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On the Petrographical Relations of the Laurentian Limestones and the Granite in the Township of Glamorgan, Haliburton County, Ontario.

By Louis Caryl Graton, B.S.

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GENERAL STATEMENT.

The region with which this paper deals lies in Central Ontario, near the southern margin of the great Northern Protaxis of the continent. It is situated in the southwestern corner of sheet 118 of the Ontario series of maps being prepared by the Geological Survey of Canada, and comprises the western portion of the townships of Monmouth and Dudley, and nearly the whole of Glamorgan and Dysart; it thus occupies the centre of the southern half of Haliburton county, and is about 75 miles north of Lake Ontario.[1]

So much has recently been written concerning the Laurentian System in Canada, among others by Dr. Frank D. Adams,[2] Professor of Geology in McGill University, that only a brief summary need be given here.

The present view is that the Laurentian consists of an underlying series of gneisses and granites called the Fundamental Gneiss, much of which may be, and probably is, of igneous origin; and an overlying series, composed largely of gneisses of undoubtedly sedimentary origin, often differing in petrographical character from those underneath, associated with crystalline limestones and quartzites, and known as the Grenville series.

The geology of this general portion of the Archæan nucleus has been variously described,[3] but the particular area here being considered, as well as all that now included in sheet 118, had received extremely little attention, and in 1894 it was said to be, from a geological point of view, almost a *terra incognita*.[4] Since that time,

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1. I am indebted to Dr. Adams for all the facts concerning the geology of this area which are set forth in the present paper, also for the specimens which are here described and for advice and assistance in carrying out the work. The accompanying sketch map is reduced from his large scale field maps

A detailed description of the whole district by Dr. Adams and Dr. Barlow will appear shortly in the form of a Report to the Director of the Geological Survey of Canada.

2. "On the Typical Laurentian Area of Canada," Jour. Geol., 1893, Vol. I., No. 4.

"Ueber das Norian oder Ober-Laurentian von Canada," Neues Jahrbuch fur Mineralogie, etc., 1893, Beilage Band VIII.

"A Further Contribution to our Knowledge of the Laurentian," Am. Jour. sci., 1895., Vol. XLIX.

"The Geology of a Portion of the Laurentian Area," Geol. Surv. Can., Ann. Rep't, 1896, Vol. VIII., Part J.

3. Murray, A., Geol. Surv. Can., Rep't of Progress, 1852-53.

MacFarlane, T., ibid., 1863-66.

Vennor, H. G., ibid., 1866-1869.

Vennor, H. G. ibid., 1870-77.

4. Adams, F. D., Geol. Surv. Can., Ann. Rep't., 1891-92-93, Vol. VI., Part J., p. 3.

a detailed geological examination of the area comprising sheet 118 has been begun and completed by Dr. Adams and Dr. A. E. Barlow.

The geology of that particular portion whose limits were given at the outset, and to which alone the following remarks refer, may be described as follows: The country is a hilly one, presenting the remarkable undulating or *roche moutonnée* surface so characteristic of the Laurentian; the depressions are usually filled with drift, and in the flats so formed are found innumerable lakes. Countless rounded bosses of bare rock protrude through the drift especially in those portions of the area occupied by several batholitic masses of granite or granitic gneiss, identical in appearance with the Fundamental Gneiss, which have penetrated and eaten into the white crystalline limestones which underlie the remaining portions of the area.

Dr. Adams has found in his recent studies in this area, the results of which will be published shortly, that in many localities at least, the Laurentian limestones, which are always much altered, were, at the contact of the Fundamental Gneiss, transformed into dark, basic rocks which still retained the banded structure of the limestone. He also ascertained that the Fundamental Gneiss contained many inclusions of dark, basic rocks, which near the contact were more angular in form, and away from the contact often assumed the form of dark elongated streaks in the Fundamental Gneiss. The field relations were such that it seemed practically certain that these fragments were portions of the basic contact rock, in a still more highly altered condition, which had floated away in the igneous mass during the process of intrusion.

It would appear then, either that new igneous material had been erupted through this limestone series, or that the underlying Fundamental Gneiss had been reheated sufficiently to fuse or to become plastic, and that the limestones had been invaded by it or had sunken down into it while in this plastic condition. Which one of these suppositions represents what has actually taken place is a difficult matter to determine. It might be that both are true in degree. Be that as it may, the action on the limestones would be practically the same, and certain it is that the great part of the intrusion is identical in character with truly intrusive igneous rock. There is still another possible explanation of the cause of these phenomena but it can only be referred to farther on.

Two specific problems now present themselves: the origin of the basic contact rocks, and the true character of the seeming inclusions. Specimens of the various rocks were collected by Dr. Adams, and some of them have been handed to the writer for investigation, in order that their mineralogical composition and character might be determined, and a comparison instituted between the several basic varieties themselves, and the limestones of which they are apparently the altered representatives.

Although the problems are distinct, several facts are encountered which render their exact and definite solution difficult. The rocks are not infrequently concealed by a mantle of drift, which is often thick; the contact itself is by no means sharp, but is instead, a brecciated zone of granite and of the invaded rocks in varying stages of alteration, and its demarcation and study would be a serious matter even if it were everywhere exposed; and fully as important as the two preceding facts, is the one that, due to the frequent similarity in appearance of rocks quite different in composition, and to the complexity of the relations generally, it is often almost impossible to realize fully, while in the field, the importance and significance of such facts as are observed—this can only be done later, when thin sections of the specimens can be examined.

The limestones are the same white or pinkish crystalline limestones or marbles everywhere characteristic of the Grenville Series, which have been described at length by Dr. T. Sterry Hunt [1] and various other writers. The source of the metamorphism which has produced this recrystallization — whether due to the heat from the igneous intrusions, to the dynamic action which has undoubtedly taken place, possibly accompanying these intrusions, or to other causes altogether different—is a subject which does not closely concern the present arguments. Away from the intrusions before described, the limestones are comparatively pure, though they sometimes contain bands of very dark hornblendic rocks or amphibolites, but approaching the igneous rocks, they are found to contain little rounded grains of pyroxene and other lime-rich minerals, and in many cases to pass into banded, basic rocks which warrant the field name of pyroxene gneiss. These become darker in color yet nearer the granite, and are still found to contain intercalated with them and with layers of limestone, bands of amphibolites, which have a harder or more granitic look than the pyroxene gneisses, but are otherwise quite similar in appearance. They are somewhat more sharply defined from the marbles than are the pyroxene gneisses, the transition from one to the other being often quite abrupt. The whole series is cut by dykes, veins, or stringers of the granite which anastomose through it in a remarkable way, and the resulting appearance is most complicated. Nearer still to the invading mass these bands become more and more broken and indefinite, the number and size of the granite dykes increase; and at last comes the state of affairs where the dark rocks occur as inclusions in the granite. In the south-western portion of the large central batholite shown in the accompanying map, these inclusions are very numerous indeed. They vary in size from a few

1. "Geology and Mineralogy of the Laurentian Limestones," Geol. Surv. Can., Rep't. of Progress, 1863-66, p. 181, *et seq.*

square inches to hundreds of yards, and have an appearance very similar to the rocks of the bands at the border, looking, however, still a little harder. Farther and farther away *from the contact they lose much of their angular* form and appear simply as dark, elongated streaks in the granite, which seems to be dissolving or absorbing them.

The granite of these intrusions, in its typical development, is red or pinkish, and somewhat foliated. Occurring all through it, however, are patches of a rock distinguished by a prevailing gray color. It cannot be stated with certainty that these gray gneisses are especially developed in the neighbourhood of the inclusions nor about the contact, though they certainly occur in those places as frequently as elsewhere.

That this contact is one of intrusion seems certain.[1] There is also evidence to show that practically all the rocks of this series have been subjected to pressure, motion, and deformation. The absence of any distinctly cataclastic structure in the rocks about the contact indicates that such deformation has not taken place to any extent since the rocks have recrystallized; but the prevalent foliation, the presence of muscovite and microcline, as well as of numerous cracks and strain shadows in the various minerals, and the absence of any fine-grained zone in the igneous rock near the contact, all point to the conclusion that the intrusion took place deep in the earth's crust when movements were in progress, and when, in consequence, the limestones were at a high temperature.

In the case of more brittle rocks, even under the conditions just mentioned, this invasion and movement would doubtless have caused a shattering and fracturing, which would now be evidenced by numerous faults and by a more or less cataclastic structure in the rocks about the contact of the intrusion. But these limestones, softened,

1. cf. Adams, F. D., and Barlow, A. E., "On the Origin and Relations of the Grenville and Hastings series in the Canadian Laurentian," Am. Jour. Sci., 1897, Vol. III p. 176.

doubtless, by the heat from the mass below, and under the burden of the rocks above,[1] have, instead, *flowed*, so that they accommodated themselves to the rather irregular form of the invading mass, and now, everywhere, their strike is seen to be the result of this intrusion and parallel to its boundary.

This subject of the flow of marble and limestone has been most carefully and convincingly dealt with experimentally by Dr. Adams. [2] Some of the structures so produced artificially in Carara marble have been compared by him with structures exhibited by the limestones of this very district and found to be identical.[3]

It is not alone to the limestones, however, that this peculiarity of strike belongs. The foliation of the amphibolites and gneisses forming the contact zone correspond to the strike of the limestone and the form of the intrusion; while even the rocks of this mass itself are foliated and banded, and both foliation and banding are parallel to its boundary. Cases which appear entirely analogous to this, as regards the matter of uniformity of strike and foliation, have been observed in the Rainy Lake region [4] and in the district about the Lake of the Woods,[5] where the so-called Fundamental Gneiss penetrates the Huronian.

In their endeavours to trace back as far as possible the geological history of the earth as recorded by the stratified deposits in its crust, the early workers—possibly deceived by the outward resemblance of these intrusive rocks to undoubted clastic rocks present in later geological formations, which were known to have undergone extensive

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1. Heim, A., "Geologie der Hochalpen zwichen Reuss und Rhein," Beitrage zur Geol. Karte der Schweiz, Vol. XXV., Bern, 1891.

2. Adams, F. D., and Nicolson, J. T., "An Experimental Investigation into the Flow of Marble," Phil. Trans. Roy. Soc. London, 1901, Series A, Vol. 195, pp. 363-401. See also Van Hise, C. R., "Metamorphism of Rocks and Rock Flowage," Bull. Geol. Soc. Am., 1898; Vol. IX., pp. 295-313, 318-326.

3. Loc. cit., pp. 389-390.

4. Lawson, A. C., Geol. Surv. Can., Ann. Rep't., 1888, Vol. III., Part F.

5. Ibid., 1885, Vol. I., Part CC.

deformation and alteration—considered that the foliation and banding in them were evidence of original stratification. And with the facilities for investigation then at their command, this is not surprising.

With increased knowledge, resulting from due consideration of the effects produced by great dynamic action, from detailed mapping in the field, and perhaps more than anything else, from the application of the microscope to the study of petrography, and the consequent recognition of the exact composition and structure of many of these rocks, this old idea has been completely superseded. And in recent years, work by Lossen, Lehmann, Daubrée, Nauman, Reusch, Schmidt, Milch, Teal, Heim, G. H. Williams, and others has proved beyond doubt that foliation may be produced in massive plutonic rocks as a result of pressure before the rock has wholly solidified; and Lawson[1] has drawn attention to the fact that "the various foliated crystalline rocks usually classified as Laurentian were largely plutonic rocks which have crystallized slowly, probably under an extremely gradual diminution of temperature, from a thickly viscid, coherent, or tough hydrothermal magma."[2] The foliation was explained as a result of "differential pressure which, by causing a yielding or deformation, induced a flow in the mass."

From these considerations it is evident that much valuable information may be obtained by adding to the results of stratigraphic methods, those of a careful microscopic examination of thin sections of the various rocks; and that has been the aim in the following division.

PETROGRAPHY.

In the pages which follow, certain terms used to describe structure may admit of a somewhat different meaning than the one given to them here; in order to avoid any

1. Opera cit.
2. Barlow, A. E., Geol. Surv. Can., Ann. Rep't., 1897, Vol X., Part I, p. 51.

ambiguity or uncertainty, they are defined at this point in the exact sense in which they are used here. *Foliation* is a "laminated structure, produced in a rock by the parallel arrangement of certain or all of its constituent minerals"; *banding* is the alternation in the form of bands, of gneisses differing more or less in composition or structure, which gneisses may or may not be foliated as well; *granitic* is the typical structure of granite, characterized by a general lack of crystalline form and a more or less complete interlocking on the part of the mineral grains; *granular* is the structure common to granites which have been somewhat deformed and have in consequence lost much of this interlocking of the grains; *granulitic* structure causes a thin section of a rock possessing it to appear as a mosaic of roughly equidimensional grains, usually of small size—it is typical of recrystallized rocks which have been subjected to movement during the process of solidification, but it may be produced by the deformation and crushing of already solidified granitoid rock-masses.

The rocks of this area, with the exception of the true limestones, present a similarity in one respect, namely, they are all foliated; in general, also, they are banded. Otherwise, however, as has already been mentioned, they present a wide variation in character, ranging in composition and likewise in properties from acid granites to basic amphibolites.

Perhaps one of the most noticeable features in the petrography of the more acid types is the occurrence of plagioclase feldspar, often in great preponderance over the orthoclase; a rock which is to all appearances a granite when examined macroscopically, being possibly of a pink color, and highly quartzose, is found under the microscope to be really a quartz diorite. This phenomenon, known as the "plagioclase phase" of granite, is not of unusual occurrence in this class of rocks.[1]

It has been found a matter of convenience, sustained by the nature of the rocks themselves, to class the rocks of which specimens have been examined into four groups, and these have been named conditionally: (1) Gneissic Granites, (2) Gray Gneisses, (3) Altered Limestones, and (4) Inclusions in the Gneissic Granites. In the following descriptions, however, each rock has been named according to the generally accepted nomenclature depending on mineralogical composition and structure, and thus there are Quartz Diorite gneisses, Scapolite Amphibolites, etc. Since all the specimens are exceptionally typical of the rocks they represent, and as each represents a somewhat different rock, it has been thought advisable to give a rather detailed description of each specimen, in order to bring out more clearly the relations of the several rocks to one another. The order followed has been made to correspond as nearly as possible to the degree of the metamorphism which the rocks have undergone, since it was thought that this would give a better idea of the gradations from one specimen to the next, and as it has the advantage of being briefer than any other arrangement could be.

GNEISSIC GRANITES.

These rocks, which are generally of a reddish color, make up the great bulk of, and characterize the batholitic intrusions. It is they, supposedly, which during the activity of the igneous forces, have metamorphosed the limestones about their contact.

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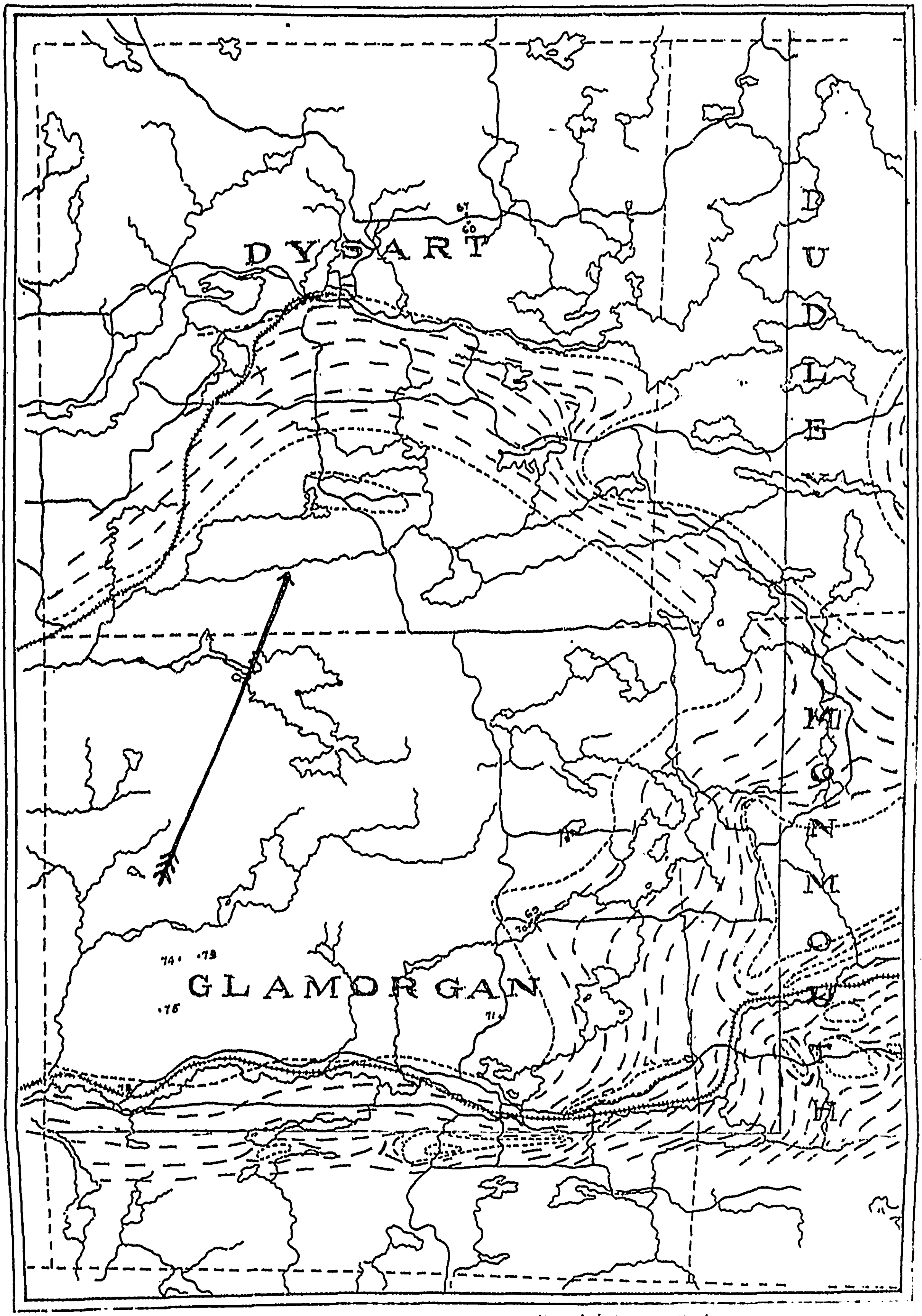
1. McInnes, H., "Geology of Seine River etc.," Geol. Surv. Can., Ann. Rep't., 1897, Vol X., Part H, p. 16.

Smyth, C. H., jr., "Crystalline Limestones and Associated Rocks of the North-Western Adirondack Region," Bull. Geol. Soc. Am., 1894, Vol. VI., pp. 266-267.

Kemp, J. F. and Hollick, A., "The Granite at Mount Adam and Eve, Warwick, Orange Co., N. Y., and its Contact Phenomena," Annals N. Y. Acad. Sci., 1894, Vol. VII., p. 641.



The relations about the contact are so complicated that on a map of this scale only the broad distinction between granite and limestone can be made.

Within the inner rectangle the geology is practically complete, and the only rocks occurring are granite and limestone. White represents granite, and the dashes represent limestone and its strike.

The small figures indicate the points from which specimens were taken; 67 represents thin section 1267, 70 represents section 1270, etc.

The scale is miles to the inch.

Foliated Granite, Township of Glamorgan, Range IX., Lot 9. (Section 1273.)

This rock is pinkish and usually fine-grained, with occasional good sized individuals of feldspar. It has a banded structure which is quite distinct, the darker constituents occurring almost entirely in fairly continuous, narrow ribbons, to which, moreover, the arrangement of the grains is parallel; this indicates a foliated structure also. The more acid bands have a greater width—an inch or more—and in them also, the dark constituents, wherever they do occur, are arranged with their long axes parallel to the banding.

Under the microscope it is seen to consist essentially of quartz, plagioclase, microcline, with some orthoclase, and biotite. Muscovite, numerous grains of magnetite, sometimes enclosing pyrite, and a few little crystals of zircon and of apatite also occur.

The quartz is in clear glassy grains, both large and small, and of irregular form. It is often cracked, and in other individuals shows well marked undulose extinction or strain-shadows. The orthoclase, which is somewhat turbid, is recognized by its being twinned according to the Carlsbad law, though this twinning is not always seen. It frequently shows slight strain-shadows, and it is without doubt from a straining of the orthoclase that the microcline has been derived. This seems especially probable, for in this rock both these minerals are pink in color. The microcline is comparatively fresh, and is distinguished by its characteristic cross-hatched appearance in polarized light. The plagioclase is generally in large individuals, and frequently turbid; it is oligoclase Both the orthoclase and the plagioclase occasionally show cleavage. The biotite is not present in large amount. It is in narrow, lath-shaped individuals, brown, with sometimes a greenish tinge, and quite strongly pleochroic; cleavage well shown. The muscovite, which also often shows distinct cleavage, is clear and colorless, and occurs in irregularly shaped masses near the feldspars or the biotite, though it does not appear to have been derived from the latter; occasionally it presents the fibrous or plumose structure of sericite. What points most strongly to its origin is its occurrence in the feldspars in detached particles, which, however, are parts of large individuals, giving simultaneous extinction and hence being similarly oriented. They are really skeleton crystals which have been formed at the expense of the feldspar. Similar phenomena have been noticed in granites from the Pelly River, British Columbia,[1] and in the Stanstead[2] granite in Quebec. Both these granites resemble in other ways the one under consideration; both have been subjected to intense pressure while deep in the earth's crust, and in the latter case, the orthoclase has been converted into microcline just as in this one. The muscovite seems to have been produced by the same forces which caused these other changes, and indicates a first stage of dynamic metamorphism, short of complete recrystallization.[3] The magnetite is frequently altered about the edges to limonite, which has infiltrated along the cleavage-planes of the feldspars. The zircon is in small, well-defined prismatic crystals, terminated by a combination of pyramidal forms which gives an almost rounded appearance. It has a broad, black boundary, denoting high refractive index, and very high double refraction, polarizing in pale blue tints. The apatite is also in well-formed crystals, of hexagonal outline, low index of refraction, and low double refraction, giving bluish gray in polarized light.

The structure of the rock is granular and allotriomorphic.

1. Adams, F. D., "On Some Granites from British Columbia, etc." Can. Rec. Sci., 1891, Vol. IV., pp. 352-354.
2. Adams, F. D., "Description of a Series of Thin Sections of Typical Rocks," Montreal, 1896, pp. 5-6.
3 cf. Harker, A., "Petrology for Students," Cambridge, Eng., 2nd ed., 1897, p. 309.

GRAY GNEISSES.

These rocks occur in patches throughout the granite mass, and are often found near the basic, highly calcareous contact rocks or inclusions. They more closely resemble the granites, however, and are distinguised from it by their gray color.

Quartz Diorite Gneiss, Township of Dysart, Lot 24, between Ranges IX. and X. (Section 1268).

This is a fine-grained, gray, and very quartzose gneiss, of uneven and interrupted foliation. The acid constituents are nearly white.

When examined microscopically, its essential constituents are seen to be quartz, plagioclase, biotite, and hornblende. Orthoclase, a very few grains of microcline, magnetite, pyrite, apatite, and a few small crystals of zircon embedded in the quartz make up the accessory constituents.

The quartz is very abundant, in grains of varying size, some of which show uneven extinction; the larger grains are much elongated in the plane of the foliation of the rock, in fact, they largely determine the direction of the foliation. Some are clear, but others are clouded with inclusions, which, however, are so minute that little can be determined concerning them, even with a high power. They are doubtless inclusions of some basic material, for considerable of the quartz separated from Thoulet's solution in which an amethyst crystal of specific gravity 2.651 just floated. The plagioclase is present in large amount, as large angular grains, fairly fresh and clear; cleavage can often be seen. It shows beautiful albite twinning, in broad and narrow bands, and is sometimes also twinned according to the Pericline law. It is probably andesine, since it gives an extinction angle of 15° and has a specific gravity of about 2.65. The ferro-magnesian constituents are not nearly so abundant as the more acid ones. The biotite is dark brown, and shows good cleavage. It is strongly pleochroic, and the absorbtion is $\mathfrak{a} > \mathfrak{c}$. Extinction is parallel. The grains are of medium size, and allotriomorphic, showing a tendency to skeleton structure, and thus interlocking with other minerals. Hornblende occurs somewhat more abundantly, in deep, yellowish-green individuals; cleavage excellent. Extinction in the clinopinacoidal sections is inclined, giving a maximum extinction angle of 33°, which indicates a basic composition. The pleochroism is very pronounced, as follows:—

$\mathfrak{a}$ = pale yellow,
$\mathfrak{b}$ = yellowish green,
$\mathfrak{c}$ = deep green.

Or to state it in the "absorption scheme,"

$$\mathfrak{c} > \mathfrak{b} > \mathfrak{a}.$$

A comparatively small number of fairly fresh grains of an untwinned feldspar of low specific gravity, about 2.56, are probably orthoclase. The apatite is in small distorted crystals of hexagonal outline. Magnetite occurs in irregular grains of varying size, alone, and also inclosing grains of pyrite. The former shows a characteristic steel-blue color and metallic lustre in reflected light, and under the same conditions the pyrite looks brass-yellow. The magnetite is sometimes altered at the edge to hematite, which, in reflected light, appears red.

The structure of the rock is granular, inclining, where individuals of the basic constituents adjoin, to a mosaic structure, and pointing to a partial recrystallization.

Quartz Diorite Gneiss, Township of Glamorgan, Corner of Lots 25 and 26, Ranges VII. and VIII. (Section 1271.)

This is a fine grained, rather light reddish gray gneiss, with foliation not very distinct.

Examined microscopically, it is seen to have as essential constituents quartz, plagioclase, microcline, and biotite. A very few grains of an untwinned feldspar, probably orthoclase, a little iron ore, probably hematite, and a few small, well-formed crystals of apatite, usually embedded in the quartz, are accessory constituents.

The quartz is abundant; it is clear and glassy, and often shows distinct strain-shadows. Microcline is present in considerable amount and presents its typical cross-hatching in polarized light, it is quite clear and fresh. The plagioclase also is abundant; it is twinned in broad and narrow bands, and often shows a slight turbidity, probably due to kaolinization, along certain lines which doubtless represent cleavage planes; some, however, is perfectly clear. It is oligoclase, having a specific gravity under 2.64, and an extinction angle of 10°. A considerable amount of biotite is present, in grains of very irregular outline. It is very deep brown, strongly pleochroic, and shows good cleavage, with extinction parallel.

The structure of the rock is typically granular.

Quartz Diorite Gneiss, Township of Glamorgan, Range VIII., southern part of Lot 7. (Section 1275).

This is a fine-grained, gray gneiss, rather distinctly foliated, the foliation being especially well brought out on the weathered surface.

Under the microscope it is found to consist essentially of quartz, orthoclase, plagioclase, biotite, and hornblende; individuals of microcline are not uncommon. As accessory constituents it holds numerous grains of sphene, a grain or two of black iron ore, and a few poorly developed crystals of apatite.

The quartz is in large and small irregular grains, clear, but often showing undulatory extinction. The orthoclase is untwinned, shows cleavage, with which extinction is frequently parallel, and though generally fresh, is sometimes decomposed along the cleavage lines. The plagioclase, which is oligoclase, is abundant. It shows Albite and Pericline twinning, cleavage is often seen, and the extinction is inclined; it tends to be turbid along the cleavages. Biotite occurs in considerable amount, in irregular individuals; it is brown and strongly pleochroic. Hornblende occurs in about equal amount, generally in irregular individuals of medium size, but some show a tendency toward rough crystallographic outline. It is very deep green and intensely pleochroic; the scheme of absorbtion is $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. In the zone of $\infty P \infty$ and $\infty P \breve{\infty}$, the maximum extinction angle observed was 22°. The sphene is in irregular grains, much cracked. It has a high refractive index, giving a dark border, and a roughened appearance to the surface, and high double refraction, polarizing in colors ranging from brilliant to almost white. Owing to its great dispersion of the axes of elasticity, extinction is never complete. Enclosed in it, or closely associated, are several grains of black iron ore which show a bluish metallic lustre in reflected light, and which are without doubt ilmenite.

The structure is granular, resembling that seen so often in granite gneisses.

ALTERED LIMESTONES.

These constitute the dark basic rocks interbanded with the limestones near the granite contact. In the field they are conveniently divided into two classes depending on the predominance of pyroxene or of hornblende, and are called respectively pyroxene gneisses and amphibolites. Bands of them are very much mixed up, with one another, and with veins or dykes of the granite.

Pyroxenite, Township of Glamorgan, Lot 27 between Ranges IX. and X. (Sections 1269 A.B.C.D.)

This is one of the pyroxene gneisses. It is a very fine-grained, friable rock, of greenish gray color. It is very distinctly banded, being made up of dark colored bands alternating with bands of medium and light color.

When examined microscopically, this banding is also very apparent, as shown by the occurrence and arrangement of certain minerals. It is thus rather difficult to divide the constituents into essentials and accessories. The dark bands are composed almost exclusively of plagioclase, hornblende and augite. The lighter ones are found to be interbanded in themselves, one which appears homogeneous in ordinary light, may be seen, when the second nicol is put in, to consist of bands possibly as follows:—plagioclase, scapolite, and augite; plagioclase, microcline, calcite, and augite; plagioclase, calcite and augite. A few irregular individuals of quartz, numerous fragments of sphene, many small crystalline grains of apatite, a few grains of ilmenite, a little epidote, and a very few irregular individuals of biotite make up the accessory constituents. All the minerals, except the calcite individuals, which are often of good size, are present in small grains.

The quartz, examined in isotropic section in convergent polarized light, shows the stationary cross of a uniaxial mineral; by this means only is it distinguished from much of the plagioclase, for considerable of the latter is clear and untwinned. Some of the plagioclase, however, is twinned, in broad and narrow bands. From the separation, there seems to be both labradorite and oligoclase present. Microcline is recognized by its characteristic twinning, and is also quite clear. A colorless mineral whose optical properties show it to be scapolite occurs in irregular individuals, at times cracked, and often turbid. Its grains show sometimes parallel and sometimes rectangular cleavage lines; its refractive index is low, but its interference colors (double refraction) very brilliant. Sections showing prismatic cleavage give parallel extinction, while those showing two sets of cleavage lines give inclined extinction, and, when the cleavages are at right angles, are isotropic and exhibit in convergent polarized light a uniaxial figure, which, with the mica and gypsum plates, is seen to be negative. In many cases the scapolite is surrounded by a colorless border, from which, in ordinary light it cannot be distinguished, but which between crossed nicols gives aggregate polarization in bright colors, yellows and blues, and which may possibly be a "lamellar aggregation of kaolin and muscovite."[1] The epidote occurs in lath-shaped individuals which are irregularly cracked. The mineral is nearly colorless, but slightly pleochroic to pale yellow; extinction is parallel. The refractive index is high, causing it to stand out from its surroundings with a dark border, and giving to the surface a roughened appearance. The double refraction is also strong, polarizing in high colors. Calcite occurs in irregular individuals of good size. It is somewhat turbid, often shows rhombohedral cleavage, and is sometimes twinned. It has a high double refraction which causes it to polarize in silvery tints. The augite is light green and very slightly pleochroic; cleavage is imperfect. In the basal sections the cleavage lines intersect nearly at right angles; in the orthopinacoidal sections the extinction is parallel; and in the clino-pinacoidal, inclined, the maximum angle being 43.° Hornblende is much less abundant than the augite. It is green, though not very deep, in color, exhibits good cleavage and strong pleochroism, the absorption in the three types of sections being as usual, the maximum extinction angle recorded was 27.° The sphene is rather dark brown, slightly pleochroic, and much cracked. It occurs mainly, along with a few grains of ilmenite and numerous distorted crystals of apatite, included in the plagioclase.

In general the grains of this rock have a smooth,

1. Rosenbusch, H., "The Microscopic Physiography of the Rock-making Minerals." Trans. Iddings, 4th ed., 1898, p. 157

distinct outline, more or less polygonal, giving to a section a defined mosaic or paving-stone appearance, characteristic of a recrystallized metamorphic rock; the structure is granulitic.

The presence of epidote, and particularly of scapolite in this rock is of special significance, since these minerals are frequent, and may almost be said to be characteristic accompaniments of certain pyroxenites and amphibolites which, in matamorphosed contact-zones, are the equivalents of granular limestones.[1] The abundance of augite, and its preponderance over the hornblende, than which it is generally a mineral richer in lime, are also noteworthy points.

Scapolite Amphibolite, Maxwell's Crossing, Township of Glamorgan, east side of Lot 5, Range VI. (Section 1272).

This is a fine-grained, eminently crystalline, and somewhat friable rock, of dark greenish-gray color. It is foliated and banded, broad or narrow bands of the darker constituents alternating with bands which contain the lighter ones.

The microscope shows it to be composed essentially of scapolite and hornblende, though in some bands considerable calcite and pyroxene are seen, and in others individuals of plagioclase are common; a little quartz also occurs. As accessories, it contains numerous small wedge-shaped or irregular grains of nearly colorless sphene, which are much cracked, and many small, well-formed crystals of apatite, which in prismatic sections sometimes show the basal parting.

Plagioclase is in good sized individuals, quite fresh, often untwinned. It is an acid labradorite, having a specific gravity of about 2.69. Calcite is distinguished by its rhombohedral cleavage and the silvery tints in which

1. Rosenbusch, H., op. cit., pp. 158 and 294.
Harker, A., op. cit., pp. 284-286 and 296-298.

it polarizes. The scapolite occurs in large colorless irregular individuals, and near the edge of the slide shows good cleavage. In sections approaching the basal, the extinction bisects the angle formed by the cleavages. The mineral is clear and fresh. It separated from the heavy solution at specific gravity 2.699, indicating high content of lime; these grains were heated with dilute nitric acid to remove any calcite, the residue was thoroughly washed, and then boiled with pure concentrated nitric acid—it was decomposed, but not entirely dissolved. The solution was decanted, diluted, and to one portion silver nitrate was added, a white flocculent precipitate indicated chlorine; the other portion was made ammoniacal, and ammonium oxalate was added, an abundant white precipitate showed lime. The hornblende is green, in large individuals of angular form; strongly pleochroic, maximum extinction angle, 31°, indicating a high percentage of basic elements in the mineral. The augite is in very irregular grains, nearly colorless to light green. It shows imperfect cleavage and is also much cracked. Pleochroism very slight, extinction angle 43°.

This rock also has a typically granulitic structure, being made up of a mosaic of polygonal grains.

Amphibolite, Township of Glamorgan, Lot 27, between Ranges IX. and X. (Sections 1270 A.B.).

This is a very dark, fine-grained, and friable rock, with no banding apparent in the hand specimen. With the aid of the microscope there is seen to be a tendency toward foliation, which, however, is slight.

The essential constituents are plagioclase and hornblende, the latter making up about two-thirds of the rock. Quartz, scapolite, calcite, and augite are also present in much smaller amounts. A few irregular individuals of orthoclase, several irregular and broken grains of sphene, associated at times with black titanic iron ore, and here and there a small crystal of apatite complete the list of accessory constituents.

The quartz is clear, and is distinguished from much of the plagioclase only by its axial figure. The orthoclase is comparatively fresh, shows Carlsbad twinning in some cases, also cleavage approaching a right angle, with extinction sometimes parallel. Its occurrence in such basic rocks is not infrequent.[1] The plagioclase is in good sized individuals; some of it, labradorite, is twinned polysynthetically according to the Albite law, in broad bands, but most of it is perfectly clear and untwinned, and is andesine, specific gravity about 2.65. The scapolite is usually altered about the border as in the other specimen from this locality (section 1269), but otherwise is quite clear. The hornblende is of medium green color, and occurs in angular individuals of varying size. It shows good cleavage, is strongly pleochroic, and exhibits the usual absorption $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$, though in this case the absorption along $\mathfrak{b}$ and $\mathfrak{c}$ is not very different. Its extinction angle is 27°. The augite is in small grains, much cracked. It is very pale green, almost non-pleochroic, and gives an extinction angle of 40°.

The rock appears as a mosaic of various sized grains, less uniform than in the preceding specimens. Its structure may be said to be between granular and granulitic, but still points to recrystallization of the component minerals.

INCLUSIONS IN THE GNEISSIC GRANITES.

These comprise the irregular dark masses in the granite, and are often near areas of gray gneiss. They present a gradation in form, appearance, and composition from angular, black, and exceedingly basic near the contact, to lenticular masses, with alternately light and dark bands, and less basic farther away in the granite mass.

1. cf. Kemp, J. F., "Crystalline Limestones, Ophicalcites, and Associated Schists of Eastern Adirondacks," Bull. Geol. Soc. Am., 1894, Vol. VI., p. 233.

Amphibolite, Township of Dysart, Lot 24, between Ranges IX. and X. (Sections 1267 A.B.C.)

This is a very dark fine-grained rock, foliated, but not banded.

When examined microscopically, it is seen to consist very largely of hornblende, with a considerable amount also of plagioclase. As accessory constituents there are a little quartz, numerous individuals of biotite, a little magnetite, sometimes enclosing pyrite, many small crystalline grains of apatite, and a very few small crystals of zircon.

The quartz grains are clear and glassy, and irregular in outline. The plagioclase, which is generally fresh, is sometimes twinned in broad and narrow bands, according to the Albite law, occasionally also according to the Pericline law. Cleavage is well seen in some cases, and extinction is inclined. This is labradorite, having a specific gravity of about 2.68 and an extinction angle, measured on the twin-lamellae, of 18. There is also a variety of plagioclase which is perfectly clear, and is untwinned. It has a specific gravity of about 2.65, and is probably andesine. The biotite occurs in elongated pleochroic individuals of brown color. It often includes grains of plagioclase, and not infrequently penetrates individuals of hornblende. This last-named constituent, which makes up about three-fifths of the rock, is present in various sized grains, often of irregular shape. It is dark brownish green in color, pleochroism is intense, and the maximum extinction angle is 30. It seems to be micro-poikilitic toward the feldspar, but this appearance is probably due to its irregular form, caused by interference while crystallizing.

Sometimes interpenetration of the grains, sometimes a mosaic effect is seen: the structure is granulitic to granular.

Quartz Diorite Gneiss, Township of Glamorgan, Range IX., Lot 8. (Section 1274).

This is a dark gray rock, fine-grained, foliated and banded, composite bands alternating with light colored and dark colored bands. Microscopically the foliation is shown extremely well by the parallel arrangement of the minerals.

The rock is found to be composed essentially of quartz, plagioclase, and hornblende, while in certain bands biotite is common, and in others microcline occurs. A very few individuals of orthoclase, a little sphene, with titanic iron ore, and a few small crystals of apatite are the accessory constituents.

The quartz occurs in large and small irregular grains, often cracked, or showing undulose extinction. The orthoclase is quite fresh, except along the cleavage planes where it is apt to be turbid. It sometimes shows parallel extinction, and is usually untwinned. The microcline is in irregular individuals of medium size. The plagioclase is oligoclase. It is sometimes turbid, and frequently cracked. It is well twinned in broad, narrow, and alternately broad and narrow bands, sometimes also according to the Pericline law. The biotite is in very elongated individuals, with cleavage distinct, and pleochroism very marked. In some cases it gives evidence of strain by the bending and crumpling of the plates. Lath-shaped individuals of this mineral frequently penetrate grains of hornblende. The hornblende occurs in large and small individuals of very irregular form. It is deep brownish green, with strong pleochroism, and an extinction angle of 28. The sphene is in small irregular masses, much cracked: pleochroic from nearly colorless to light brown. It often surrounds as a more or less even border, particles of black titaniferous iron ore, which is also found withou the sphene.

The structure is granular, approaching granitic, the grains partially interlocking and having very irregular outlines. The rock seems, in fact, to have approached very closely, both in structure and in composition, to the gneiss which lies near it.

Mechanical separations by means of Thoulet's solution were made of all the specimens. No attempt was made to separate the dark constituents, however, as a sufficient idea of their relative abundance could be had with the aid of the microscope. The following table, in which the figures represent percentage by weight, is arranged in order of the amount of basic constituents present. When the loss attendant on crushing (to 80-mesh) and washing of the powder, and the necessary error due to interposition of the constituent grains are considered, it is fully appreciated that the method by no means justifies the use of decimals, if, in fact, the units are reliable; but instead of making round numbers of them, it was thought at least as accurate, and perhaps wiser to record the actual results obtained. It may be noted that in the case of a crop of composite grains falling between the specific gravities of two minerals, half its weight was added to the weight of the crop of each mineral.

In the column at the left are the numbers of the different specimens, corresponding to the thin sections. In order to show the nature of the rocks without being obliged to turn back to the descriptions, the following symbols have been used :—

+ Gneissic Granite.
× Gray Gneiss.
± Altered Limestone.
* × Inclusion.

In the column under *Basic Constituents*, the different minerals are represented thus: A—Augite, B—Biotite, H—Hornblende; and where two minerals are present, B & H indicate that the two are present in about equal

Rock.	Basic Constituent.		Calcite.	Scapolite.	Labradorite.	Andesine.	Oligoclase.	Quartz.	Microcline.	Orthoclase.
1273 +	B	6.8	..	..	..	..	39.1	22.0	23.4	7.6
1268 ×	B<H	10.0	..	..	..	36.2	..	51.0	—	2.8
1271 ×	B	22.8	..	..	..	..	35.8	22.7	18.8	—
1275 ×	H & B	28.0	..	..	..	..	32.0	22.0	2.7	14.8
1274 *	B<H	32.4	..	..	..	..	40.5	20.7	6.4	—
1269 ‡	A>>H	34.0	12.4	3.5	27.0	..	25.1	2.0	2.3	..
1272 ‡	A<<H	57.9	8.1	26.4	5.4	..	..	2.8	..	..
1267 *	B<<H	66.5	..	..	19.0	14.5	..	—	..	—(?)
1270 ‡	A<<H	68.0	1.2	1.7	2.4	25.0	..	1.7	..	—

amounts, $B > H$, more biotite than hornblende, and $A << H$, much more hornblende than augite, etc. Wherever a mineral has been found, but in amount too small to determine quantitatively, a dash is placed.

In the granite, the gray gneisses, and sometimes in the inclusions, the feldspar is seen to be acid, while in the altered limestones and the other inclusions it is richer in lime, and consequently of higher specific gravity. Another noticeable fact is that as the amount of calcite—the remains of the limestone—decreases in the altered limestones, the augite, which is richer in lime, gives way to hornblende which is poorer; and in the rock containing the most hornblende, that is, the one farthest removed, as regards composition, from the limestone, orthoclase appears. The pyroxene is probably especially rich in lime in this case, since it is so pale in color. In the altered limestones, the color of the hornblende is not very deep green, indicating a high percentage of lime, but in the gray gneisses and inclusions it is generally quite dark, and often brownish, pointing to the presence of more iron, magnesia, etc. The range in the character of the inclusions is also noteworthy, one having practically the same composition as the gray gneisses, and another resembling the most basic or most altered of the altered limestones.

HYPOTHESES AND DISCUSSIONS OF THE ORIGIN AND RELATIONS OF THE VARIOUS ROCKS.

Further consideration of the genetic relations of these rocks may now properly be entered upon; and immediately are recalled the two questions proposed at the outset, viz., the origin of the basic rocks at the contact, and the real nature of the dark streaks and patches held by the gneissic granites. If these could be settled, the solution of the whole problem here involved would be well under way.

The first question may be still farther limited to this:

What is the source of the various basic silicates which make up the dark bands in the limestone? The principal materials which must have been added to the elements of limestone to produce the various silicate minerals observed in the altered limestones are: Silica, alumina, iron, magnesia, alkalies, and chlorine (for scapolite). As to the source of these materials, there are two possible explanations; either they existed in the limestone or in beds interstratified with it before the intrusions took place, and were subsequently metamorphosed and re-crystallized; or they have been derived in some manner from the substance of the intrusive mass. The question resolves itself, then, into one of metamorphism by diagenesis, or by metasomatosis.

It has been previously stated that the limestones are in general comparatively pure except as these igneous masses are approached. It may be noted in the first place that the peculiar manner of occurrence of these basic bands in the limestone is hardly in accord with the ordinary observed phenomena of sedimentation. Secondly, there seems to be no reason, supposing that the above mentioned materials, which may for the present be called impurities, were already contained in the limestone, why the igneous material should invariably choose just that locality for intrusion. And it is further impossible to see in the case of the pyroxene gneisses, how that supposition would account for the very general increase in the degree of metamorphism as the intrusion is approached, from pure limestones to such basic rocks. Moreover, if these impurities existed in the beds of the limestone in this region, it would be quite natural to suppose that other impurities, giving rise to different metamorphic products, might occur in other limestone regions similarly pierced by igneous intrusions. It will be shown, however, that such is generally not the case.

Too much importance can hardly be attached to the presence of certain of these minerals in this class of rocks. Scapolite has repeatedly been recorded in metamorphic zones in limestones cut by granite and other igneous rocks.[1] Several workers in the limestones of the Adirondacks have mentioned their great similarity to those of the Grenville Series of Canada,[2] and Van Hise goes so far as to suggest that they are identical. Now in these limestones of New York occur very analogous intrusions of igneous rocks, and the result are contact zones similar in nearly every respect to those under consideration here. Smyth[3] has remarked upon the presence of scapolite as a characteristic mineral in these zones, and Kemp says:[4] "Contact masses of silicates similar to those above described (scapolite, sphene, hornblende, augite, etc.) are characteristic of not a few exposures of white crystalline limestone in this eastern part of the United States, and always near them the igneous intrusions are found. Scapolite is especially characteristic of such, and invariably with it are hornblende, pyroxene, and titanite." And he continues: "In many places the contact effect of these intrusions on limestones *are so similar*[5] that one is inclined to suspect the near presence of igneous rocks wherever these contact minerals, and especially scapolite, are reported in limestones."

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1. Adams, F. D. and Lawson, A. C., "Some Canadian Rocks containing Scapolite," Can. Rec. Sci., 1888, Vol. III., p. 201.

Nason, F. L., Ann. Rep't. State Geologist of New Jersey, 1890, pp. 32-33.

Kemp, J. F., Trans. N.Y. Acad. Sci., 1893, Vol. XII., p. 74.

Zirkel, F., "Beitrage zur Kenntniss der Pyrenaen," Zeit. d. d. geol. Ges., 1876, Vol. XIX., p. 68 et seq.

Lacroix, A., "Description des Syénites néphéliniques de Pouzac, etc.," Bull. Geol. Soc. de France, 1890, p. 511.

"Contributions à l'etude des gneiss a pyroxene et des roches a wernérite," Bull. Soc. Franc. de Min., 1889, Vol. XII.

Frossard, C. L., "Sur les Roches metamorphiques de Pouzac etc." Comptes Rendus, 1890, Vol. CX., p. 1013.

2. Kemp, J. F., "Gabbros on the Western Shore of Lake Champlain," Bull. Geol. Soc. Am. 1893, Vol. V., p. 214.

"Crystalline Limestones of the Eastern Adirondacks," loc. cit. Van Hise, C. R., "Correlation Papers, Archaean and Algonkian," Bull. U.S.G.S., No. 86, p. 508.

Smyth C. H., jr., loc. cit., p. 266.

3. loc. cit., p. 279.

4. "Gabbros of Lake Champlain," loc. cit., pp. 223-224

5. The italics are the present writers.

Smyth[1] says of these intrusions that the position of the zone of extreme alteration, following all the irregularities of the contact between the two formations, is sufficient proof that it has been formed by the action of the one on the other. This action, he says, can be explained in no other way than as a case of contact metamorphism resulting from the intrusion of the igneous rock into the limestone. This conclusion is entirely supported by the mineralogical composition of the contact zone, as the species named, scapolite, hornblende, augite, titanite, etc., are all recognized contact minerals, especially in limestones.

Furthermore, there seems no reason why metasomatism should not have taken place in this occurrence as well as it admittedly has in other regions. Many instances of this kind could be cited. Among the notable ones are the metamorphism of mica schists by plutonic intrusives in south-eastern New York,[2] and near Klausen[3] in the Tyrol, which have been noted by Rosenbusch[4] as presenting very similar phenomena: the contact of limestone with monzonite at Predazzo,[5] and of the limestones of Ramsberg in the Hartz[6] with granite, in both of which cases broad zones of lime silicates have been formed; and perhaps one of the most striking instances of metamorphism is that of the Albany Granite[7] in New Hampshire,

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1. loc. cit., p. 279.
2. Williams, G. H., "The Contact Metamorphism Produced in the Adjoining Mica Schists and Limestones by the Massive Rocks of the 'Cortlandt Series,' near Peekskill, N.Y.," Am. Jour. Sci., 1888, Vol. XXXVI., pp. 254-268. On page 267 he describes a dyke which is so narrow that the result of the whole action can be viewed at once under the microscope, and there can thus be no doubt as to what has occurred. The dyke cuts and alters limestone, and colorless pyroxene is one of the minerals produced in the latter. Reference will again be made to this example. About a dyke in another place, pyroxene, hornblende, sphene and quite abundant scapolite occur.
3. Teller and von John, "Geologisch-Petrographische Beitrage zur Kenntniss der Dioritischen Gesteine von Klausen in Sudtirol," Jahrb. der K.K. Geol. Reichsanstalt, 1882, Vol. XXXII., pp. 589-684.
4. Rosenbusch, H., "Mikroskopische Physiographie der Massigen Gesteine," 3rd ed. Stuttgart, 1896, p. 263.
5. Lemberg, J., Zeit. d. d. geol. Ges., Vol. XXIV., p. 231.
6. Lossen, Ibid., p. 777.
7. Hawes, G. W., Am. Jour. Sci., 1881, Vol. XXI., pp. 21-32.

where a granite intrusion has caused profound chemical change in dark argillitic mica schists.

It seems to be a prevalent idea that *basic* magmas frequently produce such metasomatosis, but that the only effect of *granitic* intrusions, aside from insignificant exhalations in the way of boron and fluorine compounds, is diagenetic. It is possible that granites produce chemical change less frequently than more basic intrusions, but that they do produce such change in some cases is beyond all doubt when it is considered that several of the articles referred to have been based on careful chemical investigation of the intrusive, the rock penetrated, and the resulting contact zone. Hutchings[1] concludes that in many such cases there has been a transfer of material from the intruding rock to that which it metamorphoses, a transfer which is often large in proportion to the relatively small masses of igneous rock concerned in it.

Kemp and Hollick have described an intrusion in southern New York which is remarkably similar to this one. They say:[2] "Interesting and marked changes manifest themselves in both granite and limestone (near the contact). In general it may be said that either the former becomes an aggregate of light green monoclinic pyroxene and scapolite, or we find a granite-like zone formed between the two." "In résumé[3] of these contacts it may be said that the (hornblende) granite becomes richer in pyroxene as they are approached. . . . Along the contact is the 'scapolite zone' consisting of coarsely crystalline scapolite and malacolite. Next comes the coarsely crystalline limestone charged with the aggregates of silicates mentioned above"—pale pyroxene, green hornblende, scapolite, titanite, etc. And finally,[4] "those

1. "Notes on the Composition of Clays, Slates, etc., and on Some Points in their Contact Metamorphism." Geol. Mag., Decade IV., Vol. I., p. 74.

2. loc. cit., p. 644.

3. loc. cit., p. 647. 4. p. 649.

scapolites that are disseminated in the limestones in the bunches of silicates are doubtless due to solutions stimulated by the intrusive rocks." It may be added that metasomatic action is especially favored as an accompaniment to deep seated intrusions such as this Central Ontario occurrence undoubtedly was,—where the vapours and solutions cannot readily escape.

From these considerations, from their petrographical character, and from their relations in the field, it seems certain that the pyroxene gneisses are in reality altered limestones, that they are the product of metasomatic metamorphism of these limestones by the granite intrusions.

Regarding the amphibolites, the evidence is less conclusive. Dr. Adams has found bands of amphibolite which it is certain have been produced exclusively by the alteration of diabase dykes; and it is also certain that there are bands of amphibolite in the limestone away from the intrusions. These facts concerning the amphibolites, added to their probable lower content of lime and their sharper demarkation from the limestones, as compared with the pyroxene gneisses, admit of a lingering belief that none of the amphibolites were produced by metasomatic action, but that they all existed in something like their present condition in the limestone before the intrusion took place.

But their increased number within the area of metamorphic action, added to their frequent marked similarity in many respects to the pyroxene gneisses, render the support of such a belief, in the writer's opinion, very feeble: it seems highly probable that many of these amphibolites have originated in the same way as the pyroxene gneisses — that they are simply more highly altered portions of the original limestone. One thing which may account for the formation of amphibolites in one case and pyroxenites in the other is that where the amphibolites now occur might have been bands of the limestone especially favourable to the passage and action of the exhalations and solutions accompanying the magma, while where there are now the pyroxene gneisses, there were, before the intrusion, bands of the limestone which were less permeable, and in which, therefore, the addition o material was smaller and the transformation less complete. On this ground also, the presence, close to the contact, of bands of comparatively unaltered limestone would be due to the fact that they were particularly impermeable to the metamorphosing agents.

Coming now to a consideration of the true character of the so-called inclusions, there are found to be two possible explanations of that question also. Either these dark streaks and patches are basic secretions of the molten magma itself, or they are, in reality, fragments of the limestone series which have been detached and floated off from it.

The increasing approach of the rock of these masses to granitic structure and composition from the contact inward, the often-times sudden change from the true rock of the batholite to these highly basic streaks, their increasing basicity and angularity of form near the contact—in fact, the field relations generally, as well as the microscopic characters, favor the idea that they are actual fragments of the limestone series, included by the granite magma, and by it still more highly metamorphosed than their parent rocks, though possibly in a somewhat different way. The same conclusion has been reached in some similar occurrences. [1]

If this be the case, however, it may be pertinently asked why it is that although the rocks at the contact contain a basic feldspar and pyroxene and scapolite, those

1 cf. Lacroix on the Pyrenees; see Adams, F. D., "The Excursion to the Pyrenees in Connection with the Eighth International Geological Congress," Jour. Geol., 1901, Vol. IX., pp. 31-32.

of the inclusions often hold a more acid feldspar, contain no scapolite, and in place of the lime-rich augite, contain more hornblende and some biotite. That is a vital question, indeed, and unfortunately, it is a particularly difficult one to solve, especially in the absence of chemical data.

Dr. Adams thinks there may be a transition in the inclusions near the contac' from the one composition to the other, but if so, that is very abrupt. The occurrence of labradorite in some of the most basic of these inclusions supports this idea. And at any rate, at least four theories can be advanced to explain the differences between them and the altered limestones; they are:—

1. That the same metamorphic forces, viz., heat, pressure, emanations such as vapors and heated solutions, etc., acted upon both classes of rocks, and that the differing results are due to the difference in degree and length of time in which these forces acted. It seems obvious that the action would be more intense and more prolonged in the magma itself than about its edge.

2. That the same forces acted possibly also, as in (1), to a different degree and for a different time, but in the case of the contact zone, in the presence of an excess of limestone, and in the case of the inclusions, in the presence of an excess of granite; thus in the first case the tendency would be for any minerals to become richer, and richer in lime, while in the second case, the lime which the minerals held would be more and more diluted, so to speak, by accessions of more silica, alumina, iron, alkalies, etc., from the granitic magma.

3. That different forces acted on each class of rocks; that those of the contact zone were subjected to exhalations and solutions from and accompanying the intrusion, but that those of the inclusions were subjected to quite a different influence—that due to the direct action of the

molten mass itself. In reality this theory does not differ greatly from the second.

4. This is, in part, a combination of the three preceding. It has already been shown probable that the movements which took place throughout this whole area occurred during the recrystallization of the rocks. To stretch this point somewhat, it is possible that many of the fragments which now form the inclusions were broken off and floated into the igneous mass after some metamorphic action had taken place at the contact. Thus, instead of receiving fragments of practically unaltered limestone on which to act, the magma had already had part of its work done for it at its periphery, and thus the final effect on these fragments would be much greater than on the rock which remained at the periphery. Further, if there were any difference in the influences acting at the border, and within the mass, respectively, it would make its effect manifest here.

While it is at present impossible to decide even which of these theories is the most probable, it may be that with further study, one of them will be found sufficient to account for the difference in character of the metamorphosed limestones at the contact of the intrusion, and those fragments which have been included by it.

In mentioning the possible causes of all these phenomena, on a previous page, and having noted the intrusion of *new igneous material and the refusion of the underlying Fundamental Gneiss* as two of these, it was stated that there is still a third explanation possible. This is to be found in the views of certain of the French geologists regarding *the origin of granite intrusives* and their relations to the rocks penetrated.

Michel-Levy[1] was one of the first of these to state it as his belief that the origin of the so-called primitive

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1. "Sur l'origin der terrins crystallins primitifs." Bull. Soc. Geol. de France, 1887 Vol. III., p. 103.

rocks was due to the intrusion of igneous material into true sediments, which thereby received the addition of an immense amount of material, the metamorphism having been intense, and essentially metasomatic. This process he calls *granitization*, and the original sediments are said to be *granitizé*. In a later paper,[1] he describes the three-fold manner in which this res [illegible] as accomplished:—

1. By injection of molten granitic material between and around the fragments of the more or less shattered margin of the penetrated rock, and as thin layers along its foliation or lamination planes—*lit par lit*. This causes intense metamorphosis of the rock and gives to it a granitic character.

2. By action of heated mineralizing solutions carrying the essential elements of quartz and feldspar. In some manner, which he does not make very clear, these solutions penetrate the altered rock and cause the quartz and feldspar to crystallize through it.

3. By actual solution of the penetrated rock in the granite magma.

A number of workers on the geology of Mont Blanc record similar conclusions.[2] Their belief[3] opposed to the supposition of Suess that granite fills great cavities in the crust of the earth which have resulted from tangential stress, thus giving rise to batholites—is that "the granite magma first rises along lines of fracture in the crust. Its presence leads to a heating of the rock into which it is injected, and its intrusion accompanied by a *circulation intense* of mineralizing fluids, probably rich in alkalies. These produce at first a transferrence of quartz from one

1. "Contribution à l'étude du Granite de Flamanville, et des granites Français en général." Bull. des Services de la Carte Géol. de la France. No. 36, Paris, 1893.

2. Duparc, L. and Mrazec, L., "Nouvelles Recherches sur le Massif du Mont Blanc." Archives de Sci. Phys. et Nat., 1891, Vol XXXIV.

Duparc, L., "Le Mont Blanc au point de vue geologique et petrographique", ibid 1896.

Vallot, J., and Duparc L., "Sur un synclinal schisteux ancien formant le coeur du massif du Mont Blanc", Comptes Rendus, March, 1896.

3. Duparc and Mrazec, loc. cit.

part of the mass to another, and the development of biotite, which is a marked feature in contact zones. Then follows 'feldspathization' which commences by the development of little strings of quartz and feldspar, following for the most part the schistosity of the invaded rocks, and which grow in size until the whole mass of schist is transformed into granite, the texture of the schist being broken down and its elements set in motion to form with the transfused material new combinations. The granite magma or emanations thus slowly dissolve, alter, or incorporate * * * the wall rock, transforming it first into a gneiss, then into a gneissic granite, and finally into a granite. The original intrusion thus slowly enlarges its boundaries and increases its volume—eats its way into the surrounding rocks and develops itself largely at their expense.

"This process, we are told, is at work wherever granitic magmas come in contact with clastic rocks in the deeper parts of the earth's crust, and it is thus that the crystalline schists are produced." [1]

Horne [2] and Greenly in Great Britain apparently also reach similar conclusions, and they describe a case where the foliation of an intruding granite is due to a retention of the original foliation of the invaded rock.

In certain parts of the French Pyrenees are intrusions of granite into limestone, similar in nearly every way, apparently, to those herein described. Lacroix, [3] however, explains their phenomena by this same theory of "granitization" and "feldspathization". He claims that the granite dissolves the limestone to form a diorite, and that, so long as the igneous forces continue active, the invading mass advances and enlarges, surrounded by an ever-

1. Adams, F. D., "Some Recent Papers on the Influence of Granitic Intrusions on the Development of Crystalline Schists", Jour. Geol. 1897, Vol V., p.296.

2. "On Foliated Granites and their Relation to the Crystalline Schists in Eastern Sutherland", Q. J. G. S., 1896, Vol. LII.

3. Le Granite des Pyrenees et ses Phenomènes de Contact". Bull. des Services de la Carte Geol. de la France, No. 64.

widening zone of metamorphosed limestone. He says[1] "La mise en place du granite s'est effectuée par dissolution graduelle des roches sedimentaires dont il occupe la place". "L'évidence[2] de la transformation du granite par dissolution du calcaire est complète". In a thin section from south-eastern New York, described by Williams[3] and already mentioned, where a narrow dyke cuts limestone, the nature of the igneous rock is considerably modified and can be seen to have become enriched in lime from the limestone, while this latter, on the other hand, has derived silica, alumina, iron, etc., from the material of the dyke.

Of so-called intrusions in the granite, Lacroix says:[4] "Je considère donc, toutes ces couches metamorphiques isolées aujourdhui au millieu du granite comme le résidue non digéré des assises sédimentaires dont le granite a pris la placé." This may have an important bearing on the gray gneisses or quartz diorites which occur throughout these granites in Ontario.

If these views are correct, they would serve to explain nearly every phenomenon observed in this occurrence in Central Ontario. But the great weakness in them is the lack of chemical proof. Till that is at hand, it may be said that "while the transfusion of a certain amount of material into the limestones along the immediate contact of the intrusions, and also a solution of the limestones to a limited extent in certain cases seems highly probable, the wholesale transformation of limestone into diorite, or of shale into gneiss and granite—is as yet very far, indeed, from being proved."[5] It may be said in their favor however, that as the study of this area has gone on, these views have come to appear to the writer, at least less and less irrational.

1. Ibid., p. 3. 2. Ibid., p. 60. 3. loc. cit., p. 267.
4. Livret Guide, p. 15, see Adams, "The Excursion to the Pyrenees," loc. cit., p. 42.
5. Adams, F. D., "The Excursion to the Pyrenees," loc. cit., p. 46.

SUMMARY.

In the writer's opinion, the following conclusions may be drawn from the foregoing pages:

The district exhibits a development of Grenville limestone pierced by intrusions of gneissic granite which contain masses of dioritic rock.

Considerable deformation took place during the intrusion.

Between the limestone and the granite is a highly brecciated zone, holding large amounts of lime-rich silicates which are eminently characteristic of contact metamorphism.

Diagenesis took place.

To a great extent, however, the elements, other than the lime necessary for the formation of these minerals, came from the intrusion and its accompanying exhalations.

The metamorphism, then, was largely also metasomatic.

In the gray gneisses and in the granite are dark basic masses which represent fragments broken off from the limestone series and floated away into the igneous mass They have been still more highly metamorphosed than the rocks from which they came, and have been more or less dissolved and changed in character by the granite. In other words, they have been partially "granitized."

The gray gneisses, which have the composition of quartz diorites, may represent an intermediate phase of this "granitization"—between the inclusions and the granite. This theory may account for the large amount of plagioclase feldspar found in the granite itself.

Dr. Adams is now making a more extended examination of the rocks of this area, working on a greater number of specimens, from a wider range of localities, and it is expected that his studies will throw additional light on the actual processes which have been at work.

Petrographical Laboratory.

McGill University, Montreal.

A Sketch of the Progress of Botany in the Nineteenth Century.

Being the Substance of the Somerville Lecture delivered on March 13, 1902, and now published at the request of the Natural History Society.

It is not claiming too much for Botany to say that it kept pace with the most progressive of the Sciences in the last hundred years. Its domain during that period was vastly extended both from a theoretical and practical point of view. Botany as we now know it has, indeed, been largely the product of the nineteenth century. If we look into systematic treatises on the science published a century ago, or into the Botanical Journals of that period, and compare them with those belonging to the present day, we are struck with the very great difference between them, and conclude that Botany occupies quite another plane from that on which it stood at the beginning of the last century. Then the main object sought was the collecting and identifying of plants and discussing their geographical distribution; and attention was confined mostly to the phanerogamous families and to the outstanding features of plants. When a treatise on Botany of our time is taken up, or a Botanical Journal is examined, it is found that the starting point of the study of the science is entirely altered, and that the differentiation of the science is carried into the minutest details.

In 1801, the artificial system, founded by Linnæus, was still in vogue; and there were enthusiastic collectors working away in accordance with it, constantly adding to the number of determined species. But the limitations of the Linnæan system hampered progress. It was found inadequate for classifying the lower forms of life, as they came to be more fully known and needed to be dealt with.

The first very important step in advance was, therefore, taken when the Natural System of De Jussieu was substituted for that of Linnæus. Under this system, which was communicated in 1789, the entire structure of a plant and its affinities, and especially its form of fructification, are taken into account, as well as the number of its stamens and pistils, in determining its place in *nature*. The essential elements of the great work done by the distinguished Swedish naturalist have not been superseded, but form,—so far as the nomenclature of Genera and Species is concerned,—the basis of the new departure. The influence of Linnæus and his reputation as the founder of modern Botanical Science have suffered no eclipse from the changes and additions since made to it. Even long after De Jussieu's system began to commend itself, that of Linnæus continued to have its champions. For instance, the great English publication of Smith and Sowerby, begun in 1790, and extending to thirty-six volumesissued at intervals, retained the old system, even in a second edition which was completed only in 1846. Smith's "Flora Britannica," 1800–04, as well as his "English Flora" of 1823, was also constructed on the Linnæan system. William Hooker's "Flora Scotica," published in 1821, was the first work on Botany according to the new system issued from the British press. It was followed on the same lines by Lindley's "Synopsis of the British Flora" in 1828; and all subsequent publications in Great Britain have accepted and worked upon the plan laid down by the French naturalist. The system of De Jussieu was modified and improved by the labours of De Candolle, Mirbel, Lindley and Robert Brown.

The earliest students of Botany in North America—Kalm, Michaux, Muhlenberg, Pursh, Eaton, Houston and Clayton—presented it in accordance with the Linnæan system. But Professor Torry, who had been a student under Eaton, became converted to the Natural System, and he and his pupil, Asa Gray, laid the foundation of

North American Systematic Botany, by issuing as their joint work the "Flora of North America," between 1838 and 1843. The publication embraced the Polypetalæ and the Gamopetalæ, to the end of the Compositæ; and it was not till 1878 that the remainder of the Gamopetalæ was published by Dr. Asa Gray. In 1840 Sir William Hooker gave to the world his great work, "Flora Boreali Americana," in which he recorded all the knowledge then reached of the species of our Continent and of their distribution, gathered from early travellers and explorers.

Up to this period many individuals were at work on the Continent of Europe, in Great Britain and in North America, collecting and classifying species, and numerous publications issued from the press, some of them of a popular description, which created a widespread interest in Botany and disseminated information on the subject. The Hookers, father and son, who were successively superintendents of the Royal Gardens at Kew, took the lead in this good work in Great Britain, and they were aided by Balfour, Arnott, Babington and Bentham.

But a new era for the science was at hand, and as a contributory cause to its introduction were the improvements made upon the microscope. Difficulty had long been experienced in the use of lenses of great magnifying power, on account of the breaking up of the rays of light into their elementary colors. The invention of achromatic microscopes removed this obstacle. Professor Amici, of Modena, found, in 1812, that by combining concave and convex lenses the colour aberrations could be checked, and since his day improvements have gone on, until now the highest magnifying powers can be used in examining minute objects and yet a true image of them be secured.

Another factor contributing to the advancement of Botany during the past century ought to be mentioned; that is the policy of the governments of all civilized countries in instituting national surveys for the purpose of ascertaining the natural resources of the territories subject to them. Men of competent attainments have been at work under them on all departments of National History, and in the reports submitted by the botanical experts employed very full information has been obtained as to the Flora of the several countries of Europe and America, as well as of the British possessions in the Pacific, in Asia and Africa. In addition, the British Admiralty has helped materially in this good work by having naturalists attached to its ships at different times, who made collections of the Flora as well as the Fauna of the various regions visited. Parry's and Sir John Franklin's voyages,—Beechey's voyage to the Pacific and Behring's Straits, and the Antarctic voyage of the Erebus and Terror, all furnished valuable materials which were used to purpose by Sir William Hooker. It was as a Naturalist accompanying Captain Fitzroy on the surveying voyage of the Beagle, from 1838 to 1843, that Charles Darwin laid the foundation of his reputation as the first man of Science of the nineteenth century. Professor Huxley, in like manner, accompanied the "Rattle-Snake" with Captain Strachey's expedition to the Southern Pacific Ocean; and Professor Wyville Thomson went as scientist with the "Challenger" on its Deep Sea exploring expedition. No country has pursued a more enlightened policy as regards ascertaining what its natural resources are, than the United States of America. Not only the Federal government but also the several State governments have their full staffs of scientific workers, reporting on the Flora of the country, as well as on its Fauna and Geology. Canada has followed suit, but certainly not with the enthusiasm and efficiency of equipment exemplified by our neighbours. Yet, though the amount spent upon reporting on the botanical productions of Canada has been too meagre, excellent work has been done with the resources placed at the disposal of the Geological

Survey for this department. Professor John Macoun and his son, James M. Macoun, who are exceptionally gifted with botanical instincts, have given a good account of themselves, and are still busily engaged in adding to the list of plants that have been discovered within the limits of the Dominion. Macoun, the elder, was one of the men to whom the advent to Canada of Professor George Lawson, a pupil of Dr. John Balfour, of Edinburgh, proved an inspiration. He had been previously trying to work away with a most imperfect apparatus, making collections in the central part of Ontario, and identifying them as best he could, when he learned of Dr. Lawson's appointment as Professor of Natural History at Queen's College, Kingston. He was not long in making the acquaintance of the Professor, with the result that he was put in the way of acquiring that practical mastery of the subject which he has since displayed. It was not to Mr. Macoun alone that Dr. Lawson proved a stimulating teacher. He imparted an impulse to the study of Botany throughout Canada, so that in many centres,—in Montreal among the rest,—about the year 1860, there was more enthusiasm over this subject than had been before or has been, perhaps, since.

And this brings us to the date at which both Botany and Zoology entered upon a new stage of progress. It was in the year 1859 that Charles Darwin's epoch-making work, "The Origin of Species," was given to the public. I can recall, as if it were yesterday, the sensation which it at once created in scientific, literary and theological circles, in Canada as well as elsewhere. Every reader was charmed with the glow which warmed and lighted up the pages of this book, and admired the diligence and patience of the author, in the accumulation of the facts from which he inferred his inductions, as well as the modest way in which he formulated his conclusions, so as to shock as little as possible those who might be indisposed to accept his views. His main thesis was that nature makes a selection out of the different animals and plants that come into existence, there being a struggle for continuance among them, with the result that the fittest survive—namely, those forms which are best adapted to the several situations in which they find themselves—and these perpetuate the best modifications of an organic form, leading progressively to improvements which, in time, amount to the creation of a form so changed that it may be denominated a new specific type. He laid great stress on the variability, occasioned by the direct and indirect influence of the external conditions of life, or by use or disuse, along with the fact that many more seeds germinate and plants start out in life than have room or opportunity to grow to maturity. As a consequence, only a few survive, and those few, he held, must possess a fitness for the situation in which they continue; and this special quality of theirs, being exercised in constant competition, gradually acquires greater strength and prominence, while inherited qualities that are not used in competition become less prominent through disuse. The ill-adapted and less vigorous species or individuals perish in the struggle. This theory, when applied and carried backwards, he suggested, might be held to account for the derivation of all existing specific forms from one or more primitive forms.

About the same time, Alfred Russell Wallace, of London, England, formulated similar conclusions. It is rather a curious pschycological phenomenon, which finds frequent parallels in history, that two minds working independently, and even unknown to each other, should have arrived at the same result about the same time, as if there were influences at work in the air, as we say, environing circumstances and conditions leading up to this issue.

The idea of evolution, or the derivation of all existing forms and modes out of older ones, was no new one.

Lamarck in France, and Treviranus in Germany, about 1802—another noticeable coincidence—suggested that the present forms of life might be accounted for on the principle of derivation from simpler ones. Dr. W. C. Wells, in 1813, and Patrick Matthew, in 1831, asserted the principle of natural selection. Goëthe, the German poet-philosopher, not as the result of Natural History Studies, but from a comprehensive survey of the universe, also believed in evolution. All the naturalists mentioned above, Darwin included, found most of the illustrations in support of their views in the animal kingdom, because the operation of the influence of environment is more easily traced and followed among animals than among plants. Yet they did not exclude the vegetable kingdom from the scope of their theory.

In support of the theory they called attention to the striking fact that the original form of all organisms is one and the same, and that out of this one form all—the lowest as well as the highest—are developed in such a manner that the latter pass through the permanent forms of the former as transitory stages. "From this, they concluded, the presumption is that there was a period when the lowest only existed. It was further noticed that both in animals and plants rudimentary organs are found," which appear to play no part whatever in the economy of the structure, and from this the inference was drawn that they are remnants of a former structure which has not undergone modification because of the disuse of the rudimentary organ.

The scientific world was much divided as to the legitimacy of Darwin's conclusions at the time of their promulgation—the major part being sceptical, while some gave them a partial adhesion, and others suspended judgment. All, however, admitted the singular clearness and ability with which he made his points. Asa Gray was cautious. He was prepared to admit that variation might be operative along useful lines. Naëgeli's criticism was that the acquisition of characters, without any apparent usefulness in waging the warfare for existence, created a difficulty in the way of accepting the theory of natural selection. He thought the teleological argument, namely, that the plant was striving after perfection, was better supported by the facts pointed out. Mivart held that variations were definite, and often sudden and considerable, which made against the theory of imperceptibly slow variability and development from it. Others pointed out that natural selection trusts to the chapter of accidents in the matter of varieties, and asked how we get the variations without which natural selection would have nothing on which to operate, the survival of the variations being a matter really only secondary to their origin. It was pointed out that many plants of wide range and great diversity of experience remain uniform in character. Then similar modifications are seen suddenly to occur under different conditions, while, on the other hand, different modifications are found under similar conditions. Even Huxley, who was one of Darwin's warmest supporters, made the admission that nature "does make considerable jumps in the way of variation now and then, and that these saltations give rise to some of the gaps which appear to exist in the series of known forms." George J. Romanes, in criticising Darwin's main position, laid stress on the difference between species and varieties, in respect of mutual fertility, and he held that this fact made against the probability of any variety prevailing over an existing species. He held that in the process of free crossing the individual variety would be surely swamped. He also dwelt on the inutility to species of a large proportion of specific distinctions. His general conclusion from the facts presented by Darwin was that it was an accumulation of adaptations, not new species, that resulted from the struggle of existence. Herbert

Spencer, not as an expert naturalist, but as a logician and philosopher, having the facts before him, while avowing himself an evolutionist, thought that environment and functional use were far more influential than variation. Other thinkers also demanded that the term "fittest" should be defined. What was *a priori* to be regarded as fittest? They pointed out that Darwin reasoned in a circle—his whole argument assuming that that was fittest which survived. Not always the strongest and likeliest individual, they showed, got a chance to survive. The porpoise, when the opportunity presents itself, seizes the biggest, not the smallest herring; and the moth in selecting a cabbage leaf on which to lay its eggs, alights not on the worst in the garden. Darwin admitted in a later work that he probably attributed too much to the action of natural selection, or survival of the fittest. Speaking of structures now useless, he said, "such structures cannot be accounted for by any form of selection or by the inherited effects of the use and disuse of parts." He yielded up to criticism that his principle was less important than he had thought it. It is still a disputed question whether variations are insensibly minute or saltative, nor is it settled whether they are impressed upon the organism by influences exerted from without, or from causes operating from within the germ cell.

The general outcome of the discussions which took place in scientific circles undoubtedly was to gain many disciples to the side of evolution. Huxley, *Wallace and Spencer held to it. Tyndal, the great physicist, became a champion of the theory. It was he who, in his famous Belfast address as President of the British Association,

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*Dr. Wallace, now in his eighty-first year, has gone back from evolution pure and simple and entirely dissents from the views of Herbert Spencer and others who hold that man's natural and moral nature is the product of force alone. He declares his belief in the spiritual nature of man and holds "that we possess intellectual and moral faculties which could not have been developed by natural selection, but must have had another origin; and for this origin we can only find an adequate cause in the universe of spirit."

gave eloquent utterance to his belief in the ancient Lucretian philosophy, "that matter has in it the promise and potency of all life." This was the main contention of the well-known work, "Vestiges of Creation," which had long before been issued anonymously, the authorship of which was avowed by Robert Chambers, of Edinburgh, before his death. The alleged facts and arguments by which the theory as to spontaneous generation was supported in that treatise had been thoroughly exploded. But Professor Haëckel, of Germany, a well-known monist, the most thorough going of Darwin's disciples, contends for the position that all atoms are living. To combat this theory was the task Professor Rucker, President of the British Association, set himself at Glasgow, in September, 1901, which he was thought to perform successfully. For many years the meetings of the British Association were made the battle-ground around which the doctrines of evolution were fought. I have mentioned its champions. On the other side there were such stalwart men of science as Lord Kelvin, Professor Virchow, Professor Clerk-Maxwell, Professor Agassiz, Professor Clifford, Professor Sidgwick, Sir George Stokes, the late Duke of Argyll, and Sir William Dawson.

Outside of scientific circles, the great mass of men, so far as they apprehended the matter at all, remained incredulous. They see that all life now proceeds from foregoing life and takes the form substantially of that from which it originated—like begetting its like. And as to the fact that all life starts from protoplasm, they asked how is it that one specimen of protoplasm tarries at the stage of a structure of cellular tissue only, while another goes on developing until finally a man is produced? The reason of course is that each had a germ in it of the old structure from which it got its start, into a new specimen of which it afterwards developed. The common sense of mankind asked, why should all these graded forms of life be contemporaneous if there has been evolution from the lower to the higher? If the lower had ceased to exist when the higher were developed, color would be lent to the theory that the higher evolved from the lower; but the co-existence of an infinite series of beings, ranging from the micrococcus up to man, the lord of all things visible, all starting from the simple cell, satisfies the ordinary observer and thinker that the presumption is that things have gone on as they are now going, since both the higher and the lower started out on their career in the present conditions. Especially does the inertia of the popular mind present a stolid obstacle to the Darwinian theory when men of science speak of the countless millions of years needed to bring the phenomena of nature up to the present stage of the universe. The inability to grasp a situation thus conditioned produces a state of mind which amounts to incredulity.

Twenty years ago it was the vogue for a person claiming to have the scientific spirit to profess adherence to the views of Darwin, but during the two last decades of the century a reaction set in, so that even Professor Häeckel in a recent work, "The World Riddle," laments over the fact that practically all his former pupils and disciples, who have attained prominence in Germany, have repudiated his Darwinian views. The number of naturalists who oppose it, either *in toto* or at least in its original form, is constantly on the increase, in the old world. One used to hear it said that there was not a naturalist of any considerable repute who was not an evolutionist, but that can no longer be said. Indeed, it ought not to have been said at any time, when, men like Virchow and Agassiz rejected the entire Darwinian hypothesis. However, it is not a question that is to be settled by counting heads or citing names. Heads and names were against it in 1859 and it looks as if they would ere long be against it once more. At all events, science ought not to be dogmatic; for we may assume that our present outlook will be left as far behind, at the close of the twentieth century, as the science of a century ago has been left behind by the well ascertained knowledge of to-day. One of the most recent German writers, Professor Zöckler, speaking of Darwinism, says that the process of disintegration has already to a great extent undermined the theory and shown its weakness. So great is the difference between the original Darwinian position and the substitute that is now taking its place that the resemblance can often be scarcely recognized. The biology of the future, he predicts, will practically contain nothing of the one-sided monistic form of the development theory, as formulated hy Darwin and Hàëckel, notwithstanding the loud and long protests of the followers of the latter to the contrary. Professor Zöckler quotes as the best statement of the present status of the theory the recent work of the Wurzburg philosopher, Dr. Stölzle, on "Kölliker and his relations to Darwinism." Kölliker, who is eighty-four years of age, and a veteran authority in his branch, is, on all real points of issue, against the English naturalist. His opposition is chiefly on these points:

1. Darwinism does not explain the connection and harmony of the different classes of organisms.

2. Its utility principles do not explain the phenomena for which it aims to account.

3. The absence of real transitions of one species to another in our day, or in former days, as for as we can trace, is an element of weakness

I have dwelt at length on this subject because the publication of Darwin's "Origin of Species" was the beginning of a new era in biological study, and whatever estimate may be formed of the theory which goes under his name, both his spirit and his methods were admirable. He went to work in the true scientific way, and the temper of his writings was marked by moderation, as well as by a sincere desire to get at the truth. The researches and speculations to which his book gave birth imparted a mighty influence to the study of all forms of life. One immediate result was that greater attention than they had hitherto received began to be bestowed, on the beings lowest in the scale. In consequence, the methods of botanical study have been revolutionized. The microscope plays now the leading part in every botanical laboratory; and evolution has proved a good working theory. Recent treatises on Botany begin with the study of embryology, dealing with the simplest forms of plant life, and work upwards to the most complex. Whatever one's views of evolution may be, this is clearly the most advantageous as well as most philosophical starting point for the student. The researches of the last forty years have brought to light innumerable forms of minute vegetable organisms. Of diatomaceæ, for instance, there were known only about fifty species in 1800,—now four thousand at least have been differentiated on the Continent of Europe alone. A new world of fungal species, called bacteria, has been discovered, and in some of these mankind has a serious interest. That fell disease consumption is now known, since Koch traced it in 1882, to originate in the ravages of a fungus in the lungs,—*bacillus tuberculosis.* Pasteur diagnosed the malady Hydrophobia, tracing it also to a *bacillus.* Diphtheria, in like manner, is now known to be caused by a microbe, *bacillus diphthericus.* Erysipelas too takes is rise from the working of a fungus. So also does malarial fever, and the curious fact has been established that it is projected into the human system by the action of a female mosquito,—taken from one person and communicated to another. The processes of fermentation and putrefaction,—and the familiar experience of milk's turning sour in hot weather,—are all traceable to the action of fungi, so minute that a microscope is needed to discover them. Nor can you turn to a species of plant of the higher forms, but has its own parasitic fungus. Fungi are everywhere, and the section of Botany dealing with them offers scope for diligent work to the student. There is a wide field for research in this quarter.

One might be tempted to dwell on botany's affiliations with other branches of science, say, entomology on the one hand, and geology on the other; but we must forbear. Suffice it to say, that no one did more to establish the curious and intimate connection between insects and plants than Darwin, with the exception, perhaps, of Lord Avebury, better known as Sir John Lubbock. Insects, it is now known, do more than any other agency to secure the fertilization of plants. Many insects, too, find their nesting place on distinctive plants, on which, and on no other, they lay their eggs; and the science of the future must keep these two lines of study close together—Entomology and Botany.

Palæobotany has become a recognized branch of geology and helps us to imagine the prodigious climatic changes that have occurred in the history of the Earth; and we are glad to be able to claim Professor Penhallow, one of our own members, as an expert in this department of geological science. Fossil plants are playing an increasingly important part in the determination of the age of rocks.

In conclusion, I have only to remark that science is cosmopolitan. It knows no national boundaries, and each of the civilized nations of the West has borne an honourable part in the progress achieved by botany in the last hundred years. The end of the century left an eager band of workers prosecuting botany in all lands where science is encouraged and cultivated, students maintaining all the best traditions of the past, yet addressing themselves to their task, conscious that no finality has been reached or is likely soon to be reached, in their favourite science, any more than in other sciences, and hopeful that to them it may be given to elicit from nature hitherto hidden secrets and add something to the domain of useful knowledge. The twentieth century sets out on its career in the investigation of the vegetable kingdom in circumstances far more favorable than those in which the botanists of a hundred years ago were situated; and one has only to cast his eye over the array of the prominent workers in this field as set forth in the recently formed International Association of Botanists, to feel assured that a still more rapid advance may be counted on in the years that lie before us.

Geology of St. Helen's Island.[1]

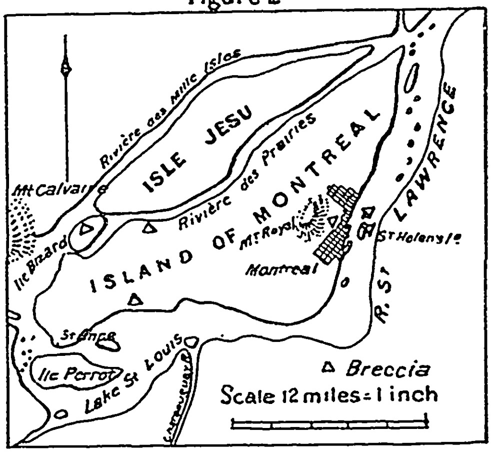
By A. W. Nolan and J. D. Dixon.

Introduction. One of the most interesting formations in the vicinity of Mount Royal is a breccia, which occurs in isolated patches at several points in the district. The best known exposure is found on St. Helen's Island, situated in the St. Lawrence River, opposite the City of Montreal. The breccia also occurs on Ile Ronde, north of St. Helen's, on Ile Bizard, at White Horse Rapids, Rivière des Prairies; and in small fissures in the Trenton limestone near Pointe Claire, and at McGill University.

1. A detailed geological survey of St. Helen's Island formed part of the Honour Course in Geology and Mineralogy in the Faculty of Arts of McGill University for the session of 1901-1902. The present paper embodies certain results of the examination of the Island, which seem especially worthy of record.

The position of these various exposures is shown on the accompanying sketch map of the Montreal district, the breccia being indicated by a triangle.

Figure 2



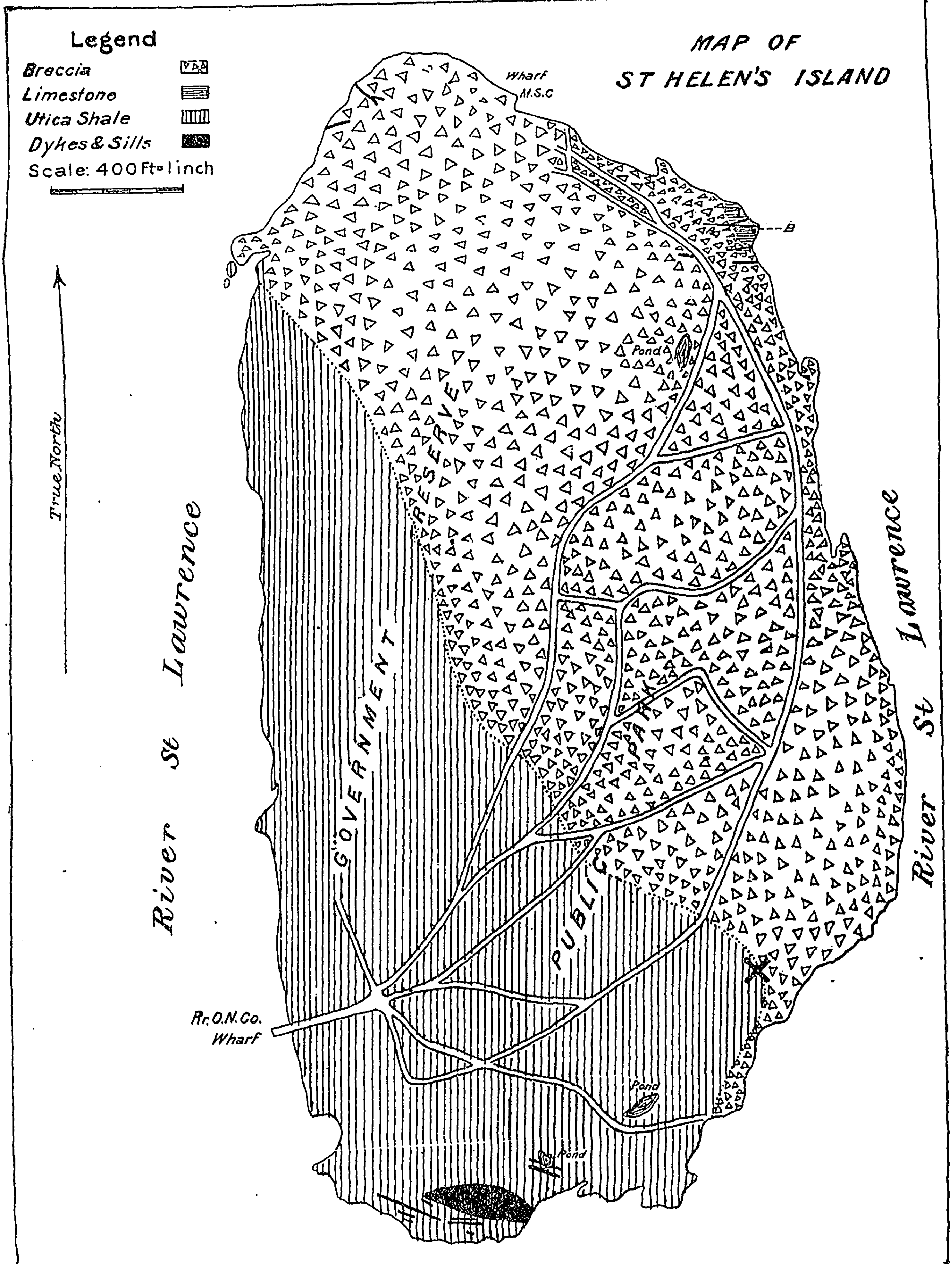
Sketch Map

Showing distribution of Breccia

In working out the geological relations of the breccia, the occurrence on St. Helen's Island being considered the most typical as well as the largest, has been made the subject of a detailed study. The other exposures have also been examined and correlated with that of St. Helen's with the view of arriving at some general conclusion which will satisfactorily account for the origin and age of the breccia.

General Geology. See map, fig. 1. Two geological formations are represented on St. Helen's Island and these have had a marked influence on the topographic features. The south-west half of the island, underlain by Utica shale, is low and level, while the north-east area, underlain by breccia, is rolling and comparatively hilly. Both shale and breccia are cut by dykes and sills which

Figure 1.


Legend
Breccia
Limestone
Utica Shale
Dykes & Sills
Scale: 400 Ft = 1 inch
MAP OF
ST HELEN'S ISLAND
True North
Wharf M.S.C
B
Pond
RESERVE
GOVERNMENT
PUBLIC
PARK
Rr. O.N. Co. Wharf
Pond
Pond
River St Lawrence
River St Lawrence

are genetically connected with the Mount Royal intrusion. These will be referred to more in detail later on.

PLEISTOCENE. The drift covering extends over almost the whole island. It varies in thickness from practically nothing on the breccia hills to 35 feet along part of the western shore, where the St. Lawrence River has cut a terrace in it, which reveals the whole section. In composition, the drift is an unmodified sandy clay, holding large and small glaciated boulders, principally of Laurentian and Trenton age, though the intermediate formations are also represented. The augen, syenitic and garnetiferous gneisses are particularly noticeable. Towards the top of the deposit fragments of breccia are common, as well as a few erratics from Mount Royal.

ORDOVICIAN. The Utica formation is only exposed at the south end of the island, the rest of the area underlain by it being covered by the drift. The rock is a dark almost black highly bituminous shale, weathering in places to a rusty brown. The ease with which it disintegrates into small thin laminæ, has masked both the strike and dip. However it is probable that the beds are practically horizontal, or dip to the east at a very low angle. No fossils were found though a diligent search was made. When cut by dykes and sills, a narrow zone of shale in contact with the igneous rock has been altered to hornstone. With one exception, the contact between the breccia and shale is concealed by drift and the approximate boundary, (see map, fig. 1), which may be considered fairly accurate, was therefore drawn from the evidence furnished by the topographic features.

DEVONIAN. (?) The breccia, which underlies the remainder of the island, is an unstratified massive rock. It is composed of fragments of rocks, which are angular, subangular, or rounded with facets, but not waterworn. These fragments vary in size from microscopic grains to boulders 12 and 15 inches in diameter, and the range in age extends from Archæan to early Devonian. They are embedded in an extremely fine grained greyish matrix, which weathers to a rusty brown. The rocks represented are red and black shales, hornstone, limestone, mainly Trenton, red and grey sandstones, the latter probably Potsdam, quartzite, granite and syenite gneiss.

No trace of stratification could be seen but vertical joint planes are numerous. Three sets were determined, the directions being N. 23° W., N. 36° W., and N. 77° W.

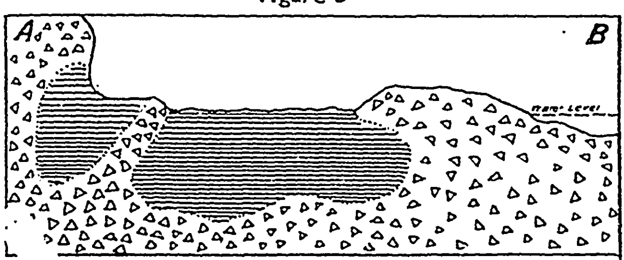
At one point only was the breccia seen in contact with the Utica (see X on map fig. 1.). The contact is a brecciated one, the shale being broken up into angular fragments with the interstitial spaces filled with a yellowish white crystalline dolomite, which dissolves out leaving the shale in relief. Part of this shale has in some way been altered to hornstone. The contact is not sharp, but there is a regular transition from the normal shale through the brecciated facies to the breccia proper.

Beside the ordinary inclusions, the breccia holds two very large masses of limestone, which merit special mention. These occur on the north-east side of the island. The south exposure is lenticular in shape, and is cut by a dyke which has been subsequently faulted. It has an area of about 100 square feet. The rock is a fine grained, light grey, friable limestone. The north exposure is 200 feet in length, and is a dark grey fine grained semi-crystalline limestone, which is somewhat bituminous. It has been brecciated along the contact with the breccia, and the angular fragments have been cemented by a paste which differs in composition from the limestone. On a weathered surface this matrix stands in relief forming a complicated network, which shows the most minute detail in structure. Both limestones are fossiliferous, being particularly rich in Brachiopods. These limestone occurrences were opened up by blasting, the material obtained being forwarded to Dr. H. S. Williams of Yale University, who has made a careful study of the fauna which they contain, and through his courtesy we are enabled to state the age of the two limestones. The larger area is of Lower Oriskany age (early Devonian), as expressed in Western Ontario and Virginia, while the smaller area is Lower Helderberg (Upper Silurian), and corresponds to the Upper Pentamerus zone of Eastern New York.

It is of peculiar interest to find remnants of these two formations in the present locality, inasmuch, as they have not been found in situ elsewhere in Western Quebec. The occurrences indicate an extension of the Upper Silurian and early Devonian seas as far north as Montreal.

An east and west section (A B figure 3) across the Lower Oriskany inclusion and the breccia, shows the relations of the two, and from this it is apparent that at an earlier period the former was wholly enclosed in the latter.

Figure 3



Section across Limestone inclusions in Breccia
Breccia ▨ Oriskany Limestone ▤
Scale Horizontal Vertical 25'

PETROGRAPHY OF THE BRECCIA. For a more minute examination, a typical specimen was chosen from the breccia near the limestone, and a thin section was made of the matrix. Macroscopically the matrix is fine grained, grey in color, quite hard and dull, with an irregular conchoidal fracture. It holds, in addition to the various rock fragments, small grains of glassy quartz, and feldspar both fresh and kaolinized. Under the microscope the following minerals were recognized, quartz, orthoclase, plagioclase, and apatite, in a fine grained quartz-dolomite groundmass. The quartz individuals are numerous. In form they are oval, angular, or rounded hexagonal. The borders are irregular, this being due, in some cases at least to a deposition of secondary silica, which is in optical continuity with the parent grain. The feldspar is present in less amount than the quartz, and is principally orthoclase. The form is angular, but a few idiomorphic individuals are present in each section. The mineral is quite turbid from kaolinization, but some of the clearer grains show a microperthitic intergrowth of orthoclase and plagioclase. The plagioclase individuals are few in number, and are twinned according to the albite and pericline laws. Apatite occurs in slender prisms, with the double pyramidal terminations.

Throughout the sections there are irregular cavities filled with secondary quartz and calcite. The latter is clear with well marked rhombohedral cleavage, and shows faint strain shadows in polarized light with crossed nicols. In the same light, the quartz is seen to have a radiate fibrous structure.

The matrix or ground mass, which makes up the greater part of the section, is very fine grained, and consists of quartz and dolomite with probably some calcite. A qualitative analysis showed considerable insoluble residue after prolonged boiling in hydrochloric acid, and the solution gave heavy precipitates of iron and magnesia, with a smaller quantity of lime.

In order to more fully examine the inclusions in the breccia, several types were separated from the matrix and thin sections made from them. These were a granite, sandstone, hornstone and limestone.

The granite was a light colored, medium grained rock, consisting wholly of quartz and feldspar. Under the microscope it presented the usual hypidio-morphic structure. The feldspar was principally ortho-clase, with subordinate amounts of plagioclase and microcline. The individuals were large with irregular borders, which interlocked with one another and with the quartz. Many of the grains were almost opaque owing to a heavy deposit of limonite along the cleavage planes. The quartz is traversed by cracks and holds minute hair-like inclusions. A few small grains of magnetite and hematite were also noted.

The sandstone selected was fine grained, and light brown in color. Microscopically it consisted of quartz, with a small amount of feldspar, the grains being cemented by silica and limonite. The quartz grains were rounded, or irregular through secondary growth. Of the feldspar the orthoclase was turbid, while the plagioclase was clear and finely twinned polysynthetically.

The hornstone was a dark, almost black rock, of dull lustre, and brittle with conchoidal fracture. Under the microscope it was seen to consist of minute grains of calcite, quartz, and pyrite. There were many spots of dark carbonaceous matter scattered throughout the section

The limestone examined was a typical Trenton specimen, being made up of fragments of brachiopods, crinoids, and corals, held together by a calcite cement.

Other Occurrences of Breccia. Before inquiring into the origin of this breccia, a brief description of the other exposures will be given, in order to show their similarity with the typical occurrence. The Ile Ronde development is an extension of that of St. Helen's Island and smiilar to it in all respects.

On the north end of Ile Bizard[1] (fig. 2), the breccia

1. Geology of Canada, 1863, p. 327.

forms a prominent hill and the rock apparently rests on the Calciferous formation. It is composed of fragments of hornstone, sandstone similar in appearance to the Potsdam, limestone, granite, and a dyke rock presumably alnoite. The matrix is grey, weathering rusty brown, and under the microscope shows a finely granular dolomite, holding a few grains of clear quartz and plagioclase feldspar. The sandstone often has a peripheral zone which is decolorized and glassy, and probably represents a zone of fusion. The limestone is in but small amount and is wholly altered to a marble of sugary texture. The fossils which it contains show it to be of Trenton age. Pyrite in small cubic crystals and in veins is present in the matrix and in the hornstone.

At White Horse Rapids, on the right bank of Rivière des Prairies, four and a half miles east of Ile Bizard (see Fig. 2), there is another mass which rests on the Trenton limestone. It differs from the Ile Bizard exposure, in containing anorthosite, different varieties of gneiss, and relatively more alnoite. The matrix is coarser in grain, and is light yellow in color. Quartz is in small amount but forms aggregates which under the microscope with crossed incols show radiate fibrous structure.

Another locality is on the line of the Grand Trunk Railway between Pointe Claire and Ste. Anne's,[2] where the breccia filled a worn fissure in the Trenton limestone.

Still another occurrence was discovered recently when excavations for the foundation of the new wing of the Medical Building, McGill University, were in progress. Here a fissure in the Trenton held a breccia principally of limestone, but holding in addition a fragment of graphitic gneiss of Laurentian age.

PROBABLE ORIGIN OF THE BRECCIA. From what has been said above it will be seen that these isolated areas of breccia are remarkably similar in character and that a satisfactory hypothesis for the origin of one ought to answer for the others.

An analogy might be drawn between this breccia and that of Mato Teepee in South Dakota.[1] Mato Teepee is an erosion remnant of columnar trachyte, underlain by horizontal strata of Jurassic age. On the side toward the Little Missouri Buttes, which are about four and a half miles to the north-west, there is an outcrop of breccai beneath the porphyry. In this are found fragments of rocks of various ages, some of which are not only stratigraphically higher than the present position of the breccia, but also higher than any of the surrounding formations. These fragments of newer rocks are apparently from the shales of Lower Cretaceous age, and the nearest occurrence of these in situ is at Little Missouri Buttes.

Mato Teepee, according to Jaggar, is a remnant of an old laccolith, the pipe through which the igneous material rose being beneath the Little Missouri Buttes. The breccia is really a decomposed porphyry, filled with fragments of rocks from all the strata through which it forced its way. The igneous material connecting Mato Teepee with the Little Missouri Buttes, together with all the overlying strata, has been removed by subsequent erosion, leaving Mato Teepee and the breccia as isolated remnants.

The St. Helen's Island breccia, like that of Mato Teepee, contains fragments of rocks which are more recent than the stratigraphical position of the breccia would lead one to expect, and the following hypothesis is put forward to account for its origin.

When Mount Royal, which in all probability was once an active volcano, was clearing its vent, a comminuted lava or volcanic ash, together with fragments of all the strata through which the lava forced its way, was thrown out and deposited upon the surrounding country. This

1. Jaggar, T. A., Jr., The Laccoliths of the Black Hills U.S. Geol. Survey 1899-1900, Part III.

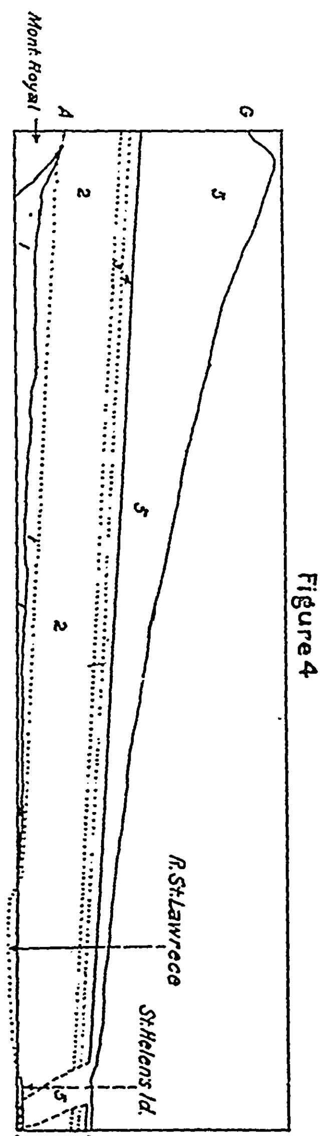
deposit would form the base of a volcanic cone, built up upon it by later eruptions of ashes and lava. Judging from the composition of the rocks of Mount Royal this ash would consist of a nepheline bearing lava, which in its finely divided state would readily alter by the action of percolating waters, to the impure dolomite now forming the matrix of the breccia. This seems a reasonable inference, as the nepheline bearing dyke rocks of the region show a marked tendency to alter to rhombohedral magnesian carbonates.

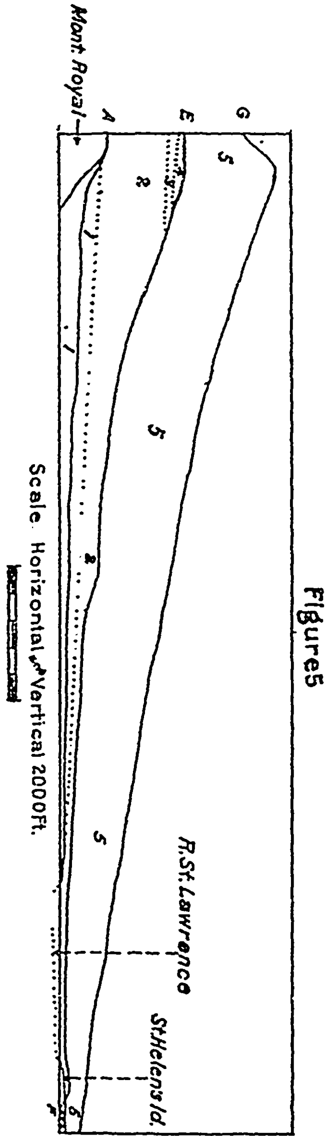
Jaggar's explanation of the breccia at Mato Teepee as a lava filled with rock fragments, constituting part of a sheet extending laterally through the strata, does not seem to be applicable in the case of the Montreal occurrences.

With respect to the position of the breccia on the Utica and other Ordovician formations, two explanations seem possible.

The first is, that deep fissures were formed during the first stages of the eruption, and that these extended down to the several formations of the Ordovician, and were filled wholly or partially by volcanic breccia. Figure 4 is a cross section from Mount Royal to St. Helen's Island. The line C. D. gives a profile of the volcano, and at the right of the section is a fissure extending down to the level of St. Helen's Island. In the other localities the fissures would extend down to the Calciferous or Trenton Subsequent erosion has reduced the surface from C. D. to A. B. as it is at present.

The second explanation demands a period of erosion after the deposition of the lower Oriskany, which would reduce the land surface to E. F. as in figure 5. Here it is seen that small remnants of the Lower Helderberg, and Lower Oriskany, remain directly over the centre of the subsequent volcanic activity. These and parts of the other formations, would be thrown out and deposited on





Scale Horizontal and Vertical 2,560 ft. to inch.

1. Utica.
2. Hudson River.
3. Lower Helderberg.
4. Driskany.
5. Volcanic ashes.

eroded surface E. F. Later accumulations would build the cone up to the line G. H. After the volcanic action had ceased, erosion would reduce the land to the line A. B., leaving isolated patches of the base of the cone or basal breccia. Of the explanations, the latter seems to be the more probable.

The breccia is post-Oriskany in age and may possibly be later Devonian.

Volcanic activity continued after its deposition as evidenced by the many dykes which cut it.

A point to be noted in this connection is that the Alnoite dykes must be older than the series about Mount Royal for as mentioned in the descriptions of the Ile Bizard and White Horse Rapids breccia Alnoite fragments are frequently found in those occurrences.

PETROGRAPHY OF THE DYKE ROCKS. It was stated on a former page that the Utica shale and the breccia on St. Helen's Island were cut by a series of dykes. About 20 of these were noted and mapped (see fig. 1), but it is probable that many more are concealed by the drift. They vary in direction from N. 60° W. to N. 80° W. Their width varies from 1 to 6 feet. Their length could not be ascertained as the drift on the one hand and the river on the other cut them off.

In addition to the dykes, a prominent sill occurs at the south end of the island. It is in two beds 0.8 and 1.6 feet respectively with a thin layer of altered shale between. Both the dykes and the sills belong to the great series which cut the Ordovician formations in this district, and which represent a phase of the Mount Royal eruption. It was found by the aid of the micoscope that these rocks could be divided into two classes, one containing feldspar, while in the other the mineral is absent.

Of the feldspathic class a specimen from the upper bed of the large sill was taken as a type.

Macroscopically the rock is porphyritic, dark grey in color, and fine grained. The lustre is dull, and the rock breaks with an irregular conchoidal fracture. Under the microscope the following minerals were recognized, plagioclase feldspar, hornblende, pyroxene, pyrite, magnetite, chlorite and calcite. The structure is typical panidiomorphic. The plagioclase is fresh and occurs in numerous slender lath-shaped individuals twinned according to the albite law. The hornblende is abundant but subordinate to the feldspar, and occurs in long slender phenocrysts. It is brown in color and the pleochroism is strong, ranging from very pale to dark brown, the absorption being $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. The cleavage is good and the maximum extinction along $\infty P \bar{\infty}$ is 12°. The phenocrysts are greatly altered, the product being a pale green almost isotropic chlorite, and magnetite dust. A pale yellow pyroxene is subordinate in amount to the hornblende, and is much altered to chlorite and calcite. Iron ore is present as numerous small grains of magnetite and pyrite scattered throughout the section. Whatever the original base was, it is now represented by a fine calcite-chlorite aggregate.

The rock is a hornblende lamprophyre, and is allied to the Camptonites.

As a type of the non-feldspathic class, a specimen was chosen from the faulted dyke which cuts the inclusion of Lower Helderberg limestone mentioned as occurring in the breccia.

Macroscopically the rock is basaltic in appearance, and is both porphyritic and amygdaloidal. The amygdules are irregular or rounded in form, and contain both calcite and analcite, the former mineral usually occupying the centre of the cavity. Microscopically the rock is composed of pyroxene, hornblende, analcite, calcite, apatite, and magnetite.

The pyroxene is comparatively fresh and occurs in small slender oblong phenocrysts with rounded terminations. These lying in all directions interpenetrate to some extent. It is slightly pleochroic, the absorption ranging from colorless to pale yellow. The cleavage is good, and the extinction along $\infty P \breve{\infty}$ is 44°. The hornblende occurs as a few large irregular individuals, and in numerous small idiomorphic ones. The pleochroism varies from deep brown to pale yellow. The extinction along $\infty P \breve{\infty}$ is 22°.

Apatite in long slender needles and idiomorphic basal sections, is well represented. The ground mass consists of a finely granular aggregate of the ferro-magnesian constituents, but there is, in addition, a very large amount of isotropic material. This is colorless, quite allotriomorphic, and has a low index of refraction. Heated with hydrochloric acid, it gelatinizes. It is optically similar to the analcite in the cavities, but whether it is primary or secondary it is impossible to state.[1]

The analcite in the cavities is secondary, and in many cases has crystallized out, showing the outline of the tetragonal trisoctahedron. It occasionally is feebly doubly refracting.

The rock is evidently an olivine—free analcite basalt which corresponds to the Fourchites[2] of J. F. Williams.

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1. The Monchiquites or Analcite Group of Igneous Rocks, by L. V. Pirsson. Jour. of Geol., Vol. IX., No. 6, 1896, p. 679, *et seq.*
2. Igneous Rocks of Arkansas. Rep. of Geol. Survey, 1890, p. 110.

Notable Display of Northern Lights During the Night of May 4th-5th, 1900.

By Mr. Charles J. Stuart.

The subject of the present note was an exceedingly interesting, and in several respects rather exceptional display of northern lights seen in this locality during the night of May 4th-5th, 1900.

Everyone is more or less familiar with the general appearance of the aurora, ever suggestive of the lone, mysterious North, and the robust poetic myth of the old Norseman, that the Merry Dancers, as they called these lights, were conducting in triumph the spirits of brave warriors to their Valhalla.

There is first the gathering ar h of light rising slowly from the northern horizon; then the commencement of "rippling streamers," and dancing "beams" travelling to and fro; and on rarer occasions the overhead tent-like canopy of nervous fuming light, climbing to the magnetic zenith. In almost every display, the three successive stages can be noticed in some degree at least. In discussing the present occurrence, the observations divide naturally into two parts or phases.

In the earlier period, the auroral light was seen to be playing between separate layers of cloud, a thing rare in itself, but, when a second recurrence of the display had fully developed, I made the surprising discovery that the whole mass of light in a succession of six or seven arches, or great scollops, was moving steadily and quite rapidly from west to east across the sky. I thought at the time that the exhibition of such a movement was quite unique, but I have since read in a paper, by Professor Loomis, that displays of aurora borealis have been seen to move every way, South, North, East, West, and also swing or "turn around the vertical;" but I have not yet been able to find particulars of an observation quite corresponding to my own on this occasion.

Either locality or the maxima and minima of periods of frequency, may have a good deal to do with variations; but at the same time, I may say that the appearances in this neighbourhood are fairly regular in behaviour, and marked by typical weather conditions. The few exceptions that I have noticed seem to owe their peculiarity to the abnormal development of some condition, rather than to any distinct difference in the circumstances of the display. I may indicate briefly why I am inclined to attach importance to the observation under discussion.

In the first place, the height of the aurora has been computed to be at from 45 up to 500 miles above the earth's surface. Lower estimates have been made, but they are generally held to be in error. Professor Loomis says: "That, although it is *possible* the aurora may sometimes descend nearly to the earth's surface, there is no sufficient evidence to prove that the true polar light has ever descended so low as the region of ordinary clouds." Now, upon this occasion, while the light appeared to play *between* cloud levels, twice very distinctly rays were seen to gather more brightly, and leap up and down beneath patches of cirro-cumulus cloud, *which was more strongly illuminated on the underside.* The general body of thin cirrus clouds above seemed bathed in light, but in these two instances, I am positive about the difference of the illumination of the cirro-cumulus cloud being coincident with the gathering of rays, about their position, which apparently clung to them in a vertical beneath, and seemed reaching to the heavy stratus cloud bank below.

When you come to consider the practical difficulty of getting any well defined edge or point, to take angular measurements upon, much of the accuracy that we are accustomed to attribute to theodolite observations disappears, and I think the question of height might be susceptible of correction in some particulars.

I have long been of the opinion that the silent auroral discharge takes place between the higher reaches of the atmosphere and lower strata, where it becomes dispersed, and where air-currents of different electric potential play a somewhat similar part to thunder clouds. It would seem that the present observation tends to confirm that view. If, however, the aurora *never* descends to cloud level,—if 45 miles above the earth's surface is the lowest limit, and 500 the upper, it would be difficult to understand what air-currents could exist at that elevation, to play the part I have in mind. We would have to fall back on a superior atmosphere of cosmic dust, or something of that kind; and while meteoric dust no doubt *gives tone* to the spectroscopic light of the aurora polaris, yet we appear as far from the mechanism of the electric display, when assuming a medium of intrusive meteoric dust, as when we confine our flights of speculative ingenuity to the air.

In the second place, the West to East motion of the succession of arches, which was a distinct feature of the latter part of this display, leads me to suppose that almost every aurora has a certain amount of motion of the kind.

In support of this idea I may point out that while the rays or beams move east or west, up or down, and while the arch swells south, or sinks back north or sways east and west,—yet during a period of say half an hour, or more, spots and patches, and more particularly crests of recurrent brightness have a marked tendency to drift off to the east, and disappear there.

Likewise when the display is fuming and flickering up overhead, cloud like fields have the tendency to be every now and then re-illuminated. If these patches are watched for, they also exhibit a slow drift in their position, always to the east. Frequently as the display fades out, these drifting overhead patches *are replaced* by thickening fields of cirrus, or cirro-cumulus clouds, moving east, at about the same rate of speed, as the previous light. The presence and arrangement of these wisps of cloud are sometimes very difficult to distinguish at night, and at the dawning, the weather conditions often change; but on several occasions I have been able to distinguish this succession plainly enough by moonlight.

Now, if it could be established that the eastward drift was a feature of the average aurora, it would I think be a step toward establishing a connection with the wind circulation beneath, and possibly give a further insight into the nature of the phenomena in general.

These remarks of course apply to local observations entirely, but would no doubt be capable of extension to a wider region.

The evening was raw and overcast. At 11.20 p.m. it was still cloudy and cold. So much so, that heavy stratus clouds looked almost like snowing. At 11.45 it was clearing up on a westerly wind—showing fair and clear to the south. Cloud banks to the north passing down N.E. The pole-star could be seen at this time well above the cloud banks. There were two visible layers of cloud with the ledge of the auroral light lying between them. These banks to the north lay at a visual angle of from 40° to 60° above the horizon—rather higher in the eastern sky, at this time, but rapidly passing down. The lower layer was of the heavy stratus banks blowing smartly off to E. by N. The upper clouds had hardly any movement that was noticeable in comparison; but in places where masses showed thickest, there was a slow motion E. by S.—or inclined that way. These high clouds also showed marks of a N. and S. streak, or probably of a N. by W. blow, making wind ruffles. They were of the cirrus varieties, the highest part barred with wind, and the under inclined to a cumulus "cotton wool" bottom, showing a slow movement E. by S. They were thinning or evaporating, and soon only remained visible in the brightest light.

The lower or stratus clouds were illuminated on the upper side, while the cirrus clouds with enough body to show a shadow, *were illuminated on the under side mostly*, although often, as it were, appeared bathed in light—whereas the under side of the low-lying stratus bank appeared very dark by contrast. The development of the several stages of the aurora was exceedingly rapid and brilliant. The beaming or streamer state, which followed the first break of the clouds within five minutes, showed a distinct tendency to gather about and play between high and low masses of cloud, and under the action, the upper "fluff" looked to melt, or at any rate perceptibly diminish in density. The light toward the lower cloud bank was brighter, but that may have been from looking into a greater depth, or field of illumination; otherwise the light showed no very unusual phase, except that the principal zone of light played in a space apparently between two layers of cloud, and was simply the familiar to and fro dancing streamers. The light on the whole was very brilliant. In dark nooks, where the city arc-lamps did not interfere, I could see a cast shadow at times. The fuming or flickering state soon came on, but I noticed that this did not occur where masses of high cirrus cloud still appeared. When the fuming light reached the zenith, the patches showed an irregular streak, or mark, like long wisps lying W. and E., somewhat like "mare's tails." Several of these masses of distinct form were observed to recur. They lighted up at intervals, roughly, of two or three seconds, and across the stars showed a motion from W. to E. by S. (this motion is the usual thing when it can be observed). I take it that these were the remains of cirrus clouds seen as such previously, but now not thick enough to show as clouds at night. Four "shooting stars" were noticed all radiating from a point somewhere S.W.—but I was facing north, and only caught a glimpse of them over my shoulder Three were into the west (low) and one high N.E. These shooting stars had no effect whatever on the aurora, unless a red and green tinge for a short time afterwards could have been connected with their débris. The prevailing color of the auroral light was the common pale greenish yellow, but iridescent colors were at one time seen low west, and also high in the east. By one o'clock (a.m. 5th) the display had subsided to a considerable extent, and the weather was then clear and cold.

The cloud effects at the earlier period were of quite an exceptional combination, in my experience. Twice before, I have seen displays above the clouds, but these happened to be almost overhead. In this case, there was a section view, as it were, and the upper clouds for a time had enough body to show reflected light. The active light seemed confined to an air space lying between the two layers of cloud. This tended to confirm me in an opinion, formed from other scattered observations—namely, that while the arches may be higher, yet the active field of light seems to lie in a stratum of air, itself lying between two other air-currents blowing in different directions, and that the phenomenon is possibly largely due to thermal electricity.

2nd Phase.

By two o'clock a.m. (*morning of May 5th*) *the arch had* reformed and indications were for a renewal of the display I sallied forth again, to the north end of Mount Royal, to get a free field of view, clear of the city lights. As the arch of the new aurora rose from the north, southward, it then exhibited a bend inwards to the northern horizon at both ends. When the arch reached a point almost overhead, the *zone of light*, which was very broad, was seen to be broken into long bands or streaks lying W. to E. but not in continuous belts, but rather mottled,—mottled streaks would describe the structure. I saw a somewhat similar appearance once before, and on another occasion in early spring three continuous bands, stretching from W. to E., right across the sky. This of course was simply the appearance of the arch viewed at an unusually high angle. The light at this period was simply a quiescent haze. At a later stage it showed a running wave transmission E. and W. (moving both ways), probably corresponding to the rippling beams. Still later it exhibited jerky leaps from streak to streak, passing south. From this time it began to sink and spread back to the north, and soon the whole broke into the fuming or flickering state.

At 2.15 a.m. this great arch had risen high and curved into the east (as is quite often seen), but to the west it had an extension suggesting an elliptical ring form. At this time the remains of the arch were sinking back north. At 2.20 a.m. I was in a position to see the horizon, *and the western extension was developing into a second arch.* I also became aware at about this time, that the whole body of the first arch *was shifting east.* The second arch from the west was followed by a third. It could then be plainly seen that the arches were not elliptical rings that might be completed below the horizon, but were great scollops or bows with a slow but steady motion from west to east. In fact, five such arches or bows *passed* within the hour, and a sixth rose high in the west; but as this last one came up, the fuming stage interfered, and the whole northern sky was soon in a flicker and continued so until dawn, which was then beginning to creep on apace.

This procession of connected arches was something quite exceptional as far as my experience goes. I never in the least suspected such a motion, but having seen it I can recall many peculiar appearances, whose explanation would be simplified by such a phenomenon. In fact, I now realize that probably every ordinary Aurora Borealis has a proper motion of this kind, but perhaps not often so rapid as it happened to be this time, also the legs or span of the arches is usually more extended, and certainly the primary phase of quiescence is very seldom so prolonged as on the occasion of this display. If for nothing else, the phenomena on this night were notable, and I hope properly observed here and elsewhere. The fifth arch to pass (at 2.50 or 2.55 a.m.) was particularly brilliant and much larger than any except, perhaps, the first at 2 o'clock. It was this fifth arch that showed the distinct divisions of the streaked movement overhead, as already mentioned,—first mottled streaks of light lying W. and E.; second, a fluctuating ripple of light running E. and W., slowly to and fro and comparatively regular in progress, succeeded by the third stage of a waving passage of light from patch to patch always fuming up to the zenith or leaping N. to S. By 3 o'clock the first streaks of dawn were reddening in the east. The aurora was then commencing the active fuming of its last stage, a process of dispersion which continued until quite overpowered by the morning light.

Three more meteors radiating from a constellation in the S. W. were seen—and again for a short time iridescent colors followed low on the N. W. horizon, but I do not think the two phenomena were connected although the coincidence was noted. There was a thick hoar frost on exposed places, which is an unusual thing with an aurora here. At the same time, there was a good deal of swampy water still lying about (from rain and the spring melting) which may account for it. Several small dark clouds drifted with, but lower than the arches. They were rather low on the horizon, passing from W. to E. The light of the aurora was bright enough for me to see the time by my watch, but not enough to write notes, or sketch by. The stars were not especially bright, nor visible within some distance of the horizon, with one exception, almost due north, which showed under the fifth arch, for a short time ruddy and green, and was covered over again by cloud, or mist.

All night, the surface wind set cold from the N. W. It was the ordinary slow and steady wind, only more westerly than is usual. Several of these minor points such as wind, moisture, and an indefinite "*look* of the weather," that I am accustomed to associate with northern nights, were exceptional this time.

Sky at Dawn.

In the morning twilight, clouds became visible. There lay a low bank of wind-swept clouds (cirro-stratus) far along the northern and eastern horizon. There were larger banks in the south, showing wind flares on the northern edge. Both those east and south for a long time did not seem to move much, but at sunrise they began to shift rapidly. There were occasional cloudlets in the north, that had been noted under the aurora arches, these had a very slow motion to the east,—they afterwards, in the strengthening light, turned out to be high cumulus of the "cotton wool" variety, pretty far north. As the light increased, high cirrus clouds were seen, exhibiting double wind bars cross hatched E. and W. and N. W. to S., or thereabouts. Long wisps or "mare's tales" also lay toward the east. Just before sunrise, two columns of heavy vapor blew up on the surface wind at a smart pace,—one N. W. and one S. E. of my position. The northern column, although it showed great speed at first in the rolling mass of its body, yet did not make much progress. The masses looked to rise and evaporate, and showed a tendency to change direction and move E. by N. in the higher parts. The southern column soon became a heavy stratus-nimbus bank, changing direction and moving slowly E. by S. E., and had got far down by 5 o'clock. The sun rose copper red. The sky was not brilliant in color. The change from blue-gray to white daylight was rather rapid. It was a cold dawn after a frosty night, and at sunrise the clouds betokened a windy sky.

The Wind at Sunrise.

In day light the higher cirrus clouds showed cross hatched wind bars--short streak N. by W. to S. by E.—long streak W. to E. The lower cirrus, of the cotton wool kind, moved slowly to the east, with a tendency that might have been N. E., but as they were well down toward the horizon it was hard to judge their true direction. These clouds were the same as already mentioned floating under the arches of the aurora. The wind and surface clouds (morning mist from the lakes lying up the river) came from the W. or S. W.

But now a notable thing happened. Some of this misty "fluff" rising from the southern column already mentioned, was caught by a *south wind* and moved to the N.E. by N., or north, quite seven or eight points back from its first direction. I noted these changes of motion by the stem of a sapling in front of where I sat; it, like the similar clouds to the north, began to thin or evaporate, and like them did not travel far, although it moved quickly for a time. Not only so, more of this fluff rising as the sun's heat strengthened, drifted from the south, but rising higher began to exhibit the N. by W. to S. by E. wind bars, and shortly joined patches of cirrus cloud marked mackerel wise, floating to E. by N. (another change of direction.) By 5.15 a.m. the sky was almost clear. At 5.30 a.m., mare's tails and white wisps were out again, but I turned in to get warm, being nearly frozen.

About 6 o'clock a.m., a spread of cirrus clouds overhead (my view was now limited) exhibited a very windy appearance, and changed form from time to time rapidly (now and again suggesting the rippling motion of the beams of aurora.) High rolling bars lying almost E. and W. had a movement S.E., while numerous lower cross wisps lay N.W. by N. to S. by S.E., and showed some movement N.E., but these wisps were small and many and seemed to fill and back, while the whole mass or field had a motion almost due east at a goodly pace. The form and figure also changed rapidly, so it was difficult to say surely what the component movements actually were. A wavy or rippled appearance would grow in places, and again the wisps would be tossed in great confusion. All this time the body or field of cloud was sailing rapidly eastward. My impression on the whole was, however, that all the appearances were due to the body of cloud floating between two cross winds, the upper from the N. by N.W., the lower current W. by S., or S.W., with a gusty drift layer lying in between and moving to the east, as the resultant in which the cirrus clouds mostly floated.

Immediately below the upper winds there was a *dry* south wind, at least up to sunrise. I judge this by certain wind flares from the southern cloud bank seen in the early morning, and the behavior of the fluffy clouds that rose in the morning sunshine as noticed. That it was a dry wind I argue from its not carrying vapour, and absorbing cloudlets that rose into its influence. The only question with me is, could the existence of this southern under current be made to explain the markings and motions of the cirrus clouds above, and bearing to the east. yet I think not altogether, for the high cumulus verging on the lower cirrus clouds were "cotton wool" spindles and cumuli plainly floating in a wind current, while the high wind swept cirrus clouds were for the most part sharply barred and streaked, of which their eastward motion was evidently a direct composition or drift. Still, in the reckoning of these winds, I may be misinterpreting the indications. Reading the clouds is never an easy thing, except in their broad aspects. Certainly there was a surface wind blowing smoke to a different point from any of the clouds above; and the clouds were of at least three kinds, and had two distinct directions in well marked levels. We may, therefore, be quite sure that there were several currents of wind one above the other. At 8 o'clock very little cirrus clouds were visible. Large low cotton wool masses of cumuli were sailing rapidly toward the sun—lower surface wind still from the W.—but weather conditions distinctly changed. It was a brilliant morning until nearly noon, when it clouded over and came on a snow flurry, which did not last long. A few minutes after 1 p.m. it cleared, the cumulus clouds drifting to the S.E. The high cirrus clouds were still far above, and still cross hatched as before, and held their course east. They continued on in this way for the afternoon, when seen, and on Sunday following, but there was no noticeable renewal of northern lights.

THE TREES OF MONTREAL ISLAND.

BY F. C. EMBERSON, M.A.

"Exiguus spatio variis sed fertilis herbis."
"Its flowers countless, tho its acres few."

About half a century ago, I saw this written over the greenhouse of the famous Dr. Ward, originator of "The Wardian Case" It is in Virgil. He defied anyone to find out where. So do I.

Flora seems to have brought out her works in three successive volumes.

I. Plants without leaves.
II. Flowers with straight veined leaves.
III. Blossoming flowers with net-veined leaves.

(By "Blossoming flowers" is meant those with petals and sepals instead of petaloids).

These three kinds of plants are distinct in every respect·

tho curiously blending into one another, and all follow the *predetermined* mathematical series,

0, 1, 2, 3, 4, ... n.

So phyllotaxis follows the series

$\frac{0}{0}$ $\frac{0}{1}$ $\frac{1}{1}$ $\frac{1}{2}$ $\frac{2}{3}$ $\frac{3}{5}$ $\frac{5}{8}$ etc.

These two series together *prove* the existence of a Creator who knew Algebra; which is good, as no knowledge. methinks, is of practical importance except in so far as it teaches us something about ourselves or God,—the latter concerning ourselves the most of the two.

VOL. I.—TREE FERNS.

"He wears fern-seed. He is invisible," As ferns have no seeds—only spores—it must be mighty hard to wear-'em.

These are not indigenous to Canada; a specimen or two may be found in the hot houses of the city.

THE CONEBEARERS.

Abies Alba—White Spruce.
A. Balsamea—Balsam.
A. Canadensis—Hemlock.
A. Rubra—Red Spruce.
A. Nigra—Black Spruce.
Juniperus nana—Juniper.
Larix Americana—Larch.
Pinus divaricata—Labrador Pine.
Pinus resinosa—Red Pine.
P. Strobus—White Pine.
Taxus Canadensis—Yew.
Thuja occidentalis—Cedar.

VOL. II.

Contains no trees such as the Dracænas and Palms indigenous in Canada.

VOL. III.

Contains trees belonging to (1) The Catkin bearers including A. The Willows. B. Poplars. C. Birches. D. Oaks. E. Walnuts, and (2) The Nettles. (3) The Maples. (4) The Rues. (5) The Lindens. (6) The Pulses or Butterflies (Leguminosæ). (7) The Roses. (8) The Olives.

III. (1)—CATKINBEARERS.

Or "Little Pussy-Cat bearers."—*Fr. Chaton.*

A. Willows.

Salix alba vitellina—Golden Osier.
S. amygdaloides—Peach-leaved Willow.
S. Bebbiana—Bebb's Willow.
S. discolor—Glaucous Willow or Bog Willow.
S. fluviatilis—Sand-bar Willow.
S. fragilis—Brittle Willow.
S. lucida—Shining Willow (Bright-eyed Salix.)
S. nigra—Black Willow or Black-eyed Salix.
S. Wardii—Ward's Willow.

B. Poplars.

Populus alba—White Poplar.
P. balsamifera—Balsam Poplar.
P. grandidentata—Large toothed Aspen.
P. monilifera—Cotton Wood.
P. monilifera, *Var.* candicans—Balm of Gilead
P. tremuloides—American Aspen.

VOL. III.—THE BIRCH.

In my day this tree did nearly half the work of the schoolmasters in England. The Headmaster of Marlborough shortly before I taught there was a mannikin named Wool. The boys called him "Much Cry, Little Wool." Of Dr. Hawkins of Eton it was said that when upborne to Heaven by Cherubim he would be regretting all the way that there was nothing to flog.

Alnus incana—Speckled Alder.
A. viridis—Mountain Alder.
Betula lenta (pliant)—Black Birch.
B. lutea—Yellow Birch.
B. papyracea—Silver-barked Birch or Canoe Birch.
B. populifolia—American White Birch.

D. Oaks or Cup-bearers.

Carpinus Americana—Blue Beech.
Ostrya Virginica—Iron Wood.
Quercus Alba—White Oak.
Q. macrocarpa—White Oak. Bur Oak. Mossy cup.
Q. platanoides—Swamp White Oak.
Q. rubra—Red Oak.
Q. velutina—Black Oak.

VOL. I. (APPENDIX)—WALNUTS.

A Spaniel, a Woman and a Walnut tree
The more you beat them the better they be.

Carya alba—Shell-bark Hickory.
C. amara—Bitter Hickory.
C. porcina—Pignut.
Fagus ferruginea—Beech.
Juglans cinerea Butternut—Grey.

Mr. Geo. Trussell, of Pied du Mont, Montreal, showed me a tree which he said was neither butternut nor walnut but perhaps a hybrid between the two. Archie Robertson, of Westmount, another good authority, agrees with him.

I have provisionally named it Juglans Trusselli or Walbutternut.

Dr. Robert Campbell, to whom I owe *all* that is of any value in this list, is dubious about it.

VOL. II.—THE NETTLES.

This order contains the Hemp—the great Necktie tree.

Celtis occidentalis—Sugarberry, (at Colonel Crawford's, Lower Lachine Road).

Ulmus Americana—White Elm.

U. fulva—Slippery Elm. (An excellent lubricant for sore throat.)

U. racemosa—Cork Elm (At and near Col. Crawford's, Lower Lachine Road)

VOL. III.—RUE.

Let "Rue for Remembrance" remind those about to marry of Schillers'—

"Short the Wooing, Long the Rueing."

or of Punch's, "DONT!"

Xanthoxylum Americanum—Prickly Ash.

VOL. III.—THE MAPLES—SAPINDACEÆ.

What Christian Grace the Maple can eclipse
With Sweetness flowing from its bleeding lips.
—EMBERSON.

Acer dasycarpum (rough-fruited)—Silver Maple.
Acer negundo—Ash-leaved Maple.
A. Pennsylvanicum—Striped Maple.
A. rubrum—Red Maple.
A. saccharinum—Sugar Maple.
A. saccharum—Rock Maple.
A. spicatum—Mountain Maple.

III.—LINDENS.

Tilia Americana—Basswood.

III.—THE SUMACHS—ANACHARDIACEŒ.

The French name is Vinaigrier—Vinegar Tree. Vinegar used to be made of it blossoms, bark and twigs in Montreal.

Rhus typhina (smoky)—Staghorn Sumach or vinegar tree. Fr. Vinaigrier. (There was once a Vinegar Factory near the Champs de Mars, Montreal, where it was made from fruit and twigs of this tree.)

III.—PULSES—BUTTERFLIES—LEGUMINOSÆ.

Robinia pseudacacia—Locust.
R. viscosa—Clammy Locust.

VOL. III.—ROSES.

The bonnie Rose blew, all yearning for Love
The Honey-bee flew and kissed from above
Faith kindles to see That some prescient Power
Made the Flower for the Bee and the Bee for the Flower.
—From Goëthe, by F. C. EMBERSON

Amelanchier botryapium—Shadbush.

A. Canadensis—Juneberry.

A. rotundifolia—Roundleaved Juneberry.

Cratægus coccinea—Hawthorn.

C. crus-galli—Cockspur Thorn.

C. macracantha—Longspined Thorn.

C. Mollis—Red Thorn.

C. punctata—Yellow Haw.

C. rotundifolia—Glandular Thorn.

C. Tomentosa—Blackthorn or Pear Thorn. (The Irishman's joy.)

There are 14 species of Hawthorn on the road between the well and so favorably known, Verdun Hospital and Montreal.

Prunus Americana—Plum.

P. Pennsylvanica—Red Cherry.

P. Virginica—Choke Cherry. (Very handsome as a little tree, more often a shrub.)

Pyrus Americana—Mountain Ash.

P. Coronaria—Crab Apple.

P. Malus hybrida—Apple. (Of this there are different varieties and subvarieties.)

P. Serotina—Black Cherry.

III.—WITCH HAZELS.

Hamamelis Virginica—Witch Hazel.

The Divining Rod Hazel—my old pupil, Mr. Hepburn, of Picton, the well known owner of the Alexandria, etc.,—says he has never failed to find water with it.

III.—OLIVES.

And then in the land of my birth will I fall,
In the land of the Olive and Phig;
And bury me deep in the What-do-yer-call
And play on the Thingamyjig.

ASHES.

"Fraxinus in silvis pulcherrima" Not thought so in houses.

Fraxinus Americana—White Ash.

F. nigra—Black Ash.

Catalogue of Canadian Plants.

CATALOGUE OF CANADIAN PLANTS, PART VII.—LICHENES AND HEPATICAE. By JOHN MACOUN, M.A., F.R.S.C., Naturalist to the Geological Survey of Canada. Ottawa: Government Printing Bureau, 1902. Price, Ten Cents.

This volume, issued under the direction of the Geological Survey of Canada, will be heartily welcomed by botanists the world over as a valuable addition to the scientific stores of the North American Continent. By this publication, the veteran author acquires new laurels as the Nestor of the botanists of the Western world. It is pleasant to note how cordially his fellows in the prosecution of this branch of science have recognized the service he has rendered to it by affixing his name to a large number of the species described in this volume, and thus his zealous work becomes honourably commemorated and perpetuated. The distinction has been well earned by the Herculean labour which he has successfully performed, the results of which are embodied in his reports to the Government of Canada. The list of Hepaticae embraced in this publication 196 species and 7 varieties—includes the catalogue of 165 species already reported in 1890, as determined by William Henry Pearson, although the latter are, many of them, classed differently. Only one of the Hepaticae, *Anthoceros Macouni* (Howe), is described, because of its being hitherto unfamiliar to students of this department of botany.

The Lichens reported number 614 species and 119 varieties, of which only one species and three varieties are described, from which we are to conclude that the rest have been previously identified as occurring in Canada and elsewhere.

Nearly one-half of the volume is taken up with additions to the list of Mosses, published in 1892 by the Geological Survey. The number previously catalogued was 953. This number is now raised to 1,196, besides 77 sub-species and varieties given in this volume. A new Genus, "Bryo Brittonia," is described, embracing a single species. There is also furnished a description of 116 other species, 22 sub-species and 15 for a large number of the habitats varieties, besides new species reported in 1892. Doubtless the science of the future will make alterations in the determinations here given to the public by Professor Macoun, elevating sub-species and varieties to the dignity of species, and perhaps combining into one two or more species counted distinct in this catalogue. But any changes that may be effected in the ranking of the large materials which he has accummulated will not lessen the value of the work he has accomplished, or detract from the obligations under which he has anew laid the scientific world by this last contribution to the Natural History of Canada. His many friends will hope and pray that he may be spared to complete his work, by giving to the public in good time lists of the Fungi and Algae of the Dominion.

The Government has done well to offer this report, with paper cover, to those interested in the subject, at the low rate of ten cents. All students of botany should order copies at once.—R. C.

CONTRIBUTIONS TO CANADIAN PALAEONTOLOGY, PART II.—ON VERTEBRATA OF THE MID-CRETACEOUS OF THE NORTH-WEST TERRITORY. By HENRY FAIRFIELD OSBORN, *Vertebrate Palaeontologist Assistant Palaeontologist.* 1. Distinctive Characters of *(Honorary) of the Survey,* and LAWRENCE M. LAMBE, the Mid-Cretaceous Fauna, by Henry Fairfield Osborn. 2. New Genera and Species from the Belly River Series (Mid-Cretaceous) by Lawrence M. Lambe.

This publication of 81 pages is a sequel to the late Prof. Cope's article on "The Species from the Oligocene or Lower Miocene beds of the Cypress Hills," and in it Mr. Lambe gives additional proof of his rapidly extending acquaintance with Palaeontology, which he has been making his specialty.

The first twenty-two pages are devoted to an introduction by Prof. Osborne, whose efficiency and gratuitous services to the Geological Survey of Canada, are heartily acknowledged by Dr. Robert Bell, administrative head of the Survey. Prof. Osborn, as Curator of the Department of Vertebrate Palaeontology, of the American Museum of Natural History, New York, has special qualifications for giving authoritative advice on all questions bearing on Vertebrate fossils. This work he undertook at the request of the late Dr. George M. Dawson, Director of the Survey. In his paper, he outlines the general characteristics of the fauna of the Mid-cretacious formation. The question he has sought to settle is the age to which the fossil remains of the Belly River series of rocks in the vicinity of Red Deer River, Northern Alberta, belong. Mr. Lambe made collections in the years 1897, 1898 and 1901, which have added materially to the data previously procured by Dr. G. M. Dawson, Mr. R. G. McConnell and Mr. J. B. Tyrrell, for determining the Geology of the region around Edmonton. Dr. G. M. Dawson had, with the materials then within reach, assigned the Belly River rocks to a later age, ranking them with the Laramie beds of Converse County, Wyoming, as Upper Cretaceous. Prof. Osborn institutes a detailed comparison between the two series named, and shows that the prevailing types of the remains of Vertebrate animals in the Belly River rocks have much more in common with the Montana or Mid-Cretaceous series. The four species most numerously found in the series under consideration are *Testudinata*, *Megalosauria*, *Iguanodontia* and *Ceratopsia*; and there are many more of these species in the Montana than in the Laramie series. His conclusion is that the Belly River formation is older than the Laramie, not only because the fauna which it embodies is more ancient in character; but also because the animals belonging to both series seem to have reached a higher development in the Laramie than in the Belly series.

Mr. Lambe's contributions to the present publication gives detailed information regarding the fossils of the Belly River series. The species collected belong, for the most part, to the class REPTILIA. They occur abundantly and in an excellent state of preservation. Five species of *Pisces* are shown first, two of them being new: *Acipenser Albertensis*, and *Diphyodus longirostris*, belonging to a new Genus, DIPHYODUS. The BATRACHIA are represented by but one species, *Scapherpeton lectum*. The PLESIOSAURIDAE are also represented by only a single species, *Cimoliasaurus Magnus*. The CHELONIA family show *Trionyx foveatus*. *T. vagans*, *Adocus lineolatus*, *A. variolosus*. *Neurankylus eximius*,— a new Genus and species. The RHYNCHOCEPHALIA family is represented by *Champsosaurus annectens*, *Troödon formosus*, *Crocodilus humilis*, and *Bottosaurus perrugosus*. There are two species of DEINODON, *Deinodon horridus* and *D. explanatus*, belonging to the DINOSAURIA. A new species of Ornithomimus is reported. *O. altus*. Three species of the Stegosauridae are given, *Palaeoscincus costatus*, *P. asper*. and among them *Stereocephalus tutus*, a new species of a new Genus. The family CERATOPSIDAE is one of the most important of those included in the Belly River rocks. Three of the species reported by Mr. Lambe are new, *Monoclonius Dawsoni*, in honour of the late Dr. G. M. Dawson, Director of the Geological Survey, M. *Canadensis*, *M. Belli*, in honour of the present acting Director, Dr. Robert Bell, *Stegoceras validus*.

Three new species of TRACHODONTIDAE are described, *Trachodon* (*Pteropelyx*) *Selwyni*, named after a former Director of the Geological Survey of Canada—*T. marginatus*, and *T. altidens*.

Mr. Lambe's paper concludes with a description of two new species of fossil mammals, *Ptilodus primaevus* and *Boreodon matutinus*, belonging to the family of PLAGIAULACIDAE. The determination of these species rests upon the fossil remains of teeth,—in the former case, the first molar and the fourth premolar are preserved; in the latter case, the type is represented by a single tooth, a premolar, having two slightly divergent roots.

Figures occur all through the paper, showing details of the several species described in the text, and an appendix is added, containing twenty single plates and one double plate, admirably figured and finely printed, in which the leading features of the several species are seen differentiated. The publication does credit to the department issuing it, and cannot but add to the reputation for careful investigation and solid thinking of Mr. Lambe, whose good work it makes known.—R. C.

ABSTRACT FOR THE MONTH OF JULY, 1902.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min.	Range.	* BAROMETER. † Mean.	Max.	Min.	Range.
1	64.2	74.0	55.0	19.0	29.87	30.02	29.81	.21
2	68.2	75.6	59.8	15.8	30.11	30.17	30.02	.25
3	63.4	69.3	60.5	8.8	29.89	30.08	29.79	.29
4	68.0	75.2	58.5	16.7	29.94	30.01	29.89	.12
5	70.0	78.2	64.0	14.2	29.87	29.92	29.85	.07
SUNDAY........ 6	67.8	77.9	55.9	22.0	30.06	30.11	29.92	.19
7	67.2	71.1	63.2	7.9	30.05	30.11	29.95	.16
8	75.0	85.5	63.2	22.3	29.91	29.97	29.84	.13
9	70.5	77.0	67.0	10.0	29.89	29.94	29.81	.13
10	66.9	73.0	60.4	12.6	29.90	30.00	29.79	.21
11	64.0	72.0	55.9	16.1	30.06	30.13	30.00	.13
12	68.5	78.0	57.5	20.5	29.93	30.00	29.87	.13
SUNDAY........13	71.4	81.0	62.5	18.5	29.89	29.94	29.84	.10
14	73.7	82.4	66.8	15.6	29.88	29.94	29.82	.12
15	64.3	73.5	57.8	15.7	29.65	29.78	29.56	.22
16	60.7	68.0	54.5	13.5	29.82	29.90	29.65	.25
17	57.3	62.0	54.0	8.0	29.74	29.90	29.59	.31
18	65.5	73.8	55.2	18.6	29.91	30.09	29.71	.38
19	65.5	75.0	57.0	18.0	30.04	30.12	29.93	.19
SUNDAY........20	65.8	73.8	60.4	13.4	29.87	29.93	29.83	.10
21	58.5	62.8	56.2	6.6	29.76	29.83	29.71	.12
22	61.4	67.3	56.0	11.3	29.92	30.02	29.79	.23
23	63.1	70.5	56.2	14.3	30.08	30.14	30.02	.12
24	67.8	75.7	60.5	15.2	30.07	30.10	30.04	.06
25	68.7	76.2	60.0	16.2	30.10	30.12	30.07	.05
26	68.9	77.0	63.0	17.0	30.07	30.13	30.01	.12
SUNDAY........27	66.7	72.0	61.5	10.5	29.94	30.02	29.81	.21
28	73.0	80.2	66.0	14.2	29.85	29.92	29.81	.11
29	72.5	80.4	63.1	17.3	29.97	30.02	29.92	.10
30	73.2	82.9	62.8	20.1	29.98	30.03	29.93	.10
31	75.2	86.0	65.0	21.0	30.01	30.05	29.93	.12
Means......	67.35	75.07	59.88	15.19	29.936	30.01	29.85	.16
28 Years means for and including this month	68.84	77.28	60.79	16.49	29.898	......	......	.14

DAY	‡ Mean relative humidity.	WIND. General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	67	N.W.	12.0	75	0.28	....	0.28	1
2	58	W.	13.3	92	....	....	....	2
3	87	N.E.	9.7	20	0.09	....	0.09	3
4	62	N.E.	8.4	85	....	....	....	4
5	81	W.	6.9	30	r	....	0.00	5
SUNDAY........ 6	55	N.E.	10.2	82	....	....	....	6..........SUNDAY
7	79	S.	16.3	18	0.25	....	0.25	7
8	75	W.	13.9	85	0.03	....	0.03	8
9	81	N.	12.8	13	r	....	0.00	9
10	61	N.W.	13.2	70	....	....	....	10
11	61	N.W.	13.5	97	....	....	....	11
12	64	S.W.	18.3	80	r	....	0.00	12
SUNDAY........13	67	S.W.	20.5	51	....	....	....	13..........SUNDAY
14	71	W.	14.2	61	0.01	....	0.01	14
15	83	W.	14.9	09	0.93	....	0.93	15
16	74	N.W.	13.9	61	0.18	....	0.18	16
17	93	W.	12.0	00	0.36	....	0.36	17
18	74	S.W.	21.1	92	....	....	....	18
19	72	S.	3.6	30	....	....	....	19
SUNDAY........20	73	S.E.	8.5	28	r	....	0.00	20..........SUNDAY
21	97	E.	19.7	00	0.76	....	0.76	21
22	83	E.	8.4	22	r	....	0.00	22
23	86	S.E.	7.2	40	....	....	....	23
24	84	S.	6.5	41	0.04	....	0.04	24
25	70	S.	11.0	89	....	....	....	25
26	73	S.	10.3	88	....	....	....	26
SUNDAY........27	90	S.	13.5	02	0.04	....	0.14	27..........SUNDAY
28	71	S.W.	20.7	90	0.17	....	1.17	28
29	71	E.	5.5	65	....	....	....	29
30	71	E.	7.0	96	....	....	....	30
31	73	S.W.	7.9	84	r	....	0.00	31
Means......	74.6	S. 6° W.	12.42	56.5	3.14	....	3.14	..............Sums.
28 Years means for and including this month	71.8	....	‖ 12.92	¶ 59.0	4.24	....	4.24	28 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction.......	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	854	709	549	675	1155	1959	2094	1248	
Duration in hrs..	68	78	70	80	103	115	133	97	
Mean velocity....	12.6	9.1	7.8	8.4	11.2	17.0	15.7	12.3	

Greatest mileage in one hour was 40 on the 18th.
Greatest velocity in gusts was 68 on the 15th.

Resultant mileage, 2,366.
Resultant direction, S. 6° W.

Total mileage, 9,243.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

¶ 21 years only. ‖ 16 years only.

The greatest heat was 86.0 above zero on the 31st: the greatest cold was 54.0 above zero on the 17th; giving a range of temperature of 32°.

Warmest day was the 31st. Coldest day was the 17th.

Highest barometer reading was 30.17 on the 2nd; lowest barometer was 29.56 on the 15th; giving a range of .61 inches.

Minimum relative humidity observed was 40 on the 6th.

Rain fell on 18 days.

Thunder and lightning on the 7th, 8th, 15th, 17th and 31st.

Solar halo on the 13th.

Lunar Corona on the 13th.

ABSTRACT FOR THE MONTH OF AUGUST, 1902.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min.	Range.	* BAROMETER. † Mean.	Max.	Min.	Range.	‡ Mean relative humidity.	WIND. General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	71.2	80.5	67.7	12.8	29.91	29.92	29.89	.03	93	N.E.	6.5	08	0.95	....	0.95	1
2	66.7	71.0	62.1	8.9	29.91	29.93	29.89	.04	92	N.E.	4.5	16	0.96	....	0.96	2
SUNDAY........ 3	72.6	80.8	62.5	18.3	29.81	29.89	29.76	.13	74	S.	9.8	70	....	....	....	3..........SUNDAY
4	67.8	74.2	62.8	11.4	29.90	29.96	29.78	.18	61	N.E.	10.9	77	....	....	....	4
5	66.4	73.6	56.5	17.1	29.87	29.96	29.73	.23	62	S.	5.0	54	*r*	....	0.00	5
6	69.6	75.9	63.9	12.0	29.64	29.73	29.58	.15	79	S.W.	10.8	36	....	....	....	6
7	63.0	68.3	57.9	10.4	29.62	29.67	29.57	.10	79	N.W.	14.8	57	*r*	....	0.00	7
8	62.[illegible]	67.2	56.7	10.5	29.71	29.80	29.65	.14	83	W.	8.4	01	0.06	....	0.06	8
9	64.4	71.0	58.0	13.0	29.98	30.11	29.80	.31	73	N.W.	13.9	96	....	....	....	9
SUNDAY........10	66.7	76.1	53.0	23.1	30.05	30.13	29.94	.19	76	S.E.	9.3	53	....	....	....	10..........SUNDAY
11	68.1	78.0	66.0	12.0	29.79	29.94	29.70	.24	81	S.	14.5	13	0.80	....	0.80	11
12	58.6	62.3	55.6	6.7	29.99	30.11	29.80	.31	79	N.W.	16.0	30	....	....	....	12
13	62.9	70.7	52.9	17.8	30.10	30.18	30.04	.14	64	N.W.	13.1	98	....	....	....	13
14	66.0	75.6	52.0	23.6	30.00	30.06	29.94	.12	70	S.W.	16.6	60	....	....	....	14
15	60.3	66.4	55.2	11.2	29.92	29.96	29.89	.07	77	N.	8.9	26	0.36	....	0.36	15
16	59.2	66.4	52.0	14.4	29.86	29.91	29.80	.11	63	N.W.	7.5	83	....	....	....	16
SUNDAY........17	58.4	65.2	50.6	15.6	29.81	29.87	29.76	.11	66	N.W.	12.0	91	....	....	....	17..........SUNDAY
18	61.8	68.9	53.0	15.9	29.78	29.81	29.74	.07	64	N.W.	12.2	97	....	....	....	18
19	63.7	71.2	55.1	16.1	29.83	29.90	29.79	.11	71	N.W.	7.7	84	....	....	....	19
20	63.0	71.7	56.4	15.3	29.96	30.00	29.92	.10	71	S.	5.7	59	....	....	....	20
21	59.6	63.8	57.5	6.3	29.79	29.96	29.67	.29	92	S.W.	11.7	02	1.18	....	1.18	21
22	61.8	70.8	53.5	17.3	29.76	29.80	29.73	.07	79	S.W.	11.7	92	0.03	....	0.03	22
23	61.8	70.0	56.5	13.5	29.90	30.02	29.80	.22	85	N.	10.0	39	*r*	....	0.00	23
SUNDAY........24	64.6	71.4	55.5	15.9	30.07	30.12	30.02	.10	72	N.E.	9.2	97	....	....	....	24..........SUNDAY
25	68.3	77.8	57.5	20.3	29.98	30.06	29.88	.18	69	W.	6.0	84	*r*	....	0.00	25
26	69.2	77.5	64.5	13.0	29.83	29.88	29.78	.10	78	S.W.	16.5	63	0.02	....	0.02	26
27	63.1	69.5	58.4	11.1	30.03	30.12	29.86	.26	61	N.E.	6.1	89	....	....	....	27
28	63.4	72.4	51.7	20.7	30.19	30.23	30.12	.11	67	E.	3.2	92	....	....	....	28
29	66.6	76.8	56.1	20.7	30.21	30.26	30.16	.10	77	E.	3.6	91	....	....	....	29
30	69.0	79.0	58.0	21.0	30.11	30.19	30.02	.17	78	S.	4.8	90	....	....	....	30
SUNDAY........31	71.7	80.1	62.7	17.4	29.95	30.02	29.84	.18	71	S.	7.8	73	....	....	....	31..........SUNDAY
Means............	64.89	72.42	57.48	14.94	29.912	29.98	29.83	.15	74.6	85° E.	9.67	61.7	4.41	....	4.41	..............Sums.
27 Years means for and including this month......	66.71	74.97	58.83	16.14	29.941	......	......	.13	73.5	....	§ 12.01	¶ 58.0	3.60	....	3.60	27 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	548	652	326	205	81	1477	1310	1807	
Duration in hrs..	73	77	66	31	113	107	112	165	
Mean velocity....	7.5	8.5	4.9	6.6	7.7	13.8	11.7	11.0	

Greatest mileage in one hour was 25 on the 6th and 26th.
Greatest velocity in gusts was 25 on the 6th and 26th.

Resultant mileage, 2,709.
Resultant direction, 85° E.

Total mileage, 7,194.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

¶ 21 years only. § 16 years only.

The greatest heat was 80.8 above zero on the 3rd: the greatest cold was 50.6 above zero on the 17th; giving a range of temperature of 30.2°.

Warmest day was the 3rd. Coldest day was the 17th.

Highest barometer reading was 30.26 on the 29th; lowest barometer was 29.57 on the 7th; giving a range of .69 inches.

Minimum relative humidity observed was 48 on the 4th.

Rain fell on 12 days.

Thunder and lightning on the 1st and 21st.

Lightning on the 31st.

ABSTRACT FOR THE MONTH OF SEPTEMBER, 1902

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min.	Range.	* BAROMETER. † Mean.	Max.	Min.	Range.	‡ Mean relative humidity.	WIND. General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	69.7	74.0	66.5	7.5	29.78	29.81	29.73	.08	93	S.W.	13.2	03	0.37	....	0.37	1
2	64.9	71.8	59.2	2.6	29.87	29.98	29.79	.19	64	N.W.	16.8	87	....	....	....	2
3	65.0	72.6	56.8	15.8	29.93	30.00	29.77	.23	72	S.W.	8.2	76	....	....	....	3
4	61.0	66.9	52.5	14.4	29.71	29.86	29.64	.22	81	S.W.	13.5	30	0.11	....	0.11	4
5	53.3	59.9	46.0	13.9	30.11	30.29	29.86	.43	67	N.W.	13.3	93	....	....	....	5
6	56.5	65.6	44.1	21.5	30.23	30.33	30.11	.22	65	S.	7.5	75	....	....	....	6
SUNDAY........ 7	62.6	72.1	55.8	16.3	29.94	30.11	29.85	.26	79	S.E.	12.0	58	0.53	....	0.53	7............SUNDAY
8	63.3	71.5	55.0	16.5	29.98	30.04	29.91	.13	74	W.	7.4	98	....	....	....	8
9	65.2	75.9	54.8	21.1	29.69	29.91	29.52	.39	78	S.W.	12.5	49	0.33	...	0.33	9
10	55.7	63.7	49.6	14.1	29.86	29.99	29.62	.37	80	S.W.	13.2	71	0.04	....	0.04	10
11	59.9	69.0	48.5	20.5	30.02	30.06	29.99	.07	77	S.W.	7.1	92	....	....	....	11
12	62.3	71.5	53.9	17.6	30.07	30.11	30.03	.08	83	S.	4.3	65	....	....	....	12
13	57.2	63.5	50.2	13.3	29.97	30.05	29.89	.16	90	S.W.	9.3	00	0.35	....	0.35	13
SUNDAY........14	51.1	57.5	44.5	13.0	30.15	30.22	30.05	.17	73	S.W.	12.3	94	....	....	....	14............SUNDAY
15	56.0	63.8	45.5	18.3	30.16	30.19	30.11	.08	73	S.W.	7.7	93	....	....	....	15
16	58.5	67.0	46.5	20.5	30.27	30.32	30.18	.14	83	S.	2.0	72	....	....	....	16
17	60.9	71.2	51.0	20.2	30.32	30.36	30.27	.09	78	S.	2.0	74	....	....	...	17
18	59.8	66.6	51.1	15.5	30.22	30.29	30.16	.13	82	S.	4.1	54	....	....	....	18
19	63.0	65.9	56.1	12.8	30.21	30.24	30.17	.07	83	S.	3.5	13	....	....	....	19
20	60.5	64.7	55.9	8.8	30.27	30.31	30.22	.09	96	N.	10.3	00	0.11	....	0.11	20
SUNDAY........ 21	65.3	74.9	57.5	17.4	30.19	30.27	30.10	.17	85	S.	2.8	50	0.05	....	0.05	21............SUNDAY
22	63.9	69.0	58.2	10.8	30.02	30.10	29.56	.14	94	S.W.	1.9	00	0.08	....	0.03	22
23	65.0	70.8	62.1	8.7	29.86	29.96	29.78	.18	95	W.	5.9	03	0.76	....	0.76	23
24	50.9	62.5	44.0	18.5	30.14	30.26	29.86	.40	65	N.E.	9.2	74	....	....	....	24
25	47.8	55.7	38.8	16.9	30.26	30.33	30.19	.14	71	E.	7.7	69	....	....	....	25
26	53.7	57.5	43.8	13.7	30.10	30.19	29.97	.22	97	S.W.	5.2	01	0.17	....	0.17	26
27	62.4	69.3	57.1	12.2	29.85	29.97	29.76	.21	90	S.	3.7	00	0.01	....	0.01	27
SUNDAY....... 28	64.8	69.3	61.2	8.1	29.74	29.76	29.71	.05	93	N.	4.3	00	r	....	0.00	28.........SUNDAY
29	64.6	70.8	60.2	10.6	29.82	29.86	29.76	.10	89	N.E.	11.8	25	....	....	....	29
30	60.2	66.6	55.7	10.9	29.78	29.86	29.69	.17	91	N.E.	9.5	02	r	....	0.00	30
Means.......	60.17	67.47	52.74	14.73	30.018	30.101	29.922	.179	81.4	S 55° W.	8.08	47.1	2.91	....	2.91	..............Sums.
28 Years means for and including this month	58.59	65.53	50.91	15.63	30.015	......	......	.185	76.4	....	‖ 22.52	¶ 53.67	3.23	....	3.23	28 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction......	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	432	605	377	151	706	8,9	868	778	
Duration in hrs..	53	66	64	20	167	216	82	52	
Mean velocity....	8.1	9.2	5.9	7.5	4.2	4.2	10.6	15.0	

Greatest mileage in one hour was 24 on the 2nd.
Greatest velocity in gusts was 30 on the 2nd.

Resultant mileage, 1,145.
Resultant direction, S 55° W.

Total mileage, 5,817.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

¶ 21 years only. ‖ 16 years only.

The greatest heat was 75.9 above zero on the 9th. The greatest cold was 38.8 above zero on the 25th, giving a range of temperature of 37.1°.

Warmest day was the 1st. Coldest day was the 25th.

Highest barometer reading was 30.36 on the 17th; lowest barometer was 29.52 on the 9th; giving a range of .84 inches.

Minimum relative humidity observed was 46 on the 6th.

Rain fell on 14 days.

Rainbow on the 1st and 13th.

Thunder and lightning on the 23rd.

Lightning on the 7th.

ABSTRACT FOR THE MONTH OF OCTOBER, 1902.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min.	Range.	* BAROMETER. † Mean.	Max.	Min.	Range.	‡ Mean relative humidity.	WIND.H General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	60.4	65.5	57.2	8.3	29.72	29.87	29.67	.20	97	N.E.	5.9	00	0.15	....	0.15	1
2	51.5	56.5	49.6	6.9	30.03	30.09	29.87	.22	92	S.W.	7.3	00	0.01	....	0.01	2
3	52.3	59.1	46.1	13.0	30.08	30.12	30.02	.10	78	W.	7.3	25	....	....	....	3
4	46.2	52.5	41.8	10.7	30.09	30.15	30.03	.12	73	N.W.	5.9	96	....	....	....	4
SUNDAY........ 5	46.1	51.4	37.3	14.1	29.90	30.03	29.71	.32	91	E.	4.0	10	0.00	....	0.00	5............SUNDAY
6	54.2	60.1	50.3	9.8	29.52	29.71	29.40	.31	93	S.W.	13.6	10	0.69	....	0.69	6
7	52.8	63.2	45.8	17.4	29.70	29.76	29.66	.10	95	S.W.	10.7	23	0.15	....	0.15	7
8	43.1	54.6	41.0	13.6	29.93	30.02	29.76	.26	78	S.W.	13.8	48	0.06	....	0.06	8
9	40.4	46.4	37.3	9.1	30.16	30.35	29.98	.37	78	S.W.	10.2	17	0.10	....	0.10	9
10	40.4	48.1	31.3	16.8	30.30	30.42	30.12	.30	73	S.W.	9.1	95	....	....	....	10
11	48.8	59.6	36.0	23.6	29.89	30.12	29.74	.38	80	S.	3.2	32	....	....	....	11
SUNDAY........12	50.2	54.2	47.4	6.8	29.80	29.88	29.74	.14	79	N.E.	10.5	04	....	....	....	12...........SUNDAY
13	53.4	62.8	41.8	21.0	29.67	29.90	29.51	.39	84	S.E.	10.0	00	0.07	....	0.07	13
14	45.9	62.8	38.3	24.5	29.78	29.93	29.55	.38	73	S.W.	18.5	74	....	....	....	14
15	44.6	46.8	37.8	9.0	29.81	29.93	29.73	.19	84	S.W.	14.4	07	0.01	....	0.01	15
16	41.6	48.0	36.3	11.7	30.02	30.24	29.80	.44	64	N.W.	10.9	72	....	....	....	16
17	34.9	39.8	30.8	9.0	30.33	30.38	30.24	.14	66	N.W.	5.2	92	....	....	....	17
18	38.9	47.6	27.1	20.5	30.16	30.34	29.95	.39	89	S.E.	2.8	03	0.01	....	0.01	18
SUNDAY........19	53.6	62.1	44.0	18.1	29.89	29.99	29.74	.25	93	S.W.	6.8	09	0.06	....	0.06	19 ....SUNDAY
20	44.9	58.6	39.8	18.8	29.97	30.08	29.87	.21	75	S.W.	21.6	67	....	....	....	20
21	37.5	42.6	34.3	8.3	30.28	30.34	30.08	.26	67	N.W.	13.7	53	....	....	....	21
22	40.4	46.6	30.2	16.4	30.18	30.35	30.00	.35	79	S.W.	8.0	32	0.11	....	0.11	22
23	37.8	44.6	33.0	11.6	30.27	30.39	30.00	.39	73	N.E.	10.6	83	0.15	....	0.15	23
24	43.0	48.8	29.8	19.0	29.97	30.34	29.65	.69	87	S.W.	0.3	00	0.20	....	0.20	24
25	42.0	58.5	34.0	24.5	30.22	30.57	29.65	.92	81	N.W.	18.5	90	....	....	....	25
SUNDAY........26	33.5	37.3	26.2	11.1	30.37	30.59	30.01	.58	79	S.W.	11.6	00	0.09	....	0.09	26...........SUNDAY
27	51.3	59.7	36.8	22.9	29.83	30.01	29.77	.24	82	S.W.	11.1	23	0.06	....	0.06	27
28	44.8	53.5	37.7	15.8	29.61	29.77	29.50	.27	92	N.W.	8.4	00	0.44	....	0.44	28
29	35.5	41.1	30.0	11.1	29.92	30.24	29.66	.58	77	N.W.	18.1	22	0.01	....	0.01	29
30	34.1	40.8	26.0	14.8	30.28	30.44	30.09	.35	71	S.W.	6.2	52	0.06	....	0.06	30
31	39.4	45.4	33.7	11.7	30.31	30.51	30.07	.44	80	S.W.	14.3	63	0.05	....	0.06	31
Means............	44.63	52.21	37.70	14.51	29.999	30.157	29.825	.331	80.7	S 75° W.	10.36	38.7	2.49	....	2.49	..............Sums.
28 Years means for and including this month	45.90	52.90	39.00	13.91	30.014	......	......	.221	77.1	....	‖ 13.24	§ 41.47	3.01	....	3.01	28 Years means for and including this month.

ANALYSIS OF WIND RECORD.H

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	149	599	370	292	123	3644	522	2007	
Duration in hrs..	22	48	62	47	41	288	70	151	15
Mean velocity....	6.8	12.5	6.0	6.2	3.0	12.7	7.5	13.3	

Greatest mileage in one hour was 32 on the 20th.

Greatest velocity in gusts was 36 on the 20th.

Resultant mileage, 3,630.

Resultant direction, S 75° W.

H The wind records are from the instruments on the tower of the City Hall, Montreal.

Total mileage, 7,706.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

§ 21 years only. ‖ 16 years only.

The greatest heat was 65.5 above zero on the 1st. The greatest cold was 26.0 above zero on the 30th, giving a range of temperature of 39°.5.

Warmest day was the 1st. Coldest day was the 26th.

Highest barometer reading was 30.59 on the 26th: lowest barometer was 29.40 on the 6th; giving a range of 1.19 inches.

Minimum relative humidity observed was 52 on the 16th and 17th.

Rain fell on 20 days. Hoar-frost on the 18th.

Thunder and lightning on the 24th.

ABSTRACT FOR THE MONTH OF NOVEMBER, 1902

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, Superintendent.

DAY	THERMOMETER. † Mean.	Max.	Min.	Range.	* BAROMETER. ‡ Mean.	Max.	Min.	Range.	‡ Mean relative humidity.	WIND.H General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	36.9	40.2	33.5	6.7	30.45	30.53	30.36	.17	83	S.W.	2.0	20	....	....	....	1
SUNDAY........ 2	45.1	54.0	33.3	20.7	30.22	30.36	30.13	.23	81	S.	1.7	71	0.00	....	0.00	2 ....SUNDAY
3	51.3	62.4	45.2	17.2	30.05	30.18	29.93	.25	80	S.W.	11.9	23	0.00	....	0.00	3
4	45.2	52.3	37.8	14.5	30.19	30.25	30.14	.11	83	S.W.	1.5	70	....	....	....	4
5	51.2	58.2	43.6	14.6	30.08	30.15	29.97	.18	77	S.	2.1	26	0.00	....	0.00	5
6	52.4	57.2	47.8	9.4	29.83	29.97	29.71	.26	87	S.W.	15.0	00	0.26	....	0.26	6
7	38.9	51.4	33.4	18.0	30.16	30.31	29.94	.37	70	S.W.	13.0	25	....	....	....	7
8	34.3	39.1	28.7	10.4	30.33	30.40	30.28	.12	76	S.E.	2.0	57	....	....	....	8
SUNDAY........ 9	38.7	46.5	29.3	17.2	30.16	30.28	29.97	.31	67	S.W.	3.0	89	....	...	....	9..........SUNDAY
10	39.5	46.9	27.9	19.0	30.07	30.30	29.94	.36	68	N.W.	13.5	38	0.01	....	0.01	10
11	27.4	36.0	22.0	14.0	30.38	30.46	30.28	.18	77	E.	5.5	12	....	....	....	11
12	30.6	33.5	28.5	5.0	29.98	30.24	29.78	.46	93	N.E.	10.4	00	1.07	....	1.07	12
13	29.7	37.8	24.5	13.3	30.20	30.35	29.99	.36	96	N.E.	9.6	00	0.47	....	0.47	13
14	39.9	42.7	34.3	8.4	30.10	30.17	29.98	.19	92	S.W.	5.5	40	0.27	....	0.27	14
15	45.2	54.3	36.2	18.1	29.90	30.03	29.78	.25	87	S.W.	11.5	04	0.00	....	0.00	15
SUNDAY....... 16	40.7	48.8	34.2	14.6	30.21	30.31	30.03	.28	83	S.W.	8.8	40	0.00	....	0.00	16 ....SUNDAY
17	34.1	38.9	31.0	7.9	30.33	30.35	30.30	.05	85	N.E.	9.9	01	....	....	....	17
18	39.5	44.8	32.6	12.2	30.17	30.30	30.06	.24	83	N.E.	7.5	00	0.08	....	0.08	18
19	45.4	49.0	41.9	7.1	30.12	30.22	30.03	.19	84	S.W.	9.4	22	0.25	....	0.25	19
20	45.9	50.2	42.5	7.7	30.19	30.28	30.05	.23	83	S.W.	3.8	01	....	....	....	20
21	46.6	50.2	42.4	7.8	29.86	30.05	29.76	.29	87	S.W.	8.7	00	0.00	....	0.03	21
22	45.9	53.2	34.5	18.7	29.48	29.76	29.24	.52	81	S.W.	17.6	01	0.07	....	0.07	22
SUNDAY...... 23	29.1	41.0	25.2	15.8	29.66	29.73	29.48	.25	77	N.W.	19.8	91	....	....	....	23 ...... SUNDAY
24	39.7	43.9	25.2	18.7	29.42	29.59	29.30	.29	84	S.W.	13.1	17	0.03	....	0.03	24
25	31.7	39.9	24.2	15.7	29.86	30.08	29.53	.55	70	N.E.	12.6	54	....	....	....	25
26	24.2	29.0	19.0	10.0	29.87	30.08	29.68	.40	83	N.E.	24.8	00	....	1.5	0.12	26
27	28.6	32.5	24.1	8.4	29.55	29.68	29.50	.18	94	N.E.	10.0	00	0.05	2.4	0.29	27
28	25.7	31.0	20.0	11.0	29.80	30.26	29.49	.77	82	S.W.	21.3	00	....	2.0	0.15	28
29	25.6	37.0	15.5	21.5	30.28	30.44	30.06	.38	75	S.E.	6.6	48	....	....	....	29
SUNDAY........30	35.0	39.0	27.4	11.6	30.01	30.05	29.97	.08	77	W.	23.4	32	....	....	....	30.........SUNDAY
Means..........	38.16	44.69	31.52	13.17	30.030	30.172	29.839	.283	79.6	S 58° W.	10.18	27.9	2.51	5.9	3.07	.... Sums.
28 Years means for and including this month	32.67	38.91	26.79	12.12	30.014	......	......	.270	80.45	....	§ 15.62	¶ 28.16	2.33	13.61	3.72	28 Years means for and including this month.

ANALYSIS OF WIND RECORD.H

Direction.......	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	122	1640	347	107	379	3513	612	610	
Duration in hrs..	17	119	58	35	112	262	47	50	20
Mean velocity....	7.2	13.8	6.0	3.1	3.4	13.8	13.0	12.2	

Greatest mileage in one hour was 44 on the 30th.

Greatest velocity in gusts was 54 on the 30th.

Resultant mileage, 2,305.

Resultant direction, S 55° W.

H The wind records are from the instruments on the tower of the City Hall, Montreal.

Total mileage, 7,330.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

¶ 21 years only. § 16 years only.

The greatest heat was 62.4 above zero on the 3rd. The greatest cold was 15.5 above zero on the 29th, giving a range of temperature of 46.9.

Warmest day was the 5th. Coldest day was the 26th.

Highest barometer reading was 30.53 on the 1st; lowest barometer was 29.24 on the 22nd; giving a range of 1.29 inches.

Minimum relative humidity observed was 53 on the 9th and 10th.

Rain fell on 16 days. Snow fell on 3 days.

ABSTRACT FOR THE MONTH OF DECEMBER, 1902.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min.	Range.	* BAROMETER. ‡ Mean.	Max.	Min.	Range.	‡Mean relative humidity.	WIND.н General direction.	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	30.2	33.4	26.0	7.4	29.86	29.94	29.81	.13	84	W.	11.5	35	....	0.0	0.00	1
2	28.1	30.5	25.8	4.7	29.89	29.94	29.80	.14	87	N.E.	7.8	00	....	2.8	0.11	2
3	26.9	30.3	23.0	7.3	29.55	29.84	29.38	.46	97	N.E.	15.3	00	0.13	3.6	0.53	3
4	17.0	29.6	11.0	18.6	29.95	30.05	29.64	.41	79	N.W.	14.5	78	....	0.2	0.04	4
5	8.6	16.6	3.9	12.7	29.99	30.10	29.89	.21	71	N.W.	12.7	00	....	....	....	5
6	6.1	11.8	2.3	9.5	30.32	30.42	30.10	.32	75	N.W.	6.5	63	....	....	....	6
SUNDAY........ 7	8.6	11.0	2.8	8.2	30.06	30.40	29.82	.58	84	N.E.	8.6	00	....	2.7	0.30	7..........SUNDAY
8	—0.8	11.0	—16.0	27.0	30.02	30.27	29.86	.41	61	S.W.	21.9	25	....	0.5	0.05	8
9	—12.0	—8.2	—20.0	11.8	30.38	30.45	30.27	.18	47	S.W.	14.3	100	....	...	....	9
10	12.8	31.2	—9.5	40.7	29.93	30.38	29.61	.77	77	S.W.	13.0	00	....	7.3	0.53	10
11	4.4	22.6	0.1	22.5	30.29	30.38	30.06	.32	62	E.	8.0	37	....	....	....	11
12	—1.0	4.0	—5.0	9.0	30.45	30.54	30.33	.21	69	N.E.	4 7	29	....	....	....	12
13	—1.5	3.2	—7.7	10.9	30.45	30.54	30.37	.17	69	N.E.	23 2	00	....	....	....	13
SUNDAY........14	—0.1	4.2	—10.7	14.9	30.62	30.69	30.47	.21	61	S.W.	7.6	100	....	....	....	14..........SUNDAY
15	7.5	10.9	—0.5	11.4	30.71	30.80	30.52	.28	76	N.E.	4.9	00	....	....	....	15
16	29.6	38.2	9.0	29.2	30.01	30.52	29.74	.78	91	S W.	10 7	00	0.24	1.2	0.42	16
17	31.9	38.5	28.6	9.9	29.64	29.74	29.57	.17	93	S.W.	22.4	05	....	0.7	0.06	17
18	28.3	34.0	18.7	15.3	29.65	29.86	29.53	.33	85	S.W.	26.1	24	....	0.8	0.04	18
19	26.6	35.3	18.4	16.9	29.82	30.09	29.64	.45	85	S.W.	13.2	07	0.00	0 1	0.00	19
20	12.4	26.4	8.0	18.4	30.43	30.54	30.09	.45	76	N E.	6.5	100	....	....	....	20
SUNDAY....... 21	20.0	35.2	9.3	25.9	30.23	30.50	29 79	.71	94	N.E.	9.1	00	0.93	0.1	0.94	21 .. ..SUNDAY
22	34.3	39.3	24.4	14.9	29.76	30.06	29.58	.48	87	S W.	19.3	00	0.13	....	0.13	22
23	14.3	28.9	7.5	21.4	30.29	30.45	30.06	.39	75	N W.	10 5	25	....	....	....	23
24	8.2	11.8	4 5	7.3	30.31	30.45	30.14	.31	82	N.E.	7.3	64	....	....	....	24
25	14.1	19.8	5.5	14.3	30.05	30.14	29.99	.15	90	N.E.	13.5	00	....	0.5	0.05	25
26	20.0	21.8	17.5	4.3	29.92	30 00	29.87	.13	95	N E.	20.9	00	....	4.8	0.49	26
27	19.1	22.0	16.0	6.0	29.79	29.88	29.71	.17	92	N.E.	14.4	00	....	4.4	0.39	27
SUNDAY...... 28	9.9	18.7	6.2	12.5	29.93	30.03	29.83	.15	73	S.W.	14.2	53	....	0.1	0.01	28..........SUNDAY
29	24.5	32.2	7.2	25.0	29.94	30.08	29.79	.29	93	S.W.	9.4	13	....	1.5	0.19	29
30	27.8	32.1	22.5	9.6	30.00	30.08	29.90	.18	87	S.W.	17.9	01	....	....	....	30
31	26.9	30.0	22.8	7.2	30.13	30.18	30.07	.11	85	S.W.	22.3	00	....	....	....	31
Means...... ..	15.57	22.78	8.12	14.67	30.075	30.237	29.912	.325	80.3	N 84° W.	11.02	24.5	1.43	32.3	4.25	..............Sums.
28 Years means for and including this month......	19.10	26.09	11 97	14.11	30.031	......	......	.296	83.3	....	‖ 15.94	§ 26.87	1.38	23.59	3.67	28 Years means for and including this month.

ANALYSIS OF WIND RECORD.н

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	516	2619	249	156	120	4033	676	1320	
Duration in hrs..	54	172	53	24	24	236	63	99	19
Mean velocity....	9.6	15 3	4.7	6 5	5 0	17.1	10.7	13.3	

Greatest mileage in one hour was 89 on the 22nd
Greatest velocity in gusts was 48 on the 22nd.

Resultant mileage, 2,260.
Resultant direction, N 84° W.

н The wind records are from the instruments on the tower of the City Hall, Montreal.

Total mileage, 9,632.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

§ 21 years only. ‖ 16 years only.

The greatest heat was 39.3 above zero on the 22nd. The greatest cold was 20.0 below zero on the 9th, giving a range of temperature of 59.3.

Warmest day was the 22nd. Coldest day was the 9th.

Highest barometer reading was 30.80 on the 15th. lowest barometer was 29.38 on the 3rd, giving a range of 1.42 inches.

Minimum relative humidity observed was 39 on the 9th.

Rain fell on 5 days. Snow fell on 17 days.

Rain and snow on 4 days.

No. inches snow on ground 18.

ABSTRACT FOR THE MONTH OF JANUARY, 1903

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY	THERMOMETER. † Mean.	Max.	Min.	Range.	* BAROMETER. † Mean.	Max.	Min.	Range.	‡ Mean relative humidity.	WIND.H General direction	Mean velocity in miles per hour.	Per cent. possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	30.4	36.0	20.4	15.6	30.07	30.14	29.98	.16	89	S.W.	20.8	84	....	....	....	1
2	29.6	34.1	25.9	8.2	30.16	30.24	29.99	.25	88	S.W.	8.6	20	....	....	....	2
3	32.8	34.8	27.4	7.4	29.54	29.99	29.38	.61	93	N.E.	5.4	00	0.24	4.3	0.67	3
SUNDAY........ 4	30.3	31.6	25.2	9.4	29.64	29.73	29.44	.29	89	S.W.	10.7	13	0.01	....	0.01	4............SUNDAY
5	20.3	28.0	14.4	13.6	29.76	29.82	29.66	.16	90	S.W.	9.0	13	....	0.0	0.00	5
6	12.6	16.6	6.8	9.8	29.69	29.81	29.60	.21	85	S.W.	6.7	09	....	0.1	0.01	6
7	4.7	11.7	0.0	11.7	29.51	29.61	29.32	.29	85	N.	10.0	13	....	2.0	0.21	7
8	5.8	11.0	0.2	10.8	29.36	[illegible]	29.26	.26	88	W.	15.0	15	....	1.0	0.12	8
9	—5.5	2.0	—11.4	13.4	29.56	29.63	29.42	.26	81	W.	11.5	33	....	0.5	0.07	9
10	—0.1	9.8	—11.8	21.6	29.88	30.03	29.68	.35	81	W.	8.3	17	....	0.1	0.01	10
SUNDAY........11	14.7	20.5	6.1	14.4	29.76	30.07	29.18	.89	91	W.	5.4	00	....	6.7	0.47	11............SUNDAY
12	14.3	23.6	6.0	17.6	29.49	29.80	29.11	.69	79	N.W.	24.5	45	....	2.0	0.16	12
13	2.3	14.2	—3.9	18.1	30.43	30.19	29.80	.39	59	N.W.	16.0	68	....	....	....	13
14	6.7	11.8	—0.9	12.7	30.12	30.21	29.91	.28	65	W.	11.5	70	....	....	....	14
15	23.1	27.9	9.9	18.0	29.69	29.93	29.60	.33	89	W.	13.2	00	....	1.3	0.08	15
16	24.8	32.4	14.6	17.8	29.80	29.86	29.70	.16	90	W.	13.2	28	....	0.0	0.00	16
17	28.7	33.9	11.9	22.0	29.47	29.70	29.34	.36	96	W.	14.4	01	....	0.8	0.09	17
SUNDAY........18	—2.1	22.4	—11.4	33.8	29.94	30.28	29.57	.71	64	N.W.	19.0	86	....	0.0	0.00	18 ....SUNDAY
19	—10.2	—4.0	—20.0	16.0	30.52	30.57	30.28	.29	54	S.W.	8.7	86	....	...	....	19
20	2.4	16.8	—10.1	26.9	30.37	30.56	30.23	.33	79	S.E.	0.4	54	....	....	....	20
21	21.6	30.8	4.1	26.7	29.85	30.23	29.60	.63	92	N.E.	9.4	00	....	13.4	1.60	21
22	15.0	28.1	10.0	18.1	29.87	29.95	29.74	.21	80	W.	6.1	48	....	0.0	0.00	22
23	11.2	23.6	0.2	23.4	30.10	30.44	29.84	.60	75	N.W.	16.2	82	....	0.5	0.04	23
24	—4.5	3.4	—10.9	14.3	30.53	30.59	30.44	.15	67	N.E.	3.2	31	....	....	....	24
SUNDAY...... 25	—3.8	3.1	—13.4	16.5	30.40	30.45	30.36	.09	63	N.	10.6	[illegible]	....	0.0	0.00	25............SUNDAY
26	6.9	11.0	1.0	10.0	30.41	30.46	30.33	.13	86	N.E.	7.5	[illegible]	....	0.0	0.00	26
27	26.2	31.5	7.8	23.7	30.16	30.33	30.12	.21	94	S.	3.0	[illegible]	0.00	....	0.01	27
28	31.6	33.8	29.1	4.7	29.94	30.12	29.89	.23	96	E.	1.1	00	0.70	....	[illegible]	28
29	34.2	[illegible]	29.0	8.3	29.80	30.03	29.42	.61	98	S.E.	3.3	[illegible]	0.21	....	0.21	29
30	30.8	38.6	13.6	25.0	29.26	29.42	29.17	.25	83	S.W.	17.1	16	0.18	0.3	0.21	30
31	18.0	21.8	10.4	11.4	29.72	29.96	29.41	.55	73	N.W.	...	73	....	0.2	0.02	31
Means......	14.61	22.00	5.84	16.16	[illegible]	30.055	29.703	.352	81.3	N 77° W.	10.33	27.3	[illegible]	31.5	4.08	.... Sum.
29 Years means for and including this month	12.77	20.77	4.51	16.26	30.046	......	......	.334	[illegible]	....	§ 16.23	¶ 34.47	[illegible]	[illegible]	3.735	28 Years means for and including this month.

ANALYSIS OF WIND RECORD.H

Direction........	N	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	552	501	190	40	[illegible]	1768	[illegible]	2059	
Duration in hrs..	59	50	41	12	31	128	217	122	60
Mean velocity....	9.4	10.0	4.6	3.3	3.3	13.3	10.5	16.9	

Greatest mileage in one hour was 25 on the 12th.

Greatest velocity in gusts was 44 on the 30th.

Resultant mileage, 4,494.

Resultant direction, N 77° W.

H The wind records are from the instruments on the tower of the City Hall, Montreal. Mean for 30 days only.

Total mileage, 7,437.

* Barometer readings reduced to sea-level and temperature 32° Fahrenheit.

† Mean of bi-hourly readings taken from self-recording instruments.

‡ Humidity relative, saturation being 100. Mean of observations at 8, 15 and 20 hours.

¶ 22 years only. § 16 years only.

The greatest heat was 38.6 above zero on the 30th. The greatest cold was 20.0 below zero on the 19th, giving a range of temperature of 58.6°.

Warmest day was the 29th. Coldest day was the 19th.

Highest barometer reading was 30.59 on the 24th; lowest barometer was 29.11 on the 12th, giving a range of 1.48 inches.

Minimum relative humidity observed was 30 on the 19th.

Rain fell on 6 days. Snow fell on 24 days.

Rain and snow on 2 days.

Fog on 4 days.

No. inches snow on ground 15.