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THE

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ON THE NORIAN OR "UPPER LAURENTIAN" FORMATION OF CANADA.[1]

By FRANK D. ADAMS, M.A.Sc., PH.D.

(Translated from the German by N. J. GIROUX, ESQ., C. E., of the Geological Survey of Canada.)

TABLE OF CONTENTS.

[1] This paper appeared in the Neues Jahrbuch für Mineralogie in 1893 (Beilage-band VIII). As it presents a somewhat exhaustive treatment of a celebrated series of Canadian rocks, it has been thought advisable to present a translation of it to Canadian readers. Since the publication of the paper further investigation has brought to light some few additional facts concerning these rocks, but it has been thought best to present the paper exactly as it originally appeared, making any necessary additions to it in the form of occasional foot notes. The editors of the Record of Science are indebted to Mr. N. J. Giroux, C.E., of the Dominion Geological Survey, for a literal translation of the paper.

The original paper in German was accompanied by two excellent maps printed in colours, from which the maps accompanying the present translation are taken. Those particularly interested in the distribution of these Norian rocks are referred to the original maps, as in these the relative position of the several areas is shown with greater clearness.

Correction in Large Map.—Owing to a mistake on the part of the lithographer, the Adirondack Archean area has been represented as Huronian. It should have been represented as of Laurentian age, since, with the exception of the Anorthosite, it consists of rocks of the Grenville series.

3. The Saguenay anorthosite area.
4. Various other anorthosite areas.
   (a) In Labrador.
   (b) In Newfoundland.
   (c) On the north shore of the Gulf of St. Lawrence.
   (d) On the north shore of the River St. Lawrence.
   (e) In the State of New York, U. S. A.
   (f) On the east coast of Lake Huron.
   (g) Elsewhere in Canada.
5. Age of the anorthosite intrusions and their relation to the margin of the archaean protaxis.
6. Occurrence of similar anorthosites in other countries.
7. General summary of the results.
8. Tables of analyses.
9. Literature relating to the anorthosites of Canada.

The present paper is based upon a study of the Canadian anorthosites in the field, a work which was carried out for the Geological Survey of Canada and occupied five summers, as well as upon the examination of a large number of thin sections of these rocks and a careful study of all the literature relating to them.

The petrographical part of the work was done for the most part in the Mineralogical Institute of the University of Heidelberg, and I take the liberty of expressing my hearty thanks to my teacher, Professor Rosenbusch, for his assistance and advice during the progress of the work.

I am furthermore under special obligations to Dr. A. R. C. Selwyn, Director of the Geological Survey of Canada, for permission to make use of material hitherto unpublished and which is the property of the Geological Survey Department.

I.—GENERAL STATEMENT CONCERNING THE GEOLOGY OF THE LAURENTIAN.

The nucleus of the North American continent consists, as is well known, of a large area of Archaean rocks which lie, for the most part, in the Dominion of Canada, and occupy an area of not less than 2,031,000 square miles. They form what Suess [1] calls "the Canadian shield" as well as the more mountainous district along the coast of Labrador.

[1] Suess, Das Antlitz der Erde, Bd. II., p. 42.

Speaking generally we may say that the southern limit of this area extends from Lake Superior in a north-easterly direction along the Lower St. Lawrence as far as Labrador, and north-westerly to the mouth of the Mackenzie River on the Arctic Ocean. North of these limits, as far as the coast of the Arctic Ocean, almost the whole area is composed of the old crystalline rocks, and although subordinate areas of Huronian rocks are found in these enormous tracts of land by far the greater part belongs to the lower Archaean or the Laurentian system.

This great rock complex consists principally of orthoclase gneiss, of nearly every variety, both as regards structure and composition. In many places these gneisses show only the most obscure foliation and resemble granite, in other areas, of great extent, they appear as perfectly stratified as any Palaeozoic formation and they then lie over great areas quite flat or in low indulations. A great part of the obscurely laminated gneiss is probably eruptive, and in some instances this has been established beyond doubt. On the other hand, we have good reason to believe that many of the stratified portions of the system are of sedimentary origin.

In certain areas, where the stratified gneiss occurs, we find in it bedded layers of crystalline limestone, quartzite, amphibolite and other rocks often of considerable extent. In such cases, the gneiss itself is usually richer in varieties, and certain of these varieties almost invariably accompany the limestone beds. These are chiefly garnetiferous gneiss and a peculiar sillimanite gneiss which weathers in a remarkably rusty manner. These gneisses, together with the accompanying granular limestones, quartzites, &c., Logan regarded as a higher division of the Laurentian, resting conformably upon a lower gneiss, which holds no limestone or quartzite, and possesses a more uniform character.[1]

He called this upper division "The Grenville Series" after Grenville,[2] in the Province of Quebec, where it was

[1] Logan, Report of the Geol. Survey of Canada 1863, p. 45, and earlier reports of the Geol. Survey of Canada from 1845-48.

[2] Logan, Rep. of the Geol. Survey of Canada 1863, page 839.

well developed, while the supposed lower gneiss, on account of its great development about the head waters of the Ottawa River was known afterwards by the name of "Ottawa gneiss." As a result of later investigations, in other parts of Canada, Vennor came to the conclusion that the higher division rested unconformably upon the lower gneiss. Whether therefore we have two distinct and unconformable series or not is a point which is not as yet conclusively determined. The facts hitherto collected, however, would rather indicate that the two are distinct. In the present essay these two names (Grenville series and Ottawa gneiss) will be employed to designate these two developments of the Laurentain respectively, and it may be here remarked that whether they be conformable or unconformable, considered from the economical standpoint, there is a very marked difference between them. The Grenville division with its crystalline limestones, quartzite, &c., carries apatite, graphite, iron ores, mica and in general all the important mineral deposits of the Laurentian, while the Ottawa gneiss, as far as we at present know, carries but little in the way of valuable minerals.

In the Grenville series we find also the earliest traces of life on our planet, since the undoubted occurrence of larger as well as smaller limestone beds which so frequently alternate with the gneiss of this series can only be explained by organic agencies. The presence of a considerable admixture of graphite, which in many of these limestones occurs in a finely dissiminated condition, and is also found in many cases in the associated gneisses, is a further important testimony in the same direction. Many of these limestones resemble precisely some of younger age where these have been metamorphosed by contact with eruptive rocks. The carbon of the limestone crystallizes as graphite in these cases, and the clayey substances, take the form of small scales of mica or grains of other minerals. Veins of graphite appear likewise, though sparingly, in these Laurentian limestones and correspond to the veins and strings of bituminous and carbonaceous substances which we find filling cracks and fissures in bituminous and carbonaceous beds in more recent formations. But the chief bulk of the graphite occurs finely dissiminated through the rocks as above mentioned.[1]

It was, however, observed by the geologists who first worked on these Laurentian rocks that there occur, in many places together with the above mentioned orthoclase gneisses, &c., great areas of a rock that is principally and sometimes almost exclusively composed of a triclinic or plagioclase feldspar. They found that in many places the structure and the appearance of this rock varied considerably from place to place; it being sometimes massive, sometimes schistose, sometimes coarse grained, sometimes fine grained. But all these structural varieties agree in having the same composition.

For this reason they were all placed together in one class and called "Anorthosite Rock" or "Anorthosite," a name derived from "Anorthose," a term proposed by Delesse to designate the triclinic feldspars, and which is thus synonymous with the term "Plagioclase" now more commonly employed. This designation therefore serves to emphasize the difference between these and the predominating orthoclase feldspar rocks of the rest of the Laurentian.

The term "anorthosite" which has been often misunderstood[2] on account of its presumed derivation from anorthite, a feldspar which rarely occurs in these rocks, has hitherto found no place in the systems most generally used in the classification of eruptive rocks. But in Canada, it has been used for many years, and will here be employed to designate a certain well defined class of rocks which belong to the family of gabbros and which stand at one end of the series, being distinguished by the marked predominance of plagioclase and the marked subordination or entire absence of all coloured constituents. Their place in the family of gabbros, corresponds in a certain way to that of the pyroxenites

[1] For further evidence see Sterry Hunt, Chemical and Geological Essays, p. 272, and Sir William Dawson: "The Dawn of Life" and many other writings.

[2] Wichman, Zeit. der Deutsch. Geol. Ges., 1884 p. 496.

at the other end of the series, in which the pyroxene largely predominates and the plagioclase occurs only in very small quantity, or that of troctolite in which the plagioclase and olivine greatly predominate and the pyroxene is absent as an essential constituent.

They constitute a well defined type which both on account of its widespread occurrence and its constant character occupies an independent position in the classification and cannot suitably be included anywhere else.

These anorthosites were found by the older geologists of Canada in parts of the Laurentian widely separatad from one another, sometimes occurring in small areas and again occupying large districts. Later investigations have made known the existence of many additional areas, great and small. The literature of the subject is extensive, the bibliography comprises about a hundred titles, but these communications are for the most part short and do not enter into descriptive details.

This anorthosite has been recognized at the following localities: To begin at the Atlantic coast (see large map), one area is known (and as far as can be ascertained from observations by travellers several probably occur) on the east coast of Labrador. From this the original labradorite was obtained, as well as the specimens of hypersthene which have found their way into mineralogical collections the world over. Another locality is on the southwest end of the island of Newfoundland. Farther to the west, on the north shore of the St. Lawrence, Bayfield mentions the occurrence of labradorite and hypersthene on a point 15 miles east of the island of Ste. Geneviévre, or about 50 miles east of the Mingan Islands.[1] Selwyn[2] found the rock on the same coast at Sheldrake, between the Mingan Islands and the Moisie River, and mentions the occurrence at this place of beautiful opal-

[1] Bayfield, Notes on the geology of the north coast of the St. Lawrence. Trans. Geol. Soc. London, 2 Ser. Vol. V. 1833.

[2] Selwyn, Summary Report of the operations of the Geological and Natural History Survey of Canada 1889, p. 4.

escent labradorite. A very large area of anorthosite was found by Hind[1] on the river Moisie and on its branch, the Clearwater. This area must be very large, although its eastern and western limits are not yet well determined. The Clearwater flows through a valley estimated by Hind to be 2000 ft, deep which is cut in these rocks.[2] They likewise occur in a number of places on the north shore of the St. Lawrence between the Moisie River and the mouth of the Pentecost River.[3]

Next in order comes what is probably most extensive of all the areas, that north of Lake St. John and the upper waters of the Saguenay, which river has its source in this lake, and runs into the St. Lawrence about 125 miles below Quebec. This mass has an irregular oblong shape and its larger diameter runs parallel to the shore of the St. Lawrence, at a distance of about 80 miles. Other areas are found in the neighborhood of Bay St. Paul on the St. Lawrence River,[4] at Chateau Richer[5] below Quebec, and in the district between the latter place and Lake St. John.[6] In the Laurentian region which lies to to the north of the St. Lawrence between Three Rivers and Montreal there are no less than 11 areas, most of which are of very limited extent, but one of these which we may call the Morin area and which lies about 25 miles north of the island of Montreal has an area of 990 square miles. Still another occurrence was discovered and described long ago by Bigsby,[7] on the north shore of Lake Huron, and many other smaller unimportant areas are recorded elsewhere in the Laurentian of Canada, but deserve no further mention. There is also an

[1] Hind, Exploration in the interior of the Labrador Peninsula, London, 1863, also Ed. Cayley: "Up the Moisie." Trans. Lit. and Hist. Soc. of Quebec. New Series Vol. V. 1862.

[2] Hind, Observations on the supposed Glacial Drift in the Labrador Peninsula, etc., Quart. Jour. of the Geol Soc., Jan. 1864, and Canadian Naturalist, 1864, p. 302.

[3] Richardson, Rep. Geol. Survey of Canada, 1866-1869.

[4] Geology of Canada 1863, p. 46.

[5] " " " p. 46.

[6] Low, Summary Rep. Geol. Survey of Canada 1890, p. 35.

[7] Bigsby, A list of minerals and organic remains occurring in Canada. Am. Journ. of Science, 1 Ser., 1824, p. 66.

area of considerable extent occurring to the south in the Laurentian of the State of New York. [1]

The stratigraphical relation of the anorthosites to the Grenville and Ottawa series are as yet somewhat doubtful. In most cases these are difficult to determine because the localities where these rocks are found are generally difficult of access and the surface is often heavily drifted or covered by a dense forest growth.

Sir William Logan [2] whose views were chiefly based on an investigation of parts of the Morin area thought that they probably belonged to a newer sedimentary formation which lay unconformably upon the Grenvilie series, and which although consisting principally of anorthosite, yet included interstratified beds of orthoclase gneiss, quartzite and limestone.

This opinion was apparently supported by the observations which Richardson made on these rocks along the lower St. Lawrence, and in the atlas which accompanied the report of the Geological Survey of 1863, Logau assigned these anorthosites together with the accompanying gneisses to a distinct and higher series which he called the Upper Laurentian.

Sterry Hunt believed that these rocks were identical with the norites of Esmark and called them in consequence of this the Norian Series.[3]

No detailed study of the stratigraphical relations of these rocks has hitherto been made in the case of any of the areas, but writers other than the above have made definite statements without exact knowledge to the effect that they form a series of strata which rest unconformably upon the Grenville series.

The sequence of these rocks is, according to Logan, as follows:

Norian series =Upper Laurentian.
Grenville series=Upper division } Lower Laurentian.
Ottawa series =Lower division }

[1] Emmons, Rep. of the geology in the second district of New York, 1842.
[2] Logan, Rep, Geol. Survey of Canada 1863, p. 839.
[3] Sterry Hunt, Chemical and Geological essays, p. 279. Also Special Rep. on the Trap Dykes and Azoic Rocks of S. E. Pennsylvania. 2nd Geol. Survey of Pennsylvania 1878, p. 160.

Other observers believed, however, that the anorthosites were eruptive, among whom were: Emmons,[1] Selwyn[2] and Packard.[3]

None of the investigations on which these views rest were either sufficiently extended or sufficiently detailed to determine definitely the true relations of the two rock series, and the question consequently remained undecided. On this account I began in the summer 1883, at the request of Dr. A. R. C. Selwyn, Director of the Geological Survey of Canada, a detailed study of the anorthosite area, discovered many years before by Richardson,[4] about Lake St. John, and the head waters of the Saguenay, and devoted the greater part of two summers to investigating and mapping this area. It proved, however, to be of much greater extent than Richardson supposed, extending back into the northern forests through a tract of country unsurveyed and almost unexplored, and which was for the most part only accessible by rivers difficultly navigable and hard to ascend, so that a very detailed investigation proved to be impossible. The southern, eastern, and western limits of the area were, however, mapped, and a good general knowledge of the character and the stratigraphical relations of the area obtained.

It was therefore thought best to select a smaller area more conveniently situated, in which to determine in detail the stratigraphical relations of these rocks. For this purpose the choice fell on that above mentioned as the Morin area, which had the advantage of being generally easy of access and which further commended itself as being the area which Sir William Logan had formerly examined, and on the study of which his opinion concerning the so-called Upper Laurentian rocks were chiefly based. A careful study of this area extending over four summers was consequently made.

1 Emmons, loc., cit.

2 Selwyn, Rep. Geol. Survey Canada 1879-1880, 1877-1878.

3 Packard, On the Glacial Phenomena of Labrador and Maine. Mem. Boston Acad. Nat. Hist. Vol. 1., part 2, p. 214.

4 Richardson, Rep. Geol. Surv. Canada 1857, p. 71.

The present essay is based on the investigation of both these large areas, and of a dozen of smaller ones, which are found in the neighborhood of the Morin area, as well as on a careful study of the literature on the whole subject.

II.—THE MORIN ANORTHOSITE AREA.

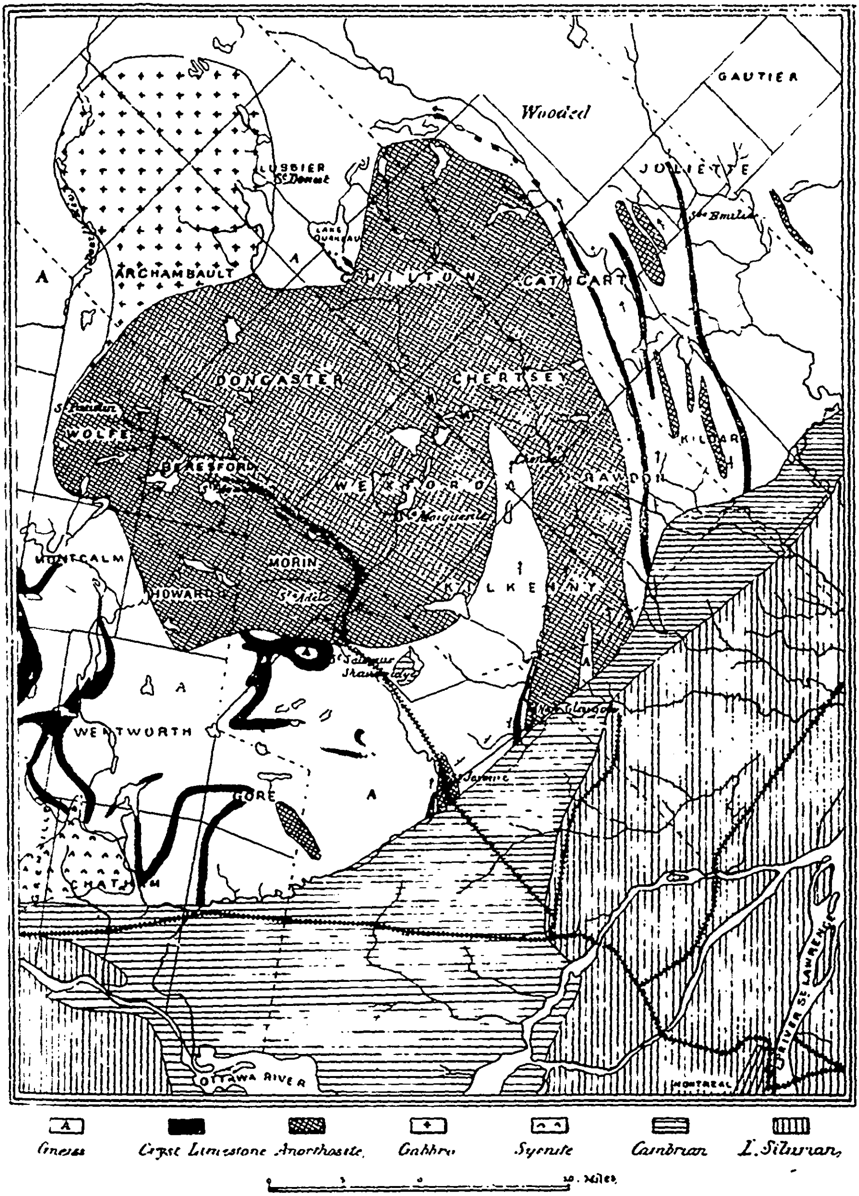
STRATIGRAPHICAL RELATIONS.

As will be seen from a study of the accompanying map[1] the Morin area consists of a mass of anorthosite nearly circular in form, from the south-east side of which a long arm-like extension projects. This mass is 37 miles in diameter and with the arm-like extension just mentioned has an area of 990 square miles. It is bounded on all sides by rocks of the Grenville series with the exception of the extremity of the arm-like extension, which stretching much farther south than the main portion of the mass, is overlaid and concealed by more recent strata of Cambrian age (Potsdam and Calciferous).[2]

The Grenville series consists, as has already been pointed out, of orthoclase gneiss, of many different varieties, with interstratified beds of quartzite, amphibolite and crystalline limestone. The gneiss is generally well foliated and in many places is distinctly banded. Its strata lie almost flat in the eastern part of the area, but to the west they are thrown up into a series of folds, which in the extreme west are very sharp. The rocks have a general northerly strike. The crystalline limestones, with the associated garnetiferous and rusty weathering gneiss, occur in many places. They are found in thin bands interstratified with the flatlying gneisess of the eastern part of the area in the cliffs along the shores of numerous lakes in the district. In the western part of the area they often come to the surface in consequence of the folded attitude of the beds already referred to.

[1] Since the appearance of the paper the railroad has been continued past St. Agathe to St. Faustin and thence to Chûte aux Iroquois, beyond the limits of the map. Another line also extends from St. Jerôme to New Glasgow and thence north-eastward to St. Juilenne.

[2] It is probable that some of the rocks bounding it on the north-western portion of its extension should rather be referred to the Fundamental Gneiss.



Map of the Anorthosite Area of Morin.

The distribution of thsse limestones is represented on the accompanying map. Since they are much softer than the accompanying gneiss, they nearly always occur in depressions and are consequently often so concealed by glacial deposits or dense forest that it is hard tc trace them out. The limestones, however, continue just as persistently as the other members of the stratified series. Single beds may be traced for many miles, while certain horizons in the gneiss at which the limestone bands occur, sometimes quite pure, and again rendered more or less impure by the presence of various disseminated minerals or thin layers of gneiss, can be traced as far as the limits of the map. It must here be remarked that many irregularities in form presented by these limestones, must be attributed to the fact that the limestones (as every observer may perceive) under the great pressure to which these rocks have been subjected are much more plastic than the associated rocks. Thin layers of gneiss interstratified with them are often by the folding of the rocks torn asunder into extraordinarily bent and twisted ribbonlike pieces which lie isolated in the limestone so that there results a pseudo conglomerate. The fact that these limestones are now and then squeezed into cracks in the associated gneisses, led Emmons in his description of the geology of the State of New York, to express the opinion that they were of eruptive origin. The greater plasticity of the limestone as compared with other rocks has also been established, as is well known, by many direct experiments. Since, therefore, they alternate with the gneiss and follow its strike, and because they are more easily distinguishable than any other of the countless varieties of gneiss, Logan recognized that a careful study of their distribution would furnish a clew for the unravelling of the structure of this or any other Laurentian area in which they occur, and moreover that by the determination of their relations to the anorthosite rocks, very important data might be obtained concerning the stratigraphical position of the latte.. In investigating that portion of the area which lies to the west of the anorthosite (for he investigated only this region) Logan found that two of the limestone bands, one on the southwest and one farther north on the west side of the area, were cut off by the Morin anorthosite, and he therefore considered the latter as a newer formation which overlay them, observing that in case it should be proved (by an extension of the observations farther to the north than it was possible for him to carry them) that two other limestone bands which he had followed up nearly to the limit of the anorthosite were likewise cut off by it, this fact might be considered as conclusive evidence of the existence of an Upper Laurentian series reposing uncomformably on the Grenville series. A careful investigation of this northwest corner of the area which was undertaken last summer, in company with Dr. Ells of the Geological Survey, showed, however, that one of the supposed interruptions really does not exist and that the drift is so heavy in this region that even if the other limestone stone bands do come against the anorthosite the contact could not be observed. A careful examination of the contact on the southwest corner of the area in the neighborhood of the village of St. Sauveur, however, leaves little doubt that the limestone is really cut off by the anorthosite at this point. The limestone underlies a plain and protruding here and there in large exposures through the drift, whilst the anorthosite rises from this plain as a steep wall or cliff. The limestone is exposed 200 yards from the foot of the anorthosite wall, but the drift covering then becomes so thick that the character of the contact itself cannot be determined. Both to the east and to the west, the associated gneiss is cut off in a similar manner.

On the northeast side of the anorthosite area there was found, moreover, another limestone band which runs through Lake Ouareau and forms in it a series of small islands. It is also well exposed on the south shore of this sheet of water. This bed disappears at the edge of the anorthosite a short distance from the south end of the lake, and no further traces of it are seen until it appears again interstratified in the gneiss at the southeast corner of the anorthosite area.

These facts together with the whole shape and character of this anorthosite area now that the mapping is completed, show that as Logan supposed, it is unconformable to the Grenville series, that is to say to the true Laurentian. But it may also be demonstrated that this unconformity is not due to superposition but to intrusion. The anorthosite does not belong, as was supposed, to a great overlying sedimentary formation, but is a great intrusive mass which cuts through gneisses with their associated limestone bands but does not overlie them.

In order to understand why Logan and other able observers who agreed with him, regarded these anorthosites as an overlying sedimentary formation, we must remember that they show here and there a more or less foliated structure. This is especially true of some places near their contact with the gneiss, and is best seen in the long arm-like extension at the south-east corner which following the line of least resistance penetrates the gneiss parallel to its foliation, and together with it is covered up by the overlying Cambrian. Moreover we find at St. Jérome a small isolated occurrence of a more or less clearly foliated anorthosite, which is included in the gneiss, and Logan, who through the lack of time could not examine the whole area, supposed this to belong to the great Morin mass, the southern boundary of which was as a matter of fact many miles farther to the north. In going from St. Jérome, therefore, at right angles to the strike of the rocks, to New Glasgow, which lies about nine miles further to the east, he passed from the gneiss over an interstratified anorthosite, then over gneiss with layers of quartzite and a limestone bed into the above mentioned arm-like extension of anorthosite, which shows a sort of schistosity parallel to the strike of the gneiss, and over this to gneiss again. Misled by this section which here is very deceptive, he decided that the whole was a great sedimentary formation of gneiss with interstratified beds of quartzite, limestones and anorthosites identical with that which to the north cut off the limestone and lay unconformably upon the Grenville series.

Instead of this, we have in reality the Grenville series throughout the entire area broken through in places by anorthosite masses which often follow the strike of the gneiss and appear to be interstratified with it.

Although at many points on the boundary between the anorthosite of the Morin area and the surrounding gneiss, both rocks come in contact without any alteration of the gneiss being visible, yet at a few places, especially between Shawbridge and Chertsey, a dark heavy and somewhat massive rock rich in bisilicates and often containing a little quartz and some unstriated feldspar appears at the contact of the anorthosite, and may possibly be a contact product. The boundary of the typical anorthosite against this rock is generally quite distinct, whereas the latter passes gradually into the gneiss of the district, so that it is difficult to decide whether it represents a distinct and abnormal variety of the gneiss, or a contact product of the gabbro. The same rock, or at least a very similar one occurs largely developed, at the northwest corner of the area, between the typical anorthosite and the gneiss, and appears here to be a peculiar variety of gabbro since it is nearly or quite massive and often shows a distinct "schlieren" structure. It cuts through the gneiss but seems to be continuous with the anorthosite. Continuous outcrops of the two rocks which would make it possible to determine their relationship have as yet nowhere been found, but there is evidence to prove that it is a part of the anorthosite mass, and not a separate intrusion, although the transition is a rather sudden one.

The anorthosite mass is cut through in many places by coarse pegmatite veins. These are especially abundant about the edge of the area where they break through the gneiss as well as the anorthosite. In mapping the anorthosite, it was frequently possible to surmise an approach to the limits of the area from the appearance of numerous pegmatite veins. They are, of course, by no means exclusively confined to the edge of the area, but also occur abundantly in certain places towards the centre. They consist of quartz, orthoclase, and often some iron ore, and are quite different in composition, and apparently independent of the anorthosite through which they cut. A number of pegmatite veins in the township of Wexford, contain the same bisilicates as the anorthosite but with quartz and potash feldspar. None of the rare minerals which frequently occur in such veins were observed with the exception of a substance resembling allanite in thin section of a single hand specimen.

About the line of contact, in the Township of Wexford, in the prolongation of the strike of the large band of gneiss which comes in between the main mass of the anorthosite, and the arm-like extension of the same, are many large masses of orthoclase gneiss enclosed in the anorthosite, an additional proof of the eruptive character of the anorthosite, if such be needed.

The anorthosite as well as the gneiss which it breaks through are also cut by numerous dykes of diabase and augite porphyry.

To sum up, we have in this area a large intrusive mass of anorthosite which cuts through the Grenville series, encloses large blocks of gneiss, sends out arms into the surrounding gneisses, and in manyplaces is bounded by what appears to be a peculiar contact product.

Mineralogical Character of the Morin Anorthosite.

The anorthosite of this area exhibits a great variation in structure and colour and in certain places even a considerable variation in composition, but is in mineralogical composition a gabbro, or norite, free from olivine and very rich in plagioclase. Hand-specimens from about fifty different places in this anorthosite area have been sliced and microscopically examined and the following description of these rocks is based on the results thus obtained. The number of minerals which the rock contains is not large, the variations in composition resulting principally from their irregular distribution. The following minerals have been observed in the rock:

Plagioclase	Muscovite and Paragonite	Epidote
Augite	Bastite	Zoisite
Hypersthene	Chlorite	Garnet
Ilmenite	Quartz	Zircon
Orthoclase	Magnetite	Spinel
Hornblende	Apatite	
Biotite	Calcite	

Of these, plagioclase, augite, hypersthene and ilmenite are by far the more important and may be considered as the essential constituents of the rock, while the others are in most cases either accessory constituents or decomposition products.

Plagioclase.—As above mentioned, Hunt gave the name anorthosite to these rocks on account of the great prevalence in many varieties of plagioclase or anorthose. He considered the type which contains only feldspar as the true anorthosite and estimated that three fourths of the anorthosites in the Dominion did not contain over 5% of other minerals.[1]

Like the other constituents of the rock, the plagioclase is quite fresh, showing but very rarely any traces of decomposition, and when it is not granulated (that is "cataclastic" in structure) presents in hand-specimens, almost without exception, a dark violet but more rarely a reddish colour. This colour is still more plainly visible in thin sections, although naturally much fainter, and is seen to be caused by the presence of an immense quantity of minute opaque black rods and extremely small opaque dark points, which give the mineral in thin sections a pecular hazy appearance. The latter probably represent in part cross sections of the rods, but are for the most part round or slightly elongated individuals of the same substance as the rods and occurring with them. Vogelsang[2] estimated, in connection with his studies of the anorthosite of Labrador, that these

[1] T. Sterry Hunt, On Norite or Labradorite Rock. Am. Journ. Sc., Nov. 1869.
[2] Vogelsang, Archives Néerlandaise T. III. 1868.

inclusions amount to from 1 to ·3 per cent of the volume of the mineral and goes on to say: "Le nombre des *microlites contenus dans un volume déterminé est susceptible* d'être apprécié avec plus de précision; les résultats toutefois s'écarteront beaucoup entre eux, suivant l'échantillon qu'on aura choisi et le point dans lequel on l'aura examiné. Dans le labradorite violet figuré le nombre de microlites s'élève au minimum à 10,000 par millimètre cube; mais pour autres variétés jaunes et gris foncées le calcul m'a donné un nombre au moins dix fois plus considérable de sorte qu'il y avait ici, dans l'espace borné d'un centimètre cube plus de cent millions de petits cristaux étrangers." The larger rods are surrounded by a zone of clear feldspar. Some inclusions are transparent and have a reddish brown colour resembling hematite; these appear in small scales which often show a somewhat distorted hexagonal outline. Objects which closely resemble the above mentioned rods, are often seen when very highly magnified to be cavities, partly filled up by the dark material of the rods. These inclusions are pretty uniformly scattered through the feldspar individuals, and not confined to certain places, nor present more abundantly in some places than in others as is the case with the gabbros described by G. H. Williams[1] or by Judd.[2] Minute fluid inclusions may often be observed arranged in rows; in these there appears now and then a moving bubble. In one or two cases small cubes were perceived in them, and in one case it was thought that a double bubble could be recognized. In two or three localities the otherwise normal feldspar contained but few of these inclusions and consequently was almost white in colour. The nature and origin of these dark inclusions, which occur so frequently in the feldspar and other constituents of the gabbro, in the most widely separated localities of the globe, have been frequently discussed.

[1] G. H. Williams, Gabbro and associated Hornblende Rocks in the neighborhood of Baltimore, Md. Bull, U. S. Geol. Survey 28, p. 21.

[2] Judd, On the Gabbros, Dolerites and Basalts of Tertiary age in Scotland and Ireland, Q. J. G. S. 1886, p. 82.

The inclusions are so minute that they cannot be isolated and chemically examined. Their form is not defined with sufficient sharpness and constancy to enable their crystallographic character to be determined. Some investigators have endeavored to gain some notion of the nature of these small bodies by observing their deportment when treated with concentrated acids, but the results obtained are contradictory. Judd (l. c.) found that they resist concentrated hydrochloric acid. Vogelsang (l. c.) treated a small piece of feldspar from Paul's Island, Labrador, which contained them, with hot hydrochloric acid for four days. He found that the acid had strongly attacked the feldspar but could perceive no alteration in the needles, except that they had become slightly paler. Hagge[1] however found that in the same rock from Labrador, all the brown scales were dissolved when treated with the acid for a time too short to effect a decomposition of the feldspar. He considered that they were probably göthite.

They are evidently some iron compound, and the peculiar color of the transparent individuals taken in connection with the fact, that, as will be shown, under certain conditions, they unite to form small masses of titanic iron, leads to the belief that the view of Professor Rosenbusch, is correct, namely that they consist principally of titanic iron ore or ilmenite. The transparent ores have the form of the mineral known as micaceous titanic iron ore, which Lattermann[1] found intergrown with magnetite in the nephelinite of the Katzenbuckel. The peculiar color of this mineral moreover resembles perfectly that of these inclusions. The diverse results which the several investigators have obtained in the matter of the solubility of these inclusions may perhaps be explained by the fact that the titaniferous iron ore in some hand-specimens might be richer in titanic acid than in others.

In this connection it must be mentioned that titanic iron ore is a mineral which is constantly found in these anor-

[1] Hagge, Microskopiche Untersuchung über Gabbro and verwandte Gesteine, Kiel, 1871. S. 46.

Lattermann in Rosenbusch Mass. Gest., p. 786.

thosites in Canada, often in enormous quantities, so that it is considered as particularly characteristic of them, while in the Laurentian proper, the iron ores in the greater number of cases, contain no titanic acid. Lacroix, [1] who has investigated somewhat similar inclusion,s which, however, are double refracting, in certain Norwegian gabbros, thinks that they are pyroxenes, especially as they frequently appear to be grouped together, forming larger grains which may be determined as belonging to this species. He says: "Les grains en question semblent avoir attiré à eux les particules pyroxéniques en suspension dans le feldspath et les avoir incorporées à leur masse." It is quite possible that these inclusions so often found in gabbros and allied rocks consist of the heavier minerals of the rock, in some cases pyroxene and in others iron ore, which were finely disseminated through the magma while the rock was crsytallizing, or which, perhaps, separated out as the several constituents crystallized. My best thanks are due to Professor Judd for a small collection of thin sections of typical gabbros and peridotites from the north of Scotland which he has described and on which he has principally established his theory of "schillerization." An examination of these shows that nowhere in them are the inclusions in question so numerous and well defined as in the Canadian anorthosites. The peculiar arrangement of these inclusions in the Scotch rocks along cracks, fissures, etc., which Professor Judd has described and which especially supports his theory of their secondary origin, is not observed in these Canadian rocks. Their inclusions are on the contrary distributed thickly and pretty uniformly through the whole feldspar individual, generally indeed throughout the feldspar of the whole rock. They disappear as above mentioned only when it has the peculiar granulated character. This remarkable fact will be referred to again.

The uniform distribution of these inclusions does not prove that they are not schillerization products, for even

[1] Lacroix, Contributions à l'étude des gneiss à Pyroxenè, p. 141. Bull. Soc. Min. Fr. Avril 1889.

if the rock were completely schillerized these products might be quite evenly distributed in it. It may be here mentioned that only in a few places in this Morin area does the plagioclase exhibit that play of colours which is produced by these inclusions in the feldspar from Labrador and elsewhere.

The plagioclase is almost invarably excellently twinned, according to both the Albite and Pericline laws, the two sets of twin lamellæ crossing one another at right angles in the thin sections. This twinning is apparently sometimes secondary and produced by pressure, as for instance when the lamellæ appear along a certain line or crack, or when they appear in places where the plagioclase individual is twisted.

In most cases, however, they are of prmary origin. Frequently in the sections there are a few untwinned individuals of plagioclase which are probably cut parallel to $\infty P \breve{\infty}$ (010.) But in certain hand-specimens there is a considerable percentage of untwinned feldspar, resembling in all other respects the plagioclase which shows a well defined twin structure. In order to determine whether in these cases two feldspars were really present, separations by means of heavy solutions were made on material from three hand-specimens from different localities in the thin sections of which these untwinned feldspars occurred, in considerable quantity. Since, however, in a solution having a specific gravity of 2.67 all the constituents sank, these untwinned individuals cannot be more acid than labradorite, to which variety the remaining feldspars likewise belong. Similar occurrences of untwinned plagioclase have been often observed. Hawes[1] who investigated some of them, gives an analysis[2] of an ordinary specimen of typical labradorite of St. Paul's Island and adds: "Some of the anorthosites described by T. Sterry Hunt in the Geology of Canada, 1863, were proved by his analysis to be composed of pure labra-

[1] Hawes, On the determination of feldspar in thin sections of Rocks, Proc. Nat. Mus., Washington, 1881, p. 134.

[2] See table of analyses at conclusion of paper.

dorite and some sections of the same which he submitted to me for examination were found to be composed of a multitude of small grains, none of which were twinned."

An examination was likewise made of well twinned plagioclase from two other localities. The first was from a hand-specimen of a typical anorthosite which occurs five miles north-west of Ste. Adèle in the Morin district. Its specific gravity was between 2.65 and 2.67, and it had therefore, also, the composition of an acid labradorite, a fact confirmed by the values of the extinction angles measured on a small fragment separated by means of Thoulet's solution. The second was from the village of Ste. Adèle itself, which lies near the southern edge of the Morin area. Here the anorthosite has porphyritically distributed through it large plagioclase crystals which sometimes are not less than four inches long. These had the following extinction angles: on $\infty P \breve{\infty}$ (010) $24\frac{1}{2}°$ to 23°, on O P (001) = 6°. An analysis of the bluish opalescent plagioclase from the Morin district will be found in the table of analyses given at the end of this paper; here again the feldspar is a labradorite.

The plagioclase of the anorthosite from these six different localities is therefore in all cases labradorite, and there is every reason to believe that the feldspar throughout the whole area belongs to this variety. Although it was generally quite fresh, a partial decomposition was observed in one or two cases where it was changed into a mixture of calcite, epidote and zoisite as mentioned in the description of these minerals.

This occurrence was found in the village of New Glasgow, where a peculiar variety of rock having a saussuritic habitus was also observed. This latter was quite a local occurrence connected with the small zones of disturbance which here run through the anorthosite. We see in thin slices that this plagioclase (the rock is composed almost entirely of this mineral mixed with a few small grains of iron ore) has suffered a peculiar alteration. The product of decomposition is a mineral mostly of fibrous structure which appears in the plagioclase in little spots. It has the optical character of a bastite or pseudophite and the decomposed feldspar resembles therefore to a certain extent that of Waldheim in Saxony described as pyknotrope by Breithaupt. In another handspecimen of the same rock from New Glasgow the feldspar is changed into a colourless mineral which forms small feather-like clusters. It shows magnificent polarisation colours and has a distinct cleavage to which the extinction is parallel. So far as this rock could be investigated in thin sections, the mineral showed all the optical properties of muscovite. It may possibly be paragonite which cannot be distinguished from muscovite under the microscope, for one would expect a soda mica rather than a muscovite as a product of the alteration of plagioclase.

Augite.—This constituent is with a few exceptions, generally present in much smaller quantity than the plagioclase, but is next to it the most abundant constituent. The rhombic pyroxeneis present however in nearly if not quite equal amount. It occurs in irregularly shaped grains of a light green color which are either non-pleochroic or exhibit a scarcely perceptible pleochroism in greenish tints. In sections which are nearly parallel to the base, we see typical cleavages which cut each other almost at right angles and are characteristic of pyroxene. They are often intersected by a third more perfect cleavage which is parallel to $\infty P \bar{\infty}$ (100) as shown by its position relative to the plane of the optical axis. In the prismatic zone the mineral shows an extinction angle from 0° to 45°.

In many sections of the pyroxene there are brownish black tables or small black rods which resemble very much the inclusions of the plagioclase above described. Where these occur they are frequently parallel to $\infty P \bar{\infty}$ (100); in other cases instead of being scattered throughout the whole individual they are confined to certain spots. The augite can often be observed to have grown around grains of iron ore. It is generally quite fresh, but in many hand-specimens is decomposed. The product of decomposition consists sometimes of a finely granular mixture of chlorite, and a rhombohedral carbonate with occasional quartz grains between them, the whole constituting a grey almost opaque mass. In other specimens the augite is changed into a yellowish bastite which then fills up not only the space originally occupied by the augite but also penetrates into the small fissures of the rock and forms thread-like veins and scales even in the feldspar grains. In other specimens it is converted into a mineral resembling serpentine. When both pyroxenes occur near one another in the rock, the angite is generally intimately intermingled with the rhombic pyroxene.

RHOMBIC PYROXENE (Hypersthene).—This mineral, which occurs so often with augite, does not essentially differ from the latter as far as can be ascertained from its thin sections either in index of refraction, in double refraction or in color. It is however strongly pleochroic with the following colors:

$\mathfrak{a}$=red, $\mathfrak{b}$=yellowish green, $\mathfrak{c}$=green.

The absorption is $\mathfrak{a} > \mathfrak{b} > \mathfrak{c}$, the difference between $\mathfrak{a}$ and $\mathfrak{b}$ being very small.

Its rhombic character was determined by the following observations in the case of a hand-specimen from the Township of Chilton in which the mineral occurred in fresh condition and in larger quantity than usual. Sections parallel to the base showed the two cleavages of the prism which intersect almost at right angles, as well as a third more perfect set of cleavages to which small black rods are often parallel. Since the direction of the extinction is also parallel to this latter cleavage it must be in the direction of a pinacoid. In convergent light there is seen on the basal section a bisectrix but not an optic axis as in the case of a monoclinic pyroxene. When a section in which an optic axis appears is examined, the above mentioned pinacoidal cleavage is found to be parallel to the plane of the optic axes. The pinacoid in question is therefore

$\infty P \breve{\infty}$, that is to say it cuts off the acute prismatic angle as $\infty P \bar{\infty}$ does in the case of diallage. In sections which show an optic axis and only one set of cleavages to which the small rods lie parallel, the cleavage is seen to be parallel to the plane of the optic axis.

In all sections which contain the mineral, we find many grains which show only one good cleavage to which the extinction is parallel.

In general it is like the augite quite fresh, in a few sections it appears however changed into bastite, and in a few others into a serpentine like mineral. It sometimes contains the dark scales and rods so often found in hypersthene, but very often these are entirely absent. It is indeed a remarkable fact that in these Canadian rocks, the iron-magnesia minerals contain only a few of these inclusions while the associated feldspar is filled with them. We have here a state of affairs the exact opposite to that in the gabbros and associated rocks of the Scotch Highlands which have been described by Prof. Judd.

HORNBLENDE.—This mineral does not occur in the anorthosite of Morin except in a few places near the contact with the gneiss. Then we always find it in intimate association with the pyroxenes in the form of irregularly defined grains generally about the border of the granulated masses of pyroxene. It occurs as a general rule only in very small quantity. It is usually green in color but is often brown. It shows the cleavages, the small extinction angle and the characteristic pleochroism of the species. In a hand specimen from the neighborhood of the contact on Lake l'Achigan, the maximum extinction angle was found to be 15° and the following pleochroism observed:

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

The absorption was $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$.

In another hand-specimen, quite close to the contact, about six miles north of New Glasgow, a brown hornblende was likewise found in small amount. The extinction angle was 18° with the following pleochroism:

$\mathfrak{a}$=light brownish yellow, $\mathfrak{b}$=deep brown, $\mathfrak{c}$=deep brown.

The absorption is $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$.

It also occurs in the peculiar rock which was referred to above as a gabbro and was found in a number of places between the true anorthosite and the gneiss.

Biotite.—Biotite never occurs in large amount but is present rather frequently in very small amount as an accessory constituent of the normal gabbro. It is usually found with iron ores or with the hypersthene and shows the characteristic brown color, strong pleochroism and parallel extinction.

Muscovite or Paragonite.—(See under "Plagioclase.")

Chlorite.—Occasionally in small quantity as a decomposition product of pyroxene or biotite.

Quartz.—It is doubtful whether this mineral ever occurs as a primary constitutent of the anorthosite. In a hand-specimen from the west side of the Achigan River, near New Glasgow, it was noticed in the form of rather small round grains disseminated through the rock and looking like a primary constituent. But the rock is much decomposed and doubtless some secondary quartz is present as a product of decomposition of pyroxene, so that the quartz which appears to be primary at first sight may be in reality of secondary origin.

In the gabbro which occurs as above stated in many places between the typical anorthosite and the gneiss, quartz is quite frequent. But in this rock many facts point to the secondary origin of the quartz. It occurs often for example in more or less sharply defined veins made up of large individuals. When it occurs in the form of separate irregular grains these extinguish uniformly, although they are often more or less fissured, but they are by no means so much broken as one would expect, if they were primary ingredients, in view of the extremely broken condition of the feldspar and the other constituents of the rock.

Ilmenite and Magnetite.—In nearly every section of anorthosite some irregularly shaped grains of an opaque black iron ore are seen. These are usually few in number. The quantity of iron ore is considerable only in a few places, and as in these cases the percentage of pyroxene increases in the same proportion, the rock here assumes a very dark colour so that it is often taken for an iron ore. These portions of the anorthosite rich in iron ores are only few and local, and they pass over into the normal gabbro of the area which as above mentioned is very poor in iron ore.

If these iron ore grains are examined by reflected light, they are seen to be black and in a few cases they can be seen to be partly changed into a grey decomposition product, evidently a variety of leucoxene. This circumstance proves that the mineral contains titanic acid in considerable amount.

In three hand-specimens from widely separated parts of the area an intermingling of two iron ores was distinctly seen. In one of the hand-specimens which comes from Wexford, range I. lot 7, one of the above mentioned localities where the anorthosite is rich in iron ore, careful observation in reflected light showed the iron ore to occur partly as a bluish black coarse grained variety, and partly as a brownish black finely granular variety both being irregularly intermingled and distinguishable only by reflected light.

When the section was treated for about half an hour on a water-bath with warm concentrated hydrochloric acid, the coarsely granular variety was entirely dissolved and the acid became strongly coloured with iron, while the finely granular variety was apparently not at all affected. We have evidently here an intergrowth of magnetite with ilmenite or at least with a titaniferous iron ore.

In another hand-specimen (from the neighbourhood of Lake Ouareau) a similar intergrowth was observed; the grains had a banded appearance in reflected light, one variety crossing the other in a single or double set of interrupted bands. When the section was treated with cold concentrated hydrochloric acid for 48 hours, no effect was produced; but when treated with warm concentrated acid in a water-bath, one variety of iron was dissolved as before while the other again remained undissolved. We have here probably an intergrowth parallel to the face of an octahedron or rhombohedron. A similar intergrowth has been described in the iron ore in the nephelinite of the Katzenbuckel, except that here the titanic iron ore occurs in the form of micaceous titanic iron ore, not as the coarse and opaque variety found in the above mentioned rocks.

It has been the invariable experience in Canada that the large iron ore deposits in these anorthosite rocks contain so much titanic acid that they cannot be profitably worked. In order to determine whether the iron ore which is disseminated in small grains throughout the whole rock was also rich in this constituent, the iron ore of three hand-specimens of the anorthosite from different parts of the area was separated and tested for titanic acid. In every case the mineral was but faintly magnetic and gave a strong titanic acid reaction.

Two specimens of iron ore from the pegmatite veins which cut through the anorthosite and the gneiss at the contact of the two formations, west of St. Faustin, and therefore do not belong to the anorthosite, showed strong magnetism and gave only a faint reaction for titanic acid. The iron ore bed, a short distance west of St. Jérome, in the orthoclase gneiss also consists of magnetite and contains no titanic acid. We therefore find that these investigations confirm the conclusion that the iron ore of the anorthosite is very rich in titanic acid while the iron ore of the Laurentian gneiss generally contains no notable quantity of this substance.

PYRITE.—A few small grains of pyrite often occur in the thin sections of the anorthosite. They are generally found associated with the iron ore.

APATITE.—This mineral is seldom observed in the anorthosite. When it does occur it is in the form of more or less rounded grains. It is more frequently found in the varieties rich in iron ore in the Township of Wexford and other localities, than in the normal anorthosite.

Latterman in Rosenbusch, Physiographie der Massigen Gesteine, p. 786.

CALCITE.—This was found only in two hand-specimens. One of these was fresh and contained a little calcite, which might possibly be a primary constituent. The other was from New Glasgow, and in this the calcite, together with zoisite, epidote, &c., appears as a decomposition product of the plagioclase in the form of a dull finely granular mixture.

EPIDOTE.—The only locality where epidote occurs is also near the village of New Glasgow. It is found in several sections of the anorthosite from this place along with chlorite and quartz as a product of decomposition of the pyroxene, and as above mentioned with calcite and zoisite as a product of decomposition of the plagioclase. In one or two places it also occurs in small bands, cutting diagonally across the anorthosite following the line of small faults. The epidote is everywhere secondary.

GARNET.—This does not occur as a constituent of the normal anorthosite, but is often found near its contact with the surrounding gneiss. It has a pinkish color, and is seen under the microscope in small irregular masses which are often mixed with or which completely surround the grains of iron ore. In the sections of the variety of anorthosite rich in iron ore from the Township of Wexford, range I, lot 7, (and from other places above mentioned), we find a pale pink garnet which forms a small zone of uniform breadth around every grain of iron ore or pyroxene where these otherwise would come in contact with the plagioclase. Between the pyroxene and the iron ore there is however no garnet. It is quite isotropic and has grown out from the iron ore or pyroxene into the feldspar, against which it is bounded by sharp crystalline outlines. These zones of garnet are analogous to the zones of actinolite and hypersthene around the olivine of the anorthosite from the Saguenay River which will be referred to later on and which have also been described in olivine gabbros of many other localities.

ZIRCON.—This mineral is not found in the normal anorthosite but it occasionally occurs in this rock near its contact with the gneiss. It is seen only in small quantity, and especially in the peculiar contact variety which occurs, as above mentioned, in some places between the anorthosite and the gneiss. It was observed in this in many localities. It has the form of small stout prisms always with more or less rounded edges, which are characterised by a parallel extinction, high refractive index and strong double refraction.

SPINEL.—Observed only in one hand-specimen, in the form of small rounded isotropic grains deep green in color occurring as inclusions in plagioclase and pyroxene.

(*To be Continued.*)

CONTRIBUTIONS TO CANADIAN BOTANY.

By JAS. M. MACOUN.

IV.

VIOLA BLANDA, Willd., var. AMŒNA (Le C.) B.S.P.

Seldom separated from the species by Canadian collectors. North Bay, Ont. (*Dr.* and *Mrs. Britton* and *Miss Millie Timmerman.*) Ottawa, Ont. (*James Fletcher.*) Wingham, Ont. (*J. A. Morton.*) The var. *palustriformis*, Gray, we consider but a larger form of the species under which we include our large stoloniferous specimens that are not certainly referable to var. *amœna.* They are from Edmonton, Ont. (*Jas. White.*) Wingham, Ont. (*J. A. Morton.*) Ottawa, Ont. (*J. M. Macoun.*)

VIOLA CANADENSIS, Linn.

Our most northern specimens of this species are from the Athabasca River. (*Miss E. Taylor.*)

VIOLA PALUSTRIS, Linn.

Between Lake Athabasca and Chesterfield Inlet in Lat. 61° 35, Long. 103° 30. (*Jas. W. Tyrrell*). Northern limit in Canada as shown by our specimens.

VIOLA SELKIRKII, Pursh.

Battle Harbor, Fox Cove, Labrador, 1892. (*Rev. A. Waghorne.*) Northern limit in Canada.

POLYGALA VERTICILLATA, Linn.

Sandy soil at Griswold, Man. (*W. A. Burman.*) Only station west of Ontario.[1]

DIANTHUS ARMERIA, Linn.

On rocks, Victoria Arm, Vancouver Island. Naturalized and spreading. In fruit July 21st, 1893. (*John Macoun.*) Not before recorded west of Ontario in Canada or Michigan in U.S.

DIANTHUS BARBATUS, Linn.

Escaped from cultivation and naturalized at Hot Springs, Kootanie Lake, B.C., 1890. (*Jas. M. Macoun.*)

SAPONARIA VACCARIA, Linn.

A weed in gardens at Kamloops, B.C. Roadsides, Nelson, Kootanie Lake, B.C.; Cameron Lake, Vancouver Island. (*John Macoun.*) Not before recorded west of the Columbia River.

SILENE ARMERIA, Linn.

Spontaneous in gardens at Rupert House, James Bay. (*Jas. M. Macoun.*) Our most northern record.

SILENE CUCUBALUS, Wibel.

Naturalized near Spray Falls, Banff, Rocky Mountains. (*John Macoun*). Not before recorded west of Ontario.

SILENE DOUGLASII, Hook., var, MACOUNII, Robinson, Proc. Amer. Acad. xxviii, 144.

Lychnis elata, Macoun, Cat. Can. Plants, Vol. I, p. 69.
Silene multicaulis, Macoun, Cat. Can. Plants, Vol. I, p. 494.
S. Macounii, Wats., Proc. Amer. Acad. xxvi., 124.

Our herbarium specimens of this variety are from Mt. Aylmer, Rocky Mts., alt. 6,800 ft.; Lake Louise, Rocky Mts.; Silver City, Rocky Mts.; Kicking Horse Lake, Rocky Mts., alt. 7,000 ft.; mountains north of Griffin Lake, B.C., alt. 6,500 ft. (*John Macoun.*) Mt. Queest, Shus-

[1] The Geographical limits given in these papers refer to Canada only.

wap Lake, B.C., alt. 6,000 ft.; Avalanche Mt., Selkirk Mts., B.C., alt. 7,000 ft. (*Jas. M. Macoun.*) Western Summit of North Kootanie Pass, Rocky Mts.; South of Tulameen River, B.C., alt. 6,000 ft.. (*Dr. G. M. Dawson.*) A part of the specimens referred to this variety are perhaps intermediate between it and the next.

SILENE DOUGLASII, Hook, var. VISCIDA, Robinson, Proc. Amer. Acad. xxvii, 145.

On slopes of high mountains at Kicking Horse Lake, Rocky Mts. (*John Macoun.*)

SILENE DOUGLASII, Hook., var. MULTICAULIS, Robinson. *S. multicaulis,* Macoun, Cat. Can. Plants, Vol. II., p. 309.

Stump Lake, South of Kamloops, B.C. (*John Macoun.*)

SILENE GALLICA, Linn.

Common at Oak Bay, Goldstream and Victoria Arm, Vancouver Island. (*John Macoun.*) Introduced.

SILENE NOCTIFLORA, Linn.

A weed in gardens at Rupert's House, James Bay. (*Jas. M. Macoun.*) In waste places at Revelstoke, B.C., and Cedar Hill, Vancouver Island. (*John Macoun.*) Not before recorded from west of Winnipeg.

LYCHNIS AFFINIS, Vahl.

Between Lake Athabasca and Chesterfield Inlet. Lat. 63° 27′, Long. 102°, 1893. (*Jas. W. Tyrrell.*) Cape Prince of Wales, Hudson Strait. (*Dr. R. Bell.*)

LYCHNIS ELATA, Wats.

Our only specimens of this species are from Avalanche Mt., Selkirk Mts., B.C., alt. 7,000 ft. (*Jas. M. Macoun.*)

LYCHNIS TAYLORÆ, Robinson, Proc. Amer. Acad. xxviii, 150.

Very slender 1 to 1½ feet high, puberulent, nearly smooth below, glandular above; stem erect, bearing 3 to 4 pairs of leaves and two or three long, slender, almost filiform 1 to 3 flowered branches; leaves thin, lance-linear, acute or attenuate both ways, finely ciliate, and pubescent upon the single nerve beneath, otherwise glabrate, 2 to 2½ inches in length; flowers terminal or subterminal on the branches; calyx ovate, not much inflated, about 4 lines long, in anthesis but two lines in diameter with green nerves interlacing above; the teeth obtuse, with broad green membraneous ciliate margins; petals 1½ times the length of the calyx; the blade obcordate, 1¼ lines long, considerably broader than the slender auricled claw, appendages lance-oblong.

Peel's River, Mackenzie River Delta, 1892. (*Miss E. Taylor.*)

LYCHNIS TRIFLORA, R. Br. var. DAWSONI, Robinson, Proc. Amer. Acad. xxviii, 149.

Calyx with principal nerves double or triple, joined by interlacing veinlets; the intermediate nerves beneath the sinuses inconspicuous or wanting; petals very narrow; the blade oblong, bifid, hardly to be distinguished from the narrow claw.

Gravel banks, Dease River, 100 miles north-east of Dease Lake. Lat. 59°, B.C., 1887. (*Dr. G. M. Dawson.*)

CLAYTONIA CHAMISSONIS, Esch.

Growing at high-water mark at Comox, Vancouver Island, 1893. (*John Macoun*, Herb. No. 29.)[1] These are our first authentic specimens of this species.

CLAYTONIA PARVIFOLIA, Moç.

Damp rocks, Sproat, Columbia River, B.C.; Griffin Lake, B.C.; Agassiz, B.C. (*John Macoun.*). Not before recorded between Selkirk Mts. and Vancouver Island.

OPUNTIA FRAGILIS, Haw.

This plant, of which specimens were collected by Mr. A. C. Lawson in 1884 on islands in the Lake of the Woods, was found again in 1894 by Prof. A. P. Coleman on Red Pine

[1] Whenever herbarium numbers are given, they are the numbers under which specimens have been distributed from the hebarium of the Geological Survey of Canada.

Island, Rainy Lake, just within Canadian territory. It covered about a square rod of the eastern end of the island and grew half-buried in lichens. The Indians with Prof. Coleman did not know of its occurrence elsewhere in that region.

GALIUM PALUSTRE, L., var. MINUS, Lge.

A comparison of specimens collected by the Rev. A. Waghorne at Long Point, Labrador, with Greenland plants shows that what was at first considered a form of *G. trifidum* is in fact *G. palustre*, var. *minus*. New to Canada.

VERNONIA NOVEBORACENSIS, Willd.

The plant from Essex Centre, Ont., referred to this species, Macoun, Cat. Can. Plants, Vol. I.; p. 206, proves to be *V. altissima*, Nutt. Specimens collected by Prof. Macoun in thickets at Pelee Island, Lake Erie, 1892, are *V. Noveboracensis.* We have seen no other Canadian specimens of this species.

SERIOCARPUS RIGIDUS, Lindl.

In open thickets Mount Finlayson and Cedar Hill, near Victoria, V. I. and Nanaimo, Vancouver Island, 1887. Oak Bay, near Victoria, V. I., Herb. No. 451. (*John Macoun.*) Collected in 1887 but not recorded.

HELIOPSIS SCABRA, Dunal.

In thickets, Kicking Horse River, Rocky Mts., alt. 4,000 ft., 1890. (*Jas. M. Macoun.*) Woods, Revelstoke, Columbia River, B.C. (*John Macoun.*) Probably introduced from Manitoba by the C. P. Ry. Not before recorded west of Manitoba.

MADIA GLOMERATA, Hook.

Dry ground at Revelstoke, Columbia River, B.C., 1890. (*John Macoun.*) Not before recorded west of Alberta.

MADIA SATIVA, Molina, var. RACEMOSA, Gray.

On dry banks, two miles from mouth of Kootanie River, B.C., 1890. (*John Macoun.*) Not before recorded from interior of British Columbia.

MADIA SATIVA, Mol., var. CONGESTA, Gray.

Specimens (Herb. No. 466) collected by Prof. Macoun at Beacon Hill, Victoria, Vancouver Island, Aug. 7th, 1893, and referred by him to this variety have been submitted to Dr. Robinson, who says, "a form showing characters of var. *congesta* (as to inflorescence) and var. *racemosa* (as to leaves and pubescence.)"

HEMIZONELLA DURANDI, Gray.

Hillsides at Sproat, Columbia River, B.C., 1890. (*John Macoun.*) New to Canada.

COTULA AUSTRALIS, Hook., f.

Ballast heaps at Nanaimo, Vancouver Island, 1893. (*John Macoun,* Herb. No. 476.) New to Canada.

ARTEMISIA RICHARDSONIANA, Bess.

Mount Rapho, Lat. 56° 13′, Long. 131° 36′, alt. 3,800 ft., July, 1894. (*Otto Klotz* and *H. W. E. Canavan*, Herb. No. 4,191.)

ARNICA LATIFOLIA, Bong. var. VISCIDULA, Gray.

Woods at Roger's Pass, Selkirk Mts., B.C., alt. 4,500 ft., 1890. (*John Macoun.*) New to Canada.

CENTAUREA PANICULATA, L.

Dry waysides, Victoria, Vancouver Island. 1893. (*John Macoun,* Herb, No. 552). New to Canada.

CASSIOPE STELLERIANA, DC.

Mt. Rapho, Lat. 56° 13′, Long. 131° 36′. Alt, 3,800 ft. In flower July 10th, 1894. (*Otto Klotz* and *H. W. E. Canavan*, Herb. No. 4,195.) First Canadian record.

PRIMULA CUNEIFOLIA, Ledeb.

Mt. Rapho, Lat. 56° 13′, Long. 131° 36′. Alt. 3,800 ft. In flower July 10th, 1894. (*Otto Klotz* and *H. W. E. Canavan*, Herb. 4,192.) New to Canada.

COLLINSIA VERNA, Nutt.

In woods near Plover Mills, Ont. In great abundance in one locality but not found elsewhere. Collected by R. Elliott, May 22nd, 1894. New to Canada.

PEDICULARIS PEDICELLATA, Bunge.

Mt. Head, Lat. 56° 05′, Long. 131° 08′. Alt. 4,200 ft. (*Otto Klotz* and *H. W E. Canavan*, Herb. No. 4,196.) Only authentic Canadian station.

UTRICULARIA RESUPINATA, B. D. Green.

Abundant on sand and mud both in shallow and gently flowing water. Phipps Lake, Long Reach, Kings Co., N.B., July 13th-20th, 1886. (*C. H. Livingstone*). Only Canadian station, though a plant believed to be this species was found by Prof. Macoun in Victoria Co., Ont., in 1868.

AMARANTUS, Linn.

Our herbarium specimens of this genus have been examined by Messrs. Uline and Bray who have either confirmed our determinations or made necessary corrections that are included in the following notes.

A. RETROFLEXUS, LINN.

Specimens collected by Prof. Macoun at Agassiz, B.C., and referred here are intermediate between *A. Powellii* and *A. retroflexus*.

A. HYBRIDUS, Linn.

References under *A. paniculatus* and *A. hypochondriacus*, Macoun, Cat. Can. Plants, Vol. I, p. 396, are, so far as our hebarium specimens are concerned, *A. hybridus*.

A. PANICULATUS, Linn.

Waste places, Sicamous, B.C., 1889. (*John Macoun.*) Our only specimens or this species.

A. GRÆCIZANS, Linn.

A. albus, L.; Macoun, Cat. Can. Plants, Vol. I, p. 397.

This species is well distributed throughout British North America. Specimens collected by the borders of saline ponds near Kamloops, B.C., by Jas. M. Macoun are near *A. carneus*, Greene.

A. BLITOIDES, Wat.

London, Ont. (*Millman.*) Port Colborne, Ont. (*John Macoun.*) Point Edward, St. Clair River, Ont. (*Jas. M. Macoun.*)

POLYGONUM.

All our herbarium specimens of this genus have been examined by Prof. John K. Small, who has made several important changes in our determinations. He had not our herbarium sheets at the time his revision of the *Polygonaceæ* was published so that the distribution of the Canadian species of *Polygonum* as given below will greatly extend the range of many North American species. I follow Prof. Small's arrangement of the species throughout.

(1.) P. VIVIPARUM, Linn.

Throughout Canada. Our most northern specimens are from Lat. 64° 26′, Long. 100° 45′, 1893. (*Jas. W. Tyrrell.*) and Great Bear Lake River. Lat. 65°, 1892. (*Miss E. Taylor.*)

(2.) P. PERSICARIA, Linn.

From Prince Edward Island to Vancouver Island. Abundant throughout the settled parts of Canada.

(3.) P. CAREYI, Olney.

Wet sandy banks, Moon River, Muskoka, Ont., 1878. (*Burgess.*) The only Canadian station.

(4.) *P. hydropiperoides,* Michx.

We have this species from but one locality, Belleville, Ont. Many of the references given by Prof. Macoun (Cat. Can. Plants, Vol. I, p. 411), probably refer to other species. This plant is certainly not of as general distribution in Canada as is supposed, or our herbarium would contain specimens from more stations than one.

Of this species and var. *strigosum* Prof. Small writes, "*P. hydropiperoides*, as well as the var. *strigosum*, has an almost invariable character which it seems, has never been recorded. The stem or branches always produce, at the distance of three-fourths of an inch or less above the angle of branching, a node with a leaf and ocrea, thus making an internode several times shorter than normal length."

Var. STRIGOSUM, Small.

In ditches at Gatineau Point near Hull, Que. (*John Macoun.*) In water near St. Patrick's Bridge, Ottawa, Ont. (*Jas. M. Macoun,* Herb. No. 1,503.)

(5.) P. HYDROPIPER, L.

From New Brunswick to Pacific Coast.

(6.) P. PUNCTATUM, Ell.

P. acre, Macoun, Cat. Can. Plants, Vol. I., p. 411.

Not rare in Eastern Canada. Agassiz, B.C., and Kamloops, B.C. (*John Macoun.*) Not before recorded west of Ontario.

(7.) P. PENNSYLVANICUM, L.

Common from Nova Scotia to Western Ontario.

(8.) P. LAPATHIFOLUIM, L.

Common from the Atlantic to the Pacific. Prof. Small thinks this species has been introduced wherever found. While this may be so in most cases, we have specimens from remote regions that are without doubt indigenous.

Var. INCANUM, Koch.

From Ontario to the Pacific.

(9.) P. AMPHIBIUM, L.

Tadousac, Que. (*Northrop.*) Wingham, Ont. (*J. A. Morton.*) Hastings Co., Ont.; Long Portage, Nipigon River, Ont.; Tail Creek, N.W.T.; near Victoria, Vancouver Island. (*John Macoun.*) Near Pincher Creek, Alberta. (*Dr. G. M. Dawson.*)

(10.) P. EMERSUM, (Michx.) Britt.

Most of the references under *P. Muhlenbergii,* Macoun, Cat. Can. Plants, Vol. I., p. 410, and Vol. II., p. 353, go here. Our herbarium specimens are from Wingham, Ont.

(*J. A. Morton.*) Leamy's Lake, Hull, Que.; Tail Creek, N.W.T. (*John Macoun.*) Indian Head, Assa. (*W. Spreadborough.*) Short Creek, Souris River, Man.; Belly River, Alberta. (*Dr. G. M. Dawson.*) "Arctic North America," no locality. (*Dr. Richardson.*)

(11.) P. HARTWRIGHTII, Gray,

Salt Lake, Anticosti, Que.; Elzivec, Hastings Co., Ont.; Vermillion Lakes, near Banff, Rocky Mts. (Herb. No. 1,481.); Revelstoke, B.C.; Kamloops, B.C. (*John Macoun.*) Near York Factory, Hudson Bay. (*Dr. R. Bell.*) London, Ont. (*Burgess.*) Muskeg Island, Lake Winnipeg. (*Jas. M. Macoun.*)

(12.) *P. Orientale*, L.

Ottawa, Ont. (*Dr. A. R. C. Selwyn.*) London, Ont. (*Burgess.*)

(13.) P. ALPINUM, All.

Peel River, Mackenzie River Delta, 1892, (*Miss E. Taylor*). The references under *P. polymorphum*, Macoun, Cat. Can. Plants, Vol. I., p. 412, probably all go with this species or its var. *lapathifolium*.

(14.) P. AVICULARE, L.

From Ontario to Vancouver Island.

VAR. BOREALIS, Lange.

Specimens collected on the East Main River, Hudson Bay, by A. H. D. Ross, in 1892, when compared with specimens from Greenland seem certainly referable here.

(15.) P. LITTORALE, Link.

P. erectum, Macoun, Cat. Can. Plants, Vol. 1., p. 407 in part.

Thunder Bay, Lake Superior. (*N. L. Britton.*) Castle Mountain, Rocky Mts.; Banff, Rocky Mts., Herb. No. 1,487; near Devil's Lake, Rocky Mts., Herb. No. 1,486. (*John Macoun.*) Walsh, Assa. (*J. M. Macoun.*)

(16) P. RAYI, Bab.

P. maritimum, Macoun, Cat. Can. Plants, Vol. I., p. 408.

Turner's Head, Labrador. (*Rev. A. Waghorne.*) Brackley Point, P.E.I.; Jupiter River, Anticosti, Que.; Qualicum and Point Holmes, Comox, Vancouver Island. Herb. No. 1505. (*John Macoun.*) Bass River, N.B. (*Fowler.*) We do not believe, that this plant, "wherever found," in Canada, has been introduced. Prof. Small found among our specimens no representatives of *P. maritimum*, and as our specimens of *P. Rayi* are from widely separated and remote localities on the Atlantic and Pacific coasts, it seems probable that we have but one species in Canada, and that it is, at least in part, indigenous.

(17.) P. PARONYCHIA, C. & S.

Beacon Hill, Vancouver Island. (*John Macoun. C. F. Newcombe.*)

(18.) P. ERECTUM, L.

Our only specimens of this species are from Winnipeg, Man.; Banff, Rocky Mts. Herb. No. 1,485. (*John Macoun.*)

Other specimens referred here by Prof. Macoun, Cat. Can. Plants, Vol. I., p. 407, are now included under other species.

(19.) P. RAMOSISSIMUM, Michx.

Petitcodiac, N,B. (*J. Britain.*) Rat Creek, Man.; Hand Hills, N.W.T.; South of Battleford, N.W.T. (*John Macoun.*)

(20.) P. DOUGLASII, Greene.

P. tenue, Macoun, Cat. Can. Plants, Vol. I, p. 408.

Not rare from Ontario to British Columbia. We have apparently no *P. tenue* in Canada.

Prof. Small says of this species, "*P. Douglasii* can be distinguished from its relative *P. tenue* at a glance, and is beautifully distinct, as Prof. Greene has pointed out, by its one-ribbed leaf in place of the three-ribbed of *P. tenue*, and the much longer, narrower and pedicelled, drooping fruit, instead of the short, thick, sessile, erect fruit of that plant."

(21.) P. AUSTINÆ, Greene.

South Kootanie Pass, Rocky Mts., 1883. (*Dr. G. M. Dawson.*) Near the glacier at the head of Lake Louise, Rocky Mts. Alt. 7,500 ft. (*John Macoun.*) Dr. Dawson's specimens were collected a year before Mrs. Austin's, and were named *P. tenue*, Michx., var. *latifolium*, Eng., by Prof. Macoun.

(22.) P. SPERGULARIÆFORME, Meisn.

P. coarctatum, Dougl.

From the Columbia River at Sproat, B.C., to Vancouver Island.

(23). P. MINIMUM, Wats.

South Kootanie Pass, Rocky Mts. (*Dr. G. M. Dawson.*) Roger's Pass, Selkirk Mts., B.C.; Griffin's Lake, B.C. (*John Macoun.*)

(24.) P. INTERMEDIUM, Nutt.

Summit of Mt. Mark, Vancouver Island. (*John Macoun.*)

(25.) P. IMBRICATUM, Nutt.

Hand Hills and Cypress Hills, Alberta. (*John Macoun.*)

(26.) P. CONVOLVULUS, L.

Common in fields and waste places from the Atlantic to the Pacific.

(27.) P. SCANDENS, L.

P. dumetorum, L., var. *scandens*, Gray.

From Nova Scotia to the Cypress Hills, Alberta.

(28.) P. CILINODE, Michx.

In pine woods and thickets from Nova Scotia to the Peace River, Athabasca.

(29.) P. SAGITTATUM, L.

From Prince Edward Island to the Saskatchewan.

(30.) P. ARIFOLIUM.

From Nova Scotia to Ontario.

(31.) P. VIRGINIANUM, Linn.

All our specimens of this species were collected in Ontario. Reported from Nova Scotia and Quebec.

POLYGONELLA ARTICULATA, Meisn.

Polygonum articulatum, Willd; Macoun, Cat. Can. Plants Vol. I., p. 409.

Sand dunes, Point Aux Pins, Lake Superior, 1869. (*John Macoun.*) Specimens collected by Dr. Richardson, and labelled "Arctic North America," are probably from the same locality.

A SATISFACTORY SULPHURETTED HYDROGEN GENERATOR.

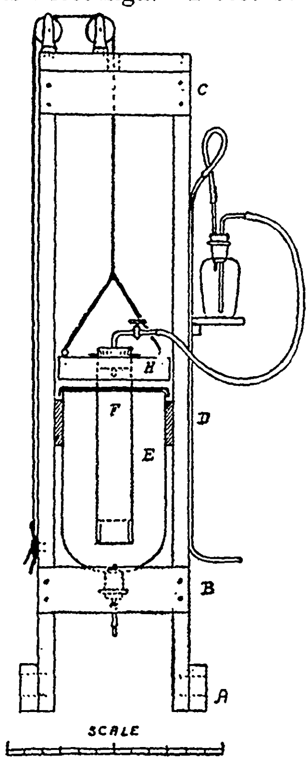
NEVIL NORTON EVANS, M. A. Sc.

To those who have much to do with general qualitative analysis or with the quantitative determination of metals, a sulphuretted hydrogen generator which is self-regulating, *economical, and always ready for use is a desideratum.* Of late years there have appeared in various chemical publications suggestions for the construction or improvement of such generators, but most if not all of these still possess one serious defect: when the generator is out of action, the separation of acid and sulphide is effected wholly or in part by the pressure of the gas; the gas, however, being soluble to a considerable extent in the dilute acid employed, slowly goes into solution and, by the diffusion of this solution through the mass of liquid, the gas finds its way to the air. Thus, there is a continuous though slow disappearance of sulphuretted hydrogen and a corresponding action of the acid on the sulphide. To prevent this, and have a generator which absolutely stops working when not in use, the separation of acid and sulphide must be effected in some other way than by the pressure of the sulphuretted hydrogen.

Many years ago an excellent apparatus was devised for this purpose by Prof. Clemens Winkler of the Royal Saxon

School of Mines, Freiberg, Saxony, and is still in use in the chemical laboratory of that institution. While working there I was much struck with the thorough effectiveness of the generator and, as the pattern does not seem to be widely known, the following description of a generator, which I constructed myself, working upon the same principles, though much smaller in size, is given.

The frame of the apparatus is made of $2\frac{1}{2}$x$\frac{7}{8}$ in. pine, and is 3 feet high. Pieces seen in end section at A, serve as feet; cross pieces nailed on front and back at B and C, and a piece flat on the top, complete the frame. E is a Winchester bottle, 3 to 4 litres, with the bottom cut off, and with its neck between the cross pieces at B, which are cut away a little on the inside to allow the bottle to rest firmly; at D, on either side, a small block cut out to fit the convex of the bottle holds the latter firmly in place. Over the bottle is placed a piece of sheet lead bent down at the edges so as to fit outside the bottle and pierced centrally with a $2\frac{1}{8}$ in. hole through which the cylinder F passes. Into the neck of E is fitted a cork through which passes a glass tube carrying a short rubber tube closed by a little piece of glass rod. F is a piece of 2 in. lead pipe 10 in. long passing snugly through a circular piece of wood H, $1\frac{1}{4}$ in. thick, over the top of which it is flanged out to prevent its slipping through. In cutting off the bottom of F, 4 pro-



jecting tongues of lead are left each 1 in. long and $\frac{1}{4}$ in. wide; these are turned up inside the pipe and upon their ends rests loosely a perforated circular piece of lead represented in the figure by the dotted line. Into the top of F is fitted a rubber cork through which a glass tube carrying a glass tap passes. (A well-greased wooden plug carrying a glass tube provided with a rubber tube and screw pinch-cock will answer.) This is connected by a rubber tube with a wash-bottle as represented, and the wash-bottle with a delivery-tube. Into H are screwed two screw-eyes to which is fastened a loop of cord which in turn passes through a loop on the end of a cord passing over the two pulleys and down to the cleat.

To set the apparatus in action, about 2 litres of dilute sulphuric acid, 1 in 10, is placed in the Winchester, and 100 grms. of iron sulphide in pieces about the size of a bean in the lead cylinder. The latter is lowered into the acid and the glass tap slowly opened until a current of gas of the rapidity desired is obtained. To put the apparatus out of action, the tap is closed and the lead cylinder raised until its bottom edge just touches the surface of the acid. If acid stronger than 1 in 10 is used ferrous sulphate crystallizes out in such quantity as to render the cleaning of the generator difficult. There are several brands of iron sulphide on the market, some of which are quite unsuitable for this generator as they are very dense and require stronger acid for their decomposition than that recommended above; a clean porous variety (sold in large lumps) is to be preferred.

The apparatus described above was employed for three months in the Chemical Laboratory of McGill College and gave the greatest satisfaction; the reason that its use was then discontinued being its replacement by a much larger "machine" working upon the same principle, and which for more than two years has given entire satisfaction. That the "machine" works economically may be seen from the fact that during the session of 1893-94, with about ninety students working in the laboratories, only about three litres of sulphuric acid were used in the production of sulphuretted hydrogen. A charge of acid and sulphide placed in the "machine" last April and used a few times remained in the apparatus during the holidays and in September, without any addition, produced a copious and steady stream of sulphuretted hydrogen. The smaller apparatus has been employed with equally satisfying results for the production of hydrogen gas.

The Apatite Bearing Rocks of the Ottawa District.

R. W. Ells. LL.D., F.R.S.C.

The present depressed condition of the foreign market for phosphate has naturally tended to lessen the interest which for some years pertained to the subject of Canadian Apatite. But while this has been true to some extent, the great amount of capital invested in this direction, and the fact that the Canadian deposits are presumably among the richest of their kind in the world, so far as yet known at least, as well as the most convenient of access, will always make the question of the availability of Canadian phosphate one of very considerable importance both to the mining and commercial communities. For while the immense deposits found in Carolina and Florida have, through their cheapness of extraction and other causes, been largely responsible for the present unsatisfactory condition of this industry, it is very doubtful if these southern sources of supply will prove to be permanent or even remunerative for any great length of time; and unless other deposits, equally extensive or accessible be found, attention must revert to the Laurentian apatites as a source of supply for this mineral fertilizer.

Much has been written from time to time on the subject of Canadian apatites and their associated rocks by experts from Canada, the United States and England, and the literature in this direction, if collected, would form a fair sized volume. Much of this has been reviewed and published in condensed form by the writer in his report on the "Mineral Resources of Quebec."[1] From these papers it is evident that a very considerable diversity of opinion has prevailed as to the origin, mode of occurrence and geological relations of this mineral. Thus while some have maintained that it is the result of organic agencies and urge in support of this view, the presence in the Laurentian of the peculiar form Eozoon, regarded by Sir Wm. Dawson, Drs. Hunt, Carpenter and others, as representing the earliest known traces of life, as well as in the presence of great beds of iron ore and graphite, others have supposed that the mineral was the result of the action of a solution, bearing fluorine and phosphorus in some unknown combination upon a bed of limestone, and that this solution was distributed by means of side fissures through the main mass of the rock in such a way that a portion of the limestone of the bed was converted into a fluor-apatite. By others again the opinion has been expressed that apatite has been derived principally from the pyroxenite in which it is generally found, presumably by a process of segregation; that the pyroxenite is of igneous origin, and formed either as submarine injections while the Laurentian rocks were being laid down or as subsequent intrusions, even though it now presents certain aspects of a bedded rock.

The eruptive origin of the apatite found in Norway has long been maintained by the Norwegian geologists Brögger and Reusch. The associated rocks in that country apparently possess many of the same characters as those in Canada, and occur under very similar conditions. Among Canadian geologists the same view as regards the Canadian mineral was strongly put forward by Mr. Eugene Coste, formerly of the Geol. Survey, in his report for 1887-88, and subsequently by Dr. Selwyn in the report for the ensuing year, who says: "There is absolutely no evidence whatever of the organic origin of apatite, or that the deposits have resulted from ordinary mechanical sedimentation processes. They are clearly connected, for the most part, with the basic eruptions of Archæan date."

[1] Rep. Geol. Sur., 1888-89, Vol, iv, p. 88-110 K.

The apparent conflict of opinions on this subject is doubtless to some extent due to the diverse views which have been held regarding the composition and structure of the Laurentian rocks themselves. These, in the early days of their study, were supposed by Sir Wm. Logan and his co workers to be very largely sedimentary in their nature, and formed just as are the sandstones and fossiliferous limestones of more recent formations. In the stratified sedimentary complex, was included not only the crystalline limestone, gneiss and quartzite, but also the anorthosites, the pyroxenes, feldspars and many of the syenitic rocks which subsequent careful study in the field and laboratory have shown to have originated in a very different manner. That the greater part of the latter group is intrusive in the stratified gneiss and limestones is now very clearly established, while the present highly altered condition of the gneiss and associated limestone is doubtless due, in part at least, to the great processes of metamorphism which have taken place during the ages subsequent to their deposition as also, to some extent, to the action of the subsequent intrusive masses.

It is impossible here to go into any elaborate discussion as to the origin of the Laurentian rocks, further than may be absolutely necessary for a clear understanding of the subject under discussion. It may however be said from the evidence at present at our disposal that they have been produced in two ways; for while it is clear that a very large proportion, by far the largest in certain areas, possesses the characters of igneous rocks, certain well stratified areas of limestones with associated quartzite and gneiss, present very many of the features of sedimentary rocks, especially in their present arrangements, and have presumably been deposited through aqueous agencies. The evidence from organic remains usually found in sedimentary rocks, is, however, wanting, but this may be due to the absence of life on the globe in those early periods of the world's history, for, if such existed, their traces have entirely disappeared from some cause not yet definitely known.

Bearing in mind, therefore, the fact that the Laurentian rocks must be regarded as divisible into two distinct groups, we find from their study in the field, certain features in regard to the occurrence of apatite which serve to throw much light upon its early history. It may be very conclusively stated, that for the most part at least it is confined to pyroxenic rocks, although certain writers have asserted that it is found equally in the stratified gneiss and limestone formations. It may, however, be said that after a careful study of all available openings in the Ottawa district, no locality has yet been seen where apatite occurs in workable quantity, or in fact in any way except as occasional scattered crystals in either the limestone or gneiss. The conflicting statement as to its presence in the limestone seems to have arisen largely from the occurrence in many of the pyroxene dykes of masses of calcite, generally of a pinkish color, some of which are of large extent but all strictly integral portions of the pyroxene, through which scattered crystals of mica and apatite are distributed, and it is from this calcite that the most perfect crystals of both these minerals are obtained.

The confusion as to the mode of occurrence has therefore in this case presumably arisen from a lack of care on the part of the earlier observers in separating the mineral calcite from the limestone formation proper, which is entirely different in character and has evidently been formed in an entirely different manner. The reputed occurrence in gneiss can also be traced to the opinion formerly held regarding the nature of the pyroxene bands, which regarded these as of purely sedimentary origin and as constituting a regularly interstratified portion of the gneiss formation, where it was known under the name of pyroxenic gneiss. In the limestone formation proper occasional small crystals of apatite are found where small dykes of pyroxene penetrate the rock, and still more rarely crystals occur in that portion of the gneiss in close proximity to the intrusive mass.

As regards the mode of occurrence of the pyroxene itself we are forced to conclude, that, like the great masses of syenite and the numerous intrusions of dolerite, it is also of igneous origin. That it is clearly intrusive in its character is evidenced by its occurrence in dyke-like masses and bands which sometimes cut directly across the regular stratification of the banded gneiss and limestone, and at others traverse these along the bedding planes for some distance and then abruptly change their course after the manner of other instrusions. In some places a gneissic structure is perceived in the pyroxene, but this, as in the case of the syenites, is doubtless a foliation due to great pressure. The pyroxene dykes are of very varying proportions, sometimes extending for long distances as narrow belts of from one to fifty or more feet in thickness, at other times presenting the form of great hills, where they are mixed with syenitic and dioritic rocks. The apatite bearing dykes are frequently cut by later dykes of syenite, diorite, feldspar or trap, beautiful examples of this interlacing being furnished at many of the openings throughout the mining districts on the Lievre and Gatineau rivers.

Various opinions have also been expressed as to the form in which the apatite deposits occur. By some they are stated to be in beds, others assert that they present rather the features peculiar to vein structure, while yet others maintain that they partake of the nature of both beds and veins. By far the greater part of these opinions is based upon the assumption that the containing rocks are sedimentary gneiss and limestone, the intrusive character of the pyroxene being for the most part ignored. Thus Dr. Harrington in his very exhaustive report on the subject which is found in the report of the Geological Survey for 1877-78 thinks that the views of the Norwegian geologists as to the eruptive origin of apatite deposits, cannot apply to those found in Canada, and supports rather the view put forth by Sir Wm. Dawson that the mineral has been produced probably through organic agencies. In its present condition he thinks that while confined almost entirely to pyroxenic rocks, the structure of the deposits partakes more of the

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nature of true veins than of beds. Dr. Penrose [1] also shows that the mineral occurs almost without exception in association with pyroxenic or hornblendic rock, especially in the Quebec district, where he says "the phosphate has never yet been found without being associated with pyroxene rock and possibly often of vein origin." He also states that "the pyroxene is never found distinctly bedded, though occasionally a series of parallel lines can be traced through it, which while possibly the remains of stratification are probably often joint planes; and sometimes when the pyroxene has been weathered, apparent signs of bedding are brought out, which are often parallel with the bedding of the country rock."

Sufficient has probably been said to warrant the opinion that the pyroxenes are as truly intrusive in their character as many of the other rock masses such as syenites, diorites, &c., which are found so abundantly throughout the great Laurentian area. So strongly impressed was the writer by the study of the relations of the several rock formations as presented in the mining districts of Buckingham, Templeton, &c., that in 1892, a number of the most interesting occurrences were carefully photographed under the direction of Mr. H. N. Topley, and subsequently colored to clearly represent the different rock masses.

In this way the contrast between the generally pinkish or greyish banded gneiss, and the green massive pyroxene was beautifully shown and the abrupt contact of the two well brought out. It may be said that these colored views were exhibited by the Geol. Survey Dept. at the World's Fair, in Chicago, where they were greatly admired by those interested in this branch of geological work; the evidence thus presented being held to be most conclusive as to the intrusive character of the apatite bearing rock.

Among places in the Lievre district where these contacts can be especially well studied may be mentioned the mines of the Philadelphia Company, the North Star, the London and the Little Rapids mines on the eastern side of the

[1] See Bulletin of the U. S. Geol. Survey, 1888.

river, and the Crown Hill and High Rock mines on the west side. At the Little Rapid mine the dyke carrying the apatite cuts the surrounding well banded gneiss at an angle of thirty degrees, while on the ridge to the south another large dyke of fifty feet or more in breadth cuts the stratified rock at an even greater angle. At the North Star mine, the strike of the principal dyke is nearly with that of the gneiss, but in the most southerly pit, the gneiss has been heaved up and bent round a portion of the dyke, the contact of the two kinds of rock being very sharply defined. At the London and Philadelphia mines the intersections of the pyroxene across the strike are well shown, as also at the High Rock workings, where there is sometimes a perfect net work of dykes of different kinds, small masses of the stratified gneiss being enclosed in the intrusions. It may be remarked that at all these mines the country rock is banded gneiss of the greyish quartzose variety, or what we regard as the sedimentary portion which underlies the crystalline limestone formation.

At the Crown Hill, in the pit on the west side of the main ridge, the capping of the gneiss upon a portion of the pyroxene is well seen, the mass of the dyke being exposed at the surface of the hill, a short distance further east.

As regards the manner in which the apatite occurs in the pyroxene, it may be said that in nearly every case throughout the entire mining district the phosphate is found in that portion of the dyke contiguous to the surrounding gneiss. In certain large dykes as at the North Star it was found along both margins of the intrusion. In some cases a certain amount of regularity in its distribution was observed for a short distance, but this was not long maintained. Frequent branches or spurs are given off into the surrounding pyroxene, and the deposits as a whole are exceedingly irregular, sometimes opening out into great masses of several hundreds of tons, while at others they dwindle down to mere strings, which cannot be profitably extracted. The central portion of the dykes are for the most part barren. No defined foot-wall can be observed, the apatite having a very irregular outline, while in cases where a foot-wall was supposed to exist this was found to be due to the presence of a cross-dyke. The hanging-wall where reported consisted in most cases of the edges of the gneiss, the planes of stratification in some cases meeting the apatite bearing portion of the dyke at very considerable angle.

An important feature was observed at several of the mines, tending to show that subsequent intrusions of dioritic or doloritic rock have apparently exercised a marked influence upon the occurrence of apatite in workable quantity. Thus at the Etna mine a large dyke of pyroxene, which extends in a southwest direction towards the Emerald mine and on the prolongation of which the latter is possibly situated, is intersected nearly at right angles by a heavy dyke of dolerite. Along the line of contact considerable quantities of iron pyrites have been developed, and the apatite which has been mined at this place to a depth of not far from 200 feet is found in that portion of the pyroxene adjacent to the dolerite intrusion, along which the workable deposit of phosphate apparently extends. A somewhat similar occurrence in the case of mica was observed at the Clemow & Powell mine in the Township of Hincks, where the main mass of pyroxene which intersects crystalline limestone is in turn cut across by a dyke of syenitic rock, principally composed of feldspar and quartz, alongside of which great masses of mica crystals, often of very large size, have developed in the pyroxene. This feature of mica and apatite occurring as the apparent result of a second intrusion, has been also noticed at other points, both in the Gatineau and Lievre districts.

With regard to the age of the different intrusions, the apatite-bearing pyroxene appears to be the oldest. Instances, as already noted, are frequent where this is clearly broken across by dykes of feldspar and syenite, which have been in turn cut by trappean rock. Other syenite masses are apparently of more recent date than the trap dykes, as these are in several cases observed to be cut through by the former. The syenite in places changes color and character to some extent when passing from the main mass into smaller dykes or spurs, especially where these latter traverse the crystalline limestone, in which case it often becomes a greyish white. This aspect can be well studied at Papineauville among other places.

These intrusions do not, however, carry apatite, at least in any observed case, though they often contain fine crystals of mica. When penetrating gneiss the feldspar dyke, if mica bearing, carries muscovite, while the pyroxene dyke carries phlogopite, which is often associated with apatite. This joint occurrence of mica and apatite is quite frequent at certain mines, more especially in the northern Templeton area.

The origin of the apatite itself has not yet been conclusively settled. From its manner of occurrence and associations it would appear to be due to chemical agency rather than to organic. In some of the smaller crystals which occur with mica in the pinkish calcite, the interior is frequently found to be composed of pink calcite, itself unchanged to apatite. These frequently penetrate crystals of mica, and cracks or fissures in the mica crystal also contain small quantities of the calcite. All pyroxene contains calcite in proportions varying from twenty to nearly thirty per cent., and since its intrusion into the gneiss must have occurred along lines of fracture or least resistance, it would appear reasonable to suppose that vapors, charged with some form of phosphoric and fluoric acids, ascended along such lines. Thus in certain portions of the mass in proximity to the margin of the dykes these vapors would tend to impregnate the softened rock, and in this way through chemical processes, the phosphate of lime might be produced. That the origin of the mineral is deep seated is clearly shown by its presence in the pyroxene at great depths. Thus it has been clearly shown in the working of the North Star mine that the quantity found in the lowest level at a depth of 600 feet from the surface was quite equal to that obtainable from the upper levels, while the same mode of occurrence near the margin of the dyke was found. So also at the High Rock mine apparently the most productive ground is that recently worked near the base of the hill, some 400 feet below the workings at the summit. There does not appear therefore to be any diminution of the mineral as we descend so long as the conditions for its occurrence continue favorable, and it might upon this theory be generally stated that the only limit in depth at which the mineral may be profitably mined will be fixed by the cost of its extraction.

NOTES ON CANADIAN FOSSIL BRYOZOA [1]

By H. M. AMI.

I.

Prof. Ulrich is well known to all students of North American palæozoic palæontology as being an eminent authority on Bryozoa. Ever since the year 1881 his researches and publications on the interesting material which occurs in such abundance in the Cincinnati and allied groups have been received and read with interest, inasmuch as they threw a mass of new light on a humble yet important and but little known class of fossils in America. This last contribution from the pen of Mr. Ulrich is a handsome and beautiful memoir on the Lower Silurian Bryozoa of the State of Minnesota. Whilst the 237 pages of text and the 28 excellent plates accompanying the same are devoted especially to Minnesota Bryozoa, Prof. Ulrich has not deemed it out of place to introduce here and there, for purposes of comparison and observation, certain marked forms coming from other localities. Among the latter may be mentioned a goodly number from Canadian rocks. The purpose of the present notice is to point these out for reference sake as work bearing on the palæontology of Canada.

[1] The Bryozoa of the Lower Silurian in Minnesota. By E. O. Ulrich. From Vol. III. of the Final Report of the Geological and Natural History Survey of Minnesota. 237 pp. Minneapolis 1893.

In Prof Ulrich's memoir and in this notice the various forms mentioned are classified under the following sub-orders and genera of Bryozoa:

(1.) CTENOSTOMATA, Busk.

To which Ascodictyon of our Devonian rocks of Western Ontario belongs.

(2.) CYCLOSTOMATA, Busk.

Including the genera Stomatopora. Proboscina, Hederella, etc., from various horizons.

(3.) TREPOSTOMATA, Ulrich.

Including the Monticuliporoid genera, Monticulipora, Prasopora, Dekayia, Callopora, Stellipora, Stenopora, Amplexotrypa, Batostoma, Spatiopora, Fistulipora, Botryllopora and allied forms from various horizons ranging from the Ordovician to the Carboniferous of Canada.

(4.) CRYPTOSTOMATA, Vine.

Including twelve families and eighty genera of which the following are represented in species from Canada: Ptilodictya, Clathropora, Phænopora, Graptodictya, Arthropora, Dicranopora, Pachydictya, Stictopora, Coscinium, Tæniopora, Rhinopora, Helopora, Sceptropora, Arthroclema, Thamnotrypa, Fenestella, Archimedes, Phylloporina.

(5.) CHILOSTOMATA, Busk.

Including only three genera, as yet, of which the first Paleschara, Hall, is the only Canadian form known to the writer.

Taking the forms obtained from various places in Canada which are described or figured by Prof. Ulrich in this volume we find the following :—

Lower Silurian Bryozoa from Canadian rocks.

A.—CYCLOSTOMATA, Busk.

I. Genus STOMATOPORA, Brown.

1. *Stomatopora inflata*, Hall, occurs in the Trenton limestone of Ottawa, Canada.

II. Genus PROBOSCINA, Audouin.

2. *Proboscina frondosa*, Ulrich. Recorded from the Ordovician strata of Stony Mountain, Manitoba, and previously recorded in Contrib. to the Micro-Pal. of Canada, Part II., p. 28.

B.—CRYPTOSTOMATA, Vine.

III. Genus PACHYDICTYA, Ulrich.

3. *Pachydictya acuta*, Hall, p. 155.

4. *Pachydictya triserialis*, Ulrich, p. 159. This form is described "as yet known only from the Trenton limestone of Montreal, Canada." It is figured on Plate X., figs. 11 to 14.

IV. Genus PTILODICTYA, Lonsdale.

Here, Prof. Ulrich classifies the known forms of Ptilodictya and gives the following Canadian species:

Section *a.—Species without monticules.*

5. *P. gigantea*, Nicholson, Corniferous, Canada.

6. *P. Canadensis*. Billings, Hudson R. group, Canada.

7. *P. gladiola*, Billings, H. R. and Anticosti groups, Canada.

8. *P.* (?) *sulcata*, Billings, Anticosti group, Canada.

Section *b.—Species with monticules.*

9. *P. Whiteavesii*, Ulrich, H. R. group, Manitoba.

V. Genus ESCHAROPORA, Hall.

10. *E. recta*, Hall, Trenton limestone, Canada.

VI. Genus PHÆNOPORA, Hall.

11. *P. incipiens*, Ulrich, from the Trenton limestone of Montreal, Canada, where it was collected by the late Mr. T. C. Curry, of the Peter Redpath Museum.

VII. Genus ARTHROPORA. Ulrich.

12. *Arthropora bifurcata*, Ulrich. A species closely related to if not identical with this is said to have been found in the Trenton limestone of Canada, the precise locality not being indicated.

VIII. Genus STICTOPORELLA, Ulrich.

13. *Stictoporella exigua*. Ulrich. Trenton and Canadian

are the horizon and locality respectively to which Prof. Ulrich has ascribed this species.

14. *Stictoporella proavia* (*Coscinium, Eichwald,* as of Billings) from the "Trenton" of "Canada."

IX. Genus ARTHROCLEMA, Billings.

15. *Arthroclema pulchellum,* Billings. Trenton limestone, Hull, Que.

16. *Arthroclema Billingsi,* Ulrich. This is recorded from the Trenton limestone of Ottawa, Canada.

X. Genus NEMATOPORA, Ulrich.

17. *Nematopora ovalis,* Ulrich. Trenton limestone, Montreal, Canada.

XI. Genus PHYLLOPORINA, Ulrich.

18. *Phylloporina Trentonensis,* Nicholson. No Canadian locality is indicated in this volume, but the writer has seen several specimens of *P. Trentonensis,* Nich., from the Trenton limestone of Montreal in the Peter Redpath Museum of McGill College, and these were named by Prof. E. O. Ulrich.

C.—TREPOSTOMATA, Ulrich.

XII. Genus MONTICULIPORA, d'Orbigny.

19. *Monticulipora Wetherbyi,* Ulrich. This species is recorded by Prof. Ulrich as coming from the limestone beds St. Andrews, Manitoba.

XIII. Genus HOMOTRYPA, Ulrich.

20. *Homotrypa similis,* Foord. "The types are from the Trenton at Ottawa, Canada." The species was described by Mr. A. H. Foord, F. G. S., on p. 10, "Contr. to Micro-Pal. of the Cambro-Silurian Rocks of Canada," Ottawa, 1883.

XIV. Genus PRASOPORA, Nicholson and Etheridge, Jr.

21. *Prasopora simulatrix,* Ulrich; var. *orientalis,* Ulrich, Canada. This new var. of *P. simulatrix,* Ulrich, has been created to receive such Canadian and New York forms as showed a number of distinctive microscopic characters and

was founded on a form referred to *Monticulipora* (*Diplotrypa*) *Whiteavesii*, Nicholson. It is interesting to note that Mr. Ulrich thinks that "this species (*P. simulatrix* var. *orientalis*, Ulrich) may really be the one referred to by Vanuxem in 1842 (Geol. 3d Distr., N. Y., p. 46), when he speaks of "The puff-ball favosites (*Favosites lycopodites*) as being highly characteristic and in great numbers in the Trenton limestone of New York." Mr. Ulrich further states that "the variety *orientalis* is common in the Trenton limestone at Ottawa, Peterboro and other localities in Canada," and in the figures on p. 248 he quotes from Canadian localities a number of characteristic species which he there (*loc. cit.*) figures as follows :

21. *Prasopora Selwyni*, Nicholson (fig. 15*a* and *b*). This species is restricted, in this volume, to a particular type, such as was originally described by Nicholson from the Trenton limestone of Peterboro, Ontario, Canada, and Prof. Ulrich adds that "Foord says the species is abundant throughout the Trenton formation at Ottawa, Canada. Also that it has been found in the upper beds of the Chazy at Nepean (Hog's Back, *teste* H. M. A.) near Ottawa.

22. *Prasopora oculata*, Foord (figs. 15*c* and *d*). This interesting form, which was originally described by Foord in his "Contr. Micro-Pal. Cambro.-Silur. Rocks, Canada, p. 11," as coming from the Trenton formation at Ottawa and Hull, Canada, has been recorded by Ulrich from several localities in Minnesota.

In connection with this species another Canadian *Prasopora* is referred to as being closely related, viz.:

23. *Prasopora affinis*, Foord, also from the Trenton formation of Canada.

Prasopora affinis, Foord, is here mentioned as being closely related to *P. Selwyni*, Nicholson, the characteristic difference separating *P. oculata*, *P. affinis* and *P. Selwyni* being briefly and clearly outlined. All three species have been discovered in the Trenton and Galena shales of Minnesota.

XV. Genus MESOTRYPA, Ulrich.

This genus was been founded to receive a number of forms usually referred to the genus *Diplotrypa* by Foord, Nicholson, Ami and Ulrich himself. The following species of *Mesotrypa* from Canada are recorded:

24. *Mesotrypa Quebeoensis*, Ami (fig. 15*e* and *f*, p. 248.) The type of this species described by the writer[1] from the hard compact and indurated limestone bands of Cote d'Abraham, Quebec City, Canada, is here recorded (p. 259) from the Galena shales at Decorah, Iowa, also from "shales of the Trenton group at Burgin and Danville, Kentucky," and also from "the Trenton limestone at Trenton Falls, New York."

25. *Mesotrypa Whiteavesi*, Nicholson, sp. (fig. 15*g* and *h*). This species was originally described from the Trenton limestone of Peterboro, Ont., Canada, and is here referred by Prof. Ulrich for the first time to his new genus *Mesotrypa*. Since this species was described by Nicholson, Foord and others have discovered it in other localities in Canada, including Ottawa, Ont., and Hull, Que., in the Trenton limestone of both localities.

Besides the above species of *Mesotrypa* Ulrich mentions casually, but does not describe elaborately, as in other cases, the following species from Canada:

26. *Mesotrypa regularis*, Foord. This species was described in Contrib. Micro-Pal. Cambro-Silur. Rocks, Can., pp. 13 and 14, and obtained by Mr. Thomas C. Weston in the "Trenton formation at Ottawa."

XVI. Genus ERIDOTRYPA, Ulrich.

27. *Eridotrypa mutabilis*, Ulrich. Recorded by Ulrich from the Trenton limestone of Ottawa, Canada, and from a large number of localities in Wisconsin, Iowa, Tennessee, Kentucky and Minnesota.

XVII. Genus CALLOPORA, Hall.

28. *Callopora multitabulata*, Ulrich. Of this species, which Mr. Ulrich first described in the "Fourteenth Ann.

[1] Can. Record of Science, Montreal, April, 1892, p. 101.

Rep. Geol. Nat. Hist. Surv. Minn., Minneapolis, 1886, p. 100," the following remark is made: "The same species apparently occurs at Ottawa, Canada." From this statement I would conclude that Prof. Ulrich has amongst his material from Ottawa a form which he refers with a certain amount of uncertainty to the above species.

XVIII. Genus HEMIPHRAGMA, Ulrich.

29. *Hemiphragma Ottawaense*, Foord. This species was first described by Foord[1] as *Batostoma Ottawaense* from the Black River and Trenton formations of Canada in the Ottawa River Valley.

XIX. Genus MONOTRYPA, Nicholson.

30. *Monotrypa undulata*, Nicholson. This species is the type of the genus *Monotrypa* (pars), Nicholson, as restricted by Prof. Ulrich. In has been recorded from Canada, from the Lorraine (=Hudson River) rocks of Toronto and other localities in Canada.

31. *Monotrypa* (*? Chætetes*) *cumulata*, Ulrich. This species is for the first time described by Prof. Ulrich in this interesting memoir on pp. 307 and 308, and is recorded from the "Trenton limestone of Canada."

XX. Genus BYTHOTRYPA, Ulrich.

32. *Bythotrypa laxata*, Ulrich. This species was first described and recorded from the Trenton formation of St. Andrews, Manitoba, Canada, in "Contrib. Micro-Pal. Cambr.-Sil. Rocks Can., 1889, part II, p. 37." It was there doubtfully referred to the genus *Fistulipora*, but on examining large collections of the species Ulrich was led to regard this a new genus, which he founded upon this species as the type, a prototype of *Fistulipora* and gave it a new generic designation.

XXI. Genus DIAMESOPORA, Hall.

33. *Diamesopora Trentonensis*, Ulrich. From the Trenton limestone at Ottawa, Canada.

The text is accompanied by twenty-eight full page quarto

[1] Contrib. Micro-Pal. Cambro-Silur. Rocks Canada, Cttawa, 1883, p. 18.

plates of illustrations drawn on stone from nature and from sections by Prof. E. O. Ulrich himself. They are excellent and give, as a rule, all the necessary views required wherewith to determine the generic as well as specific characters described in the text or observed in related species described elsewhere.

It follows then from the above digest made of Prof. Ulrich's work on the Lower Silurian Bryozoa of Minnesota that thirty-three references to Canadian species are found belonging to twenty-one generic forms.

II.

In his previous elaborate work entitled: "PALÆONTOLOGY OF ILLINOIS, Part II., Section VI., PALÆOZIOC BRYOZOA, by E. O. Ulrich, pp. 283 to 688, the following is a list of species of fossil bryozoa therein recorded from Canadian localities:

1. *Protocrisina exigua*, Ulrich, Trenton, Montreal, Que. (= *Gorgonia* [?] *perantiqna*, Hall, 1847.)

2. *Leioclema minutum*, Rominger [?] Western Ontario. (= *Callopora minutissima*, Nicholson, 1875.) Devonian.

3. *Batostomella Trentonensis*, Nicholson, Trenton limestone of Ontario.

4 *Botryllopora socialis*, Nicholson, Hamilton formation, Arkona, Ontario, Canada.

5. *Arthroclema pulchellum*, Billings, Trenton of Canada.

6. *Helopora fragilis*, Hall, Clinton formation, Hamilton, Ont., Canada. (Fig. *d*, p. 643.)

These make in all twenty-seven genera and thirty-nine species from Canada.

OTTAWA, June 18th, 1894.

THE RIDEAU LAKES.

By A. T. DRUMMOND.

The term Rideau Canal is rather a misnomer. If we except the five miles of actual canal between the Dufferin Bridge at Ottawa and Hogsback, and. again, the one mile or more each of excavation at Poonamalie and Newboro, the whole one hundred and twenty six miles of water route between Ottawa and Kingston now comprise merely two rivers and a chain of lakes—the Rideau River, which, flowing for sixty five miles on the one side of the watershed, falls at Ottawa into the Ottawa River; the Cataraqui River, which, descending for eighteen miles on the other side, falls at Kingston into Lake Ontario; and, connecting the head-waters of these two rivers, a continuous group of nine beautiful lakes, each lying close to the next and all more or less studded with islands.

Canal journeys are slow and often monotonous. The tourist, whose memories of the beautiful in Canadian river scenery are associated with the Thousand Islands, and who when speeding down the rapids of the St. Lawrence has observed, in striking contrast, the tedious progress through the St. Lawrence canals of the returning steamers as they wend their way back again to the upper lakes, is hardly prepared for the information that, inland, on what is, officially, but, by a misnomer, known as the Rideau Canal, there is for fifty miles a succession of lake scenery more beautiful and more varied than that of the Thousand Islands. And yet it is so. These Rideau Lakes were better known fifty years ago than now. With the opening of the St. Lawrence canals and the construction of railways, the Rideau route ceased to be a main thoroughfare, and is now only locally known.

The character of the scenery here is largely due to the geological features of the country. The cañon at Kingston Mills which forms the bed of the Cataraqui River, is walled by low Laurentian hills of 150 to 200 feet in height, and shows in the bevelled edges of the gneiss near the water's edge, as well as in the worn crests of these hills, that it has been at one time the track of an ice flow. The softer sandstone cliffs skirting the same river on its southern side in Pittsburg, have had their general S 36° W direction made for them by the same great force. The islands are generally the lower peaks and crests of the Laurentian ridges which the waters of the lakes on finding an outlet have left unsubmerged. And everywhere in the immediate vicinity of the lakes these same Laurentian ridges, green with trees and shrubs to the water's edge, add attractiveness to the scenery and especially beautify the narrow passes and gorges which connect the different lakes.

The Rideau lakes are, in part, artificial. Sand, Opinicon and Indian Lakes and probably also Mud and Clear Lakes, were no doubt somewhat enlarged by the dams at the outlets of the first three lakes, whilst Cranberry Marsh which was one of the sources of the Cataraqui River, became by the construction of the Brewer's Mills dam, the long, narrow but picturesque Cranberry Lake, with every trace of a marsh effaced, and the Whitefish River became, by the erection of a dam near Morton, the equally long and narrow Whitefish Lake.

The effect of these last named dams being on the same level has been to unite Cranberry and Whitefish Lakes sufficiently for navigation purposes. How far they were originally connected has been an open question. Lieut. E. C. Frome, R.E., describing in the Royal Engineers' Reports in 1837, the original line of communication before the canal was constructed, alludes to the route being through Whitefish Lake and by a channel through a quantity of marshy land which had been flooded by dams erected at Whitefish Falls and at the Round Tail, the source of the Cataraqui River. Mr. Andrew Drummond whose personal experiences here date back to 1832 is of opinion that there was a connection between them, and he writes as follows in regard to the sources of the Cataraqui and Gananoque Rivers and to the route of the Rideau Canal here as originally projected: "I think, originally, there was a flow from Lougborough Lake into the Cataraqui through what was then known by the name, not of Cranberry Lake, but of Cranberry Marsh, which became a lake when the waters were raised by the artificial dams at Brewer's upper mill and at Whitefish Lake. The latter, as far as my recollection serves, was considered the source of the Gananoque River."

"From a mere commercial point of view, the first engineering report recommended the construction of the Rideau navigation route by the way of the Whitefish or Gananoque River, but the British Government decided that it must be built by the Cataraqui River to Lake Ontario direct, and not by an outlet on the St. Lawrence River, where vessels would be more or less subject to annoyance from the United States in time of war."

The great importance of maintaining as far as possible the level of Upper Rideau Lake, by conserving the waters of its tributary lakes, has been forcibly illustrated during the past summer. The long continued drought during August led to the waters falling so low that steamboats and barges drawing five feet constantly grounded in the long, narrow cut at Newboro, and it became a question whether navigation for the larger vessels would not have in consequence to cease over the entire system. This is a difficulty likely to occur more frequently in the future in the Rideau Lakes on account of the gradual removal of large sections of the surrounding forests by fire, and the uncontrolled cutting down of even the smaller sizes of timber there by lumbermen.

A Rideau Lakes Reserve.

What is needed here is a forest reserve around the systems of lakes which form the feeders of the Rideau Lakes. By protecting the reserve from bush fires and absolutely withdrawing it from settlement, the trees will be allowed to grow again; and the accumulations from the melted snows and from the summer rains which presently are quickly drained off, will be held back within the forests and only gradually find their way to the lakes. As in other sections of both Ontario and Quebec, the country here is now reaping the results of a past unwise Government policy under which no practical effort was made to protect the forests from fires or to punish those who carelessly or wantonly were the causes of these fires, and under which the right of cutting timber on the Crown lands has been freely sold with the object of securing for the Government a present cash return, and without the slightest effort at conserving the forests in order to make them a continuous source of revenue in coming years. Though somewhat late and only after so many of its townships had been largely burned over, an effort has been made during recent years by the Ontario Government in conjunction with the lumbermen, to limit forest fires, but more or less apathy still prevails in Quebec, and the general criminal law of the Dominion still fails to grapple practically with the subject. Nearly all forest fires are the result of criminal carelessness or of wanton destructiveness, and are therefore preventable. When will our Governments learn that by year after year showing apathy over the burning of the country's forests, they are wasting not only the country's present revenues but the revenues which would continue to be derived from timber for scores of years to come.

Heights of the Lake Levels.

Assuming the waters of Lake Ontario to be 237 feet above the sea—some authorities mention 232 feet—the heights above tide water of the different Rideau lakes and of some of the upper lakes which supply them are, as determined by the Government surveys, as follows:

	Feet.
Upper Rideau	402
Lower Rideau	398
Mud, Clear and Indian	398
Opinicon	386
Sand	377
Whitefish and Cranberry	317
Bobbs	621
Knowlton	454
Loughborough	403
Canoe	466

DISTRIBUTION OF POTSDAM SANDSTONE.

The recent surveys made by the railway engineers between Rideau and Elgin emphasize the suggestion I have elsewhere made that the Potsdam sandstone has probably had a wider distribution throughout this Laurentian isthmus than was at first supposed. After leaving Rideau Station on the Grand Trunk Railway, the sandstone is met with on lot 9 in the 4th concession of Pittsburg whence it continues to lot 11 in the 5th concession. The beds furnish an excellent building stone. It appears again in the middle of lot 12 in the 5th concession and continues to lot 15 in the same concession when the gneiss again takes its place. Further on, at Brewer's Mills, a few feet of sandstone cap the low Laurentian ridge to the north of the locks, and at the outlet of and at places around, Loughborough Lake a few miles farther north, and also around Knowlton Lake, it is also found. Immediately beyond Morton, on lots 4 and 5 in the 5th concessiou of South Crosby, and at Jones Falls it reappears, at the latter place forming cliffs of about 70 feet in height. The splendid locks and dam at Jones Falls are built of sandstone. East of Morton it probably underlies the broad stretch of flat country lying between that village and Lyndhurst and thence towards Seeley's Bay. Beyond Lyndhurst about Bass Lake and on the north side of Charleston Lake, it is also met with. On the north western side of Lower Rideau Lake and continuing to Perth aud thence north to about the Mississippi River within a short distance of Lanark, there is a broad display of the Potsdam sandstone It appears also in South Elmsley, and at Portland in Bastard has been used as a building material, though the upper rocks in this vicinity may be of calciferous sand rock. Among and in the neighborhood of the Thousand Islands, the Potsdam sandstone occurs at one or two points on the St. Lawrence side of the Township of Pittsburg, at and around Gananoque, on the lower end of Howe Island, and on Hay, Tidds, and parts of Round and Wellesley Islands, whilst farther down the river, it appears near Alexandria

Bay and continues at intervals to Brockville. There is thus a widespread distribution of it in patches or small areas nearly across the Laurentian isthmus which connects the Adirondacks with the Laurentian country to the northward. And in this locality where glacial action has been so marked, we can imagine that these softer rocks may at one time have had a greater development than now appears.

Laurentian Rocks.

Writing generally of the Laurentian rocks in the Counties of Lanark, Leeds and Frontenac, the late Mr. H. G. Vennor in the Geological Survey Report for 1870, characterizes them as made up of granitoid gneisses, composed of flesh colored feldspar, with grey quartz, greenish hornblende, and some mica, and much cut up by granitic veins. They have, in places, great crystalline limestone bands which can be traced continuously through two or three townships, and sometimes they include broad areas of granitic rocks containing red orthoclase and white quartz.

The economic minerals met with in the neighborhood of the Rideau lakes are iron ore in large quantity at several points, lead and yellow sulphuret of copper but not, thus far, in paying quantities, phosphate of lime at numerous points, mica, marble, granite for paving blocks, and thick bedded sandstone for building material. The iron ore generally, has assayed from 52 per cent. to 60 per cent. of metallic iron, but is occasionally associated with 6 per cent. to 12 per cent. of titanic acid and some sulphur.

The leading physical features of the country—the lakes, the islands, the low overlooking hills—are all due to the Laurentian rocks, and to the line of direction which these hills or great ridges have taken. At Brewer's Mills on the Cataraqui River the direction is about N. 20° E. From this point to Seeley's Bay their course is about N. 34° E., whilst south-east of Seeley's Bay there are ridges lying N. 30° E. A long, conspicuous gully here which has afforded a probable opening to the engineers for location, takes, however, a course, for a considerable distance, of N. 82° E.

The general dip is towards the St. Lawrence River and the small streams south of Seeley's Bay are tributary to the Gananoque River and not to Cranberry and Whitefish Lakes.

FLORA.

The flora of the country surrounding the lakes is essentially that common to Central and Eastern Ontario and to the vicinity of Montreal. Even the Western Ontario peninsula would differ from it rather by the prevalence there of western and southern forms than by the absence of species found around the Rideau lakes. Eastern Ontario is, however, the meeting ground of some outliers from floras whose centres of development are elsewhere. Among trees, *Pinus Banksiana*, the Northern Scrub Pine, has made its way from higher latitudes to the southern townships of the County of Renfrew, *Pinus rigida*, the Pitch Pine, a denizen of the Atlantic Middle States, has found a congenial home near Mallorytown and Gananoque and in the township of Torbolton, *Juglans nigra*, the Walnut, has wandered from its native wilds in the west to Ottawa and Montreal, and *Quercus Castanea*, the chestnut oak, has ventured from the Middle and Western States, as far east as Kingston. Among shrubs, *Rhus copallina*, although somewhat common in the United States, is thus far known in Canada only among the Thousand Islands, near Gananoque, where its congener *R. typhina* attains a wonderful development in numbers, whilst *Pyrus sambucifolia* found along the more northerly portions of the United States, occurs at Ottawa and Montreal and ranges thence northwestward to the Rocky Mountains and northeastward to Labrador. Among herbaceous plants there are also a few outliers from other floras, and one or two species like *Podostemon ceratophyllum* found at Ottawa, which have probably been overlooked elsewhere in Ontario.

Are these outliers the advanced guard of their respective species paving the way for a more extended range by becoming acclimatized, or do they constitute a stationary force which physical and climatic influences have precluded from going farther, or are they a rear guard representing what remains of a retreating force whose maximum stage of activity has been passed, whose area of distribution has been diminishing, and the individuals of whose species are being gradually reduced in numbers. The questions involved are interesting. The suggestion is intelligible that each species has its place and purpose to fulfil in life, just as the lower animals and man have, and has its development and ultimate decline in strength and activity in each individual as well as in the numbers of its species, until, in long course of time, that place is either left void or is taken by some other form or variety more suited to the changes of circumstances which time is gradually but continuously bringing about. Many plants, at the present time, are thus at their maximum stages of activity in individual growth and reproduction, and have now their maximum breadth of distribution; some are merely in the early or initial stages of this activity and at the initial points of their ultimate area of range; whilst others must be on the decline when activity in reproducing the species is lessening, and the area of distribution is being circumscribed. When the stage of decline has been reached, climatal and other causes which would in the ordinary course limit the range, would have greater effects on the species than upon others which were in the progressive stage of activity or had reached the maximum.

Lake Salmon.

One of the finest of our fresh water fishes—the lake salmon—occurs in the Lower Rideau Lake, and is the attraction every summer to many American as well as Canadian sportsmen. It is a deep water fish confined here to this lake more probably because it is the largest lake of the Rideau system and the only one which has a general depth exceeding 100 feet, than because its waters are clearer than those of others of the system. The lake salmon is caught by trolling with the live minnow at depths of 100 to 150 feet, and, like its nobler friend from the salt water, it affords to the sportsman exciting play for considerable time before it permits itself to be taken.

Care will have to be observed that this valuable fish is not exterminated in this lake. As railways render the locality more accessible, the beautiful scenery must attract tourists and sportsmen in increasing numbers and lead to extinction of the fish unless the lake continues to be periodically restocked with the fry, and fishing is permitted under stringent regulations which are not only made but are also properly enforced.

OBITUARY.

GEORGE HUNTINGDON WILLIAMS.

George Huntingdon Williams died at Utica, N.Y., on the 12th of July, at the age of 38. He was born at Utica, and graduated from the Utica Free Academy, entered Amherst College in 1874 and took his first degree with the class of 1878. While in college he caught his enthusiasm for geology from his teacher, Professor B. K. Emerson, and spent a year in graduate studies at Amherst.

He then went to Göttingen where he perfected his knowledge of German and studied for several semesters under Professor Klein. Leaving Göttingen he proceeded to Heidelberg where he continued his studies in minerology and petrography with Professor Rosenbusch, taking his Ph.D. degree—*summa cum Laude*—in 1882.

The following year he became a Fellow in the Johns Hopkins University, where he was subsequently appointed Associate, and in 1885 Professor of Inorganic Geology, which position he held at the time of his death.

Petrography and crystallography were the special departments of geology which he cultivated, and his text-book on crystallography is a lucid exposition of the methods of research in this line. At the time of his death he was at work on a treatise on the microscopic structure of American crystalline rocks. He was one of the best authorities on these subjects in America, and served as oneof thejudges of award in the department of minerology at the Columbian Exposition. His untiring devotion last summer at Chicago to the duties thus put on him, it is feared may have laid the foundation of the disease which overcame his otherwise vigourous constitution.

Professor Williams was an attractive teacher and had a peculiarly charming manner in both private conversation and public address, and the animated and clear descriptions he gave of even the most technical subjects went far to interest his hearers in any topic he chose to speak upon. His broad education, attractive personal qualities and thorough acquaintance with the facts of his science gave him a prominent place among his fellows, and although still a young man he was rapidly rising to honour and fame. His loss will be keenly felt by all who knew him, especially by those who had the rare privilege of belonging to the circle of his intimate friends.

Proceedings of the Society.

Montreal, Oct. 29th, 1894.

The first monthly meeting of the Society was held this evening, Dr. Wesley Mills, President, in the chair.

The minutes of the annual meeting were read and approved.

Minutes of Council meetings of May 28th, Oct. 15th and Oct. 22nd were read.

The following donations were reported:—Birch bark war canoe, donor, C.P.R., per J. Stevenson Brown; specimens of iron ores and pig iron from G. J. Drummond, also fossils from Radnor Forges, Quebec, from the Canada Iron Furnace Company; fossils from Low Bay, N.S., from J. G. Grenfell, of the Deep Sea Mission; two living snakes, the red-bellied (*Stoveria occipitamaculata*) and the garter (*Entaenia sirtalis*) from J. B. Williams; six specimens of snakes in alcohol, from Trinidad, from G. H. Fisher, per Alfred Griffin; fossil bone and geological specimens from R. Felch; Gar Pike (*Lepidostens osseus*) from James Wilson, Beauharnois, per W. Henderson; Pine Grosbeak (*Pinibola Canadensis,*) shot at the Back River, from Alfred Griffin; Barred Owl (*Syninum melulosume*) and short eared owl, (*Brachyolus lassinii*) from David Denne; sandstone from Barbadoes and infusorial earth, Fahleigh Lake, U.S., from D. Bryce Scott, per J. B. Williams; large section of elm 175 years old, containing an iron gate staple imbedded therein, from R. Elliott; a piece of the first cotton made in Canada, from the Hon. J. K. Ward.

On motion of E. T. Chambers, seconded by the Rev. Dr. Campbell, the hearty thanks of the Society were tendered to the several donors.

The Librarian reported the receipt of a large number of the usual exchanges, among them the report of the Smithsonian Institution and the Bulletins of the United States Geological Survey, also "Amphioxus and the Ancestry of the Vertebrates," and "From the Greeks to Darwin," from Messrs. MacMillan & Co., and "Bird Nesting," from E. D. Wintle.

On motion by J. S. Shearer, seconded by James Gardner, the rules were suspended, and the secretary empowered to cast one ballot for the election of the following members. Carried.

F. A. Scroggie proposed by N. C. McLachlan, and George Kearley proposed E. T. Chambers, seconded by Dr. F. D. Adams.

It was moved by J. S. Shearer, seconded by Walter Drake, that the Society accept the recommendation of the Council to hold a Conversazione. Carried.

Moved by George Sumner, seconded by the Rev. Dr. Campbell, that Dr. Mills, Justice Wurtele and Dr. Stirling be appointed a committee to wait upon His Excellency the Governor-General with the view of ascertaining whether he can be present.

Sir William Dawson then read his paper on "Bivalve Shells found in the Coal Formation, and what they tell us of the Origin of Coal."

On motion of Dr. Smyth, seconded by George Kearley, the thanks of the society were tendered to Sir William Dawson for his interesting paper.

Dr. F. D. Adams then read a paper on "The Effects of Great Pressure on Certain Rocks."

It was moved by Dr. Campbell, seconded by E. T. Chambers, that the thanks of the society be also extended to Dr. Adams for his valuable communication.

MONTREAL, Nov. 26th, 1894.

The second monthly meeting of the Society was held this evening, Dr. Wesley Mills, President, in the chair.

The minutes of last meeting were read and approved.

Minutes of Council of Nov. 19th, were read.

The librarian reported that "The Canadian Ice Age" and "Life of Peter Redpath, Esq.," by Sir William Dawson, had been presented by the author to the library. It was moved by Mr. Chambers, seconded by Mr. Edgar Judge, that the thanks of the Society be tendered to Sir William Dawson.

Mr. G. Dunlop, proposed as an associate member Mr. E. Wintle, seconded by G. Sumner, was elected by acclamation, the rules regarding ballot having been suspended.

The president reported progress with reference to the Conversazione.

Prof. D. McEachran then presented a paper on "The Mechanism of the Horse's Foot and its Management from a Humane Standpoint." It was moved by P. S. Ross, seconded by J. A. W. Beaudry, that the thanks of the Society be given to Dr. McEachran for his interesting paper. Carried.

Dr. Wesley Mills then read a paper on the "Psychic Development of Young Animals and its Physical Correlation."

Moved by R. W. McLachlan, seconded by E. J. Chambers, that the thanks of the Society be tendered to Dr. Mills for his highly instructive communication.

Book Review.

On the Cambrian Formation of the Eastern Salt Range of India.—By Dr. Fritz Nœtling, of the Geological Survey of India. Records of the Geol. Surv. India, vol. xxvii., Part 3, pp. 71-86, August, 1894.

From researches made in the palæozoic rocks of the Eastern Salt Range of India by the Geological Survey of that country, Dr. R. D. Oldham has gathered [1] together most of the evidence obtainable regarding the succession of Cambrian strata in this region. Lists of fossils accompany the description of these lower palæozoic rocks, and include such genera as *Olenellus*, *Hyolithes*, *Conocephalites*, and *Neobolus*. Yet, the natural succession or proper interpretation of the relations of the older palæozoic zones had not been determined. In this paper, Dr. Nœtling gives a resumé of the result of his recent explorations and researches in the Salt Range. He separates the upper and middle portion of the palæozoic from the lower and Cambrian proper.

An historical sketch of the work done by Mr. Wynne, by the late Dr. Stoliczka, by Dr. Waagen of Vienna, Dr. Wartte, Mr. Middlemiss and Mr. Datta, he states that the Cambrian of the Salt Range of India is divisible into four groups, in descending order, as follows :—

4. Bhaganwalla group, or Salt Range pseudomorph zone.
3. Jutana group, or magnesian sandstone.
2. Khussak group, or Neobolus beds.
1. Khewra group, or Purple sandstone.

We note here that Dr. Nœtling has found "that at the top of the Khussak formation a fauna occurs, which is most likely the equivalent of the Olenellus of other countries, while for those fauna below it, no representative can be found in the Cambrian of other countries." [2] The Khussak group is itself sub-divided as follows in descending order:—

V. *Olenellus* zone.
IV. *Neobolus Warthei* zone.
III. Upper Annelid sandstone.
II. Zone of *Hyolithes Wynnei*.
I. Lower Annelid sandstone.

In the next higher group, the "Jutana group," Dr. Nœtling has found the following succession in descending order :—

X. Upper magnesian sandstone.
IX. Upper passage beds.
VIII. Middle magnesian sandstone.

[1] Manual of the Geology of India, Calcutta, 1893, Chap. V., p. 113 *et seq*.
[2] *Loc. cit*, p. 79.

VII. Lower passage beds.

VI. Lower magnesian sandstone.

In the lower magnesian sandstone Dr. Nœtling obtained a species of *Stenotheca*, which he correlates with but little doubt with Billings' species; *Stenotheca rugosa, var. aspera*—and an obscure *Lingulella*. The fossil remains collected during the exploration have been sent to Dr. Waagen for determination, and we are all anxious to hear what forms occur in the *pre-Olenellus* zones of India. One thing is evident, viz.: that there seems to be no new division or system to be created below the Cambrian in which to include the primordial or oldest fossiliferous strata.

H. M. AMI.

ABSTRACT FOR THE MONTH OF NOVEMBER, 1894.

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 pressure of vapour.	‡ Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles perhour	SKY CLOUDED IN TENTHS Mean.	Max.	Min.	Per cent. of Possible Sunshine.	Rainfall in inches	Snowfall in inches.	Rain and snow melted.	DAY
1	46.87	50.5	43.2	7.3	29.8460	30.037	29.651	.386	.2413	75.5	39.5	S.W.	27.7	6.7	10	0	20	0 07	....	0.07	1
2	44.65	51.2	38.5	12.7	30.1358	30.269	29.884	.385	2155	74.5	36.2	S.W.	13.1	3.7	10	0	00	....	....	...	2
3	47.08	53.6	40 1	13.5	29.4968	29.752	29.387	.365	.2735	82 8	42.0	S.W.	27 9	8.3	10	0	07	0 87	...	0 87	3
SUNDAY.........4	.....	43.5	37.0	6.5	......	.....	... .	.	...	..		S.W.	16 4	....	....		1.00	....	....	..	4 ....SUNDAY
5	33.80	39.7	32.2	7.5	29.8443	29.875	29 814	061	1615	83 2	29.0	N.	20 1	10 0	10	10	00	....	0.5	0.05	5
6	31.53	35.4	28.0	7.4	29.7708	29.814	29.699	.115	.1657	93 2	29.8	N.W.	22.6	9 5	10	6	23	....	....	....	6
7	28.88	31.7	25.2	6.5	29.9647	30.046	29 912	.134	.1365	85.7	25.2	W.	16 5	6.7	10	0	21	...	..	....	7
8	28.63	31.6	25.6	6.0	30.1405	30.170	30 099	.071	.1353	85 7	24.8	N.	5.2	7.7	10	3	08	....	....	....	8
9	27.37	32 6	22 6	10.0	30.0617	30 144	29.934	.210	.1262	83 7	23.0	E.	6.0	6 8	10	0	00	....	0.2	0.02	9
10	31.87	33.8	28.5	5 3	29.7350	29.860	29.651	.209	.1673	93 2	30.2	S.E.	6.6	10.0	10	10	00	....	7.1	0 64	10
SUNDAY.... .. 11	. ...	33 7	24.3	9.4	.. ...	......	......	....	. .	.	....	W.	15.7	...	..	.	00	....	0.2	0.02	11 ....SUNDAY
12	21 73	27.5	17.5	10 0	30.1895	30 263	30 071	.192	.0963	83.3	17.5	W.	8 2	8 3	10	0	00	....	0.1	0 01	12
13	29.65	34.5	17.7	16.8	30 0977	30.256	29.963	.293	.1388	84.2	25.7	S.	9.6	9 0	10	4	16	...	0 2	0.02	13
14	34 47	37.4	32 0	5.4	29.7540	29.873	29.660	.207	.1765	88.8	31 3	S.	15.6	10.0	10	10	00	0.05		0.05	14
15	33.62	39.8	27 0	12.8	29.7645	29.885	29.633	.252	.1592	82.3	28 7	S.	20 2	9 8	10	9	00	.	0.4	0.04	15
16	43 05	49.8	34.8	15.0	29.7105	29.768	29 659	.109	2173	78.2	36 2	S W.	20 5	4 0	10	0	50	....	....	...	16
17	34 47	36.2	29.1	7.1	29.9745	30 129	29.822	.307	.1403	70.0	25.7	W.	18.7	4.8	10	0	16	Inap.	....	Inap.	17
SUNDAY 18	.....	34.5	22.5	12.0	....	....	......	...	...		....	W.	11.7	....	...	..	79	....	...		18 ....SUNDAY
19	20.45	36 1	6.6	29.5	30.0210	30.310	29 720	590	.0977	77.7	14.8	W.	22 4	4.8	10	0	60	....	0.7	0.07	19
20	16.38	24.8	6.4	18.4	30.4125	30.525	30.214	.311	.0697	75.0	09 8	S.W.	14 6	5.3	10	0	85	....		...	20
21	38.18	44 1	19.1	25.0	29 9987	30.094	29 920	.174	.1817	77.5	31.5	S.	17 8	10.0	10	10	10	....	....	....	21
22	32.53	39 0	25 6	13.4	30.2277	30.288	30 125	.163	.1343	73.2	24.8	S.W.	10.3	9.0	10	0	24	...	..	....	22
23	36.98	45.7	25.1	20 6	29.9567	30 099	29 755	.344	1847	82.0	32 0	S	19.5	9.7	10	0	13	0.48	...	0.48	23
24	32.37	36 4	28.2	8.2	29.9537	30.074	29.786	.288	.1477	80.7	27.0	W.	6.2	8.7	10	2	31	....	Inap.	Inap	24
SUNDAY. 25	.....	31.6	19 7	11.9	......	......	......	....	....	....	....	N.	19.5	....	.	..	26	....	0.1	0.01	25 .... SUNDAY
26	17.17	20.3	12.2	8.1	30.1563	30.350	29 771	.579	0765	80.8	12.5	S.	10 6	7.5	10	0	67	....	0.4	0.04	26
27	30.92	37.4	13.0	24.4	29.4783	29.611	29.387	.224	.1312	75.8	24 0	S.W.	21.5	7.8	10	0	19	. ..	1.1	0.11	27
28	16.98	31.0	14.0	17.0	30 1250	30.481	29.826	.655	.0662	70 5	09 3	W.	29 3	5.3	10	0	46		....	....	28
29	10.45	14.4	7.3	7.1	30.7160	30.763	30.615	.148	.0472	68 2	01.7	W.	14.7	1.7	10	0	90	....	...	..	29
30	15.93	21.5	8.1	13.4	30.4882	30.658	30.359	.299	.0712	78.2	10 5	N. E.	7.4	10.0	10	10	00	...	...	....	30
31																					31
....Means	30.23	35 98	23.70	12 27	30.0008	....	......	.272	.1446	80.15	24 72	S. 67⅔° W.	15.89	7 5		.	27.0	1.47	11.0	2.10	Sums ....
20 Years means for and including this month	32.32	38.76	26.39	12.38	30.0074	....	....	.263	.1552	79 39	....	......	....	7 4	..	.	¶29.3	2.27	12 8	3.60	20 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	1276	150	311	515	1619	3155	3665	731	
Duration in hrs	96	20	37	42	107	152	209	46	11
Mean velocity...	13 3	7.5	8.4	12.3	15.1	20 8	17 5	15.9	

Greatest mileage in one hour was 42 on the 3rd.
Greatest velocity in gusts 60 miles per hour, on the 3rd.

Resultant mileage, 6088.
Resultant direction, S. 67⅔° W.
Total mileage, 11462.

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

§ Observed.

† Pressure of vapour in inches of mercury

‡ Humidity relative, saturation being 100

¶ 13 years only.

The greatest heat was 53.6° on the 3rd; the greatest cold was 6.4° on the 20th, giving a range of temperature of 47.2 degrees.

Warmest day was the 3rd. Coldest day was the 29th Highest barometer reading was 30.763 on the 29th: lowest barometer was 29.387 on the 3rd and 26th giving a range of 1.376 inches. Maximum relative humidity was 99 on the 2nd. Minimum relative humidity was 53 on the 29th.

Rain fell on 5 days.

Snow fell on 12 days.

Rain or snow fell on 17 days.

Auroras were observed on 17th and 25th nights.

Hoar frost on 2 days.

Lunar halos on the 6th, 8th and 11th.

ABSTRACT FOR THE MONTH OF DECEMBER, 1894.

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 pressure of vapour.	‡ Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles perhour	SKY CLOUDED IN TENTHS Mean	Max.	Min.	Per cent. of Possible Sunshine.	Rainfall in inches	Snowfall in inches.	Rain and snow melted.	DAY
1	26.77	31.1	16.2	14.9	30.2442	30.315	30.197	.118	.1273	86 2	23.5	S.W.	9.0	10.0	10	10	00	....	Inap.	Inap.	1
SUNDAY. 2	.....	31.1	19 7	11.4	......	.....	.....	...	.....	...	..	N.	12 2	....	....		00	....	0.1	0 01	2 .... SUNDAY
3	19.27	30.9	10.0	20.9	30.1115	30.194	29.970	.224	0825	76.3	13.3	S.W.	17.9	6.8	10	0	84	....	0.6	0.06	3
4	31.47	33.8	26.8	7.0	29.9413	29.993	29.905	038	1587	89 3	28 8	S.W.	20 1	7.3	10	0	00	....	0.4	0.04	4
5	33.92	38.8	28.2	10.6	29.9360	30.019	29 843	.176	.1505	78.5	27.5	S.W.	14 5	9 2	10	5	29	...	....	....	5
6	32.93	38 8	25.0	13.8	29.9850	30.174	29.854	.320	.1358	71.5	24.8	S W.	19 0	2.0	10	0	71	....	....	....	6
7	20.72	28.3	17.0	11.3	30.2207	30.252	30.202	.050	.0888	80.2	15.7	N.	7.5	6.7	10	0	39	....	0.1	0.01	7
8	21.25	26.8	16.8	10.0	30.1150	30 191	30 015	.176	.0927	81.3	16.3	N.	22.2	9 0	10	4	00	....	0.1	0.01	8
SUNDAY.... ... 9	. ...	20.4	14 0	6.4	.. ...	.....	......	....	. ..	....	....	N.	20 8	...	...		00	....	7.5	0 75	9 ... .SUNDAY
10	12.20	17.5	9.9	7.6	30.3505	30.404	30 223	.181	0597	78.7	6 8	N.	17 9	3 3	10	0	83	....			10
11	25.40	35 2	10.4	24.8	30.3182	30.398	30.204	.194	.1165	81.2	20.7	S.E.	13.4	10 0	10	10	00	....	0.8	0.08	11
12	37 52	44.8	33.5	11 3	29 7742	30.029	29.457	.572	2053	91 0	35.0	S E.	22 5	10.0	10	10	00	0.55	....	0.55	12
13	32.33	44.2	26.0	18.2	29.6262	29.859	29.406	.453	.1502	81.0	27.3	W.	34 9	10.0	10	10	00	Inap.	...	Inap.	13
14	33.93	37.8	25 6	12.2	29 8460	29.864	29.821	.043	.1658	84.5	29.7	W.	25 9	9 2	10	7	00	...	Inap.	Inap	14
15	38.85	43.9	34.1	9.8	29.9092	30.011	29.856	.155	.1928	81 5	33 5	S.W.	22 2	1.5	7	0	60	....	...	...	15
SUNDAY 16	....	46.0	31.2	14.8	. .....	.....	......	...	.	.	...	S.	13 7	...	....		00	Inap.	....	Inap.	16 ....SUNDAY
17	36.53	48.3	23 8	24.5	29.9533	30.182	29.783	.399	.1727	77.0	29.8	W.	29 0	7.8	10	0	00	....	Inap.	Inap.	17
18	18.35	31.0	15.0	16.0	30.3015	30.357	30.252	.105	0722	72.0	11.0	W.	23.5	0 0	0	0	95	...			18
19	29.45	35.4	12.1	23.3	30 0827	30 164	30 041	.123	.1227	76 2	22.3	S.	13.7	9 3	10	6	04	....	Inap.	Inap.	19
20	35.30	39.5	31.2	8.3	30.2350	30.317	30.135	.182	.1673	81 3	30.0	S.	9 6	5.0	10	0	53	....	.	...	20
21	37.20	45 6	29.0	16.6	30.0817	30.294	29 789	.505	.1888	83.3	32.5	S.	10 7	7.2	10	0	44	Inap.	....	Inap.	21
22	27.30	45.6	14 6	31.0	30.1178	30.383	29.800	.583	.1265	79 5	21.8	N.W.	20 2	6 7	10	0	91	Inap.	...	Inap.	22
SUNDAY.. 23	.....	18.1	1 0	17.1	....	......	......	....	...		....	N.	7 3	....	..	.	97	....	..	....	23 .... SUNDAY
24	16.97	39 8	3 6	36.2	30.1660	30.471	29 807	.664	0895	84.5	13.3	S.W.	11.9	5.2	10	0	12	....	Inap.	Inap	24
25	20.25	34.3	2 9	31.4	29.8980	30.226	29.645	.581	.1225	81.2	15.5	W.	17 7	5.3	10	0	37	....	1.2	0.12	25
26	3.22	7.0	0 9	6.1	30 4710	30.535	30.330	.205	.0373	73 7	— 3 7	N.	10 4	3.3	10	0	93	..	....	....	26
27	2.03	8.0	— 3.6	11.6	29 9923	30.359	29.617	772	0432	90.0	— 0 2	N.	35.2	8.3	10	0	00	....	11.0	1.10	27
28	— 9.52	0.8	—13 2	14.0	30.1761	30.211	30 105	.106	.0227	83 0	—13 5	W.	10 2	0.5	3	0	89	..	....	....	28
29	— 7.95	— 3.5	—14.1	10.6	30 0722	30.177	29.940	.237	.0258	86.7	—11 2	W.	1 3	1.3	4	0	55	...	....	.	29
SUNDAY........30	.....	23.9	— 6.5	30.4	... .	.....	......		.	...	....	S	5 1	....	....		00	...	1.2	0 06	30 ....SUNDAY
31	15 03	22.8	11 0	11 8	30.1602	30.206	30.083	123	.0758	87.3	12 0	W.	1 0	9.3	10	7	17	....	Inap.	Inap.	31
....Means	22.72	30 51	14.58	15 93	30.0802	...	.....	.282	1144	81.4	17 8	S. 78⅔° W.	16.5	6 3		.	34	0.55	23.0	2.79	Sums ....
20 Years means for and including this month	18 78	25.99	11.50	14.49	30.0269	....	.....	289	.0983	82 2	....	....		7 0	..	.	§29.3	1.29	24 0	3 64	20 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	3023	97	37	574	1410	3791	2880	471	
Duration in hrs	163	14	7	41	97	204	152	30	36
Mean velocity...	18 55	6 93	5.28	14.00	14 54	18.58	18 95	15.70	

Greatest mileage in one hour was 49 on the 27th.
Greatest velocity in gusts 72 miles per hour on the 27th.

Resultant mileage, 5488.
Resultant direction, S. 78⅔° W.
Total mileage, 12283.

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

§ Observed.

† Pressure of vapour in inches of mercury

‡ Humidity relative, saturation being 100.

¶ 13 years only

The greatest heat was 48.: on the 17th; the greatest cold was —14.1° on the 29th, giving a range of temperature of 62.4 degrees.

Warmest day was the 15th. Coldest day was the 28th Highest barometer reading was 30.535 on the 26th: lowest barometer was 29.406 on the 13th, giving a range of 1.129 inches. Maximum relative humidity was 97.0 on the 24th. Minimum relative humidity was 54 on the 5th.

Rain fell on 5 days.
Snow fell on 16 days.
Rain or snow fell on 21 days.
Auroras were observed on 1 night.
Lunar halo on the 10th.

Meteorological Abstract for the Year 1894.

Observations made at McGill College Observatory, Montreal, Canada. — Height above sea level 187 ft. Latitude N. 45° 30′ 17″. Longitude 4^h 54^m 18·55^s W.

C. H. McLEOD, *Superintendent.*

Month.	Thermometer. Mean.	¶ Deviation from 20 years means.	Thermometer. Max.	Thermometer. Min.	Thermometer. Mean daily range.	* Barometer. Mean.	Barometer. Max.	Barometer. Min.	Barometer. Mean daily range.	†Mean pressure of vapour.	‡Mean relative humidity.	Mean dew point.	Wind. Resultant direction.	Wind. Mean velocity in miles per hour.	Sky clouded per cent.	Per cent. possible bright sunshine	Inches of rain.	Number of days on which rain fell.	Inches of snow.	Number of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain *and* snow fell.	No. of days on which rain *or* snow fell.	Month.
January	12.99	+ 1.21	41.2	— 12.7	19.72	30.1271	30.776	29.273	.362	.0766	85.6	9.6	S. 78° W.	17.2	54.	45.	0.90	7	19 2	15	2.81	2	20	January
February	12.65	— 2.78	38.7	— 19.5	16.88	30 1033	30.833	29.462	.2[illegible]9	.0740	81.8	8.1	S. 50° W.	17.8	55.	47.	0.12	1	9.1	11	1.03	1	11	February
March	31.59	+ 7.20	57.0	5.0	12.34	29.9939	30.4[illegible]9	29.396	.293	.1385	74.5	24.4	S. 49° W.	16.5	59.	46.	1.45	11	7.4	9	2.19	3	17	March
April	44 89	+ 4.95	69 5	15.0	18.52	30.0177	30 386	29.623	.183	.1840	58.6	30.1	N [illegible]6° W.	16 2	53.	55.	0.59	8	1.2	1	0.71	1	8	April
May	56.04	+ 1.62	79.0	37.7	18.01	29.9135	30 372	29.436	.197	.3030	67.0	44.2	S. 50° W.	14.7	62.	51.	3.73	17	...	..	3.73	..	17	May
June	65.83	+ 1.03	85.2	44.8	17.16	29.8805	30.213	29.377	.113	.4991	76.2	57.5	S. 6[illegible]° W.	14 4	58.	30.	4.02	17	....	..	4.02	..	17	June
July	68.73	— 0.09	89.8	5[illegible].0	17.82	29 9214	30.292	29.587	.134	.513[illegible]	73.2	59.2	S. 58° W.	13.0	53.	56.	2.82	19	...	..	2.82	..	19	July
August	62.82	— 3.93	80.6	44.8	16.86	29.9591	30.213	29.666	.129	.4146	71.7	53 0	S. 63° W.	13 7	57.	47.	1.80	16	....	..	1.80	.	16	August
September	59.65	+ 1.13	78.5	35.0	16 22	30.0608	30.626	29.5[illegible]2	.192	.4141	79.6	52.9	S. 31° W.	12 7	54.	34.	2.73	14	...	.	2.73	.	14	September
October	48.62	+ 3.06	65.5	31.1	13.07	29.8942	30.299	29.174	.256	.2801	80.7	42.6	S. 62° W.	11.8	70.	21.	4.03	22	In p.	2	4.03	1	23	October
November	30.23	— 2.09	53.6	6.4	12 27	30.0008	30.763	29.387	.[illegible]72	.1446	80.1	24.7	S. 68° W.	15 9	75.	27.	1.47	5	11.0	12	2.10	..	17	November
December	22.72	+ 3.94	48.3	14.1	15.93	30.0802	30.535	29 406	.282	.1141	81.4	17.8	S. 79° W.	16.5	63.	34.	0.55	5	23.0	16	2.79	..	21	December
Sums for 1894	....	...	....	....	....		....	....	....	....		....		....	....	....	24.21	142	70 9	66	30.76	8	200	Sums for 1894
Means for 1894	43.06	+ 1.27	....	....	16 24	29.9960	....	....	.226	.2630	75.9	35.3	S. 62° W.	15 01	59.4	41.1	....	....	....	..	2.57	..	17	Means for 1894
Means for 20 years ending Dec. 31, 1894.	41.79	....	...	....	...	29.9790	....	....	....	.2507	74.5	....	....	*a* 15.18	67.2	§ 45 4	17.98	133	120 0	81	39.67	16	200	Means for 20 years ending Dec. 31, 1894.

* Barometer readings reduced to 32° Fah. and to sea level. † Inches of mercury. ‡ Saturation 100. § For 13 years only. ¶ "+" indicates that the temperature has been *higher*: "—" that it has been *lower* than the average for 20 years inclusive of 1894. The monthly means are derived from readings taken every 4th hour. beginning with 3 h. 0 m. Eastern Standard time. The anemometer and wind vane are on the summit of Mount Royal, 57 feet above the ground and 810 feet above the sea level. *a* For 8 years only.

The greatest heat was 89.8 on July 2: the greatest cold was 19.5 below zero on February 10. The extreme range of temperature was therefore 109.3. Greatest range of the thermometer in one day was 39 5 on Januuary 25; least range was 5 2 on March 22. The warmest day was July 28, when the mean temperature was 80.18. The coldest day was February 24. when the mean temperature was 12.58 below zero. The highest barometer reading was 30.833 on February 24, Lowest barometer reading was 29.174 on October 17, giving a range of 1.659 for the year. The lowest relative humidity was 17 on April 14. The greatest mileage of wind recorded in one hour was 69 on January 30, and the greatest velocity in gusts was at the rate of 84 m. p. h. on January 30. The total mileage of wind was 131,482. The resultant direction of the wind for the year is S.62° W., and the resultant mileage was 50,870. Auroras were observed on 19 nights. Fogs on 14 days, Thunder storms on 20 days. Lightning without thunder on 7 days. Lunar halos or coronas on 14 nights. The sleighing of the winter closed in the city on March 25. The first appreciable snowfall of the autumn was on November 5. The first permanent sleighing of the winter was on December 27.

NOTE.—The yearly means of the above, are the averages of the monthly means, except for the velocity of the wind.