Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- [ ] Coloured covers/ Couverture de couleur
- [ ] Covers damaged/ Couverture endommagée
- [ ] Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- [ ] Cover title missing/ Le titre de couverture manque
- [ ] Coloured maps/ Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- [x] Bound with other material/ Relié avec d'autres documents
- [x] Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure
- [ ] Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.

- [ ] Coloured pages/ Pages de couleur
- [ ] Pages damaged/ Pages endommagées
- [ ] Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached/ Pages détachées
- [x] Showthrough/ Transparence
- [ ] Quality of print varies/ Qualité inégale de l'impression
- [x] Continuous pagination/ Pagination continue
- [ ] Includes index(es)/ Comprend un (des) index

Title on header taken from:/ Le titre de l'en-tête provient:

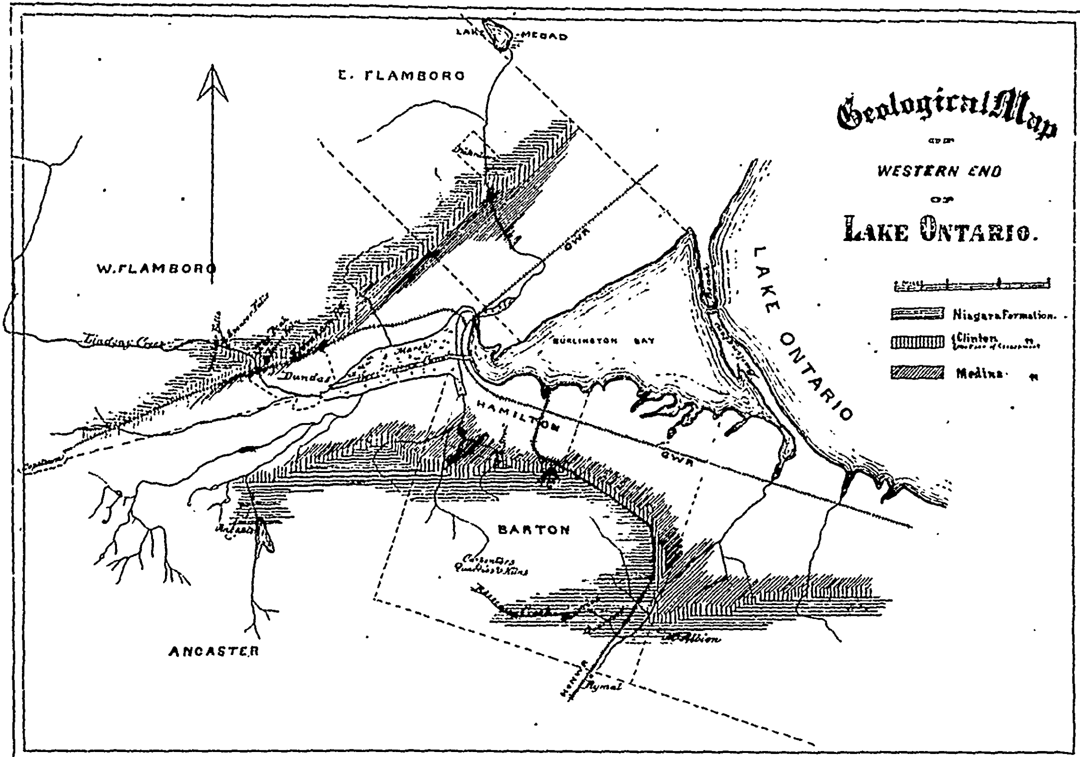
- [ ] Title page of issue/ Page de titre de la livraison
- [ ] Caption of issue/ Titre de départ de la livraison
- [ ] Masthead/ Générique (périodiques) de la livraison

- [ ] Additional comments:/ Commentaires supplémentaires:

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

| 10X | | 12X | 14X | | 16X | 18X | | 20X | 22X | | 24X | 26X | | 28X | 30X | | 32X |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | |

Ratio checked: between 22X and 24X (√)



Geological Map
of
WESTERN END
of
LAKE ONTARIO.
Niagara Formation.
Clinton
Medina
LAKE ONTARIO
BURLINGTON BAY
E. FLAMBORO
W. FLAMBORO
HAMILTON
BARTON
ANCASTER
LAKE MEDAD
GWR
Dundas
Binkley Creek
Albion
Rymal

THE

# CANADIAN NATURALIST

AND

# Quarterly Journal of Science.

## PALÆOZOIC GEOLOGY OF THE REGION ABOUT THE WESTERN END OF LAKE ONTARIO.

By Prof. J. W. Spencer, B.A.Sc., Ph.D., F.G.S.,

Vice-President of King's College, Windsor, Nova Scotia.

Preface.—In 1874, I published, in this Journal, a short paper on the "Geology of the Neighbourhood of Hamilton." Subsequently (1877-80), I made an additional study of the region, and found an immense amount of geological information obtainable. This paper on the Palæozoic Geology was ready for print in the autumn of 1879, but its publication was delayed in order to complete the work; but as the completion seems some distance off, I present this paper on the first portion of the subject of the Geology about the Region of the Western End of Lake Ontario. A very large amount of new material in Palæontology has been collected and is now ready for press.

Although the principal facts of the Surface Geology have been collected, yet the study is not yet completed, it being very large, as more than local phenomena are involved.

### I.—Introduction.

Skirting the Western End of Lake Ontario, in our Canadian Province of the same name, there are excellent exposures of the various portions of the Silurian formations (or Upper Silurian of the New York Geologists) overlying, to a depth of several hundred feet, the upper members of the Cambro-Silurian Age (of the Hudson River epoch) about the city of Hamilton, whilst between Oakville and Toronto, the rocks of the latter age appear at the surface of the country.

Those members of the Silurian formation which are exposed in the region under consideration belong to the Medina, Clinton, and Niagara epochs. The best localities for making geological examinations are at Thorold, Grimsby, Hamilton, Dundas, Limehouse Station (G.T.R.) and Rockwood. Nowhere in Eastern America are there better exposures of the various rocks of this age, though in some localities, especially in the Western States, the fossils are in a better state of preservation. However, in the above localities there is a very great difference in the preservation of the fossils found, and nearly 200 species of organisms can be procured from a limited number of localities. A considerable variation of texture is observed in the rocks in the different places, and although the number of species of animal remains is considerable, yet owing to the crystalline texture of the limestones, one is rewarded with meagre returns for his day's labor.

As we will see further on, the rocks under consideration are intermediate in character between those of the State of New York to the eastward, and those of Ohio to the westward, being more calcareous than their equivalents in the former State, and more argillaceous than those in the latter.

In the study of the various rocks of the Niagara group, I have examined the microscopical structure, and have made a number of chemical analyses. At the end of the present paper there will be found a catalogue of all the species of fossils in my own collection, with some few that have been obtained by others, but of which I have not been fortunate enough to obtain specimens. This will be found to be the fullest catalogue of Canadian fossils from the Niagara group yet published.

Again, a few minerals are procurable at various localities from cavities in the Niagara limestones, as well as mineral waters from several natural springs and artificial openings, all of which will be noticed in their proper places.

As no part of the Province affords a greater variety of interest to the student of geology than the region about the western end of Lake Ontario, I will endeavour to give a full but concise account of those features and objects of attraction that will assist the geological observer and student in the pursuit of this most attractive and useful study of Nature.

## II.—TOPOGRAPHY AND DISTRIBUTION.

Extending along the southern shores of Lake Ontario, at distances varying from one to a few miles from its waters, there is a ridge of hills, or more properly an escarpment, known to geologists as the "Niagara Escarpment," extending from the State of New York into Canada, and entering our country near Queenston, whence the *cañon* of the Niagara Falls has worked backward for several miles. From the Niagara River this ridge extends westward to the town of Dundas, and thence the trend is a little west of north to Lake Huron and Manitoulin Islands.

This range everywhere forms a bold feature. Along the southern shore of Lake Ontario, the brow is 400 feet above the lake, while near the "Peak," north of Dundas, the height is 520 feet, from which place the ascent is gradual as it extends northward, until just west of Limehouse, the cliffs have a height of 847 feet, whence the plateau gradually rises to 936 feet at Rockwood (on the G. T. Railway), and northward, in Amaranth township, it has an elevation of 1400 feet above Lake Ontario. In its course, south of Lake Ontario, the slope is generally more abrupt than after the range assumes a northerly trend,—the upper portion often forming almost perpendicular cliffs from 100 to 250 feet above the rising slope at its base. The brow where the H. & N. W. Railway ascends the mountain (four miles east of Hamilton) is 395 feet, and at the head of James street, Hamilton, it is 388 feet above the lake, while the plateau above gradually rises to 493 feet, five and a half miles south of the former place, and to 485 feet, two miles south of the latter. This height of land forms the watershed between Lakes Ontario and Erie, and from it the country gradually slopes to the latter lake.

The rocks of this range belong to the various subdivisions of the Niagara Group of the Silurian Age. The Canadian Geological Survey, many years ago, separated the Niagara and Guelph groups from the overlying Lower Helderberg group, and called these Middle Silurian, whilst the New York geologists placed them all together, and called them Upper Silurian. We will adopt that nomenclature which recognises the rocks of the various groups from the Niagara to the Lower Helderberg (inclusive), as being members, not of the middle or upper, but of the one great Silurian Age, and consider the Lower Silurian formations (Trenton and Hudson River groups of America) of the New York Geological Survey, under the name Cambro-Silurian—a name given by one of the fathers of English Geology (Professor Sedgwick) before Sir R. Murchison included their Welsh equivalents as the lower portion of his "Silurian System," as the character of the organic remains is intermediate between *Sedgwick's Cambrian* and *Murchison's Original Silurian Systems.*

In the State of New York the Niagara group is divided in ascending order into the ONEIDA, MEDINA, CLINTON and NIAGARA EPOCHS, and overlies the Hudson River formation.

The Oneida of New York consists of a conglomerate, and is wanting in Canada, but all the other members of the series are present in the Province. At the head of Lake Ontario, the Medina is underlaid by the rocks of the Hudson River epoch; and the rocks of the Niagara period form the surface deposits adjacent to the lake region, while twenty miles to the westward, they are overlaid in the neighbourhood of the towns of Galt and Guelph by the deposits of the Guelph formation.

In the Niagara Peninsula, south of Hamilton, the Niagara formation is succeeded by some of the members of the Helderberg group, unless there be some thin concealed deposits of the Guelph group not exposed.

The general dip of the whole series is 25.5 feet in the mile in a direction of about twenty degrees west of south.

## III.—GEOLOGICAL SECTIONS.

During the summer of 1879, the writer, with the assistance of the late George Beasley, Esq., C. E., made instrumental measurements of four Geological Sections—the most complete that could be obtained. Two of these sections were at Dundas, one at Hamilton, and one south-east of the city, from the watershed between Lake Ontario and Lake Erie, along the exposures of the Niagara Limestones in the bed of the Rosseaux Creek, to its falls at Mount Albion. These measurements required several days' levelling over many miles of ground. In addition to the principal sections, several smaller exposures were measured in order to compare the continuity of various strata.

The thickness and character of the lowest portions of the Medina formation were ascertained from the log of an Artesian well, sunk to a depth of 1600 feet, in the western part of Dundas.

Mr. Beasley and myself connected the thickness between the adjacent summit of the Medina group, which is 264 feet above the lake, by levelling (and allowing for dip) with the mouth of the well of which we had the record, and were thus enabled to calculate accurately the thickness of the formation.

Before advancing further we will give a tabular view of the four sections measured.

The first section is at the western end of Dundas, (near the place where the Artesian well was sunk.) The height of the mouth of the well was found to be 139 feet above Desjardin's Canal. Afterwards we levelled to the summit of the cliffs along the south-western side of the ravine, which is formed by the union of the two streams from Spencer's and Webster's Falls—the highest point of the exposed rocks being at the junction of the two glens, where the top beds are composed of the cherty bands of the same horizon as those which form the capping strata south of Hamilton. By means of this section and the Artesian well, we were able to ascertain the whole thickness of the Medina formation, the whole thickness of the Clinton formation, and the lower portion of the Niagara proper.

But the western side of the ravine is more than one hundred feet lower than the eastern side, although the rocks are nearly horizontal. This has been owing to the local denudation in the spur of rocks between two great valleys, which will be noticed in a future paper on the surface geology.

The ravine or *cañon* just referred to is more than 300 feet deep, if we calculate from its eastern (or rather north-eastern) side. Owing to the absence of the higher beds of the series, we levelled up the escarpment on the opposite side of the great glen, at the Limekilns, just east of the "Peak," where the highest rocks are 516 feet above the lake, although the soil rises a few feet higher a short distance to the northward.

By these measurements, and the necessary calculations in correlating the adjacent measurements, it was found that the whole thickness of the Niagara group is 800 feet at Dundas, of which the lowest 545 feet belong to the Medina series.

The second section is along the Sydenham road at Dundas. The third section is at Hamilton, between the head of James street and the Jolly Cut road. The fourth section, as we have seen, was taken along the Rosseaux Creek to Albion Falls.

SECTION I. (at Dundas).

In descending order: Beds 20-14 were measured above Limekiln. Beds 13-2, measured at the south-western side of Glen Spencer, are correlated with those above. Series of beds numbered 1 is at Artesian Well.

---

| *Beds. No.* | NIAGARA FORMATION. | *Thickness. Feet.* | |
|---|---|---|---|
| 20 | Fine grained gray arenaceous dolomite. Top bed glaciated. (Height above Lake Ontario 517 ft.) .. | 10.6 | |
| 19 | Dark dolomites (somewhat bituminous) containing concretionary masses of a brecciated appearance.. | 9.7 | |
| 18 | Measures concealed........................ | 10.2 | |
| 17 | Gray and drab dolomites in thin beds—the upper portion forming brow of escarpment just east of "Peak."........................ | 28.3 | |
| 16 | Earthy dolomites with conchoidal fracture......... | 3.2 | |
| 15 | Dolomitic shales covered with incrustations of epsomite........................ | 3.5 | |
| 14 | Gray and variegated dolomites in thin beds with earthy partings........................ | 38.4 | |
| | | —— | 103.9 |
| 13 | Cherty dolomites (?) concealed, by measurement 3.1 feet, but allowing for dip, 3.0 feet must be added, and this connects the section at the Limekiln with that measured at western side of Ravine from Webster's to Spencer's Falls.................... | 6.1 | |
| 12 | Gray dolomites with numerous cherty nodules, this forms the brow of cliff at junction of Ravines from Spencer's and Webster's Falls.................. | 12.0 | |
| 11 | Shaly dolomites, with shaly partings.............. | 2.0 | |
| 10 | Compact dark gray dolomites, more or less argillo-arenaceous, in beds from two to two and a half feet thick........................ | 16.9 | |
| 9 | Dolomitic blue shales, with shaly dolomites........ | 13.1 | |
| 8 | Compact light gray dolomite in one bed. This bed is constant for many miles, and it was from this that the dip was calculated, and checked in by other beds........................ | 5.3 | |
| 7 | Niagara dolomites, covered here, but exposed elsewhere........................ | 10.0 | |
| | | —— | 65.4 |

---

CLINTON FORMATION.

| | | | |
|---|---|---|---|
| 6 | Clinton bluish shales, with numerous thin beds of argillaceous dolomites, some of which are also very ferruginous, others are more arenaceous. Many contain fossils. Portions of the series are covered, but, being exposed in numerous places, show the character of the whole formation just described... | 77.5 | |
| 5 | Argillo-arenaceous dolomites, which may be considered as beds of passage to the Medina beneath. | 8.2 | |
| | | —— | 85.7 |

MEDINA FORMATION.

| Beds. No. | | Thickness. Feet. | |
|---|---|---|---|
| 4 | Bluish sandstones in two beds, splitting in slabs.... | 2.7 | |
| 3 | Coarse sandstone—the GRAY BAND—varying much in thickness. This is separated from the beds above by shaly parting.... .... ........... ........... | 7.3 | |
| 2 | Medina shales — green, red, or variegated — partly covered here, but various portions exposed in many places.......... ...... ..................... ........ | 141.0 | |
| 1 | Red, green, and variegated shales (measured in Artesian Well)......................................... | 394.0 | |
| | | —— | 545.0 |
| | Total thickness................ | | 800.0 |

SECTION II. (at Dundas).

This section was measured partly along the Sydenham road, and partly in the glen just west of it. The measurements are in descending order, and the numbers of the beds refer to the equivalent beds in Section I.

NIAGARA FORMATION.

| | | | |
|---|---|---|---|
| 13 & 12 | Cherty dolomites, forming brow of escarpment along Sydenham road. The upper portion in the section represented at the "Peak," by more than 100 feet, being removed by denudation for some distance back of the brow.... ........................ | 19.0 | |
| 11 | Dolomitic shales ............ .................. | 0.8 | |
| 10 | Compact gray dolomite, more or less argillo-arenaceous, in beds from 2 to 2.5 feet thick............. | 14.0 | |
| 9 *b* | Shaly dolomites .............................. | 4.5 | |
| 9 *a* | Dolomitic shales ........................ ......... | 6.0 | |
| 8 | Compact gray dolomite in one bed, highly crystalline, with cavities filled with minerals........... | 5.5 | |
| 7 | Gray dolomite, more or less argillaceous........... | 10.0 | |
| | | —— | 59.8 |

CLINTON FORMATION.

| | | | |
|---|---|---|---|
| 6 & 5 | Clinton shales, with thin beds of areno-argillaceous dolomites, sometimes ferruginous, some of the beds are fossiliferous. About 20 feet from the top there is a bed of red ferruginous, calcareo-arenaceous sandstone, rich in casts of fossils ................ | 85.7 | |
| | | —— | 85.7 |

MEDINA FORMATION.

| | | | |
|---|---|---|---|
| 4 | Bluish sandstone splitting into thin slabs.......... | 2.1 | |
| | Shaly parting.................................. | 0.8 | |
| 3 | Coarse gray sandstone—the "Gray Band"—varying in thickness from 6.7 to 9 feet.................. | 8.1 | |
| | See below, | | |
| 2&1 | Medina variegated shales (as calculated).......... | 535.0 | |
| | | —— | 546.0 |
| | Total thickness................ | | 691.5 |

SECTION III. (at Hamilton).

This section was measured along the brow of the escarpment at the city of Hamilton, between the ravine at the head of James street and the "Jolly Cut" road, about half a mile to the eastward. The section is in descending order. The numbering of the beds connects the section with the corresponding beds at Dundas. (See note in Appendix.)

| *Beds. No.* | NIAGARA FORMATION. | *Thickness. Feet.* | |
|---|---|---|---|
| 12 | Thin gray dolomites, with an abundance of cherty nodules. This bed is known as the "Chert Bed," and forms the brow of the escarpment at Hamilton and eastward, being 388 feet above lake at head of James street. At head of Queen street this series is 19 feet thick ........................................ | 12.0 | |
| 11 & 10 | Argillaceous dolomites, with shaly partings—upper portion known as the "Blue Building Beds." Beds 0.5–1 foot thick. (See analysis and fossils.)...... | 15.5 | |
| 9 | Dark hard dolomitic shales and dolomites weathering to gray—and lower beds most shaly. (See analysis.) | 10.5 | |
| 8 | Thick bed gray crystalline dolomite (nearly pure)... | 4.5 | |
| 7 | Argillo-arenaceous dolomite in beds from 1–1.5 feet thick. (See analysis)...................................... | 8.8 | |
| | | —— | 51.3 |
| | CLINTON FORMATION. | | |
| 6b | Earthy dolomite, with shaly partings................ | 8.0 | |
| 6a | Clinton shales, all dolomitic, with thin beds of harder rock, some of which are arenaceous, and others to a thickness of about 7 feet, are areno-ferruginous. The upper 9 feet may be considered as passage beds | 76.9 | |
| 5 | Passage beds of argillaceous dolomites. (Top projecting portion is glaciated, and is 254 feet above lake) | 8.8 | |
| | | —— | 93.7 |
| | MEDINA FORMATION. | | |
| 4 & 3 | Coarse gray sandstone—"Gray Band." This bed varies in thickness.................................... | 6.5 | |
| 2 & 1 | Medina variegated red and green shales. Thickness from calculation of Dundas Artesian Well........ | 538.5 | |
| | | —— | 545.0 |
| | Total thickness ............... | | 690.0 |

SECTION IV. (along Rosseaux Creek).

This section along Rosseaux Creek, extends from Albion Falls (in Barton Township) to Carpenter's Limekilns, on the Hamilton and Caledonia road. This line follows nearly the strike of the formation. The section is in descending order. The numbering of the beds refers to the corresponding strata at Hamilton and Dundas.

Only the Niagara Formation is represented.

| Beds. No. | | Thickness. Feet. | |
|---|---|---|---|
| | Dark gray bituminous dolomites at Carpenter's Limekiln, R. VI, lot 15, Barton. The top bed is two feet thick, with glaciated surface. This bed contains abundance of Stromatopora | 11.5 | |
| | Beds concealed | 42.7 | |
| | Grey bituminous dolomites (Range VII, lot 7, Barton) beds 0.25–1.0 foot thick, containing cavities filled with barite, calcite, selenite, fluorite, galenite, sphalerite, and other minerals in beautiful crystals, besides bituminuous matter | 15.1 | |
| | Covered beds | 5.7 | |
| | Earthy compact dolomite (Range VII, lot 5) | 6.2 | |
| | (The following is down the creek, R. VII, lots 4–1.) | | |
| | Fine grained dark dolomite, in one bed, with glaciated surface | 2.2 | |
| | Areno-argillaceous dolomites, in thin beds with shaly partings, 0.2–0.4 foot thick | 12.3 | |
| | Dark brown flags, areno-argillaceous, with films of dolomite | 1.3 | |
| | Shaly dolomite (with abundance of *Streptelasma*) | 2.5 | |
| | Blue arenaceous shales, hardened with crystalline particles of dolomite | 2.9 | |
| | Argillaceous dolomites | 3.2 | |
| | Blue and red shaly rock | 3.0 | |
| | Dolomitic flags (Avicula bed), dark brown arenaceous | 5.4 | |
| | Covered beds | 3.0 | |
| | Earthy dolomites, forming bed of creek | 7.5 | |
| | Covered beds | 3.7 | |
| | Thin gray dolomites (areno-argillaceous), forming brow of escarpment, just west of Falls | 4.0 | |
| | | | 132.2 |
| 11,12 & 13 | Cherty dolomites, at Albion Falls | 18.4 | |
| 10 | Argillaceous dolomites, in thin beds, with shaly partings | 22.6 | |
| 9 | Blue hard dolomitic shales, with beds of shaly dolomites | 12.0 | |
| 8 | Gray crystalline dolomite, in one bed | 4.9 | |
| 7 | Argillo-arenaceous dolomites, in thin beds | 7.7 | |
| | | | 65.6 |
| | Total thickness of Niagara beds | | 197.8 |

## IV.—THE MEDINA FORMATION.

In referring to the Geological Reports of the State of New York, we learn that the Medina formation rests on what is known as "Oneida Conglomerate," which in Oneida County has only a thickness of 25 feet, though elsewhere it is as much as 100 feet thick, while in the State of Pennsylvania it is developed to the extent of 700 feet. There appears to have been a gradual passage from the band of gray sandstone, terminating the Hudson River formation in Oneida and Oswego counties, to the overlying conglomerate, both of which deposits, however, are wanting in the western part of the State, and are entirely absent from the series in Canada, as indicated at a short distance east of Oakville, on the north-western side of Lake Ontario, where the upper beds belonging to the close of the Cambro-Silurian Age are seen to rest beneath those at the commencement of Medina epoch.

In tracing the Medina formation from Oswego County, N.Y., it is found to increase in thickness until it attains a development of several hundred feet in the western part of the State, and at Dundas, at the head of Lake Ontario, it is 545 feet thick. Again the group gradually dies out to the westward, and is only represented in the State of Ohio by ten or twenty feet of red and blue mottled shales.

Almost the whole series is made up of more or less calcareous shales, some of which are also arenaceous (and almost resemble thin flags of unpure sandstone). In color the shales are red, green, or variegated. The series is capped by a coarse sandstone, which is irregularly deposited and has a thickness in the region of Dundas and Hamilton, varying from seven to ten feet. It is known by the name of the "Gray Band," and is a characteristic stratum from the Niagara River to the Georgian Bay. Sometimes, however, it thins out to mere wedges, but the hollows occasioned by the sudden thinning process is filled up with earthy calcareous sandstones. This structure is well illustrated by a section in the glen just west of the Sydenham road, Dundas—the following section would not be represented longitudinally by more than thirty feet:

| | | |
|---|---|---|
| 2.1 feet | Bluish sandstone.............................. | 2.1 feet. |
| 0.8 " | Shaly partings.......... ................. | 0.8 " |
| 3.7 " | Thin shaly sandstones | 6.7 " |
| 4.0 " | Sandstone: The "Gray Band." | |
| 1.3 " | Sandstone..... ......................... | 0.9 " |

By this means it will be seen that the whole series does not materially alter in thickness, but that the undulations of the surface of the "Gray Band" resulted from unequal deposits of sand along the sea margins, and afterwards the inequalities were filled up by sediments of slightly different character. Sometimss the "Gray Band" shows ripple marks on its upper surface, while the more shaly partings have their surface characterised by wave action.

At Grimbsy, the lower portion of this band is of the usual gray color, but it passes into bright red sandstones irregularly deposited, and conspicuously mottled by large spots of a gray tint. At this locality the *Arthrophycus harlani* is very abundant, and though found in both the gray and red sandstones, it is more common in the former.

At Dundas the capping portion of the "Gray Band" consists of a bluish sandstone resembling quartzite, though this subdivision in the character of the beds is not noticeable at Hamilton.

All the thicker beds of Medina sandstone form excellent building material, though difficult to work on account of its compactness and toughness.

Along the *cañon* of the Niagara River more than 200 feet of the shales are exposed. So, also, there are excellent exposures in many of the gorges about the head of Lake Ontario. Perhaps the best section of the shales is to be obtained by following up the stream which flows into Burlington Bay after passing by the village of Waterdown. In the deep gorge of this stream the upper 250 feet of Medina shale is more or less exposed, though in some places covered by land-slides. The base of the Medina is exposed at a short distance east of Oakville.

At Dundas, an Artesian well was sunk a few years ago, and the following is the log of the boring, as published in the *Dundas Banner*:

| | | |
|---|---|---|
| Boulder Till | 26 | feet. |
| Blue Clay | 48 | " |
| Clay and Black Sand | 5 | " |
| Red Shales | 341 | " |
| Limestone and Grits | 550 | " |
| Total Depth | 1600 | " |

The record of the character of the lower portions of the boring was not given. The "limestone and grits" represent rocks of the Hudson River formation. The record also stated that at 290 feet from the surface there was a thin bed of sandstone with a flow of gas and water; at 300 feet there was a flow of water rising eight feet above the surface; at 970 feet there was a heavy flow of gas. This imperfect record is unfortunately all that remains of much money that was expended in seeking for a supply of water for the town. The secretary of the Well Company has since died, and the complete record is lost. However, it serves a purpose, and by connecting the levels of the mouth of the well (which is 139 feet above Lake Ontario) with the adjacent Medina beds, we are enabled to calculate the thickness of the whole formation.

Other wells have been sunk to a considerable depth, years ago, but unfortunately their logs are not in existence. One, at an oil refinery, east of Hamilton, was sunk into the Medina shales, or perhaps just through them, when a sufficient supply of water was obtained, but which was strongly alkaline (see analysis below). At 40 feet from the surface (about 275 from top of the Medina series) a thin bed of sandstone was found. Another thin bed of sandstone comes to an out-crop at Burlington, on the northern side of the bay of the same name. The beds found at these two places are probably of the same horizon although their continuity is broken by the cause which originated Burlington Bay.

There was another important well sunk to a depth of 1009 feet, at the Royal Hotel, Hamilton, but though some water was procured by me and then analysed, the record of the boring was lost in a burning building. The eastern part of Hamilton is situated almost directly on Medina clays; but the surface of these is covered to a considerable thickness in the western part of the city by drift, which partly fills a Pliocene valley. (See a future paper on Surface Geology.)

The character of the Medina shales is shown by the following chemical analysis. The specimen chosen was typical of the green indurated shales which on weathering become red. It was obtained from a freshly broken surface at an artifical ditch in Ainsley's Hollow, west of Hamilton.

| | |
|---|---|
| Silica | 50·2 |
| Alumina | 12·0 |
| Iron Protoxide | 1·5 |
| Lime | 17·7 |
| Magnesia | 5·8 |
| Carbon Dioxide | 11·6 |
| | 98·8 |

A portion of the lime and magnesia was present as silicates, some of which was decomposed by acids. In various analysis of the Medina shale, made by Dr. Sterry Hunt. less than one per cent. of fixed alkalis was found to be present. Under the microscope, these rocks exhibit small crystalline dolomitic particles scattered through the mass, sometimes uniformly, and sometimes in thin layers.

From the geological evidence adduced by the Ohio Geological Survey (as will be noticed under the Clinton formation), the Hudson River formation was raised up into a shore line before the deposition of the members of the Niagara group. In the State of New York the Medina seas laved the shores of the Shawangunk Mountains, whence the pebbles for the conglomerate of the lower portion of the series were derived. The western margin of the sea was bounded by the "Cincinnati Arch," which has been an upland since the close of the Cambro-Silurian Age. The arenaceous material of the Medina series was obtained largely from the adjacent highlands to the eastward, although a portion of the sediments that form the "Gray band" was probably derived from the denudation of the more siliceous portions of the Hudson River formation of the Canadian shores.

The shaly beds of the Hudson River series, and particularly those of the Utica formation of the Canadian highlands, formed an abundant source whence denudations could derive an ample supply of clay to produce the wide-spread off-shore deposit of Medina shales in the northern portion of the sea. The period was generally one of subsidence until its close, when the "Gray band" was deposited, to be followed by the Clinton shallow seas, which were to be filled up with impure limestones, alternating with muddy sediments brought down from the adjacent shores.

*Organic Remains.*—One or two fragments of obscure sea-weeds have been noticed by Col. Grant in the shales, otherwise they appear to be devoid of organisms.

The "Gray Band," however, contains a few poorly preserved casts of shells, besides several species of sea-weeds. The fossils are usually found crowded together on some portions of the surface of the sandstones, overlaid by more or less earthy partings, particularly at the junction with the overlying Clinton, or those beds that might perhaps be considered beds of passage.

The sea-weeds are the most common. *Arthrophycus harlani* is abundant at Grimsby. The branches of this organism is sometimes connected with lobed nodules, having the appearance of fruit pods; however, some palæontologists consider *Arthrophycus* as worm tracks, and, if this be the case, these lobed expansions are simply worm burrows at the end of the tracks.

A considerable number of undoubted worm tracks or Ichnites is also found. All the fossils consist of nothing more than casts in the sandstone.

The following meagre list of fossils has been obtained.

CATALOGUE OF MEDINA FOSSILS.

| *Genera and species.* | *Reference.* |
|---|---|
| *Arthrophycus harlani* ............. | Hall, 1852, Pal. N. Y., Vol. II. |
| *Locality*—Grimsby, Ont. | |
| " " Fruit (?)...... | |
| *Locality*—Grimsby. | |
| *Palæophycus* sp.................... | |
| *Locality*—Hamilton and Grimsby. | |
| *Zaphrentis bilateralis* ............... | Hall, 1852, Pal. N. Y., Vol. II |
| *Locality*—Hamilton and Grimsby. | |
| *Atrypa oblata* ................. ... | Hall, 1852, Pal. N. Y., Vol. II. |
| *Locality*—Hamilton and Grimsby. | |
| *Modiolopsis orthonota*............... | Conrad, 1839, Ann. Rep. N. Y. |
| *Locality*—Hamilton. | |
| " sp..................... | |
| *Locality*—Dundas, Hamilton, and Grimsby. | |
| *Murchisonia subulata* ........ ........ | Conrad, 1842, Jour Acad. Nat. Sc. |
| *Locality*—Hamilton. | |
| " *conoidea* ............... | Hall, 1852, Pal. N. Y., Vol. II. |
| *Locality*—Hamilton and Grimsby. | |
| *Pleurotomaria litorea*............... | Hall, 1852, Pal. N. Y., Vol. II. |
| *Locality*—Hamilton and Grimsby. | |
| " *pervetusta*............ | Conrad, 1838, Ann. Rep. N. Y. |
| *Locailty*—Hamilton and Grimsby. | |
| *Ichnites* (several species)............ | |
| *Locality*—Hamilton and Grimsby. | |

## V.—CLINTON FORMATION.

In southern Herkimer County, N. Y., the Medina formation is wanting, and the Clinton rests on thin deposits of Oneida conglomerate, which itself dies out farther to the east. In the more eastern portions of the State of New York, where the Clinton series succeeds the Medina, it partakes of its lithological characteristics. However, as the Clinton extends westward its shales become intercalated with calcareous deposits that form a conspicuous feature. The calcareous beds increase in importance as the formatiom extends westward in the Province of Ontario, and at Hamilton they so nearly resemble those of the overlying Niagara, that the line of separation becomes almost arbitrary. The New York Geologists placed a hard layer of dolomite, containing remains of *Pentamerus*, and known as the "Pentamerus Band," as the upper bed of the Clinton of New York, while the Canadian Geological Survey considered it as the lowest bed of the Niagara series, which in our Province, it most nearly resembles. The latter division, between the Clinton and Niagara, I have adopted in this paper, if indeed, a division, except for convenience, should be made. In fact, the upper nine feet of the Clinton deposits at Hamilton might well be placed with the Niagara above. Nor are there any palæontological grounds of separation.

The Clinton group may be described as dolomitic shales, with numerous thin beds of argillo-arenaceous dolomites, some of which almost resemble impure sandstone. The indurated shales are generally of blue or dark gray, but in weathering they assume a red, brown or buff color. Many of the more calcareous bands are highly fossiliferous. About twenty feet from the top of the series there is a red or brown ferruginous calcareo-arenaceous rock, about eight feet thick, holding an abundance of casts of fossils, which are mostly of the genera *Modiolopsis* and *Lingula*.

It may be here remarked that none of the *Lamellibranchiate* shells retain any part of their original tests, while the *Lingulæ* have their shells well preserved, and often of a blue color.

This bed of red ferruginous rock is the representative of that peculiar bed of oolitic iron ore, called "Fossil Ore," forming a characteristic element of the Clinton group, extending from Wisconsin to New York, and thence along the Appalachian Chain to Tennessee and Alabama. In some places the "fossil ore" is only represented by ferruginous stains on the rock. This iron matter came probably from the denudation of the extensive iron ore deposits, Huronian Age, just north of the Clinton sea, in what is now Michigan.

The lower nine feet of the Clinton beds are composed of argillaceous dolomites with shaly partings, which are sometimes bituminous. Some of these layers are so granular and arenaceous as almost to resemble sandstones. From the few fossils obtained here, these rocks may be considered as beds of passage from the Medina. Including the beds that I have placed as beds of passage at the base and those at the summit of the Clinton formation, the whole thickness at Hamilton is 94 feet, and at Dundas 88 feet.

In New York, on the Genesee River, the Clinton group has a thickness of 80 feet, consisting of calcareous shales with thin beds of shaly dolomite, together with the characteristic *Oolitic iron ore* bed.

In Ohio this formation is represented by salmon-colored dolomitic limestones which vary in thickness from 15 to 40 feet.

As has been noticed, the Clinton deposits lithologically resemble those of the Medina, in eastern New York, while in the western part of the State, they approximate to the overlying Niagara. This resemblance is still greater in Canada, where much of the shaly matter is replaced by calcareous rocks, and in Ohio, according to the Geological Survey of that State, the argillaceous beds are wholly replaced by limestones. Again those differences in the fossils which characterise the respective Clinton and Niagara formations in eastern New York largely disappear in the more western deposits. In Canada the palæontological differences seem to be due to the state of preservation of organic remains in the shales and limestones respectively; for the forms which occur in the Clinton limestones are generally found in the calcareous rocks of the overlying Niagara, whilst the principal differences are in those fossils preserved in the Clinton shales, which are not represented above by similar rocks. In fact there is no more variation in the fossils found in the Clinton and Niagara formations at Hamilton than there is between those of the Niagara "Chert Bed" at Hamilton and of the upper layers at Barton, five miles distant.

Professor Orton found that the Clinton of Ohio contains pebbles of the "Cincinnati (Hudson River) limestones." In the south-western part of that State the deposits under consideration rest either on rocks of the Cincinnati group, or on the thin development of Medina shales (which are from ten to twenty feet thick). The conglomerates show that the underlying formations of the Cambro-Silurian Age had been hardened and uplifted into cliffs and shore lines before the commencement and deposition of the sediments in the seas of the Clinton epoch. At this time the Canadian Sea was one of shallow water. At Dundas, Hamilton and elsewhere, various thin hard beds from the base to the summit of the formation have their surfaces covered with ripple marks. As the muddy sediments, which filled up the northern and north-eastern portion of the Medina Sea, were principally derived from the *débris* of the Utica and Hudson River groups of the Canadian highlands, so also the Clinton shales appear to have been derived from the same source; but these muds gradually gave place to the organic limestone in the western portion of the Clinton seas.

*Organic Remains in the Clinton Formation.*—Recently an interesting group of small fossils was discovered by George J. Hinde, Esq., F.G.S., in Glen Spencer, Dundas. These organisms appear as black shining chitinous objects on the surface of the stone, usually about the twelfth of an inch in length or less, and were recognized by Mr. Hinde as the jaws of annelids or worms. They will be found described and figured in the August number of the "Quarterly Journal of the Geological Society of London," for 1879. Excepting the jaws, no portions of the heads of the animals were found. The following is a catalogue of Mr. Hinde's species:

FROM THE CLINTON BEDS.

*Eunicites clintonensis.*
*Eunicites coronatus.*
*Eunicites chiromorphus.*
*Œnonites amplus.*
*Œnonites fragilis.*
*Arabellites elegans.*
*Lumbriconereites basilis.*
*Lumbriconereites triangularis.*
*Lumbriconereites armatus.*
*Glycerites calceolus.*

Besides these, he describes three species from the Niagara formation; and as I have not the specimens in my collection, I will include them here with the Clinton species:

*Œnonites? infrequens.*
*Arabellites similis.*
*Staurocephalites niagarensis.*

The following is a catalogue of the Clinton fossils obtained at Hamilton and Dundas. This catalogue does not contain all the species that are included with the Niagara group proper, which Col. Grant and myself have found in the so-called Clinton beds, but only the more conspicuous species, or those not found higher up at Hamilton.

CATALOGUE OF CLINTON FOSSILS OCCURRING AT HAMILTON.

| GENERA AND SPECIES. | REFERENCE. |
|---|---|
| *Buthotrephis gracilis* ........... | Hall. Palæont, N.Y., 1852. |
| " " var. *crassa* .. | " " " |
| " *palmata* .......... | " " " |
| Roots of various *Algæ* ......... | " " " |
| *Stromatopora* sp. ......... | |
| *Conophyllum niagarense* .... .... | Hall, Palæont, N.Y., 1852. |
| *Monticulipora lycoperdon* ....... | Say, " 1847. |
| *Zaphrentis bilateralis* ........... | Hall, Palæont, N.Y., 1852. |
| *Graptolithus clintonensis* ........ | " " " |
| *Retiolites venosus* .............. | " " " |
| *Palæaster granti* ................ | Spencer, Niag. Foss. 1882. |
| *Eucalyptocrinus decorus* .... ... | Phillips. Murch., Sil. Syst.. 1839. |
| *Helopora fragilis* ............... | Hall. Palæont. N.Y., 1852. |
| *Clathropora frondosa* ........ ... | " " " |
| *Fenestella prisca* .... ........ | Londsdale, Murch., Sil. Syst., 1839. |
| " *parvulipora* ..... .... | Hall, 26th Rept. of Regents. N.Y., 1875. |
| " *tenuis* ............... | Hall, Palæont. N.Y., 1852. |
| " *bicornis* ..... . ..... | Spencer, n. s. Niagara Fossils, 1882. |
| *Polypora incepta* .... .... ..... | Hall, Palæont. N.Y., 1852. |
| *Rhinopora venosa* ........ ..... | Spencer, n. s. Niagara Fossils, 1882. |
| *Retepora angulata* .... ......... | Hall, Palæont, N.Y., 1852. |
| *Trematopora tuberculosa* ........ | " " " |
| *Merista cylindrica* (?) ... ....... | " " " |
| *Athyris* (*Meristella*) *naviformis* ... | " " " |
| *Strophomena rhomboidalis* ...... | Wahlenberg, Act. Soc. Sci. Upsal, 1821 |
| *Orthis elegantula* .... ......... | Dolman, 1837. |
| *Lingula oblonga* ............... | Conrad. Ann. Rep.. N.Y., 1839. |
| " *oblata* .... ............ | Hall, Palæont, N.Y.. 1852. |
| *Posodonia* (?) *alata* ... ........ | " " " |
| *Posodonomya* (?) *rhomboidea* .... | " " " |
| *Orthonota* sp. (?) ........ | |
| *Modiolopsis*, sev'l undetm'd spe's. | |
| *Platyostoma niagarense* .......... | Hall, Palæont, N.Y., 1852. |
| " sp. .......... | |
| *Orthoceras clavatum* ..... ...... | Hall, Palæont, N.Y., 1852. |
| *Oncoceras subrectum* ..... ...... | " " " |
| *Conularia niagarensis* .... ...... | " " " |
| *Tentaculites distans* ............ | " " " |
| *Rusichnites bilobatus* ..... ..... | |
| *Ichnites*, four undeterm'd spec's. | |

## VI.—NIAGARA FORMATION.

*Topography and Distribution.*—Overlying the Clinton formation, the most important member of the series—the Niagara (proper)—is much more widely developed than the lower portions of the group which are largely made up of mechanical deposits. Owing to the hard limestones of the Niagara epoch surmounting several hundred feet of soft Medina and Clinton shaly rocks, it forms a conspicuous feature in the country—the summit of the Niagara escarpment—as along its northern and north-eastern margins, the softer material forming the base of ridge has been removed by erosion, leaving abrupt cliffs.

The most eastern exposures of this formation in New York are near the town of Catskill, on the Hudson River. From this place it extends westward through the central and western parts of the State, forming the bold slopes, a few miles south of, and parallel to, Lake Ontario. Entering Canada at the Niagara River, its direction is westward, nearly parallel with its *strike*, as far as Dundas, at the extreme western end of Lake Ontario. Here the range of hills changes its course and extends to Cape Hurd, and thence through Manitoulin and Cockburn Islands. The range of hills south of the lake, as we have noticed, is about 400 feet high and generally has an abrupt face. However, from Dundas to Georgian Bay, although the country is of a higher altitude, the features are less broken on their eastern side, as they recede from Lake Ontario.

The southern portion of the basin of Lake Ontario is excavated in Medina shales, while its northern side is scooped out of the various rocks of the Hudson River, and the shales of the Utica formation, which once formed the margin of the old sea in the Niagara period.

From the northern end of Lake Huron the Niagara formation extends into Drummond Island, and thence along the whole northern and western shores of Lake Michigan. Again, the margin of the seas in this period abutted against the Appalachian chain as far south as Tennessee, as is shown by the remains of their old deposits. The large island of the "Cincinnati Arch" formed part of the barrier at the southern margin of the Mediterranean Sea, which extended over a region of thirteen degrees of longitude and eight of latitude, in the Niagara period, or, we may say, in the Silurian age.

In Canada many streams cut through the rocks of the region under consideration, and give fine exposures of their geological structure. The streams invariably excavate picturesque glens, at the head of which are usually cascades in magnitude from the Falls of Niagara to others forming a mere series of rapids.

*Development*—The best exposures of the Niagara formation in the State of New York are at Lockport, Rochester and Niagara River. It attains a thickness of 264 feet in that State. In Canada the upper portion of the series is so denuded in the neighbourhood of Lake Ontario, that it is impossible to get a complete section; and even many miles away where it passes into the overlying Guelph formation, as near Rockwood the line of junction is generally obscured by drift.

At Hamilton, by level measurements, a section of the lower 52 feet (being beds from 7 to 12 of Section III) was made by Mr. S. D. Mills and myself, between the exposure at the head of James street and the "Jolly Cut" road, a half mile to the east. Here the escarpment averages 390 feet in height above the lake. The cherty dolomites (No. 12 of Sections) form the capping stratum of the "Mountain." Along the Sydenham road (section II), the section, composed of the same beds, measured 60 feet (seven feet more of the "Chert bed" is exposed here than at Hamilton). Again, at the junction of Glen Spencer with Glen Webster, the same "Chert beds" form the capping stratum of the cliffs, and here the Niagara beds are a little thicker than elsewhere. However, on the eastern side of these ravines there is an additional exposure of 104 feet near the "Peak," which has not been removed by denudation, thus giving a maximum thickness of 169 feet at Dundas. However, by measuring the section at Albion Falls, and then levelling up Rosseaux Creek and along the strike of the formation to Carpenter's Limekilns, on Lot 15, and Range VI, Barton, two miles south of the brow of the "Mountain," at Hamilton, I succeeded in measuring a section of 198 feet from the base of the Niagara (proper). The height of the last station is 480 feet above the lake, and in addition the rocks are covered with five feet of soil, at the Church, on the same lot. Here the rocks have their surfaces grooved with ice action. It may be remarked that the capping bed in this place is almost wholly made up of the remains of *Stromatopora*.

This last section carries us to a higher horizon than any other measurable, yet the highest members of the series is still beyond our reach, being covered by the drift over the gently sloping country. However, if we follow the line of strike westward, and take the levels here, and at the nearest exposures of the Guelph formation, at Galt (which is a few miles north of the line of strike of the Barton Beds) and make allowance for dip, it would approximately be found that the unexposed upper beds of the Niagara formation reach to an additional 80 or 100 feet in thickness.

According to the reports of the Geological Survey of Ohio, the formation has a thickness of 275 feet in Highland county, and probably 350 feet in the northern part of the State. The Canadian Geological Survey estimated the whole thickness at 450 feet in the neighbourhood of Cape Hurd, if the dip were uniform.

Thus we see that from the western part of New York to Ohio there is no great variation in the thickness of the Niagara deposits, where the surface is not removed by erosion, and we may fairly place the accumulations in the Canadian portion of the Niagara sea at 280 feet.

Not only is the deposition of the whole series literally uniform, but there are certain strata which are recognizable as constant over the region under consideration. Of these, the most conspicuous are the "Chert bed" (No. 12 of sections), and a thick compact bed of light gray dolomite (varying from four-and-a-half to five-and-a-half feet thick, and numbered 8 in the sections). It was from taking the levels of this last bed at Albion Falls, Hamilton and Dundas, that I estimated the dip at 25·5 feet in the mile, in direction, about twenty degrees west of south. Locally, however, I found the dip sometimes amounting to 37 feet. The distances of the sides of the triangle formed by the three stations above named, were taken from the large county map. The calculation agreed closely with that made from the approximate height of the base of the formation at Limehouse, and that known at Dundas, and taking the direction of the dip to be that found by the above mentioned triangle.

At Limehouse the surfaces of some of the strata are almost as irregular as those of the Medina at Dundas. On the north side of the Dundas Valley the rocks in some places are almost horizontal, but again they are found dipping a few feet in the mile to the northward. This being the case, generally, would make the Dundas Valley an anticlinal valley, with the slope in each side less than one degree.

*Character of the Rocks.*—In New York the lower part of the Niagara formation is represented by 80 feet of dark fossiliferous calcareo-argillaceous shales; at Thorold, Ontario, these are much thinner, and at Hamilton and Dundas they are not represented by more than from six to ten feet of muddy sediments (No. 9 of sections), whose upper portions graduate into more calcareous beds. The general character of the series at the western end of Lake Ontario may be represented by the following section in descending order:

| | |
|---|---|
| (*a*) Thin beds of dark (often limestone and earthy) dolomites, with shaly partings. Some layers are fossiliferous.. | 132 feet. |
| (*b*) Thin beds of light-colored dolomitic rocks, containing an abundance of cherty nodules; fossiliferous............ | 19 feet. |
| (*c*) Dark blue or gray shaly dolomites; fossiliferous..... | 16 feet. |
| (*d*) Dolomitic compact shales........................ | 10 feet. |
| (*e*) Light drab crystalline compact dolomite, in one bed. | 5 feet. |
| (*f*) Dark gray compact dolomite, in moderately thick beds, the lowest of which contains *Pentamerus*................ | 10 feet. |

At Limehouse, only the lower beds are exposed near their junction with the underlying Clinton rocks. Here the deposits consist of light colored dolomites, of uniform texture in thick compact beds, holding only casts of fossils.

The representatives of this formation in Ohio consist of the Dayton limestone of five feet in thickness, succeeded by 60 feet of shales, over which there are 180 feet of limestones, and in Highland County the series is surmounted by 30 feet of sandstone. In referring to these western beds, we find included the Cedarville limestones, beds which are considered of the same horizon as the Guelph dolomites.

The color of the limestones becomes lighter on going westward, especially after turning a point at Dundas, which formed a right-angled prominent cape in the sea of the Niagara period. Even within a few miles, near Dundas, one can notice the lighter color of the purer calcareous deposits, and at Limehouse, to the north-west of the old cape, coloring matter and shale are almost wanting.

*Composition and Chemical Analysis of the Limestones.*—The Niagara limestones, in Canada, consist almost entirely of the double carbonates of lime and magnesia, with a varying percentage of clay, free sand and silicates of the alkaline earths. Sometimes, however, there is an excess of carbonate of lime over what is required for the production of the double carbonate. Under the microscope this excess of calcite is seen occupying the small spaces between the more uniformly crystalline particles of dolomite. The quantity of iron is generally small, and present in the state of protoxide, though in some of the beds it occurs as pyrites. Bituminous coloring matter is present in many of the strata, and in a number of beds it occasionally fills small cavities. There are but few beds east of Dundas which have not a considerable quantity of earthy matter present.

The shales in this region differ from limestones only in the larger quantity of clay and other silicates present in place of the calcareous matter, for they all contain a large percentage of carbonate. In fact many of the beds are of an intermediate character, that it is difficult to decide whether to call them earthy limestones or calcareous shales. Of several beds at Hamilton, I made the chemical analyses, together with a microscopic examination. A few of the results are here given.

*Analysis I.*—The sample was taken from near the base of the series (No. 7 of section) at the "Jolly Cut," Hamilton. Under the microscope only a mass of transparent particles of dolomite, separated by dark amorphous earthy matter, was visible.

| | |
|---|---|
| Calcium carbonate | 46·6 |
| Magnesium carbonate | 36·5 |
| Ferrous carbonate | 1·7 |
| Calcium silicate } Magnesium silicate } | 3·6 |
| Alumina | 4·4 |
| Silica | 6·7 |
| Moisture | 0·3 |
| | 99·8 |

*Analysis II.*—This analysis represents the composition of the thick bed of light gray dolomite (No. 8 of section) at the "Jolly Cut," Hamilton. The rock is highly crystalline, and shows crystalline plates of crinoids and shells, but seldom contains complete casts of fossils. Under the microscope it shows a mass of crystalline semi-transparent particles of dolomite, full of small cavities, which are often lined or filled with pure calcite, consequently the carbonate of lime is in excess. This bed contains many large cavities of several inches extent filled with foreign minerals, which will be noticed further on.

| | |
|---|---|
| Calcium carbonate | 59·7 |
| Magnesium carbonate | 38 2 |
| Alumina and oxide of iron | 1·5 |
| Silica | 0·4 |
| | 99·8 |

*Analysis III.*—The bed from which this sample was taken is about five feet above No. 8 of section, and is one of the harder and more compact layers (No. 9 of section) of that portion of the geological horizon which I have identified as the Niagara shales at the "Jolly Cut," Hamilton. It is said to produce hydraulic cement, but if so it would be of inferior quality.

| | |
|---|---|
| Calcium carbonate | 33·8 |
| Magnesium carbonate | 25·2 |
| Calcium silicate | 6·6 |
| Magnesium silicate | 2·7 |
| Alumina | 5·1 |
| Ferrous carbonate | 1·8 |
| Ferric oxide | 1·6 |
| Ferrous disulphide (Pyrites) | 1·9 |
| Silica | 20·0 |
| | 98·7 |

*Analysis IV.*—The sample for this analysis was obtained from the "Chert bed" (No. 12 of sections). The portion taken was free from cherty concretions, as these portions would be nearly made up of pure silica. Under the microscope there was only the usual crystalline structure of the dolomitic particles separated by dark earthy matter.

| | |
|---|---|
| Calcium carbonate | 46·6 |
| Magnesium carbonate | 38·9 |
| Calcium silicate }<br>Magnesium silicate } | 2·8 |
| Ferrous oxide | 0·8 |
| Alumina | 2·4 |
| Silica | 9·3 |
| | 100·8 |

A large number of other specimens were examined under the microscope, but they were all of essentially the same structure, and more or less homogeneous, except some of the more flaggy beds where the crystalline calcareous matter was deposited in alternating layers with the more earthy matter.

As many of the dark beds are colored with bituminous matter some of the calcareous rocks burn to a white lime.

By way of comparing the Niagara rocks in Canada, with those in Ohio, I here quote several analyses of the limestones of this formation in that State, as made by Professor Wormley.

| | I. | II. | III. | IV. | V. |
|---|---|---|---|---|---|
| Calcium carbonate........ | 85.50 | 54.45 | 50.90 | 55.50 | 54.20 |
| Magnesium carbonate..... | 11.16 | 42.23 | 39.77 | 43.28 | 44.80 |
| Calcic & magnesic silicates. | —— | —— | 7.07 | —— | —— |
| Alumina and iron......... | 2.00 | 0.40 | 1.19 | 0.30 | 0.10 |
| Siliceous matter.......... | 2.20 | 2.00 | .70 | 0.60 | 0.80 |
| | 100.86 | 99.08 | 99.63 | 99.68 | 99.90 |

*Analysis of the Shales.*—As noticed before, the Niagara shales are analogous to the limestones where the calcareous matter is partly replaced by argillaceous material.

*Analysis V.*—The sample here examined was from one of the most shaly layers (No 9 of the sections) of the shaly portion of the formation at the "Jolly Cut," Hamilton. Under the microscope the earthy matter seemed to be held together by the crystalline particles of dolomite.

| | |
|---|---|
| Calcium carbonate.................. | 29·4 |
| Magnesium carbonate................ | 23·9 |
| Calcium silicate } Magnesium silicate } | 4·5 |
| Ferrous oxide...................... | 0·9 |
| Ferric oxide....................... | 1·6 |
| Alumina............................ | 15·0 |
| Silica............................. | 24·4 |
| | 99·7 |

The following analysis of the Niagara shale of Ohio was made by Professor Wormley:

| | |
|---|---|
| Calcium carbonate.................. | 34·00 |
| Magnesium carbonate................ | 30·87 |
| Calcium silicate .................. | 8·48 |
| Alumina and iron................... | 8·40 |
| Silica............................. | 12.21 |
| Water (combined)................... | 5.40 |
| | 99·36 |

*Source of the Mechanical Deposits.*—From the character of the rocks and their distribution in the Niagara period, as seen by glancing at a map of the Palæozoic Geography of America, we see that the mechanical sediments (shaly matter), of the northern and north eastern margin of the old inland sea came principally from the Canadian highlands. The Hudson River group formed the shore line of most places, from the beginning of the Medina epoch, both in New York and Canada as well as along the "Cincinnati Arch." The eastern portion of the Province of Ontario was covered by the limestones of the *Trenton group;* the central portion, by the great accumulation of dark *Utica shales*, and these last by shales with intercalated limestones and sandstones of the *Hudson epoch*, extending along their western margin, and forming the north-eastern shores of the sea, as developed at the beginning of the Silurian Age (proper), in the region from what is now the western end of Lake Ontario to Georgian Bay.

It may be noticed that the limit of the Utica shales is not west of the meridian of the Niagara River. At the close of the Cambro-Silurian Age the deposits belonging to that period extended much farther southward than at present, probably to a latitude not far north of the southern shores of Lake Ontario —at least, in its eastern extension. It was in this soft material that the lake basin was subsequently excavated, the erosion having extended but a few miles into the Niagara limestones, and their underlying shales, and left the escarpment in bold relief.

Now, on examining the sediments south of the Canadian shores of those days, we find only thin beds of shale in the more eastern deposits, but these gradually thicken in extending westward, until, in the neighbourhood of Rochester, they amount to 80 feet (the place being south of the shores composed of Utica shale). Again, the shales begin to thin out at Thorold, Ontario, where they amount to fifty feet, while thirty miles westward, as at Dundas, they are only a few feet thick, and almost entirely disappear after turning the ancient Cape and passing west of the line from this town to Lake Huron, as the waters, there, were protected from the muddy eastern currents. The northern end of the sea was not subjected to the influx of mud to any extent, as in that direction the shores were adjacent to the old crystalline Huronian and other mountains. However, more shales make their appearance in the western area, having been derived from the somewhat shaly Hudson group of the "Cincinnati Arch," or, perhaps, from the margins of Medina shales that may have existed on the south-western island coast. Of course in the eastern portion of the old sea much shale came from the disintegrations of the other Appalachian highlands. During the Medina epoch, in this region, five hundred feet of shales were carried down into the eastern or north-eastern portion of the sea, while only twenty feet of sediments were deposited to the south-westward.

Again, the turbid waters in the Clinton epoch interrupted periodically the growth of impure organic calcareous beds, while the western portion of the old sea was nearly free from the influx of mud.

*Character of the Marine Life and Origin of the Limestones.*—We have observed that the greater portion of the upper beds of the Niagara epoch in New York, almost all in Ontario, and the greater portion in Ohio, together with a considerable portion of the Clinton epoch in Canada, and all of that horizon in the more south-western State, are made up of dolomitic limestones of a greater or less degree of purity. Let us examine into the condition of the seas and of the life that flourished at this time.

During the earlier days of the Mediterranean sea in the Niagara epoch, in the eastern and south-western areas, the waters were of a turbid character, though freer from earthy matter in its northern extension. Later, however, and during the greater period of its existence, only a small amount of shaly sediment was occasionally carried down, thus producing favorable conditions for the growth of marine life.

The limestones in Canada are of a highly crystalline texture, and consequently most of the traces of the organisms that contributed to their original formation are obliterated. Out of numerous specimens of rocks examined under the microscope, none show any organic structure, except some parts of those beds containing *sponges* or *stromatopora*, with here and there a place where a stray fossil has escaped obliteration, in the re-crystalization of the calcareous mud. In fact, as regards both shells and corals, there is seldom anything left more than their casts preserved in the stone. Even when, by chance, a portion of the original bed has escaped obliteration, it has become highly crystalline. Here and there is an exception to this statement, as in the case of the phosphatic shells, *Lingula* and *Discina*, in which frequently portions of the original tests remain. In the region under consideration nearly 200 species of fossils have been obtained from the beds of the Niagara group, yet the collector may spend days and obtain a mere handful of specimens to reward him for his trouble.

It may be noticed here that there is a bed near the top of the series at Dundas, several feet thick, that appears to be made up of breccia, the fragments being derived from older portions of the adjacent rocks.

During the long period required for the deposition of the limestones, the character of the organisms which inhabited the sea was subject to some important changes. One of these conspicuous periods has left its stamp in the "Chert beds," which are classed as No. 12 of the sections. The average thickness of this series of thin beds of limestone, filled with numerous concretions of cherty material, is eighteen or nineteen feet. The limestones are dolomites, as is shown by the previous analysis. By far the greater proportion of concretions show no organic structure, but yet, such large numbers when broken, show the internal sections of sponges, which mostly belong to the genera of *Astylospongia* and *Aulocopina*, that the origin of the siliceous nodules is at once apparent. On some portions of the brow of the escarpment, both at Hamilton and Dundas, these beds form the summit, and as the surface soil of the rocks weather, just beneath what is only a few inches of soil, the complete forms of the sponges become exposed by the action of the frost and of the plough. The sponge-life was very considerable, that it could have afforded a sufficient source for so much soluble silica as to have produced the enormous amount of chert found in these beds. We know also that the variety of species was considerable. Nor was the sponge-life all that adorned the sea at that time. These beds are by far the richest in variety of species, from the lowest radiates to the higher types of life that are found in the Niagara series. It is also worthy of notice that it is in this small series that the greater portion of the rich *Graptolite fauna*, to be described in a succeeding paper, is found.

Just beneath these beds (No. 11 and 10) which are more shaly in character (of which the upper strata are known as "blue building beds"), we find our greatest number of *Trilobites* together with the high-type Crustacean, *Pterogotus canadensis* (Dawson), recently discovered by Col. Grant.

Another conspicuous epoch in the history of the ancient sea is marked by the great bed of dolomite (No. 8 of section). At no time was the sea so free from the influx of mechanical sediments. This bed with a thickness of about five feet forms an enduring monument for the myriads of crinoids whose remains most largely led to its formation, although subsequently it has absorbed magnesia, which in the re-crystallization of its molecules has obliterated all but the fragments of the original segments of their stems.

Another noticeable change in the rock-making organisms is found in a bed of dolomitic rock two and a half feet thick, almost literally filled with the remains of three or four species of *Stromatopora*. This stratum is near the surface bed at Carpenter's Limekilns, (Range VI, lot 15 of Barton) about three miles south of the centre of the city of Hamilton.

Besides the remains of life, as shown in these few more conspicuous beds, we find throughout the whole Niagara epoch that Bryozoons were numerous; Crinoids were abundant (in places, as at Grimsby, where some of the beds consist simply of masses of these stems). Corals were dominant in some localities, and Mollusks of every class were largely represented.

The Niagara limestones have been largely derived from broken shells, corals and other calcareous organisms, but subsequently the calcareous matter has combined with, or a portion of it has been replaced by, magnesia which had been precipitated amongst the comminuted organisms.

Henry C. Sorby, Esq., F.R.S., President of the Geological Society of London, (Q.J.G.S., May, 1879,) has shown that the condition in which calcareous matter is present in the structure of shells, or of allied forms of life, has much to do with the subsequent preservation of their remains in the rock, on the crystallization of their particles into solid limestones.

The principal condition in which lime is present in calcareous organisms is as the carbonate, either in the form of calcite or aragonite. However, there are some structures like the *Lingula*, where the lime occurs, as the phosphate, the same as in bones. The phosphate of lime is less apt to change its molecular condition than the carbonate, and, as a result, the shells of that material, or partially of it, are generally better preserved in the fossil condition than those of the carbonate. But these phosphatic shells have not contributed to any extent in the formation of the Niagara limestones.

The crystalline form of aragonite may be considered as an abnormal form of carbonate of lime, and Mr. Sorby shows that under various circumstances, it is easily resolved into the more stable form of calcite, whilst the carbonate, in the crystalline form of calcite, cannot be changed by any known process into that of aragonite. These two minerals form the principal constituents of the tests of shells—in some classes the aragonite being present, in others the calcite, and again in others the inner layer may be of aragonite and the outer of calcite, or *vice versa*.

Mr. Sorby gives the following classification of the mineral composition of the different orders of shells:

(*a*) *Crustacea.*—The mineral matter of crustaceans consists of calcite hardened on the surface with phosphate of lime.

(*b*) *Cephalopoda*—These shells are made up of aragonite together with a small amount of phosphate of lime.

(*c*) *Gasteropoda.*—In most of these genera the shell is wholly made up of aragonite, but in some the outer layer consists of calcite.

(*d*) *Lamellibranchiata.*—In many species of this group the tests are composed wholly of aragonite, in some entirely of calcite, whilst other shells have their inner layer of one material and the outer of the other.

(*e*) *Brachiopoda*, are composed wholly of calcite.

(*f*) *Echinodermata.*—Here the mineral matter is calcite.

(*g*) *Polyzoa* are composed of various mixtures of both minerals.

(*h*) *Hydroida and true corals* are made up of aragonite—the former class having a small quantity of phosphate of lime.

(*i*) *Foraminifera* are probably composed of calcite.

The removal of the organic matter holding the particles of the shell together disturbs the stability of the structure, and not only causes it to crumble by the disintegration along the lines between the different minute crystals, but also hastens a subsequent re-arrangement of the molecules into larger and less constrained crystals. Especially is this the case with fragments of aragonite which soon take the form of calcite, as is shown by the experiment of Mr. Sorby, where powdered coral (aragonite) kept for only a few weeks in water began to change into the condition of calcite. Moreover, this is not only an experimental test under favorable circumstances, but it is found that the modern limestones now forming about some of the West Indian Islands, have in places entirely lost or are losing the natural forms of the organic fragments of which they are composed. Again, the disintegrated fragments, which are assuming the more crystalline condition have their interspaces filled with carbonate of lime dissolved in the water, which was probably derived from the original material of the shells.

If the organic remains be included in a matrix of the same color, not only the form but also the certainty of its former presence in any position is apt to be lost. Especially is this the case with the corals and shells which are composed of aragonite. However, if the surfaces of the organisms were covered by thin layers of some foreign matter, as pyrites or mud, the former may still be preserved, but the place occupied by the structure will be found to have a more highly crystalline structure than the matrix itself, as the carbonate of lime of the shells, not having a great surface exposed by being broken into fragments, has more time for gradual re-arrangement of molecules, and, consequently, larger and more perfect crystalline forms are produced. This is found to be particularly the case with Lamellibranchiate shells (aragonite) in the rocks of the Niagara group at Hamilton, where only the remains of casts, procured in the manner just described are to be found, although some beds indicate that they were originally made up of a mass of these shells. The best preserved fragments of organic structure in our rocks are stems of crinoids, but these are generally re-crystallized, although they were even at first in the forms of small crystals of calcite.

The corals generally have become silicified but the forms are so far changed as to show that the original calcareous matter was re-crystallized before its replacement with silica was accomplished.

Some of the Graptolites are well preserved owing to the large amount of corneous matter that may have arrested molecular change. From obscure casts some of the beds of limestones appear to have been derived from Orthoceratа. Brachiopods are the commonest fossils retaining any of their original appearance. Polyzoa are fairly preserved, especially in the "Chert bed," where also a few Gasteropoda retain their calcareous structure. In fact nearly all the fossils are better preserved in the "Chert bed" than elsewhere. This fact may in some way be accounted for owing to the presence of soluble silica derived from the sponges having cemented the calcareous plates together at the time when the animal matter of the structures was being gradually removed, for many of the fossils seem to be saturated with siliceous material.

The obliteration of the original calcareous organisms was completed by the physical changes which resulted in the combination of the calcareous matter, with the magnesian carbonate and the subsequent re-crystallization in the form of the double salt. According to the experiments of Mr. Sorby this was effected by the magnesia replacing a portion of the lime. But Dr. Sterry Hunt, many years ago, announced that, as indicated by his experiments, all magnesian limestones are derived from the precipitation of both carbonates simultaneously in an inland salt sea. At least as far as the Niagara dolomites are concerned, the calcareous organisms have played a most important part in furnishing calcareous matter, although the magnesian salt may have been exclusively derived from the evaporation of the waters in the immense inland Niagara waters, for at Grimbsy a bed of this dolomite shows its derivation almost exclusively from crinoids, and at Hamilton a similar bed in a more highly crystalline state, and filled with pores from the shrinkage, forms a marked feature of the series.

In the molecular change a condensation in volume would occur, thereby leaving the rock porous and permitting the carbonate of lime of the calcareous fossils to be washed out; as illustrated in the great bed of dolomite (No. 8 of sections) and some other beds, where the cavities have not been subsequently filled with argillaceous mud.

As a further illustration of the subsequent removal of the material of the shells by water, we need only go a little beyond the present region of study to the Guelph dolomites, where are numerous casts of shells in the porous stone, with the whole shell and its filling removed, thus leaving numerous cavities in the rock.

Dr. Hunt has conducted a series of experiments which throw light on the origin of dolomites. In lake basins where there is a considerable evaporation going on, the waters containing bicarbonate of soda cause the separation of all the lime as carbonate, and the formation of soluble bicarbonate of magnesia, which, subsequently on evaporation, separates in the hydrated form. The salts mingled together under pressure and heat will combine to form double carbonates. From the disintegration of feldspars and other rocks, an abundance of carbonates of soda, lime and magnesia, are constantly being brought down by streams and emptied into the sea basins. These chemical precipitates mixing with (and replacing according to Sorby) a portion of the calcareous sand derived from the organic remains in this region, have probably in a great degree given rise to our Niagara limestones, all of which are more or less of the character of true dolomites, but where some contain mechanical *detritus* as siliceous and argillaceous mud.

From this examination of the character of the limestones of the Niagara group, it is not surprising that there is such a paucity of fossils in this great development of rocks so largely composed of their remains. In very many strata I have found no fossils whatever, and even in those where they are most abundant, one is rewarded only after a long patient search. Yet, with all these difficulties, the geologist may collect in the region of our study a large number of species, of which there are catalogues under those parts of this paper on the Medina and Clinton epochs, and a still larger list at the end of this portion of the paper on the Niagara epoch proper.

## VII.—MINERALS OCCURRING IN THE NIAGARA GROUP.

Excepting the beds of stone fit for building purposes and for burning to lime, there are no minerals about the western end of Lake Ontario of economic importance. However, many years ago some futile attempts were made south of the village of Beamsville to work a small "find" of galena. The only sandstones fit for building purposes is the "Gray band" of the Medina formation. Blocks of this stone of any dimension that can be handled are obtainable. This stone has been extensively worked at Dundas, Hamilton, Grimsby and Beamsville. A great drawback in quarrying this material is that it can only be procured along the edge of the escarpment, and requires a vast amount of the shaly rocks of the Clinton formation to be removed, and even then the supply is of a limited quantity. The stone is very tough and hard on tools. I am informed that this rock was formerly manufactured into grindstones. The majority of the beds of limestone are too thin, or inferior, for anything more than the roughest building material. However, there is a sufficient number of layers to supply an abundance of building material of which the handsomest is obtained from the great dolomite (No. 8) and the subjacent beds. In fact all the beds belonging to the Niagara series, that will at all admit of use, are quarried at Hamilton, and the broken material of the "Chert band" and other layers is used for road metal, and only the more shaly limestones are rejected. The "Blue-Building beds," although somewhat earthy, form fair building material. At the old quarry along Rosseaux Creek, and elsewhere, in the higher portion of the series, good, fairly thick blocks of dolomite can be obtained

Though the limestones are generally rather dark, they burn to white lime, as the coloring is derived from organic matter. The principal limekilns are supplied from the highest beds of the Niagara series in the region of Hamilton and Dundas, while at Limehouse, on the Grand Trunk Railway, the lower beds are light colored, rather pure, and form excellent lime—Toronto and many other places being supplied with immense quantities of the product of these kilns. Some of the beds also burn to hydraulic cement.

However, there are interesting minerals in this region, other than those which can be turned to use in the arts. The first of these minerals that we will notice is *epsomite*. This mineral occurs on both sides of Glen Spencer. It is found as an efflorescence on the edges of the Niagara shales which are protected by overhanging thick beds of dolomite. This salt has arisen from the disintegration of the adjacent dolomitic beds and the action of decomposing pyrites. In various other protected places this efflorescence is seen, but it does not consist of pure *epsomite* being mixed with carbonate of lime, carbonate of iron, sand and clay.

In the five foot bed of dolomite (No. 8) fine cabinet specimens of *selenite* and crystalline *barite* can be obtained. Also massive *gypsum*, handsome crystals of *calcite* (variety of dog-tooth spar), *celestite* and *quartz* in small crystals, as well as *iron pyrites* are found. Many of the cavities when broken open are found to be filled with alkaline waters. In one of the Clinton beds, east of the "Jolly Cut" road, I have found fine red and green crystals of *barite*. However, the handsomest specimens were obtained in Carpenter's Quarry, on lot 7, Range VII, of Barton, not now worked. Fine specimens of crystallized *dolomite* (pearl spar), *calcite* (in large scalene dodecahedrons, and in other modifications of rhombohedrons), *blende*, *pyrites*, *galena*, purple, smoky and yellow *fluorite* in fine cubes, and several forms of *bituminous matter*, both liquid and solid (a variety of which was elastic) were found in considerable quantities filling the cavities of the rock, and often lining what were once crystallites. It was in beds of similar horizon at Beamsville that the galena was found and worked many years ago. The horizon of the beds is from 130 to 145 feet above the base of the Niagara in the neighbourhood of Hamilton.

In numerous places mineral waters are found. These are of two classes—alkaline and sulphuretted waters. Of the former class there are numerous springs along the sides of the escarpment. Similar waters have also been obtained in various wells that have been bored to a considerable depth. One of these wells was bored nearly, or perhaps, quite through the Medina shales at the Ontario Oil Refinery, east of Hamilton. The water of this place, I analysed in 1871.

| | |
|---|---|
| Sodium chloride.... | 2·28 |
| Magnesium chloride | 0·60 |
| Calcium Chloride | 1·67 |
| Potassium chloride | a trace |
| Calcium sulphate | 0·20 |
| Residue | ·10 |
| Water | 94·90 |
| | 99·75 |

Another of these mineral waters was obtained at a depth of 1009 feet in Cambro-Silurian beds from the Artesian well at the Royal Hotel, Hamilton. The following analysis was made in 1870:

| | |
|---|---|
| Sodium chloride | 6·3711 |
| Magnesium chloride | 1·2723 |
| Potassium chloride | traces |
| Calcium chloride | 5·2723 |
| Calcium Sulphate | ·1167 |
| Silica, iron, carbonic acid, iodine and bromine | traces |
| Water | 86·9676 |
| | 100·0000 |

Unfortunately the record of this well was burned, although a little of the saline water still remains in my possession.

Of the second class—sulphuretted waters—we find a few springs, the principal being at Mount Albion, and at Sulphur Springs, Ancaster. One of the old springs near Mount Albion is now dried up. From others in this place the supply of gas has continued to be evolved for many years, and three jets of this gas, essentially sulphuretted hydrogen, are used to light Albion

Mills; the proprietor having built a reservoir of hydraulic cement over the spring. At "Sulphur Springs," Ancaster, the amount of gas is not so large, and the supply is scarcely more than enough to saturate the water, from which the sulphur is precipitated on exposure to the air. In both of these localities the gas arises from decomposing pyrites in the surrounding rocks.

## VIII.—CATALOGUE OF NIAGARA FOSSILS FROM CANADIAN LOCALITIES.

In the following catalogue I have endeavoured to give a full list of all the fossils that have been discovered in the region under consideration. As no extensive Canadian catalogue has been published, I have been compelled to depend largely on my own collection, many species of which have been presented to me by Col. Grant. A few of the included species are not in my collection, having years before been sent away from the region by the collectors, of whom Col. Grant is the most indefatigable. The best collection of *Sponges* and *Stromatopora* is that of Mr. A. E. Walker. Of the former group several species have remained undescribed. Some of the species, including most of the *Graptolite family*, are the TYPE SPECIMENS, descriptions of which are about to be published. Had Col. Grant retained all his own collection, he would have been able, no doubt, to have considerably swelled my list.

The best localities at Hamilton for collecting fossils are at the "Jolly Cut," and in the adjacent openings in the quarries along the sides of the "Mountain," both east and west of this place. Also, in the gorges at the heads of James and Queen streets; at the "Bluff," near the city reservoir; along the Hamilton and North-Western Railway to the summit of the hills; in the ravines near Mount Albion; on lots 4 and 5, Range VII, of Barton, along the Rosseaux Creek; and on lot 15, Range VI, of the same township. At Dundas, the various glens form the best localities, as well as Sydenham road. At Grimbsy the richest fauna is found up the "Ravine," where the fossils are in a better state of preservation than at any other place in our Province. Other localities are at Thorold, Limehouse (on the G. T. Railway), and Rockwood.

## CATALOGUE OF NIAGARA FOSSILS.

| GENERA AND SPECIES. | AUTHORITY AND REFERENCE. |
|---|---|
| *Stromatopora concentrica* .......... | Goldfuss, 1820, Germ. Petref. |
| *Caunopora walkeri* .......... | Spencer, 1882, Niagara Fossils. |
| " *mirabilis* .......... | " " |
| *Coenostoma constellatum* .......... | Hall, 1852, Pal. N. Y. |
| " *botryoideia* .......... | Spencer, 1882, Niagara Fossils. |
| *Dictyostoma reticulata* .......... | " " |
| *Astylospongia praemosa* .......... | Goldfuss, 1880, Petref. Germ. |
| " *sp.* .......... | |
| *Aulocopina granti* .......... | Billings, 1875, Can. Nat. |

### HYDROZOA.

#### GRAPTOLIDÆA.

| | |
|---|---|
| *Phylograptus* (?) *dubius* .......... | Spencer, 1882, Niagara Fossils. |
| *Dendrograptus ramosus* .......... | " " |
| " *simplex* .......... | " " |
| " *dawsoni* .......... | " " |
| " *frondosus* .......... | " " |
| " *praegracilis* .......... | " " |
| " *spinosus* .......... | " " |
| *Callograptus niagarensis* .......... | " " |
| " *granti* .......... | " " |
| " (*Dendrograptus*) *multicaulis*. | " " |
| " *minutus* .......... | " " |
| *Dictyonema retiforme* .......... | Hall, 1852, Pal. N.Y. |
| " *gracilis* .......... | " " |
| " *websteri* .......... | Dawson, 1868, Acad. Geol. |
| " *tenellum* .......... | Spencer, 1878, Can. Nat. |
| *Calyptograptus cyathiformis* .......... | " " " |
| " *subretiformis* .......... | " " " |
| " *micronematodes* .......... | " 1882, Niagara Fossils. |
| " (?) *radiatus* .......... | " " " " |
| *Rhizograptus bulbosus* .......... | " 1878, Can. Nat. |
| *Acanthograptus granti* .......... | " " " |
| " *pulcher* .......... | " 1882, " |
| *Inocaulis plumulosa* .......... | Hall, 1852, Pal. N. Y. |
| " *bella* .......... | Hall & Whitfield, 1874, Pal. Ohio. |
| " *walkeri* .......... | Spencer, 1882, Niagara Fossils. |
| " *problematica* .......... | " 1878, Can. Nat. |
| " *diffusa* .......... | " 1882, Niagara Fossils. |
| " *ramulosa* .......... | " " " " |
| " *cervicornis* .......... | " " " " |
| " *phycoides* .......... | " " " " |
| *Thamnograptus bartonensis* .......... | " " " " |
| " (?) *multiformis* .......... | " " " " |
| *Ptilograptus foliaceus* .......... | " 1878, Can. Nat. |
| *Cyclograptus rotadentatus* .......... | " 1882, Niagara Fossils. |

## ACTINOZOA.

### TABULATA.

*Favosites niagarensis*............ ............Hall, 1852, Pal. N.Y., Vol II.
" *favosus*.................................Goldfuss, 1826, Germ. Petref.
*Astrocerium* (*Favosites*) *constrictum*..Hall, 1852, Pal. N.Y., Vol. II.
*Syringolites huronensis*.............Hinde, 1879, Geol. Mag.
*Cladopora multipora*...............Hall, 1852, Pal. N.Y., Vol. II.
*Striatopora flexuosa*................ " " " "
*Halysites catenulatus*...............Linnæus, 1767, Syst. Nat.
*Syringopora verticillata* (?) .... ....Goldfuss, 1826, Germ. Petref.

### RUGOSA.

*Cyathophyllum radiculum*.........Rominger, 1876, Fos. Corals in Geol. Mich., Vol. III.
*Omphyma stokesi*..................Milne-Edwards, 1876, Fos. Corals in Geol. Mich., Vol. III.
*Petraia Streptelasma calycula*......Hall, 1852, Pal. N.Y., Vol. II.

## ECHINODERMATA.

### ASTEROIDEA.

*Petaster bellulus*.....................Billings, 1865, Pal Foss., Vol I.

### CRINOIDEA AND CYSTOIDEA.

*Lyriocrinus dactylus*..................Hall, 1852, Pal. N.Y., Vol. II.
*Thysanocrinus liliiformis*........ .... " 1852, " "
*Eucalyptocrinus decorus*...........Phillips, 1829, Murch. Sil. Syst.
*Stephanocrinus angulatus*.... ......Conrad, 1842, Jour. Acad. Nat. Sc.
*Caryocrinus ornatus*..... ........Say, 1825, " "

### POLYZOA.

*Ceramopora foliacea*.. ..............Hall, 1852, Pal. N.Y., Vol. II.
*Clathropora* (?) *gracilis* ...........Spencer, 1882, Niagara Fossils.
*Fenestella elegans*...................Hall, 1852, Pal. N. Y., Vol. II.
*Polypora* (*Fenestella* ? ) *albionensis*..Spencer, 1880, Niagara Fossils.
*Lichenalia concentrica*.............Hall, 1852, Pal. N.Y., Vol. II.
*Trematopora osteloata*............ " " " "

## BRACHIOPODA.

### SPIRIFERA.

*Spirifera crispa* ..... ..............Hisinger, 1826, Act. Acad. Nat. Sc.
" *niagarensis*.... ...........Conrad, 1842, Jour. " "
" *radiata* ...................Hisinger, 1857, Petref. Suecica.
" *sulcata*...................Sowerby, 1825, Min. Concl.
" *plicatella*, var *radiata*.....Hall, 1867, 20th Regent's Report.
*Atrypa reticularis*.. ...............Linnæus, 1767, Syst. Nat.
*Athyris* (*Meristina*) *nitida*...........Hall, 1852, Pal. N.Y., Vol. II.

### RHYNCONELLIDAE.

*Rynconella neglecta*.................Hall, 1852, Pal. N.Y., Vol. II.
" *obtusiplicata*............. " " " "
" " var........... " " " "
" *rugosa*................ " " " "
*Pentamerus oblongus*...............Vanuxem, 1842, Geol. 3 Dist. N.Y.
*Sricklandinia canadensis*...........Billings, 1859, Can. Nat.

STROPHOMENIDAE.

*Strophomena profunda*..............Hall, 1852, Pal. N.Y., Vol. II.
" *rhomboidalis*..........Wallenberg, 1821, Act. Soc. Sci. Upsala.
*Strophodonta semifasciata*..........Hall, 1863, Trans, Alb. Inst.
*Streptorhyncus tenuis*.............. " 1858, " "
*Leptena transversalis*..............Dalman, 1827, Kongl. Vet. Acad. Hanal.
*Orthis elegantula*..................Dalman, " " "
" *flabellelum* .................Hall, 1843.
" *porcata*..... ..............McCoy, 1846, Sil. Foss. of Ireland.

CRANIADÆ.

*Crania anna* ....................Spencer, 1882, Niagara Fossils.

DISCINIDAE.

*Discina tenuilamellata*.............Hall, 1852, Pal. N.Y., Vol. II
" *clara*......................Spencer, 1882, Niagara Fossils.

LINGULIDEA.

*Lingula oblonga*..................Conrad, 1839, Ann. Rep. N.Y.
" *lamellata*................Hall, 1852, Pal. N.Y., Vol. II.
" *ingens* ... ..............Spencer, 1880, Niagara Fossils.

LAMELLIBRANCHIATA.

*Avicula emaccrata*................Conrad, 1842, Jour. Acad. Nat. So.
*Pterinea brisa*...................Hall, 1867, 20th Regent's Rep. N.Y.
*Posodonomya rhomboidea*.......... " 1852, Pal. N.Y., Vol. II.
*Modiolopsis subalata*.............. " " " "
" sp.................. " " " "

GASTEROPODA.

*Platyostoma niagarensis*..... .....Hall, 1852, Pal. N.Y., Vol. II.
*Lonoxema leda*.................. " 1867, 20th Regents Rep., N.Y.
*Pleurotomaria clipeiformis* .........Spencer, 1882, Niagara Fossils.

PTEROPODA.

*Conularia niagarensis*..............Hall, 1852, Pal. N.Y., Vol. II.
" *magnifica*...............Spencer, 1879, Can. Nat.
" *rugosa*............ . " 1882, Niagara Fossils.

CEPHALOPODA.

*Orthoceras virgatum*..............Sowerby, 1839, Murch. Sil. Syst.
" *annulatum* ..... ...... " 1818, Min. Concl.
" *simulator* .............Hall, 1876, 28th Reg. Rep. N.Y.
" *crebescens* (?)......... " 1867, 20th " "
" *bartonense*.............Spencer, 1882, Niagara Fossils.
*Cyrtoceras reversum*. ............. " " "
*Lituites niagarensis*.. ............. " " "

ANNELIDA.

*Cornulites flexuosus*................Hall, 1852, Pal. N.Y., Vol. II.

CRUSTACEA.

TRILOBITA.

| | |
|---|---|
| *Illaenus barriensis* | Murch. 1839, Sil. Syst. |
| *Encrinurus ornatus* | Hall, 1852, (vid Cybele punctata). |
| *Sphaerexochus romingeri* | " 1867, 20th Reg. Rep. N.Y. |
| *Calymene blumenbachii* | Brongniart, 1822, Hist. Nat. Const. Foss. |
| *Homalonotus delphinocephalus* | Green, 1832. |
| *Dalmanites limulurus* | " " |
| *Lichas boltoni* | Bigsby, 1825, Jour. Acad. Nat. Sc., |
| *Acidaspis halli* | Spencer, 1880, Niagara Fossils. |

EURYPTERIDÆ.

| | |
|---|---|
| *Pterygotus Canadensis* | Dawson, 1879, Can. Nat. |

APPENDIX.

Besides the previous catalogues of fossils found in the different formations of the Niagara Group in Canada, Messrs. Nicholson and Hinde have obtained the following species:

CLINTON.

| | |
|---|---|
| *Scolithus verticalis* | at Dundas. |
| *Arenocolites sparsus* | " |
| *Planolites vulgarus* | " |
| *Stromatopora lundii* | at Owen Sound. |
| *Zaphrentis stokesi* (?) | " " |
| *Chætetes fletcheri* | at Dundas. |
| *Phænopora ensiformis* | " |
| *Ptilodictya crassa* | " |
| " (?) *raripora* | " |
| " *punctata* | " |
| *Leptocœlia planoconvexa* | " |
| *Orthis calligramma* | " |
| *Leptaena sericea* | " |
| *Tentaculites neglectus* | " |
| *Glyptocrinus plumosus* | " |

NIAGARA.

| | |
|---|---|
| *Stromatopora hindei* | at Owen Sound. |
| *Heliolites interstincta* | " " |
| *Favosites venusta* | " " |
| " (?) *multipora* | " " |
| " *dubia* | " " |
| *Cœnites (Limaria) laminata* | " " |
| " *lunata* | " " |
| *Alveolites fischeri* | " " |
| " *niagarensis* | at Richmond. |

| | |
|---|---|
| *Astræophyllum gracile*......... | at Owen Sound. |
| *Caunopora annulata*. ......... | " " |
| *Syringopora retiformis*......... | " " |
| *Zaphrentis Roemeri*..... ..... | " " |
| *Cystiphyllum vesiculosum* ...... | at Thorold. |
| *Petraia pygmæa*.............. | " |
| *Diphyphyllum cæspitosum*...... | " |
| *Clathopora fondosa*............ | " |
| " *intermedia* ...... | " |
| *Retepora asperato-striata*....... | " |
| *Trematopora osteolata* ......... | at Niagara River. |
| *Fenestella tenuiceps* ..... ...... | " " |
| *Athyris intermedia*.... ....... .... | " " |
| *Strophomena subplana*..... ... | at Thorold. |
| *Orthis biforata* ............... | " |

In the catalogue above-named we find 34 species of Clinton and 49 of Niagara fossils, collected by Messrs. Nicholson and Hinde, of which the above 39 species have not been obtained by me, or in so poorly preserved condition as to be rejected from my cabinet. In the catalogue the names of fossils are not usually placed in two formations, but only in that where they more generally occur.

In the catalogue of the fossils of the Medina, Clinton and Niagara, given here, there will be found 121 species of Niagara and 53 of Clinton and Medina, of which only a few species are repeated in the lists. The principal omissions in my cabinet are in the poorly preserved specimens of the Clinton, at Dundas, and in the species found at Thorold and Owen Sound. Neither of the lists includes 13 species of annelid jaws, recently described by G. J. Hinde, Esq.

---

## APPENDIX A.

### *Catalogue of Fossils of the Hudson River Formation, found in the Old Beaches at the western end of Lake Ontario.*

The study of the occurrence of these fossils belongs, strictly speaking, to the Drift, which will be described in a subsequent paper. From the Palæontological point of view, they are more interesting in connection with this portion of the study of the Geology of the Region about the Western End of Lake Ontario than in that of the Surface Geology.

The following is a list of the fossils which I have obtained in considerable quantities from the fossiliferous pebbles of both the ancient and modern beaches in the region of Hamilton:

*Stenopora fibrosa*, Goldfuss.
*Columnaria alveolata*, Billings.
*Athyris headi*, Billings.
*Strophomena alternata*, Conrad.
*Strophomena deltoidea*, Conrad.
*Leptæna sericea*, Sowerby.
*Orthis testudinaria*, Dalman.
*Orthis occidentalis*, Hall.
*Orthis lynx*, Eichwald.
*Obolella crassa*, Hall.
*Modiolopsis modiolaris*, Conrad.
*Modiolopsis* ——— (several undermined species).
*Cyrtodonta harrietta*, Billings.
*Orthonota* ———
*Ctenodonta* ———
*Lyrodesma poststriata*, Emmons.
*Ambonychia radiata*, Hall.
*Avicula demissa*, Conrad.
*Murchisonia gracilis*, Hall.
*Cyrtolites ornatus*, Conrad.
*Orthoceras lamellosum*, Hall
*Ormoceras crebiseptum*, Hall.
*Leperditia canadensis*, Jones.

---

## APPENDIX B.

Since writing the Report on the Palæozoic Geology of the Region about the Western End of Lake Ontario, I have observed that Dr. Hunt, in his Report on the Canadian Petroleum Regions of Canada (1863-66), gives the log of a well sunk on the eleventh lot of the seventh range of Barton, which is as follows:

| | | |
|---|---|---|
| Limestones with a little shale........ | 250 | feet |
| White sandstone........ .... ....... | 5 | " |
| Red shales with bluish bands......... | 595 | " |
| Bluish and grayish shale............. | 23 | " |
| | 873 | " |

The location of this well is about two and a half miles southward of the brow of the "Mountain" at Hamilton. The upper 250 feet include both the Niagara and Clinton formations, which measurement is almost precisely the same as the thickness of these strata ascertained by measurement at Dundas. Consequently, we may consider the summit beds in both places as nearly identical, whilst the beds at Carpenter's Limekilns, not much more than a mile distant from the Barton well, are geologically and geographically higher than at its mouth, but geographically lower than the inferior beds at Dundas, on account of the dip of the strata.

The five feet of sandstone constitute the prevailing "Gray Band" of the Medina formation.

The thickness of the Medina shales appears to be 595 feet. I have placed the thickness of the Medina shales at 535 feet; this being derived from the record of the well at Dundas, where they are underlaid by "limestones and grits," whilst in the Barton well the *red shales* are underlaid by "bluish and grayish shales," which probably belong to the Hudson River group.

It must be remarked that the Dundas well is not far beyond the turn in the bend of the Niagara escarpment, which I have designated by the name of ancient Cape Dundas. In the previous Report attention has been frequently called to the fact that all the shaly deposits decrease, and those which are calcareous increase the moment that we pass around the provisionally called Cape Dundas. In proceeding northward the Medina shales thin out and are last seen at Cabot's Head, and, according to Dr. Bell, are entirely absent from the series in the Manitoulin Island. Therefore this difference of about 60 feet is one of thickness and not of error. It was also noticed that in proceeding south-westward towards Ohio, that the Medina shales almost entirely disappear.

Had I known of the existence of the well in Barton at the time that I took the levels over the adjacent localities, it would have given an additional point for correcting the estimate of the dip. The altitude of the place, about a quarter of a mile north-east of the well, is 435 feet above Lake Ontario, while at a quarter of a mile to the eastward, it is 424 feet, on a surface of rocks. Calculating from these data, the dip would be between 22 and 27 feet in a mile, but as the well is between these two points, we can retain our old estimate of 25.4 feet in a mile, having a direction of 20 degrees west of south.

# THE GEOLOGY OF ST. IGNACE ISLAND, LAKE SUPERIOR.

By Charles Robb,

Mining Geologist, Montreal.

(*Read before the Natural History Society, Feb.* 27, 1882.)

The region bordering on the North or Canadian Shore of Lake Superior is daily rising into importance both in a scientific and practical and, I may add, in an æsthetic point of view; affording, as it does, ample scope for the investigations of the geologist and naturalist, the explorations and operations of the miner, and the delectation of the tourist and artist in search of health and of the picturesque in nature. Not very many years ago this region was regarded as remote and almost inaccessible; but the modern facilities for travel, and the ever active and expansive growth of commerce and civilization, are rapidly bringing it within the reach of all; and a new interest has very recently been added to it, by the fact that the Canada Pacific Railway will, it is hoped, within a few years be constructed along, or near its shores. Already the South Shore of this great lake, for a considerable part of its extent, is occupied by a numerous, thriving and rapidly increasing population. It is to be feared that our side, in consequence of numerous and insurmountable natural obstacles, can never compete with the American in that respect; but, notwithstanding the extremely rugged and sterile nature of the country, enough remains in its mines and fisheries, and in its grand and beautiful natural features, to make it a place of great interest and importance.

During the course of last summer I had occasion to visit professionally and spend about three months on the Island of St. Ignace, one of the largest of the out-lying islands on the North Shore, where I was engaged with a small party in mining explorations, or rather in searching for mineral veins which might serve as a basis for mining operations, on a ten square mile location, lying at the south-eastern extremity of the island, and belonging to the Quebec and Lake Superior Mining Association of this

The paper was illustrated by maps and numerous specimens.

city. Partly to aid in the object of my visit and partly with the idea that it might be interesting in a scientific point of view, I took occasion to make a somewhat minute and careful geological and topographical examination of the coasts of the location, which are, in fact, almost the only parts available or accessible for such a purpose; and I have thought the results might be of sufficient interest to lay before this Society, having been invited and encouraged by our worthy president, Dr. Dawson, to do so. So far as I am aware, no minute or detailed examination has hitherto been made of this island, or indeed of any part of the North Shore of Lake Superior. Many important points in regard to its structure are involved in considerable obscurity from the want of such details; and I hoped that my humble efforts might serve as a contribution, however slight, to such knowledge, and as an addition to the general stock of information on the subject.

The Island of St. Ignace is, as already stated, one of the three largest on Lake Superior; the largest, Isle Royale, is on the American side, or at least claimed by and conceded to the State of Michigan, and the other two, Michipicoten and St. Ignace, are very nearly the same size, or about 16 miles long by 8 miles in width, or 128 square miles area. The Island of St. Ignace fronts the mouth of the Nipigon River, being separated therefrom by a wide bay or channel; and is distant about 230 miles from Sault St. Marie, at the eastern end of the Lake, which is here nearly 100 miles wide. In approaching St. Ignace from the east, one is at once struck, at the distant view, with the change from the somewhat tame and monotonous contour of the Laurentian and Huronian hills, to the extremely rugged and picturesque outlines of the Volcanic Mountains; and a closer inspection suffices to show these features in all their wild grandeur. Being still, for the most part, unexplored and very rarely visited, and being entirely devoid of human occupants, it is almost in a wilderness condition, and is exceedingly rough, rocky and mountainous, and being, moreover, densely covered with timber, underbrush, matted roots, moss, etc., it is very difficult to penetrate into the interior. The coast is also much exposed to the storms from the lake, and is generally fringed with steep rocky cliffs, rising abruptly from the deep waters of the lake, but varied frequently by bays and beaches; and the numerous small islands and projecting promontories existing along its southern shores afford occasionally deep and sheltered harbors, although, by reason of the sunken rocks, much caution and vigilance have to be exercised in approaching them by boats. The camping ground which was selected by me, towards the south-eastern end of the location, is a good example of one of these harbors, and is in fact the only safe one on the place.

The geological structure of this part of the island (and I believe it is nearly the same throughout) is extremely simple, and will be readily understood. A deep bay running north and south, (St. Ignace Bay) and forming the eastern boundary of the location, cuts the rocks transversely and affords an excellent natural section. The rocks belong to what is designated by Sir William Logan the upper group of the Upper Copper-bearing Rocks of Lake Superior, corresponding to the Keeweenian Formation of Dr. Hunt; and are regarded by Sir William as the equivalents of the metalliferous rocks of the Eastern Townships of Lower Canada, which he has denominated the Quebec Group of the Lower Silurian system. They form part of the same series in which the great native copper mines of the South Shore of the Lake have been opened up; and there seems no reason to doubt that they are of volcanic origin. The rocks of the location under notice are probably at the extreme upper part of the formation.

The prevailing rock of the country is a granular amygdaloid trap or melaphyre,* consisting of a small-grained mixture of dark brown feldspar, with angular grains of dark-green chloritic mineral, probably delessite. It varies frequently in its structure, and the upper part, to which this notice refers, contains amygdules, or small spherical masses or nodules of calcspar and delessite. To this it may be added that quartz, chiefly in the form of agate, jaspar and amethyst, is of frequent occurrence in the amygdules, as also epidote, prehnite and laumontite, with various zeolite minerals. It is to this rock also that the metals would seem chiefly to belong; such as copper and silver, both native and sulphuretted, also magnetic and specular iron; although workable deposits of these metals are only to be looked for in veins traversing the rocks, or at the planes of junction between them and another description of rock; and it is to be remarked that the vein stones are always composed of the same minerals as are found in the amygdules.

---

* According to the description given by Mr. Thomas Macfarlane, of corresponding rocks occurring at Mamainse. See this Journal, Vol. VII

The amygdaloid trap, although not of sedimentary origin, in the ordinary acceptation of the term, is regularly bedded, having a very distinct dip to the south, at an angle of about 13°; and is overlaid, at numerous points, by a compact, very hard and heavy, finely-crystalline trap or greenstone, or it may be diabase or basalt. Which of these is the more correct term, I confess I am not sufficient of a mineralogist to determine, nor could it be accurately determined without an analysis. It is probably composed of the same mineral ingredients as the body of the amygdaloid trap, but with a very different texture and appearance; and is entirely devoid of the characteristic amygdules or small rounded masses of foreign minerals which occur so copiously in the other rock. This overlying rock is, I believe, that which, by the South Shore miners, is always designated as *Greenstone*, and it is there well understood that it is generally at or near its junction with the underlying amygdaloid trap that the productive metalliferous veins or deposits are to be found. In the present case it overlies the amygdaloid in numerous isolated knobs, patches and ribs, distributed along the eastern shore of the location, and some of the small outlying islands, standing out in bold precipitous bluffs and precipices, sometimes about 100 feet high, plunging into the deep waters of the lake; the intervening spaces being excavated by the waves into deep bays terminated by gravel beaches.

In some instances the masses of crystalline trap or greenstone are abruptly terminated downwards, at or very near the level of the lake; and their planes of junction with the amygdaloid are distinctly visible at that point, maintaining the regular dip of the amygdaloid beds, although the greenstone itself shows no tendency to a bedded structure. In other instances there appears to be a sort of passage between the two—I mean only in so far as their distinctive mineral characters are concerned. In two places the greenstone assumes a basaltic columnar structure both vertical and horizontal; and the surfaces of the rocks are there sometimes found to be coated with pitchstone, or perhaps the rare mineral tachylyte, as suggested to me by Dr. Harrington.

By reason of the hardness and extremely refractory nature of the crystalline trap, the masses exposed on the shores of St. Ignace Bay stand up conspicuously above the general level of the amygdaloid, with steep mural faces to the north; forming ridges running inland in a due westerly direction, conformably with the strike of the amygdaloid beds. I had no opportunity of observing, in most instances, how far they extend inland; but in two cases they are distinctly terminated at a very short distance from the shore—the serrated and indented aspect of which is doubtless due to the resisting qualities of the harder rock acting like the enamel on a tooth. With perhaps two exceptions which I shall proceed to notice, the crystalline trap masses cannot be regarded as intrusive, as supposed by Sir William Logan, at least not at this place. The impression conveyed to my mind by the whole phenomenon—if I may be allowed to theorize—was that the materials of the amygdaloid had been first ejected in the form of volcanic mud or ashes, and thereafter overflowed by a fluid current of molten matter of nearly the same chemical constitution, but very different mechanical properties, filling up cracks, fissures and depressions in the original surface, and thereafter denuded, leaving only such portions as we now find in the form I have attempted to describe.

One very notable exception (or perhaps two) to this arrangement has to be remarked. I refer to the existence of a great dyke of the same hard crystalline trap, undoubtedly penetrating the amygdaloid in a nearly vertical direction to an indefinite depth, and also extending indefinitely inland to the west, parallel to the strike, in a perfectly straight line, and preserving a uniform thickness of about sixty feet. It is of a transversely horizontal columnar or rather sub-columnar structure, the columns lying truly at right angles to the direction of the dyke, and dipping south at an angle of 7°, or exactly at right angles to its downward direction, which deviates to this extent from the perpendicular. The dyke juts out boldly into the deep waters of St. Ignace Bay about the centre of the location; and, no doubt, together with the hardness of the adjacent masses of crystalline trap, has been the cause of the existence of the great projecting cape of amygdaloid to the north, by protecting it from the wasting action of the waves. It is flanked on either side by veins of a remarkably promising character for silver and copper; the vein-stone, which is entirely different from the inclosing rocks, although containing fragments of them, being composed of quartz, calcareous spar, baryta, laumontite, prehnite and much chloritic matter, together with garnets, native silver in very fine loose particles, and vitreous copper ore. It was to these veins, after discovering them, that I chiefly directed my attention in connection with the main object of my visit to the island, but the details of these operations I do not propose to describe on the present occasion.

This dyke may have been filled, like the other crystalline trap masses, from above; but I am more inclined to the opinion that it was injected or intruded from below, and may, in fact, have been the vent from which the others were supplied; for which latter opinion I have some special reasons which I shall submit further on. There is another somewhat similar, but evidently much less important dyke, occurring near our camping ground, and running in an entirely different direction, but it is unnecessary now to do more than merely mention its existence.

Towards the southern end of the location, and also in one of the small outlying islands, red sandstones, breccias and conglomerates appear to overly the amygdaloid in small detached patches; but I have no doubt that these mark only the basset edge or northern extremity of a great mass or stratum of the same character, forming the bed of the lake and extending indefinitely southwards under it. Associated with these at the locality under notice occur enormous masses of porphyritic trap, to which, as being a rather remarkable rock both for its scientific or geognosic interest and for its beautiful appearance, especially when polished, I desire to direct your special attention. Although not apparently a bedded or even a jointed rock, it occurs interlaminated with the red sandstones, or at least distinctly overlying them in regular planes of junction, conforming with the dip of the sandstone, which is 30° to 40° to the south It is also seen at one place conspicuously to overlie the amygdaloid (which here dips at the same higher angle) conformably at or near the water level, at the base of a high beetling cliff of the porphyry, the significance of which facts I shall presently proceed to explain. The same rock occupies uninterruptedly, for about two miles, almost the entire southern limits of the location, forming a succession of bold headlands fronting on Lake Superior; and is succeeded in going west by the underlying red breccias.

From these facts, I think it will undoubtedly be obvious that the porphyry belongs to, and is newer than the sandstones and amygdaloids lying to the north of it.

These rocks I take to be the same as those described by Dr. T. Sterry Hunt, in his able "Report on the Trap Dykes and Azoic Rocks of South-Eastern Pennsylvania, 1878," which are by him stated to be highly characteristic of the Huronian series, and his description seems to me to be so exactly applicable to the present case, that I shall take the liberty of quoting it, together with a summary of his inferences and conclusions; although my own deductions may be somewhat at variance with his as to their relations with the surrounding rocks.

In the above-mentioned Report, page 192, Dr. Hunt says:

"Felsites and felsite-porphyries are well-known in eastern Massachusetts, and may be traced from Macchias and Eastport in Maine along the southern coast of New Brunswick to the head of the Bay of Fundy, with great uniformity of type, although in every place subject to considerable variations, from a compact jasper-like rock to more or less coarsely granular varieties, all of which are often porphyritic from feldspar crystals, and sometimes include grains and crystals of quartz. The colors of these rocks are generally some shade of red varying from flesh-red to purple; pale-yellow, gray, greenish and even black varieties are, however, occasionally met with. These rocks are throughout this region distinctly stratified, and are closely associated with dioritic, chloritic and epidotic strata. They apparently belong, like these, to the great Huronian series."

Again, speaking of the same rocks, at page 193, he says:

"These were compared with the similar strata along the Atlantic coast, from Rhode Island to New Brunswick, interstratified with rocks having the characters of the Huronian series, to which great division I have provisionally referred these bedded petro-silex rocks, with the suggestion that they probably occupy a position near the base of the series. These rocks were declared to be identical in lithological characters with the *Halleflinta*, or stratified flint-rock of the Swedish geologists, which is by them assigned to a horizon just above the more ancient or Primitive Gneiss; and are important, as including in Norway, the most considerable deposits of crystalline iron ores. These same rocks are met with in various localities in the Huronian series, on the Upper Lakes, and are well displayed, as observed by the writer, in a small island lying a little to the south of St. Ignace Island, and for some distance along the shore to the adjacent mainland to the southwest. Epidote, chlorite and a steatitic mineral are occasionally met with in these petro-silex rocks, and magnetic and specular oxyds of iron occur disseminated, in interstratified masses and in veins intersecting the strata."

Again, at pages 229 and 232, he says:

"The reader is now prepared to understand the significance of the question raised by the writer in 1871, as to the existence of the felsite or petro-silex porphyries in place in the Lake Superior region; since these rocks, which had then been found by him to belong to the

Huronian series, occur in pebbles in the conglomerates of the Upper Copper-Bearing series. Besides the locality already mentioned," (the Albany and Boston Mines) "the great cupriferous bed of the Calumet and Hecla Mine is a remarkable example of a rock made up almost wholly of the ruins of these peculiar petro-silexes. In 1872, as already described, he found these rocks *in situ* on the north shore of Lake Superior."

Referring to the small island, lying a little to the south of St. Ignace, he further states at page 232:

"These rocks, from the lithological descriptions given, including the microscopic characters, and the results of chemical analysis, are evidently identical with the orthofelsites or petro-silex poryphyries previously described by the writer as characteristic of the Huronian series along the Atlantic coast, etc. They are the same with those discovered by him on the north shore of Lake Superior, and which enter so largely into the cupriferous conglomerates of the Keeweenian series, on the south shore of the lake."

My inference from Dr. Hunt's remarks is, that he undoubtedly regarded these porphyries, even where they occur "on a small island lying a little to the south of St. Ignace," as belonging to the Huronian formation, and even to the base of that series. The island referred to obviously occupies the same geological position and may even be in the same area as that described by me, but I think we have positive and conclusive proof in the facts which I have adduced, that the latter are associated with and overlie the great Upper Copper-Bearing or Keeweenian group, which, according to Dr. Hunt's determinations, overlies his Taconian and Montalban terrains. And if this peculiar rock can be shown *not* to be exclusively characteristic of the Huronian, we need not, perhaps, go so far down in the geological series as to that horizon to seek for the origin of the pebbles in the Calumet and Hecla conglomerates; and, if my deductions are correct, they may similarly affect many determinations cited on the highest authority. Even if we had no direct evidence of the superposition of the porphyries on the amygdaloids and conglomerates, the fact that the latter, at this place, contain *no pebbles* of the porphyry is, in my view, a strong corroborative proof of the more recent age of the porphyry. If these rocks are Huronian, there must be an interval, according to Dr. Hunt's own figures, of at least 50,000 or 60,000 feet of strata between them and the rocks with which they are so intimately associated. This could hardly be accounted for by a fault, even if the relative conditions of the rocks could lend any countenance to such a theory, which they do not. May not this, I would respectfully ask, be an instance of the danger of yielding undue prominence to lithological characteristics in determining the comparative age of rocks, in the absence of stratigraphical or palæontological evidence?

Some of the high lands in the interior of the location are composed of a different and probably much more recent description of eruptive or volcanic rocks than any of those described. Thus at a point about two miles from the southern and one mile from the eastern boundary (or lake shore), a mountain of trachyte or phonolite rises to an altitude of from 800 to 1000 feet, in which there occurs a remarkable rift or cavity, evidently connected with the dykes or veins which traverse the subjacent rocks, thus proving that the origin of these latter is of a more recent date than that of all the rocks through which they have penetrated. I should add here, *en parenthèse*, that besides the great dyke and associated mineral veins which I have noticed as occurring here, there are distinct traces of the former existence of a great parallel vein, or set of veins immediately to the south, which, by breaking up the continuity of the rocks and thereby weakening them, have given rise to the remarkable deep bay lying immediately to the south.

I have referred to a line of weakness and probable rupturing of the rocks eastwards from the great rift, fissure or crater in the trachyte mountain, giving origin to the deep peculiar shaped bay, which I have called Mines Bay. If we trace the same line still further eastwards to the other side of the bay, we find a deep narrow channel between the south end of Harrison's Location and Bead's Island to the Chenal Ecarté, running up from Lake Superior to Nipigon Bay. This narrow channel probably owes its origin to the same cause, namely, the weakness of the rocks forming its bed; and we may also observe that the same metalliferous veins which have been discovered and partially explored on Harrison's Location, correspond in position and direction with those which I have recently discovered, without being aware of this relation, on the main land of St. Ignace.

The intervening great bay has evidently been scooped out by a glacier, as the glacial striae are exceedingly well marked and conspicuous, running exactly parallel with the direction of the axis of the bay; and they are more strikingly displayed on the hard porphyry rocks than on the softer amygdaloids; this being, no doubt, due to the more resisting character of the former.

## Notice of a Memoir on Glaciers and Icebergs in relation to Climate, by Dr. A. J. Von Wœickoff. (In the Proceedings of the Geological Society of Berlin, 1881.) With remarks by Principal Dawson, F.R.S.

This memoir presents a very clear statement of the physical causes and conditions of the accumulation and distribution of snow and ice in different parts of the world, in illustration of the possibility of the existence of continental glaciation in the Pleistocene age. The following is a free translation of the author's summary of his conclusions, which though sufficiently trite as matters of physical geography, are deserving of repetition at a time when the principles of that science are treated with so great contempt by certain schools of glacialists.

1. The presence of water tends to moderate the extremes of temperature both in *place* and in *time*.

2. It does this, both by virtue of its great capacity for heat, and by its cooling and heating powers when passing from the solid into the liquid and gaseous states, and the reverse.

3. These effects extend widely in place and time. For example, near the south pole, the higher strata of air are warmed by the abundant congelation of vapour into snow, and the snow having fallen and having been changed into the ice of glaciers and icebergs, is in that condition carried far to the north, and hundreds of years after it has fallen as snow, is active in cooling the ocean and the air as far north as the latitude of 40°.

4. The general effect of the changes of condition of water, along with the resulting formation of clouds and mists, is to raise the temperature of winter and to depress that of summer.

5. The currents of the ocean have an especially great influence in the mitigation of the extremes of temperature, the direct effect of which is much greater than that of the winds.

6. The winds appear to act mainly in diffusing the temperature of the ocean currents.

7. Though the winds may be in the first instance the motive power of the main oceanic currents, yet the effects of the distribution of land and of the form of the sea-bottom become paramount in influencing these when once set in motion.

8. At the present time, the distribution of the trade-winds and monsoons is such as to divert a large quantity of warm equatorial water into the northern hemisphere, producing an excess of warmth above that of the S. Hemisphere between latitudes 40° and 59° N.

9. This effect is intensified by the narrowing of the seas to the north, and is of course especially felt on the western sides of the continents.

10. Not only does the Southern Hemisphere thus lose a large share of its warm water, but the effect of the remainder is dissipated by being spread over a vast expanse of sea.

11. This great expanse of ocean in the Southern Hemisphere is favourable to the deposit of snow and formation of glaciers, by furnishing a great evaporating surface, and at the same time a low general temperature facilitating precipitation. This applies to the Antarctic continent, and also permits the formation of glaciers far to the north in New Zealand and in South America.

12. On the other hand the present condition of the Northern Hemisphere is unfavourable to glaciers, because the sea is so warm that deposition near the coasts is rather as rain than snow up to pretty high latitudes, while the continents are so wide that there is little precipitation in their interior.

13. Thus there are no glaciers in Eastern Siberia, even in the mountains, where the mean temperature is only 15° to 16° C., and Central Asia generally is unfavourable to glaciation on account of its dryness, while Eastern Asia is acted on by the monsoons. If, therefore, the extent of land in Asia has not materially changed since the Pliocene period, there could not have been great glaciers there since that period. Even the submergence of the great plain of China could not materially affect this result, though it might cause glaciers in the mountains of Japan.

14. To explain the great Post-pliocene glaciers, of which traces are found in Western Europe, it is necessary to suppose that the temperature was lower, either on account of submergence of the low lands or of diversion of warm currents, or both causes may have operated. A submergence connecting the White and Baltic Seas would greatly promote the production of snow and ice. But this could not affect the interior of Russia or of Asia, so long as their plains remained above water.

15. The submergence of the plains must be a necessary condition of the general glaciation of the higher lands.

16. Astronomical changes do not affect this result. With a great eccentricity of the orbit and the winter in aphelion the colder winters and hotter summers would produce more powerful monsoons, while on the opposite condition the interior of the continents would have warmer winters and cooler summers and weaker monsoons. In either case the conditions for continental glaciers would not be improved.

17. These considerations show that general coverings of ice stretching from the Pole to perhaps 45° are impossible. Under conditions of submergence of the plains the sea must keep open, in order to afford material for snow on the remaining high lands, and with large continental plains the climate will be too dry for glaciers. Thus there must always be seas free from ice, or continental plains free of ice, and under most supposable conditions there must be both.

Applying these very simple geographical truths to the North American continent, it is easy to perceive that no amount of refrigeration could produce a Continental glacier, because there could not be sufficient evaporation and precipitation to afford the necessary snow in the interior. The case of Greenland is often referred to, but this is the case of a high mass of cold land with sea mostly open on both sides of it, giving, therefore, the conditions most favourable to precipitation of snow. If Greenland were less elevated, or if there were dry plains around it, the case would be quite different; as Nares has well shown in the case of Grinnel land, which in the immediate vicinity of Greenland presents very different conditions as to glaciation and climate

If the plains were submerged and the Arctic currents allowed free access to the interior of the continent of America, it is conceivable that the mountainous regions remaining out of water should be covered with snow and ice, and there is the best evidence that this actually occurred in the glacial period; but with the plains out of water, there could never have been a sufficiency of snow to cause any general glaciation of the interior. We see evidence of this at the present day in the fact that in unusually cold winters the great precipitation of snow takes place south of Canada, leaving the north comparatively bare, while as the temperature becomes milder the area of snow deposit moves further to the north.

The writer of this note has always maintained these conclusions on general geographical grounds, as well as on the evidence afforded by the Pleistocene deposits of Canada, and he continues to regard the supposed evidence of a terminal moraine of the great Continental glacier as nothing but the southern limit of the ice-drift of a period of submergence. In such a period the southern margin of an ice-laden sea where its floe-ice and bergs grounded, or where its ice was rapidly melted by warmer water, and where consequently its burden of boulders and other debris was deposited, would necessarily present the aspect of a moraine, which by the long continuance of such conditions might assume gigantic dimensions.

In the recent remarkable work on glaciers by Messrs. Shaler and Davis, it is apparently maintained that in North America a continental glacier extended in temperate latitudes from sea to sea, and this glacier must, in many places at least, have exceeded a mile in thickness. Independently of the physical difficulties attending the movement of such a mass without any adequate slope, difficulties with which the authors endeavour to deal, though not very satisfactorily, it is obvious, from the considerations above stated, that the amount of snow necessary to the production of such a glacier could not possibly be obtained. With a depression such as we know to have existed, admitting the Arctic currents along the St. Lawrence Valley, through gaps in the Laurentian watershed, and down the great plains between the Laurentian areas and the Rocky Mountains, we can easily understand the covering of the hills of eastern Canada and New England with ice and snow, and a similar covering of the mountains of the west coast. The sea also in this case might be ice-laden and boulder-bearing as far south as 40°, while there might still be low islands far to the north, on which vegetation and animals continued to exist. We should thus have the conditions necessary to explain all the anomalies of the glacial deposits. Even the glaciation of high mountains south of the St. Lawrence Valley would then become explicable by the grounding of floe-ice on the tops of these mountains when reefs in the sea. The so-called moraine, traceable from the great Missouri coteau in the west, to the coasts of New Jersey, would thus become the mark of the southern limit of the subsidence, or of the line along which the cold currents bearing ice were abruptly cut off by warm surface waters.

Whatever difficulties may attend such a supposition, they are small compared with those attendant on the belief of a continental

# REPORT ON THE PETER REDPATH MUSEUM OF McGILL UNIVERSITY.

*Prepared by* PRINCIPAL DAWSON *for the first meeting of the Museum Committee, March 11th*, 1882.

[In the terms of the gift of the Peter Redpath Museum to the University, it is provided that the immediate management of the Museum shall be entrusted to a "Standing Committee of the Corporation, to be called the Museum Committee, to consist of the Principal as Chairman, and three other members of the Corporation, with whom shall be associated the Logan Professor of Geology and the Professors of Mineralogy, Zoology and Botany, and of other departments of Natural History in the Faculties of Arts or Applied Science of McGill College, should there be such Professors. The Committee shall have power to appoint any of its members Honorary Curator or Curators of the Collections or of any part thereof, and to arrange the times at which different Professors and their classes may teach or study in the Museum."

A Museum Committee was accordingly appointed by the Corporation of the University, at its meeting in January, 1882, and consists of the following members: The Principal (*ex officio*), Peter Redpath, Esq., Hon. Mr. Justice McKay, Dr. G. W. Campbell, Dr. B. J. Harrington (*ex officio*). The following report was presented by the Principal to the first meeting, with the object of placing on record the steps taken by him up to that time in his capacity of Curator of the Museum, under the regulations of the University.]

The noble Museum, erected for the University by the munificence of Mr. Redpath, has now so far advanced toward completion, that it will probably be ready for the reception of specimens in May next, and it is extremely desirable that the collections to be contained in it shall be in as perfect a condition as possible at the time of the formal opening, which is intended to take place on the 24th of August, on occasion of the meeting of the American Association in Montreal. In view of these dates, it has been necessary to devote special time and attention for some months past to the arrangement and preparation of the specimens in the present Museum, and in the collections recently added to it by donation or purchase. The present report is intended to record the steps which have been taken or are in progress toward this end.

### ARRANGEMENT, LABELLING, ETC.

In June. 1881, Mr. Thomas Curry was engaged to mount, label and otherwise prepare specimens, and has been steadily engaged in this work since that time. The expense of mounting materials has been charged to the Museum fund. Mr. Curry's salary has been paid by the liberality of a lady of this city, who has also placed at the credit of the Museum a sum sufficient to secure his valuable services for some time longer.

Mr. P. Kuetzing has been employed, for a part of his time, to remount and renovate the specimens of vertebrate animals and to prepare some new specimens which have been purchased. He has up to this time been occupied more especially with the collection presented by the heirs of the late Dr. McCulloch. It is hoped that by the end of May he will have gone over the whole of the material of this kind possessed by the University and will have brought it up to a creditable condition.

Dr. Harrington and myself have been giving as much attention as possible to the proper naming of the minerals, rocks and fossils, and to their orderly and systematic arrangement, preparatory to removal to the cases of the new building.

### DONATIONS AND EXCHANGES.

Under this head reference will be made to the principal contributions recently made to the collections, and more especially to those particularly intended for the Peter Redpath Museum.

Principal Dawson's collections in the Geology and Natural History of Canada are in process of being arranged and mounted, along with the other specimens. The conditions of this donation, approved by the Board of Governors, are, that the specimens, while not kept separate from the general arrangement, will be labelled with the name of the donor, and that he and Dr. G. M. Dawson shall have access to them for purposes of study, and with reference to their safe keeping. The total number of specimens in the collection cannot as yet be definitely stated, but is estimated at from six thousand to ten thousand specimens, besides much material available for exchanges. It may be stated here that for the past twenty years the duplicates of this collection, and more especially of the new species described by Dr. Dawson, have been used in exchanges for the benefit of the Museum, and that a large part of the specimens now in the cases and drawers have been obtained in this way.

The following are among the more important of the other donations recently received:

From the Director of the Geological Survey, about 500 specimens of fossils and minerals, and twenty-three casts of large and unique fossils.

From Dr. T. Sterry Hunt a collection of thirty-two species of Canadian fishes, prepared by Mr. W. Couper, of Montreal.

From the heirs of the late Dr. McCulloch, the whole of his valuable collections of birds and mammals, including 170 species—a collection having an historical value, in connection with the labours of Dr. McCulloch and the revision of the nomenclature of the specimens by the late Prince Charles Lucien Bonaparte.

From George Barnston, Esq., a valuable collection of fossil fishes from the Devonian of Scotland.

From Lieutenant-Colonel Grant, of Hamilton, Ontario, a large number of fossils from the Niagara formation, some of them of great rarity and interest.

From the American Census Commissioners, a valuable collection of American woods.

From the New York Museum of Natural History, through Professor Whitfield, a collection of 700 specimens of fossils, named by Professor James Hall. In exchange for this a complete collection of the Devonian plants of Canada, from the collections of the Principal and of Professor Hartt, has been given to the New York Museum.

From Peter Redpath, Esq., the skull of a Greenland whale, with the baleen perfectly preserved.

From Dr. G. M. Dawson, specimens of mammals from the N. W. Territories.

From Dr. Spencer, of Kings' College, Windsor, specimens of fossils from the Niagara and Corniferous formations.

In addition to these, valuable contributions have been received from the Smithsonian Institution, Prof. Marsh of Yale College, Charles Gibb, Esq., of Abbottsford, Professor Hilgard of Washington, Captain J. A. Vibert, E. De Cew, Esq., of Cayuga, Mr. Damon of Weymouth, Mr. Chatfeld of Syracuse, Mr. F. Starr of Auburn, A. J. Hill, Esq, C.E., Charles Robb, Esq., J. G. Miller, Esq., Mr. H. M. Ami, J. F. Torrance, Esq., B.A., T. Bland, Esq., of New York, J. F. Whiteaves, Esq., Professor Cope of Philadelphia, W. S. Davidson, Esq., of Edinburgh, and others. Details of these gifts have from time to time appeared in the public prints and in the College Calendar.

## PURCHASES AND EXPENDITURES.

In order to complete the collections in a manner worthy of the new building, and to make up for the loss sustained by the removal of the collections of the Geological Survey from Montreal, it has been necessary to make some purchases and to engage the services of collectors to supply certain deficiencies.

The collection of Devonian plants in the possession of the late Professor Hartt of Cornell University, at the time of his death, was purchased for $250. It has afforded a few new species which have been described, several good museum specimens and materials for exchanges.

Casts of fossils, models of animals and specimens, have been purchased from the collections of Messrs. Ward and Howell of Rochester, for $451.

A few valuable and rare birds, not in our other collections, have been purchased of Mr. Passmore of this city for $55.

The sum of $25 was expended in procuring a collection of the interesting silicified fossils of Paquette's Rapids, on the Ottawa.

A collection of fossil fishes from the Cretaceous of Mt. Lebanon, has been purchased for $34.

From E. De Cew, Esq., of Cayuga, an important collection of Corniferous corals, including some specimens of unusual size and perfection, was purchased for $50. Mr. De Cew also presented some other fossils of interest from his own collections.

The valuable services of James Richardson, Esq., late of the Geological Survey of the Dominion, were secured during the past summer, with the view of procuring specimens of some of the more rare and characteristic fossils of the Cambrian and Lower Silurian rocks. Mr. Richardson has engaged in this work without remuneration, and he was enabled to obtain a large number of valuable specimens at a very moderate expense.

One of Professor Ward's excellent copies of the great skeleton of the *Megatherium* in the British Museum, and a number of other large casts have been contracted for and are to be delivered in the course of next month. The net cost of these casts is $568, and with the freight and fitting up it will amount to about $800.

A number of smaller collections and single specimens have been purchased from time to time as opportunity offered. The expense of some of the above purchases has been borne by the Museum fund. The sums paid for the others have been advanced by the Principal.

I have much pleasure in adding that several of the larger and more important specimens and collections referred to under this head are intended to form a memorial in the Museum to the late Sir W. E. Logan, and when the mounting of them has been completed will be paid for by a donation from his heirs.

Certain expenditures have been required on the grounds in the vicinity of the Museum. A portion of these have been defrayed by the University; but the greater part by private contributions, among which may be mentioned the donation of new and rare shrubs and trees by Charles Gibb, Esq. The arrangement of the grounds will be continued in the spring, but without any considerable expenditure.

### CONCLUDING REMARKS.

The work of arranging, re-labelling and mounting specimens is so far advanced that we shall be able to occupy the Museum so soon as its cases can be fitted up.

The cases have been contracted for by Mr. Roberts, and will, it is believed, be as nearly as possible perfect in their arrangements for the protection and display of the specimens. Mr. Redpath has added to his other liberal gifts the provision of these cases at an expense of $10,000.

The plan of the arrangement of the collections has been fully decided beforehand, with reference to the dimensions of the hall and the character and position of the cases. It is hoped that it will provide in the most effectual manner for the display of the specimens, along with the greatest possible facilities for their scientific study. The Museum will thus afford advantages for the study of Geology and Natural History not previously enjoyed in this country.

Provision has been made on the ground floor for a large and well-arranged lecture theatre and two class-rooms, which will also afford space for reference collections for the use of lecturers and students, and for the herbarium. In the basement there is a large laboratory for the preparation of specimens, and ample space for the storage of material.

It is proper to add that while Mr. Redpath has kindly undertaken to bear the current expenses of the New Museum for a few years, no special provision exists for the work of teaching within its walls, except the very inadequate amount afforded by the endowment of the Logan chair of Geology. Endowments are urgently required for Mineralogy, Botany and Geology, and it is hoped that the example of Mr. Redpath may stimulate other benefactors to supply these deficiencies. Aids of this kind would also relieve the general funds of the University.

It should further be borne in mind that the erection and endowment of the Peter Redpath Museum affords an illustration of what may be done by other benefactors for the departments of Physical and Chemical Science, and for our Faculty of Applied Science. Each of these requires for its full development buildings and endowments. In connection with this I have pleasure in stating that A. C. Hutchison, Esq., one of the architects of the Peter Redpath Museum, proposes to prepare a plan and elevation showing how the buildings required in the future for the above and other University purposes may be erected in due relation to the present buildings, and in harmony with the plan of the new Museum.

It is proposed that Reports on the Museum shall be printed from time to time, recording its progress; and that in future these shall include lists and short descriptions of new species, and statements of new scientific facts which may be discovered. Some unpublished material already exists in the collections, and has been laid aside for description, and it is hoped that future reports may shew that the museum, in addition to its educational work, will be a means of advancing the knowledge of Canadian geology and natural history.

# NATURAL HISTORY SOCIETY PROCEEDINGS.

The third meeting of the session 1881–82 was held on Monday evening, December 15th—Principal Dawson in the chair.

The following gentlemen were proposed as ordinary members of the Society:

Rev. Dr. Sullivan.
D. J. Greenshields.
M. H. Gault, M.P.
J. Hodgson.
R. L. Gault.
E. R. Greenshields.
Geo. Sumner.
G. A. Greene.
Jacques Grenier.
H. A. Nelson.
R. Reford.
H. Shorey.
A. M. Cassils.
Jas. Wilson.
J. E. Moss.
T. L. Harrison.
Richard White.
R. Wolff.
Alfred Wright.
Dr. Geo. Ross.
Jno. McDougall.
Jas. Ewan.
Wm. Angus.
W. Roach.
D. Morrice.
Geo. Boulter.
A. M. Foster.
Benj. Tooke.
J. W. Mills.
Anthony Force.
Thos. Trumble.
Jno. Stirling.
Alex. McPherson.
A. F. Gault.
E. W. Gnaedinger.
A. S. Ewing.
Jno. Beattie.
Jno. Hope.
J. C. Holden.
W. T. Costigan.
W. J. Ingram.
Jas. Corristine.
W. Tees.
Hugh Graham.
Fred. Boas.
Jno. Fulton.
A. Ramsay.
J. W. Tester.
Hugh Watson.
Jas. Gardner.
Jno. Lewis.
Wm. McLaren
Jas. Stewart.
W. Wilson.
J. R. Wilson.
Geo. Hague.
D. Yuile.
Jos. Barsalou.
Thos. Montgomery.
M. McCready.
Jno. Ogilvy.
D. Torrance Fraser.
J. B. Picken.
R. C. Jamieson.
S. H. Ewing.
J. A. Harte.
T. J. Dawson.
Wm. Eward.
Adam Darling.
C. Cassils.
S. C. Stevenson.
J. H. Semple.
C. McArthur.
H. Birks.
H. Saunders.
Jno. Blyth.
C. R. Black.
Wm. Minto.
Jno Fair.
H. D. Moss.

The members then adjourned to the museum, where the Cabinet-keeper pointed out changes and improvements that had been made, and called attention to specimens recently added.

The fourth meeting was held on 30th January. The President occupied the chair. The gentlemen proposed at last meeting were elected, and the following proposed for election:

| | |
|---|---|
| Hon. J. R. Thibaudeau. | Jas. Hutton. |
| F. W. Hughes. | Col. E. A. Whitehead. |
| J. S McLachlan. | W. Simpson. |
| S. Greenshields. | Robt. Linton. |
| W. J. Patterson. | Jas. Donnelly. |
| E. N. Heney. | P. J. Martin. |
| A. Racine. | J. A. Robertson. |
| J. H. Starns. | Jno. McLean. |
| A. L. Lockerby. | Jacob Wilson. |
| R. W. McDougall. | J. M. Kirk. |
| Wm. Darling, jr. | J. B. Sutherland. |
| Geo. Lightbound. | Geo. Bourgoin. |
| Louis A. Brais. | Arch. Campbell. |
| Reid Taylor. | J. H. Mooney. |
| G. R. Prowse. | A. W. Atwater. |
| Geo. Barry. | W McLea Walbank. |
| A. N. De la Motte. | |

Mr. Henry M. Ami, student-in-arts at McGill then read a very interesting paper on the "Utica Slate Formation in Canada," with special reference to the deposits occurring in the vicinity of Ottawa city, where the writer of the paper has been making investigations and collecting specimens for the past three years.

In the course of the paper, the origin, the mode of deposition, the mineral and the lithological characters, as well as the fossils of that formation, were considered. Some new and interesting notes on *Triarthus spinosus* (Billings) were given. Several species were added to the Canadian list of fossils from the Utica slate. In the list of fossils appended to the paper, sixty-six (66) species were given as occurring in different localities throughout Canada of which only thirty-two have been previously recorded. It was also mentioned that in the United States the total number of species belonging to that formation, as recorded by Mr. C. D. Walcott was exactly one hundred, and that consequently the diligent searcher of Canada should be amply rewarded, as there remain still some thirty-four (34) species to fill up our list and make it as complete as that of the United States.

Dr. Dawson then made some remarks concerning the whale at that time on exhibition in the city, showing the difficulty of classifying the whales on account of our meagre knowledge of specific characteristics. Total length of specimen is 48 feet, circumference 20 feet. Its head is 11 feet in length, with lower jaw wider and deeper than upper.

[The balance of Proceedings to date is left over to next number through want of space.]

Published 25th April, 1882.