly opposite the middle of Vancouver Island, where the channels separating it from the continental shore are most contracted, the ice has flowed south-eastward, forming the Strait of Georgia glacer, and north-westward as that of Queen Charlotte Sound.

North of Vancouver Island, wherever looked for in the proper situations, marks of heavy glaciation are found in all the channels and fjords, to the southern extremity of Alaska where my observations terminated, though a coast-line similar in its general features, and doubtless characterized by the same signs of a former glaciation, extends far to the north-westward. The glacier ice has not only filled the narrow fjords to a great depth, but passing westward has occupied the wider straits which separate the outer islands of the group which fringes the coast.

In the Queen Charlotte Islands, parted widely from the mainland, traces of local glaciation only, due to ice accumulating on its own mountain system, are found. The northern shore of these islands is however strewn with erratics which may have

come from the mainland. Along the eastern shore of Graham Island, a long line of cliffs displays deposits of clays and sands similar to those previously described as occurring in the southern part of Vancouver Island. Many of the beds contain boulders and some hold marine shells of the species found in the deposits just referred to, with occasional fragments of wood.

Quite recently, a great addition to our knowledge of western geology has been made by the publication by Clarence King of the volume of his series on the fortieth parallel, devoted to systematic geology. In this the quaternary period is treated at some length, and in a comprehensive manner, enabling comparisons to be drawn between the condition during the glacial period of that part of the Cordillera system included in British Columbia, and its southern continuation in the vicinity of the fortieth parallel.

King has failed to find any evidence of a great southward-moving ice-mass, or general glaciating agent, and no sheet of boulder-clay covers the region; the superficial deposits being either directly due to the descent of torrents from the mountains and high lands, or to the rearrangement of these by water action in lakes. Two great sheets of water which have been called Lakes Lahontain and Bonneville, spread widely in the high plateau region between the Sierra Nevada and the Rocky Mountains. Local glaciers were, however, extensively developed, coming down to altitudes of 2000 to 5000 feet above the sea in the Sierra Nevada, which was exposed to the moisture-bearing winds of the Pacific, but seldom reaching below a height of 7000 to 8000 feet in the dryer eastern ranges. These constitute the local expressions of the general change which further north produced great ice-fields, but at no time was more than about one-thirtieth of the area embraced in the fortieth parallel survey covered with ice.

The most interesting point established by King, however, is the existence of two periods of moisture and flooding of the lake basins, alternating with two of extreme drought, the latter of which still continues. The evidence of these is found both in the relative arrangement of the stratified and unstratified materials of the old lake bottoms, and in the chemical character of the deposit from their waters. These periods of great precipitation are correlated with great probability with the two epochs of glaciation proved in British Columbia. King, however, adopts extreme views as to the power of glaciers in eroding

valleys, attributing most of the canons of the region he has examined to their action. He draws attention to the V-shaped gorges which become U-shaped in their upper reaches, and supposes that the former were cut out by flood waters accompanying and following the first period of glaciation, while in the latter we have the unaltered work of the glaciers of the second period, stating that the work of erosion in these valleys has been absolutely trivial since the glaciers left them. It is also advanced in support of these views that many if not most of the canons of which the age can be determined, have been cut out since Pliocene times, and that in the surfaces of the Archæan masses which must have stood out as islands during long geological periods, nowhere shew the junction of newer formations with them, to follow other than broad rounded curves.

To this theory of the origin of canons and mountain-valleys, it may be objected that whatever be the case in the fortieth parallel area, vast post-glacial erosion and the formation of deep valleys and gorges since that period have elsewhere been discovered; that glaciers are never now found to exert such active erosive power, and that the idea that so sluggish and inert a portion of a glacier as its *névé* should produce the great amphitheatrical valleys or cirques of the central mountain regions, seems inconceivable. Further, the post-pliocene age of the canons, supposing it to be correctly assigned to them in all cases, may mean nothing more than that the progressive elevation of the plateau area by which the cutting down of canons may be explained, was most active about that time. Canons and fjords are in any case rather exceptional phenomena, they occur only, on any hypothesis, in regions long raised above the sea level, and the chances that such features should be preserved during a depression of the land and afterwards brought to light in the particular portions of the lines of contact of newer and older rocks exposed by denudation, are exceedingly small.

ON SOME POINTS IN LITHOLOGY.

By Prof. James D. Dana.

(*From the American Journal of Science.*)

I. On some of the characters employed in distinguishing different kinds of Rocks.

Lithology is a department of Geology, rocks being the material in and through which geological problems are presented for study. The true aim of the science of lithology is to describe the kinds of rocks mineralogically and chemically, and to note down their distinctions in such a manner as shall best contribute to the objects of geology; and these latter objects include, as regards rocks, the origin of the minerals and mineral associations, constituting or occurring in rocks; the origin of the rock masses and their relations to other geological phenomena; and the origin of all changes or transformations that have taken place in rocks in the course of the earth's physical development. Geology, chemistry and mineralogy have each to be considered in determining the proper distinctions between the kinds of rocks. Should lithology make much of mere difference in texture, or in ingredients that are present only in minute proportion, geology might rightly say that, for such a purpose, these points are of small importance compared with the nature or composition of the mass.

The defining of rocks is attended with special difficulties on account of their mutual transitions. From granite down they are, with very few exceptions, mixtures of minerals, as much so as the mud of a mud bank. They graduate into one another by indefinite blendings, as the mud of one mud bank graduates into the mud of others around it. In fact a large part of the crystalline rocks were once actual mud beds or sand beds; and even part of the eruptive rocks may have been so in their earlier history. Strongly drawn limits nowhere exist. Rocks are hence of different *kinds*, not of different *species;* and only those mixtures are to be regarded as *distinct kinds* of rocks which have a sufficiently wide distribution to make a name important to the geologist. Other kinds have to be classed as *varieties*, if worthy of that degree of recognition.

In the following pages I propose to consider the value of some of the distinctive characters which are generally accepted at the present time in defining certain kinds of rocks.

1. "*Older*" and "*younger*."—The distinctions "older" and "younger" often applied to a number of kinds of eruptive rocks, seem to imply that the earth has generated different *kinds* of rocks as it has grown old. The terms have reference, however, to only one epoch of abrupt change—that between the cretaceous and tertiary, "older" signifying pre-Tertiary, and "younger" Tertiary or later in date. It is of eminent importance to geology to know definitely whether this epoch was one of great change in the earth's ejections, and an epoch so marked that the rocks on one side of the time-boundary are deserving generally of different names from those of the other; for thus lithology, judging from some recent works, as well as older, has seemingly decided. Some examples of the "older" kinds are *dioryte*, *diabase*, and a large part of *felsyte*; and some of the "younger" are *propylyte*, *doleryte* or *basalt*, and *trachyte*. The value of the distinction may be learned from a comparison of the rocks of one of these series with the rocks of the other.

First as to *diabase* and *doleryte*. Typical diabase consists according to the descriptions, of labradorite and augite, with some magnetite or titanic iron; and so does doleryte. Diabase, to a large extent, is a crystalline-granular rock, so is doleryte. Diabase was formerly supposed to be peculiar in containing chlorite, but it is now proved, as asserted by Rosenbusch, that chlorite is not an essential characteristic, so that diabase may be chloritic or not; and the same is true of doleryte. Old diabase was described as differing from the younger rock doleryte in containing no glassy portions or grains among the crystalline grains; but this is also set aside by later observations, and Rosenbusch accordingly divides diabase into (1) massive granular diabase, (2) diabase-porphyrite, and (3) glass-bearing diabase; and corresponding subdivisions are as good for doleryte. Thus in chemical composition, in mineral composition, in texture, in the presence or absence of chlorite, in the presence or absence of glassy portions, the two rocks are identical. Analyses of "diabases" from the Archæan to the Tertiary, and of "dolerytes" of subsequent time, have shown that material of essentially the same composition, has been ejected in all geological ages, as has been well urged by Allport and others. The analyses might be

cited; but this is not necessary, since in mineral composition typical diabase and doleryte are admitted to be identical.

The facts as regards these two rocks, then, give no foundation for the idea of such a transition epoch in rock-making at the close of the Cretaceous period. And if not, it is bad for geology to have such epithets as "younger" and "older" treated with so great distinction.

Again: the difference between *dioryte* ("older") and *propylyte* ("younger") is not in the chemical or mineral composition of the rocks; and hence, whatever difference there be is only in texture and is, therefore, of little geological value. Again, *felsyte* and *trachyte* are rocks of one and the same chemical and mineral constitution. Ordinary felsyte consists of orthoclase, or orthoclase and oligoclase with sometimes disseminated hornblende or quartz; and the same is precisely the constitution of some kinds of trachyte. They differ in aspect, and feel differently under the fingers, and still some varieties of felsyte differ from ordinary trachyte only in having the disseminated orthoclase crystals not translucent, a difference of very small value mineralogically, and not less so geologically.

The rock of certain felsitic dykes in Canada and Vermont, Paleozoic in age, is called trachyte by T. Sterry Hunt in the Canada Geological Report, because of the essential identity with that rock; and Mr. G. W. Hawes, in his New Hampshire Report, says (p. 187), of New Hampshire's "orthoclase-porphyry," "Were it not that the feldspar is opaque othoclase, instead of clear sanidin [that is, glassy orthoclase] one would immediately think of trachyte on examining these rocks." Moreover, Messrs. E. Reyer and Suess, eminent geologists of Vienna have shown that trachyte occurs in the Euganean Hills of Cretaceous and Jurassic age, as well as of Tertiary. Further, there are felsytes among the "younger" rocks of the globe, that is, among the products of volcanoes, where there is no trachyte; and, on the other hand, trachyte sometimes graduates indefinitely into felsyte. The facts show, consequently, that orthoclase rocks, or orthoclase and oligoclase, have been erupted from Paleozoic time onward, and that the distinctions found in some of the latest kinds are superficial: a little rougher surface, more translucency in the feldspar, and some glass at times among the crystalline grains; but nothing that has any geological weight. While then it may be well to retain the names of trachyte and

felsyte, on account of the obvious external differences and the wide extent to which the two varieties of rock are distributed over the earth's surface, the epithet "younger" as applied to trachyte and some felsyte can subserve plainly no good use. The essential chemical identity of the "older" and "younger" rocks is further exhibited in the fact that the hornblende-bearing rock *labradorite-dioryte*, called one of the "older," has the same ultimate constitution as the augite-bearing rocks, "older" and "younger," called diabase, doleryte and basalt. This fact emphasizes the great truth, that the rock-making materials of former times are the same as those of recent.

During and since the Tertiary era more subærial volcanic eruptions have taken place than in any one ancient period; but there were also many then. As to fundamental differences between the materials ejected by the "older" and "younger" world there appear to be none which are of essential importance. *Glass or no glass* is made an important criterion; but glass is simply a result of comparatively rapid cooling, and alone indicates no essential differences in the melted mass.

Dropping the adjectives "younger" and "older" would require the dropping of the distinctive names based on them, unless some better reason exists for retaining them.

If diabase is not distinct from doleryte in some important way besides that of time of eruption, the name *diabase* (the newer of the two) is unnecessary. In fact, the rocks are not distinct in external characters any more than in chemical or mineralogical. The rock of the Giant's Causeway was pronounced diabase on microscopic grounds when its geological age was unknown; but it has since been proved to be Miocene Tertiary; and now, although just as much diabase in constitution as before, it becomes, on the "younger" and "older" scale, doleryte or basalt.

Some of the differences attributed to difference in age may be due to differences in origin—that is, to the rock's being metamorphic in one case, and eruptive in another. There are distinctions of this kind of great interest yet to be followed out; and they may sometimes have a sufficient geological value for recognition in distinct names, although this may not be generally the case.

2. *Foliated or not.*—Some rocks are described as having foliated pyroxene or foliated hornblende, that is, diallage, pseudohypersthene or smaragdite as the characterizing ingredient. The question here is whether the distinction of *foliated* or *not foliated*

is of sufficient importance to be used as a distinction among kinds of rocks. In the *first* place, it is trivial as a crystallographic distinction. *Secondly*, although mineralogy once made much of the distinction, it now makes little of it. *Thirdly*, it is not sustained by the analyses of the varieties of foliated pyroxene—diallage and the wrongly called hypersthene being essentially identical in composition with common augite of eruptive rocks, and the smaragdite, with other crystallized hornblende. This is shown in any work giving full lists of analyses of minerals, and is well understood; yet the introduction here of a few of the analyses may not be superfluous. Nos. 1 to 5 are of diallage and pseudo-hypersthene, and 6 to 8 of augite crystals from Etna and Vesuvius.

	SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	H_2O	
1. Florence, *Diall*.....	53·20	2·47	8·67	0·38	14·91	19·09	1·77	=100·49 Köhler.
2. Piedmont, *Diall*.....	50 05	2·58	11·98	—	17·24	15·63	2·13	= 99·61 Regnault.
3. Graubündten, *Diall*..	49·12	3 04	11·45	—	15 33	18·54	1·46	= 98.94 v. Rath.
4. Harzburg, *Hyp*.....	52·34	3·05	8 84	—	15·58	19·18	0·66	= 99·65 Streng.
5. Neurode, *Hyp*.....	53·60	1·99	8·95	0·28	13·08	21·06	0·86	= 99·82 v. Rath.
6. Etna, *Augite Cryst*....	50·55	4·85	7·96	—	13·01	22·29	——	= 98·66 Kudernatsch.
7. Vesuvius "	50·90	5·37	6·25	—	14·43	22·96	——	= 99·91 Kudernatsch.
8. Vesuvius "	49·61	4·42	9·08	—	14·22	22·83	——	=100·16 Rammelsberg.

The mineralogical and chemical differences are thus too slight to make the distinction of any lithological importance, and this importance can be sustained, if at all, only on geological considerations.

The particular rock, in the description of which the character stands prominent, is that called *Gabbro* in Germany. It is well known that this Italian word was the provincial name originally of common serpentine. Ferber, in his "Briefe aus dem Wälschland" (Letters from Italy), written in the years 1771, 1772, and published in 1773, describes so well the rock near Florence, that we cite briefly from him. He first says, in a letter from Florence, of Dec. 11, 1771 (in which he gives scientific notes on the minerals and rocks of the regions), that the Gabbro of the Italians, occurring in Italy, Tuscany and Genoa, is identical with the serpentine of Saxony. Then, in another of May 23, 1772, he repeats the statement and describes particularly, and with scientific precision, the gabbro of Mt. Impruneta, near Florence, and mentions the occurrence in it of a talky, micaceous mineral,

which affords, he says, a powder greasy to the touch (the diallage), and also amianthus. He then adds that "in *horizontélen* Schichten in den Gabbro-Bergen um Impruneta findet sich der sogenannte *Granitone*, welcher aus weissen Feldspat, der an einigen Stellen Kalchspatartig ist und mit Säuren brauset, etwas grünlichtem silberfarbigen würflichten Glimmer, und grünlicher Serpentin-Erde, besteht:" a description that distinguishes the gabbro from the granitone. Further, he says that some of the granitone consists of the "white feldspar in large parallelopipeds and green gabbro-earth, without the micaceous mineral."

The word *Gabbro*, as it is now used (and was so first by von Buch, in 1810), is applied to the *granitone*, the associate of the Italian gabbro; but, besides this, to rocks consisting of foliated pyroxene (sometimes called hypersthenite), and cleavable labradorite, the idea of *foliated* standing out prominently; and also to an eruptive diabase-like or doleryte-like rock, in which the augite happens to be *foliated*. In this last variety, as the analyses show, there is evidently no foundation whatever for separating the rock from other labradorite-augite eruptive rocks. Granitone is the same as *euphotide*, a rock distributed at intervals along the Alps from Savoy and Isère, in France, through Piedmont, to the valley of the Saas, north of east of Monte Rosa, and the Graubündten, occurring also in Silesia and on the island of Corsica, and found commonly associated with serpentine. Its chief characteristic is—not its *foliated* diallage or smaragdite (either of which is usually a mixture of hornblende and pyroxene), but its consisting largely of the compact jade-like material called *saussurite*; for it would be the same rock, essentially, whether the hornblende and pyroxene were distinctly foliated or not; and, in fact, in part of it the texture is aphanitic, and nothing foliated is distinguishable. Saussurite has a close relation to some of the feldspars in its constituents, it being essentially a soda-lime-alumina silicate; and still, as has long been recognised, it is not a feldspar. This has been rightly sustained by the fact of the high density, which is over 2·9 (2·9 to 3·4) in saussurite, and less than 2·765 in the feldspar group.

It is further proved by its occurrence occasionally under the crystalline forms of a triclinic feldspar, but with a fine granular or aphanitic structure; thus having, instead of the cleavage structure belonging to the feldspar, a feature belonging to a pseudomorph. In such cases it was once feldspar; but some

change has come over it that has resulted in a molecular transformation, affecting both the crystalline character and the density. Saussurite appears to cover a group of minerals, like feldspar. *One* kind is between anorthite and zoisite in composition, though differing from both in the soda and magnesia, and from all feldspars in its not having the feldspar-ratio between the silica and soda. A *second* has the composition of labradorite; and a *third* the composition nearly of oligoclase. A *fourth*, from Corsica, analysed by Boulanger, is a lime-alumina silicate, like anorthite and zoisite. The saussurite group, with density between 2·9 and 3·4, runs nearly parallel with the feldspar group. The first is *Saussurite*, Th. de Saussure having named thus the Lake Geneva variety, after his father, in 1806; the third is *Jadeite;* and the second may be called, from one of its localities, *Genevrite.*

The following are the analyses of three prominent kinds, and of normal anorthite, labradorite and oligoclase.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O K_2O ign
1. L. Geneva	43·59	27·72	2·61	—	2·98	19·71	3·08 — 0·35 = 100·04 Hunt.
2. L. Geneva	45·34	30·28	—	1·37	3·88	13·87	4·23 — 0·71 = 99 68 Fikenscher.
3. Schwartzwald	42·64	31·00	—	2·40	5·73	8·21	3·83 3·83 = 97·64 Hüttlin.
II.							
4. Mt. Genèvre	49·73	29·65	—	0·85	0 56	11·18	4·04 0·24 3 75 = 100 00 Delesse.
5. Silesia	50·84	26·00	2·73	—	0·22	14·95	4·68 0·61 1·21 = 101·24 v. Rath.
6. Silesia	51·76	26 82	1·77	—	0·35	12·96	4·61 0·62 0·68 = 99·57 Chandler.
7. Unst	52·21	29·64	0·48	—	0·26	12·43	4·00 0·44 0·11 = 99·56 Heddle.
8. Unst	53·14	29·99	0·25	—	0·21	12·29	3·86 0·47 0·21 = 100·42 Heddle.
9. Durance	56·12	17·40	7·79	—	3·41	8·74	3·72 0·24 1·93 = 99.35 Delesse.
III.							
10. *Jadeite*, China	59·17	22·58	—	1·56	1·15	2 68	12·93 *tr.* — = 100.07 Damour.
11. " Switz	58·89	22·40	—	1·66	1·28	3·12	12·86 0·49 0·20 = 100 63. Fellenberg.
12. " "	58·28	21·86	—	2·41	1·99	2·53	13·97 — — MnO 0·22. Fellenberg.
13. Normal anorthite	43·1	36·9	—	—	—	20·0	— — — = 100
14. Normal labradorite	52·9	30.3	—	—	—	12.3	4·5 — — = 100
15. Normal oligoclase	61·9	24·1	—	—	—	5·2	8·8 — — = 100

Specific gravity of 1. 3·227; of 2, 3·3-3·4; of 3. 3·16; of 4. 3·10; of 5, 2·998; of 6, 2.74; of 7. 2.96; of 8, 2 54; of 9, 2.923; of 10, 3.33-3.35; of 11, 3 32; of anorthite, 2·66-2·763; of labradorite. 2 67-2·76; of oligoclase. 2·56-2·72.

To No. 9, add Cr_2O_3 0·51. and to 11, ZnO 0.73. Nos. 10 to 12 are only known worked into ornaments, but the kind may yet be found in the Alps. No. 5 has the specific gravity of labradorite and was therefore that species, a mineral that would be present where the crystallization took place without, or with only partially, the conditions needed to produce saussurite. No. 9 is of the globules of the " Variolite of Durance," a rock associated with euphotide.

Boulanger's saussurite, from Corsica, is near *zoisite* in composition and density (G. 3·18), as stated by T. S. Hunt, who referred all true saussurite to zoisite confirming his view by his analysis above), and the part near labradorite to that of feldspar. Damour obtained for *jadeite* the ratio 1 : 2 : 6.

The relation to the feldspar group indicates the occurrence of special geological circumstances, which turned feldspathic material into saussurite. The circumstance that determined the crystallization or metamorphism may have produced, in its incipient stage, soda-lime feldspar; but it ended in making a large *part*, or the *whole*, saussurite. Moreover the hornblende has been shown to be, in part at least, pseudomorphous after pyroxene; so that the foliated ingredient bears like evidence of this mode of origin. Consequently saussurite rocks not only differ molecularly from any labradorite or feldspar rock, but are indications of peculiar geological operations on a large scale; and this connected with other differences, makes it desirable to distinguish such rocks by a special name. The saussurite and not the *foliated* mineral is the chief ingredient on which the distinction rests.

Euphotide is therefore a different rock from any, consisting of *cleavable* labradorite and pyroxene or hornblende, both on mineralogical and geological grounds. The *foliated* condition of the latter constituent is not reason enough for overlooking the more fundamental differences. As the name *gabbro* has covered rocks of so different kinds, lithology would be freer of ambiguities without it.

The true labradorite-and-pyroxene rock of Scandinavia, the Adirondacks, British America, and other regions, sometimes called *Noryte*—the third kind of gabbro—has the chemical and mineralogical constitution of diabase or doleryte. But it differs from these in its granitoid aspect and geological relations, and is of metamorphic origin; and as it is of wide geographical distribution, geology seems to require for it a distinct name, and *noryte* is an appropriate one.

The pyroxene, though generally foliated, is not always so. When, in place of pyroxene, there is *true* hypersthene, a mineral of different composition and character, as at St. Paul's, Labrador, the rock is then rightly called *Hypersthenyte*, and this name is so used by Zirkel.

3. *Porphyritic Structure.*—Porphyry naturally took the position of a species in the mineralogy of the ancients. But it is now well known, and generally admitted, that the porphyritic structure is largely due to conditions attending the former temperature and cooling of the rock-mass, and distinguishes only varieties. But still it is usual to find dioryte divided, for its primary subdivisions, into ordinary dioryte and dioryte-porphyry;

diabase into granular diabase and diabase-porphyry or diabase-porphyrite; felsyte into felsyte and felsyte-porphyry; and so on, as if the porphyritic structure were deserving of first prominence in the question of division into varieties, even greater than mineral constitution; and sometimes it is even made the basis of a distinct kind of rock. But, *first*, this porphyritic feature is only one grade in the crystalline condition, and is of no more value as regards rock-distinctions than other grades.

Secondly, it is of far less importance in this respect than any variations in chemical or mineral compositions, such as are made the basis of other varieties.

Thirdly, it has often little stability in a rock-formation; for transitions in a dioryte from porphyritic dioryte to non-porphyritic are often found to take place at short intervals, laterally as well as vertically; and so it is with other porphyritic rocks.—Within three miles west of New Haven, Connecticut, a labradorite-dioryte undergoes many such transitions in intervals of a few rods, illustrating the little value of the distinction based merely on this condition in the feldspar. Half a dozen miles farther west there is porphyritic granite which graduates, *in a few yards* at some points, into porphyritic gneiss (the crystals of orthoclase, two inches long and three-fourths of an inch broad) and this last graduates near by into ordinary gneiss; and gradations from porphyritic to ordinary gneiss are very common in the region. Such facts make it evident that the porphyritic structure is a characteristic of little relative importance; that a porphyritic variety may have rightly a place on a level with other ordinary varieties, but never above one based on variations in composition. The porphyritic structure is an easy character to observe; but this is not an argument in its favor that science can entertain. Such names as *felsite-porphyre, amygdaloporphyre, granito-porphyre, melaporphyre* (this last signifying "black porphyry") and others (abbreviated sometimes to felsophyre, amygdalophyre, granophyre, etc.) have high authority. But they seem to belong rather to books on polished stones than to scientific works on lithology.

The occurrence also of the augite of an eruptive rock in distinct crystals, or of quartz in double pyramids, and other similar cases, can have nothing more than a small *varietal* value. The criterion—crystals or not—is sufficient to distinguish only varieties in mineralogy; and lithology can rightly make no more of it.

(To be continued.)

NOTES ON CANADIAN FERNS.

[Having particular reference to the discovery of *Aspidium Lonchitis* at Gaspé in 1875.]

By Jno. B. Goode, Esq.

(*Read before the Natural History Society, Montreal, Jany. 27th*, 1879.)

The mounted specimens which I have now the pleasure of exhibiting to the members of this Society, represent thirty-five of the species indigenous to the Provinces of Ontario, Quebec, New Brunswick and Nova Scotia combined, leaving some eight to ten species to complete the list of the Ferns of these Provinces.

Many of the specimens now before you, were collected at Gaspé last July, in the neighbourhood of Grande Grève, which is rather rich in ferns, some of the rare species being there found in abundance.

Asplenium viride. This species was first discovered in Canada, by the late John Bell, M. D. It was found in Gaspé in the summer of 1863, since which I have found it in abundance at Grande Grève, where it can be seen in perfection, growing in the seams of the limestone ridges, in shady, cool aspects.

Pellæa gracilis is not rare there, and appears to thrive in the immediate vicinity of the sea, similar in this respect to the *Asplenium marinum* on the western coast of England; it thrives best in damp, rocky fissures, or caverns in the shore cliffs, so close to the sea, that in rough weather it must receive a liberal sprinkling of spray. This fern, I may mention, is one of the most difficult to establish in cultivation, and, consequently, although a very pretty one, is rarely or never seen in greenhouse collections.

Asplenium marinum, to which reference has just been made, has been reported on the coast of New Brunswick, on one occasion. I may say that my diligent researches on the Gaspé coast were unsuccessful, and, I think, before accepting it as a Canadian species, it should be found in other localities.

Aspidium aculeatum, var. *Braunii.* A beautiful and rather rare fern; is common in certain localities at Gaspé, preferring cool, shady woods on eminences, or slopes.

Aspidium Lonchitis, or Holly Fern of the Old Country. This species I discovered at Grande Grève in 1875, previous to which the only known locality, I believe, was Owen Sound, where plants had been found, in 1859, by the Rev. Professor Hincks.

I again found it in the neighbourhood of Grande Grève, last summer, where my specimens were collected. It is a very handsome fern, but losing much of its beauty when in cultivation; throwing out a circle of rich, shining, green and narrow lanceolated fronds, often two feet in length; it appears to thrive luxuriantly amongst the weathered, broken limestone rocks, that have fallen from the heights above and become mixed with the fallen leaves. Evidently perfect drainage for the roots is essential to a vigorous growth, combined with a cool, breezy atmosphere, with a northerly to easterly aspect. I have transplanted some roots of this fern, as well as Asplenium viride and Asplenium aculeatum, to suitable situations on our own mountain, and hope there will be opportunities of seeing them in their early, brilliant spring beauty.

The foregoing are the only rare ferns I have found at Grande Grève. *Aspidium spinulosum* there presents several beautiful forms, as shown in the specimens before you.

Pellæa atropurpurea. For this specimen I am indebted to the kindness of Mrs. Roy, of Owen Sound, where I believe it is sparingly located. I found this fern in 1875, on the cliffs overhanging the whirlpool at Niagara, on the American side; but last year, I found it on the Canadian side, and in the most frightfully dangerous-looking places, on the perpendicular sides of high calcareous rocks, which had become partially detached from the main rocks, and were slowly moving, preparatory to a final plunge into the turbulent river beneath. Its dark, tough, wiry roots penetrate the smallest fissure, and thrive with less soil than any other fern with which I am acquainted. No doubt the great amount of humidity from the falls and rapids helps to counteract the want of root nourishment, the atmosphere being constantly filled with light particles of moisture; otherwise, I think they would be burnt up, being exposed to the scorching sun. I have never seen this species in any other locality.

Aspidium fragrans. For the present fine specimen I am indebted to the Rev. Robert Hamilton, of Grenville, who collected it on one of the mountains in that locality. It is a rare species, growing in the seams or fissures of limestone rocks, into which

its strong wiry roots penetrate, and possesses a most pleasant perfume, almost equalling the sweet-scented violet. It thrives only indifferently well in cultivation.

Camptosorus rhizophyllus, or Walking Leaf. This specimen was contributed from Hemmingford; it is found on Isle Jesus, on large, mossy boulders, and throughout Quebec and Ontario. This species is the only one of our Canadian ferns which possesses the property of forming new plants from the rooting of the attenuated extremities of the old fronds, and in this manner travels over the face and sides of the rocks.

Asplenium Trichomanes. This fern, so common to collectors in the Old Country, appears to be rare in Canada, the only places I have found it being at the rapids below Niagara Falls, and at Bolton Springs, in the Townships, where I collected the fine specimen now exhibited, last summer. I have transplanted some roots of this neat and pretty fern to our own mountain.

Dicksonia punctilobula. This fern is very beautiful in its early stages, and emits, while drying, a strong odor, like sweet hay. I have not yet found it on the Island of Montreal; but it is very common in the Eastern Townships, especially at Knowlton, opposite Rockwood, Boscobel, and other places. Its creeping rhizomes push vigorously in every direction, soon forming immense clumps.

Botrychium gracile. The specimens of this pretty dwarf species were found at Gaspé, last summer. I have never seen it elsewhere.

Our Montreal mountains and their surroundings contain a very fair share of ferns. I have collected twenty-five species there, twenty-four of which were seen last summer, the following being a list:

Polypodium vulgare, -	- abundant on N. E. side, amongst loose rocks.
" phegopteris,	- N. E. base.
" dryopteris,	- luxuriates on well-rotten stumps, in shady woods.
Struthiopteris germanica,	- in swamp, S. E. side Mount Royal Cemetery.
Pteris aquilina, - -	- dry, open spots.
Adiantum pedatum, -	- very abundant off Mt. Royal Cemetery avenue.
Asplenium angustifolium	- rather rare; grows on N. W. side Mt. Royal Cemetery.

Asplenium thelypteroides,	western side Mt. Royal Cemetery.
Asplenium filix fœmina,	in rich damp woods; common.
Woodsia Ilvensis,	on exposed rocks, top of mountain overlooking the city.
Cystopteris bulbifera,	abundant on N. E. slope of the mountain, beyond Sir Hugh Allan's.
Cystopteris fragilis,	in rocky seams or cracks, in shade.
Aspidium thelypteris,	swamp between Cemeteries.
Aspidium Noveboracense,	between Cemeteries; turns nearly white in autumn.
Aspidium spinulosum,	swamp between Cemeteries.
Aspidium cristatum,	" " "
Aspidium marginale,	common on rocky slopes; shade preferred.
Aspidium acrostichoides,	back of Sir Hugh Allan's and behind Cemetery; is getting scarce.
Onoclea sensibilis,	common in wet places.
Osmunda regalis,	swamps top of mountain and Smith's swamp.
Osmunda Cinnamomea,	
Osmunda Claytoniana,	Smith's swamp.
Botrychium lunarioides,	dry open spot top of mountain, back of the Redpath property.
Botrychium Virginicum,	rich woods, westerly side.
Aspidium Goldianum,	have not found for some years; was formerly on the northern and western mountain.

Other species than the forgoing have been reported as found on the mountain, but are now probably extinct.

NOTES ON ELEPHANT REMAINS FROM WASHINGTON TERRITORY.

By J. T. Donald, B.A.

The molar now before us forms part of a collection of elephant remains found at Hangman's Creek in the south-western part of Washington Territory. The entire collection numbers over 300 pieces, supposed to represent at least six individuals.

These remains were found in a bog, at a depth of twelve feet below the surface. It is thought the same locality, on careful search, would yield more bones.

It is with a portion of this collection—found in a position to indicate that it probably belonged to the same individual—we are concerned. The principal bones of this portion are, a lower jaw, a pelvis, the first lumbar vertebra, a left scapula, and a horn or tusk. The lower jaw is nearly perfect, and contains the two molars in a good state of preservation. Its length on the outer curve is thirty-six inches; shortest line from posterior summit of condyle to mandibular extremity, twenty-two and one-half inches. Distance between condyles, fourteen inches; distance between outer sides of condyles, twenty-two inches; height of symphysial gutter, four inches; width of same, three inches.

The pelvis weighed when exhumed one hundred and thirty-five lbs. The following are some of its measurements: transverse measurement of sacrum within the arch, ten and one-half inches; distance from symphysis pubis to summit of pubic arch, thirty inches; distance from sacrum to pubis, twenty inches; direct diameter of acetabulum, seven and one-half inches. The transverse superior diameter of the lumbar vertebra with processes is ten inches; its vertical diameter, exclusive of spinous processes is nine and one-half inches; height of spinous process, six and one-half inches; greatest breadth of same, two and one-quarter inches.

The scapula weighed when taken from the earth forty pound s. Its extreme length is forty and one-half inches; its width twenty-five and a-quarter inches. The extreme width to base of spine of posterior spinous fossa, is nineteen and a-half inches.

The horn or tusk weighed when exhumed one hundred and forty-five lbs. Its length on outer curve is one hundred an

twenty inches. Depth of conical opening at base, twelve inches; circumference at base, nineteen and one-half inches; circumference two feet from base, twenty-two inches. This horn curves somewhat obliquely in about two-thirds of a circle, being more oblique near the point, as if worn. A small portion of the base appears to be wanting.

Can we refer these remains, or any part of them, to any known species of elephant? In the 'Canadian Naturalist' for the year 1863, page 135, there is a description by the late Mr. Billings, of an elephant's lower jaw, found in a cutting on the Great Western Railway near Hamilton. This jaw is referred to *Eulephas Jacksoni* of Briggs and Foster.

Calling the jaw now under consideration, A. and that described by Mr. Billings, B. we can tabulate the measurements of the jaws as follows:

	A ins.	B ins.
Shortest line from posterior extremity of condyle to mandebular extremity	22½	23
Greatest width of jaw	25	22
Length of symphysis along median line	5	5½
Width of symphysis	3	2⅛

The similarity of the dimensions of the two jaws thus shown, leads us to regard the two as belonging to the same species.

The study of the molar before us, which is similar to those contained in the jaw just mentioned, strengthens this belief. Calling our molar A. and that described by Mr. Billings B. we can tabulate dimensions as follows:

	A inches.	B inches.
Greatest length of tooth	12	18½
" width "	3¼	3¼
Length of crown	8¾	11
Number of plates in tooth	20	26

In A. *sixteen plates* are brought to view in a surface of *seven and one-half inches.* In B. *nine worn plates* occupy a length of *four inches*, thus giving in each case a little less than one-half inch to each plate; a strong point in favor of the identity of species in the remains represented by the two molars.

Among the remains for which the species *E. Jacksoni* was proposed was a horn or tusk. A comparison of this with the horn belonging to the W. Territory collection also favors the view that the latter is referable to *E. Jacksoni.* Calling the

tusk belonging to the remains for which the new species was formed, B. and the one from W. Territory, A. we can make the following table:

	A	B
Weight of tusk	145 lbs.	180 lbs.
Length on outer curve	120 ins.	129 ins.
Circumference at base	19½ "	20 "
" two feet from base	22 "	22 "

The remains on which the species *E. Jacksoni* was founded, were discovered in a "deposit accumulated just after the close of the northern drift period, and while the river terraces were in process of formation." Other elephant remains, found at Zanesville, Ohio, in 1852, described by Prof. J. Wyman in the proceedings of the American Association for 1857, and referred to *E. Jacksoni*, were found in what is called "valley drift." This drift is composed "of loam, sand and gravel filling up the original valley of the stream that had been excavated out of the palæozoic rocks." The remains described by Mr. Billings, and now in the museum of the Geological Survey, were taken from strata "apparently formed just after the close of the upper drift period, and belonging to the well-known lake ridges and terraces." The remains from Washington Territory were taken from a bog representing, most probably, a drift deposit filling up a former valley and, therefore, in all probability, corresponding in geological age to the deposits whence the specimens of *E. Jachsoni* above mentioned were obtained.

On comparing, therefore, as we have just done, the elephant remains from Washington Territory with bones referred by three different authors to *E. Jacksoni*, and taking into consideration the probable identity in geological age of the several deposits yielding these remains, we are led to the belief that the elephant remains represented by the molar before us belonged to an individual of the species *Elephas Jacksoni* of Messrs. Briggs and Foster, and that this individual lived either immediately anterior to the appearance of man, or just after his advent upon this planet.

But this question still confronts us: Were the peculiarities upon which *E. Jacksoni* was proposed of sufficient importance to warrant the formation of a new species, or were they only of varietal value?

Of this Mr. Billings seems to have been uncertain, for he says,* "Should it be admitted that *E. Jacksoni* is distinct from *primigenius*, etc., etc."

Again, Prof. Boyd Dawkins, in a paper read before the Geological Society,† speaking of the mammoth, says. "The animal ranged over the whole of North America, fr m the frozen cliffs of Eschscholtz Bay as far south as the Isthmus of Darien—the *Elephas americanus* of Leidy and the *E. Columbi* of Falconer (*E. Texianus*, Owen) being mere varieties of the same sort as those observable in the European mammoths, founded merely on the relative width and coarseness of the plates composing the grinders; while the *E. Jacksoni* of Billings merely supplies a slight variation in the form of the lower jaw.

In the light of all the evidence thus adduced, I think we may finally refer the elephant remains of Washington Territory, represented by this molar, to *E. primigenius*, var. *Jacksoni*.

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY OF MONTREAL.

The first meeting of the Natural History Society for Session 1878–79 was held in the rooms of the Society on the evening of Monday, October 28th. Principal Dawson occupied the chair.

A paper was read by Dr. Harrington on apatite and the minerals associated with it in the region north of the Ottawa which has recently attracted so much attention. The general similarity between the apatite-bearing veins of this district and that of Ontario was referred to, and also the striking parallelism between the constituents of the deposits here and in Norway. The minerals occurring in the Norwegian veins, as enumerated by Broegger and Reuesh,‡ are apatite, kjerulfin, quartz, orthoclase, albite, oligoclase (and albite, so-called Tschermakite), esmarkite, aspasiolite, scapolite, pyroxene, enstatite, hornblende, phlogopite, chlorite, talc? tourmaline, titanite, rutile, specular iron ore, titanic iron ore, magnetite, chalcopyrite, pyrrhotite, pyrite and calcite. In the Ottawa region the following have

* Can. Nat. and Geol., Old Series, Vol. VIII, p. 144.

† Quart. Journal Geol. Soc., Vol. XXXV, p. 145.

‡ Zeitschrift der Deutschen Geol. Gesellschaft, XXVII., s. 646.

been observed: apatite, quartz, orthoclase, albite, scapolite, pyroxene, hornblende, phlogopite, chlorite, prehnite, tourmaline, titanite, rutile? hematite, chalcopyrite, pyrrhotite, pyrite, calcite, fluorite, epidote, garnet, zircon, wilsonite, chabazite, sphalerite, molybdenite, graphite, galena. Of the minerals in the latter list several have not before been mentioned as constituents of the apatite-bearing veins of Canada.

Attention was called to the occurrence of interesting pseudomorphs of hornblende after pyroxene. The crystals are often of considerable size, and in some cases only partially, in others completely, converted into an aggregation of little hornblende prisms, constituting a sort of uralite. The change, so far as observed, begins at the surface of the pyroxene crystal and extends inwards. Other pyroxene crystals are interesting on account of the inclusions which they contain; scales of mica, for example, being sometimes arranged approximately parallel to the faces of the crystal. Some fine zircons have been obtained; one crystal from the township of Templeton being no less than $4\frac{1}{2}$ inches long, and the faces of the prism an inch across. The usual combination is ∞ P.P. 3P. 3P3. The hydrous silicate called chlorite in the above list is a dark green foliated mineral with a specific gravity of 2·61. It contains 12·5 per cent. of water, and is evidently a member of the chlorite group. The supposed albite has not been analysed, but from its physical and blowpipe characters there can be little doubt as to its being that mineral.

Principal Dawson then spoke of apatite from a geological point of view. He said the substance was a constant ingredient of the bones of all the higher animals. In answer to this demand we find it very widely distributed in nature, generally however, in small quantities. But in the Laurentian region it appears in large quantities, very irregularly distributed. As to the origin of the Laurentian apatite there are two theories. One is that it has been accumulated by animals which have passed away and left no trace of their structure. The other is that we have in the Laurentian rocks an original deposit of the mineral. He was, however, inclined to hold the former view, and thought there might yet be found some traces of the organisms of which it once formed a part.

During the evening specimens of the minerals mentioned by Dr. Harrington were handed round and carefully examined. A vote of thanks being tendered the President and Dr. Harrington, the meeting closed.

The second meeting was held on the evening of Monday, Nov. 25th.

Dr. T. Sterry Hunt addressed the meeting on "Geological notes of a summer tour in Europe." Among other things he called attention to the fact that European geologists were coming more and more to regard Canada as the land of the typical Eozoic rocks. He also stated that the animal structure of Eozoon was now pretty generally admitted by European scientists.

The third meeting was held on the evening of Monday, Jan. 27th. A. R. C. Selwyn, Esq., F.R.S., occupied the chair in the absence of Principal Dawson.

Six new members were elected, after which Dr. Edwards announced the subjects and dates of the Sommerville lectures for the present winter.

Mr. John B. Goode then read a paper on Canadian ferns, to illustrate which he exhibited his fine collection of native ferns. This paper we publish in full elsewhere. Mr. J. W. Tayler presented the Society with an Esquimaux bow and six arrows obtained from a settlement on the west coast of Davis Straits. The donor called attention to the fact that ancient sculptors represent the classic bow formed in the same manner as this; and that Apollo is represented as bearing an *ivory* bow constructed on the same principle. The bow is made of three pieces of reindeer horn, bound together with deerskin thongs. It is strung in the reverse way of its curve, an impetus being given the arrow, not from the spring of the horn, but from the elasticity of the thongs which bind the pieces together. The arrows are tipped with iron and winged with feathers of the Ger-Falcon.

Mr. Caulfield then exhibited the insects taken at St. Jerome on 1st June last, the Society's field-day. With one or two exceptions all are found in Montreal and vicinity. The following is a list:

COLEOPTERA.

Cicindela sexgutta, Fabr.
" purpurea, Oliv.
" vulgaris, Say.
Calosoma calidum, Fabr.
Plutynus cupripennis, Say.
Agonoderus pallipes, Fabr.
Aphodeus fimetarius, Linn.
Dichelonycha elongtula, Schon.
Corymbites cylindriformis, Herbst
Photinus curruscus, Linn.
Tetropium cinnamopterum, Kirby.
Asemum atrum, Esch.

Arrisodactylus discoideus, Dej.
" baltimorensis, Say.
Laccophilus maculosus, Germ.
Silphx peltata, Cates.
Attagenus megatoma, Fabr.
Ips fasciata, Oliv.
Cytilus varius, Fabr.
Onthophagus latebrosus, Fabr.
Aphodeus fosser, Linn.
Acmæop proteus, Kirby.
Lema trilineata, Oliv.
Labidomera trimaculata, Fabr.
Doryphora decemlineata, Say.
Galerneа sagitturiæ, Gyll.
Disynyca alternata, Herbst.
Melandryœ striata, Say.
Hylobius confusus, Lac.
Tricalophus alternatus, Say.

LEPIDOPTERA.

Papilio Turnus, Linn.
" Asterias, Fabr.
Pieris rapæ, Linn.
Colias plilodice, Godart.
Pyrameus cardui, Linn.
" Attulanta, Linn.
Neonympha Eurytus, Fabr.
Lycœna Lucia, Kirby.
Chrysoplanus americanus, Harris
Hesperia vialis, Edw.
Sessia diffines, Harris.
" Thysbe, Fabr.
Euchætes collaris, Fitch.
Eufidonia notataria, Pack.
Lozogramma defluata, Walk.
Tetracis lorata, Grote.

Mr Whiteaves remarked that of the plants found at St Jerome, four were rare species and had not yet been found on the Island of Montreal.

The chairman made some remarks in reference to the Paris Exhibition, and the Canadian Exhibit which excited wonder and surprise in the numerous visitors from all countries. Special mention was made of the gold octahedron, the huge mass of plumbago, the pyramid and tunnel of coal, and the representation of Canada's lumber wealth. The latter was a timber frame supporting a section of an immense British Columbian pine, placarded "This tree was at least 150 years old when Columbus discovered America."

Views of the Canadian Exhibit and pamphlets showing Canada's natural productions were passed round during the evening and carefully examined.

The fourth meeting was held on the evening of Monday, Feb. 24th. Principal Dawson occupied the chair. There was a large attendance of members and friends. The evening was spent in hearing a paper from A. R. C. Selwyn, Esq., F.R.S., director of the Geological Survey, on "The Stratigraphy of the Quebec Group and the older Crystalline Rocks of Canada," with a discussion on the same. Mr. Selwyn's paper, which we publish in this issue, was illustrated by maps, sections and specimens. A hearty vote of thanks was tendered to him for his able and exhaustive paper.

MISCELLANEOUS.

THE MOUND BUILDERS OF THE WEST.

Dr. Schultz, M.P., sends us the following, originally communicated by him to the *Free Press*.

"Sir,—Permit me through your columns to correct some of the current absurd rumors as to results obtained from excavations recently made for me in the county of Lisgar. Those of your readers who may have had occasion to travel the river road running through that county, will doubtless have noticed the circular elevation between it and the Red River, which occurs about three miles below St. Andrew's Rapids. From the river face of this mound the earth has, from time to time, fallen, and the bones and ornaments disclosed led to the conjecture that it was used as a place of sepulture for the dead of a race far more ancient than the "Ojibways" and "Crees" who lately, or the Assiniboine branch of the "Dakotahs" who formerly, occupied this country.

This mound is one of a group of half a dozen in the vicinity, which are interesting as being farthest north of any of the works of that curious mound-building race, who, for purposes of defence, sepulture, or worship, built the primitive earthworks which are found along the banks of the chief rivers from the Gulf of Mexico to the great lakes. From recent excavations, accidental disclosures, the observations of that careful observer, Hon. Donald Gunn, as well as excavations made by the Commandant at Fort Pembina last year, I am disposed to believe the mounds in this country to be all sepulchral in character, and to have been built by a race who came from, or at least bartered with, people of the far south, who possessd the art of making pottery, bnt had no acquaintance with the metals, a race of medium stature, with crania superior to that of the average Indian of to day, and possibly to have been a smaller, weaker branch of the race, whose interesting relics of early constructive skill are found in such profusion in Ohio and Wisconsin.

The mounds here have been built near the dwellings of the bnilders, who employed fire to render them durable; the upper crust of the soil seems to have been removed and on the flattened clay floor an oven-shaped roof of the same material has been

erected; intense heat being then applied gave consistency to the arched roof, and if sprinkled with sand would cause the vitreous appearance the roof and floor show. The dead, placed in rows, were in a sitting posture with the hands folded, and the face toward some cardinal point of the compass, food in earthen dishes before them, and upon them were hung their ornaments. There is, however, a curious absence of weapons, and the skulls show no sign of violence, though in the neighbouring fields stone hatchets and war clubs as well as flint arrow-heads have been found. The skeletons show no peculiarity of stature, but the crania differ widely from the Cree and Ojibway branch of the great Algonquin family now found here. The skull now before me is of average Caucasian size, and the well worn teeth show middle age as well as the nature of the food. The forehead, though somewhat narrow, is neither low nor receding, orbits well rounded, superciliary ridge low, malar bones only moderately developed, zygomatic arches slight, nasal bones prominent, occiput fairly rounded, and in other peculiarities differing from the typical Indian skull of living races. The ornaments consist of neck-laces formed of hollowed tubes of the soft stone used by the present Indians for pipes, and shells variously cut and pierced for earrings, some from their size suggesting breast ornaments. These shells are unlike anything found here, and similar ones sent by Hon. Donald Gunn to the Smithsonian Institute were of a kind found only on the shores of the Gulf of Mexico. The pottery, made apparently with clay of this country, was confined to simple forms, and the remains of food found in them were the bones of the beaver or some other small animal and the shells of the present river mollusks. None of this group of mounds seem to have been connected wrth others, and the surface appearance is the same with the exception, of course, that on some large trees are growing. Our own Indians have no traditions at all in regard to them, implements and ornaments are alike strange to them, and the practice of the present and preceding Indians was to dispose of their dead on elevated stages rather than to inter them.

Whence came they then, these quiet sleepers, who with fleshless palms crossed as in mute expectancy, might have slept on till the resurrection morn but for the curiosity which disturbed their rest? what has become of this mound building race, who, from the shadow of the Andes to this far north have traversed the conti-

nent? No one knows, and if in our efforts to find a solution of the problem in their tombs their spirits feel aggrieved at the desecration, they may find some comfort in the reflection that the graves of millionaires are equally unsafe in this, the day of our later and boasted civilization.

Prof. Edward S. Morse, we learn from the New York *Nation*, has written an interesting paper on the "Traces of an Early Race in Japan," which throws light on a subject hitherto wholly obscure. A race of men called Ainos are believed to have come down from Kamtchatka and to have taken possession of Japan, which they held until displaced in their turn by the Japanese from the south. Of the two races, the Ainos and the Japanese, authentic records exist; but nothing has been known concerning the ancient people whose territory was appropriated by the Ainos. The only knowledge obtained of them has been ingeniously acquired by Mr. Morse by a careful study of "shell-heaps" in all respects similar to those found along the shores of Denmark, New England, and Florida. The deposit discovered by Mr. Morse near Tokio contained pottery and broken bones, many of which were human. It is generally admitted by ethnologists *that a people that has once acquired the art of pottery* will always retain it; but as neither the Esquimaux, the Kamtchatdales, nor the Ainos are essentially earthen-pot-makers, these remains naturally point to the former existence of a race in Japan who preceded the Ainos. Again, both the human and the deer bones found in this shell-heap were broken in a manner to facilitate the extraction of the marrow, or to enable them to be placed in a cooking-pot, a circumstance which points to the existence of cannibalism among the people by whom the shell-heaps were made. On consulting Japanese scholars and archæologists, Mr. Morse learned that the Ainos were not only not cannibals, but were of an especially gentle disposition. The existence of an ancient race of cannibals in Japan before the occupation of that country by the Ainos is, therefore, made very probable. We hope to see another paper before long containg an account of Prof. Morse's later researches.—*Nature.*

A Gigantic Conularia of the Niagara Group of Hamilton, Ont.—In 1872, two large specimens of Conularia were found at Hamilton, Ontario, and since, a few fragments

have been obtained. One of these was given to McGill College, some time since, by Dr. Spencer, of Hamilton, Ont., who has proposed the name *Conularia magnifica*. The larger of these two specimens measures nine inches in length, and at aperture about seven inches in width, gradually tapering to a rounded apex about an inch broad. The shell is flattened, but shows one of the quadrangular pyramidal sides, which is entire, and marked by a medial depression throughout the length; on either side portions of two other sides are shown. The entire side shows a width, at greatest end, of four and three-fourths inches, gradually tapering to a rounded axis, where the converging edges meet at an angle of about 30 degrees. The surface is ornamented with numerous fine transverse costæ (about 50 in one-tenth of an inch towards the axis, while there are 90 in the same space towards the other end). The furrows between costæ are shallow. Numerous fine longitudinal furrows cross the costæ, leaving a papillose appearance. A complete description is promised shortly.

DEVELOPMENT OF FILARIA SANGUINIS HOMINIS, AND THE MOSQUITO CONSIDERED AS A NURSE.—Microscopists have discovered in human blood and in the blood of dogs, swarms of thread-like worms: these are the *Filariæ*. If they could grow and breed in the body in which they first appear, that body would soon die. "If, for example, the brood of embryo *Filariæ* at any one time free in the blood of a dog moderately well charged with them, were to begin growing before they had each attained a hundredth part of the size of the mature *Filaria*, their aggregate volume would occupy a bulk many times greater than the dog itself. I have calculated," says Mr. Manson, in a paper to the Linnean Society, "that in the blood of certain dogs and men there exist at any given moment more than two millions of embryos." Obviously this minute creature is a formidable parasite. Were it not that large numbers disintegrate and perish, or are voided with the secretions, having even been found in the tears, the natural function of the blood would be impossible.

Nature requires that for further development the *Filaria*, as well as other parasites, should enter some other body. Knowing that mosquitoes suck human blood, Mr. Manson made arrangements by which he captured a number of the insects which had gorged themselves on the blood of a filarious Chinaman who had been 'persuaded' to sleep in a mosquito chamber. On examining

the insects by aid of the microscope, the subsequent development of the *Filaria* could be well made out: it passes through three stages, in the last of which "it becomes endowed with marvellous power and activity. It rushes about the field (of the microscope), forcing obstacles aside, moving indifferently at either end, and appears quite at home." Referring to the papillæ which, appearing at one extremity of the creature, are supposed to be the boring apparatus, Mr. Manson says: "This formidable-looking animal is undoubtedly the *Filaria sanguinis hominis*, equipped for independent life, and ready to quit its nurse the mosquito." And concerning the subsequent history of the creature he remarks that the *Filaria*, "escaping into the water in which the mosquito died is, through the medium of this fluid, brought into contact with the tissues of man, and that, either piercing the integuments, or, what is more probable, being swallowed, it works its way, through the alimentary canal, to its final resting place. Arrived there, its development is perfected, fecundation is affected, and finally the embryo *Filariæ* we meet with in the blood are discharged in successive swarms and in countless numbers. In this way the genetic cycle is completed."

It is in warm climates that the presence of these microscopic worms is most to be feared. In Brazil, Demerara, India, China, and other tropical countries, the existence of *Filaria* has been but too clearly made out, and that its presence is associated with painful and disgusting diseases, and "not improbably with leprosy itself." It is found too in Natal, in company with a noxious parasite of another kind. If, as is thought, there is some relation between the infested blood and certain epidemics, the question is one well deserving of careful study.—*Chambers's Journal.*

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