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THE

CANADIAN NATURALIST

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Quarterly Journal of Science.

ON THE SURFACE GEOLOGY OF THE BAIE DE CHALEUR REGION.

BY ROBERT CHALMERS,

(Read before the Natural History Society of New Brunswick, Feby. 7th, 1882.)

In a paper which I had the honor to read before this Society in March, 1881, on "The Glacial Phenomena of the Baie de Chaleur Region," * I described the glaciation of that district, so far as it came under my notice, and also treated of the distribution of the till or glacial drift and the kame deposits within the same area. I now purpose bringing before you some facts relating to the stratified marine clays and sands which form a series of deposits skirting that body of water and the estuaries connected with it, and shall also refer briefly to the recent formations and the evidences of a subsidence of the land in the northern part of the Province. But first I shall advert to some additional observations made during the past summer on drift phenomena, chiefly in the district referred to, as tending to confirm the conclusions arrived at in my previous paper, and shall note the localities where striæ, till, etc., were met with for the first time.

GLACIAL STRIÆ.

On McPherson's farm, Charlo River, ledges of trap rock were seen, finely striated and rounded on the west side; direction of striæ east and west, referring them to the true meridian to which all the bearings given in this paper are reduced.

* Canadian Naturalist, Montreal, Vol. X., No. 1.

A mile farther east along the post road, scratches were detected on similar rocks, having a course of east and west to north 70° east. All the scratches correspond with those previously observed in this vicinity.

Between Belledune and Elm Tree Rivers the rocks are extensively glaciated along the line of the Intercolonial Railway, as stated in my former paper. A more detailed examination shows that scratches occur everywhere within this area down to the present shore of the Bay, the course being about south 80° east. To a height of 75 or 100 feet above tide level, the more exposed rock masses have the striæ obliterated, probably from the action of the sea when it stood higher relatively to the land, and these rocks were eroded by the waves and coast ice, and it is only on the low-lying ledges which have been protected by a covering of earth that the finer ice markings can be detected. Above the level stated the exposed rocks still bear traces of ice action in the *moutonné* form they present although they have been subjected to atmospheric wear for long ages.

In Robertville, which lies in rear of Petite Roche, and also in the vicinity of the so-called Nigadoo silver mines, striæ were found with nearly an east and west course. In the St. Louise settlement adjoining Robertville on the east striæ were noticed trending north 85° east to north 80° east. It would seem as if the ice sheet in its passage over this part of the district had been swerving round from a course having a southerly bearing to one north of east.

Southeast of the above-mentioned settlements in the area extending towards Bathurst and Nepisiguit River striæ were observed in a great many places, both on the front lots and also in the Dunlop, Dumfries and Tattagouche settlements, as far back from the coast as ten or twelve miles, with an average course of north 25° east. In the immediate vicinity of Bathurst however, the striæ have more northing and trend about north 20° east to north 22° east.

All these striæ afford conclusive evidence, in the rounded form of the ledges on the southwest sides, and in other respects that they were produced by ice moving towards the northeast. They likewise show a convergence towards the depression known as Nepisiguit Bay.

TILL, OR BOULDER CLAY.

In addition to the places mentioned in my former paper till was observed at Jacquet River, on the right bank near its mouth. Here it consists of a coarse, reddish clay and gravel derived from subjacent Lower Carboniferous rocks, and contains glaciated transported boulders.

It is also met with on the west side of the mouth of Nigadoo River, forming the basal portion of a bluff on the shore.

Also on the banks of the Tattagouche River, near Brown's mill, where it is composed principally of the *débris* of the granite rocks occurring in the vicinity. The river has apparently worn a passage for itself through the till at some points, as it is seen on opposite sides of the stream.

On the banks of the Nepisiguit there is evidently a considerable bed of till. This was referred to in my former paper, but a further examination during the past summer showed that my remarks are applicable only to the upper portion of the deposit, and that the lower portion is a coarse, gray, granitic *débris* packed with boulders, chiefly of granite, derived from the rocks of the neighbourhood.

The foregoing data showing the occurrence of the till along the banks of the principal rivers would indicate that it must originally have been deposited in these river valleys to a considerable depth, probably filling some of them entirely, and that it has subsequently been denuded by the action of the streams, the deposits met with on their banks now being only remnants of the original mass.

ERRATICS, OR LOOSE BOULDERS.

Great quantities of loose boulders are strewn over the surface or embedded at a slight depth in the soil, within the region embraced in my observations. In general they appear to have been shifted eastwardly or northeastwardly from the original rock. It is often very difficult to trace them to their parent beds, but in the case of the granite blocks we know of only one source whence they could be derived, namely the granite belt running southwestward from Bathurst. Now in regard to these, it may be stated that they are strewn about on both sides of the granite axis, having been met with on the northwest side at Nigadoo River and even at Elm Tree, ten miles or more from their source, becoming scarcer however, the farther we recede from the granite *in situ*. On the southeast side we find them along the Intercolonial Railway and the old post road, scattered over the Carboniferous sandstones as far as the Miramichi River. Among these granite boulders we also find others of felsite, diorite, etc, which appear to be derived from the sub-crystalline belt flanking the granite on the west.

KAMES, OR SAND AND GRAVEL RIDGES.

The kame in Restigouche, described in the paper already cited, was examined more closely during the past season, and it was found that its summit, at the western extremity, was 125 to 150 feet above sea level; thence it decreased in height gradually towards the east till it ran out into a bluff on the Bay shore near Nash's Creek. Its general direction is nearly east and west, corresponding with the glacial striæ in the vicinity, but it has several lateral branches, and in a few plaçes is spread out into level areas or terraces. These branches are often concealed from view by a covering of later deposits. Hollows, or kettle holes as they are called, were observed in this kame, especially where it flattens out, as at Black Lands and New Mills. The great road from Nash's Creek to River Charlo, 11 to 12 miles, runs along its summit nearly all that distance.

At the mouth of the Great Cascapedia River, in the Gaspé peninsula, there is a series of gravel hills, some of them assuming the appearance of ridges, which must originally have formed one continuous, well-developed kame. These hills were traced a distance of two to three miles along the left bank of the river, where they form bluffs which stand up "like a row of artificial ramparts," and increase in height as we ascend the stream. When I visited the locality last summer I had not time to follow this kame to its highest or northern extremity, but it probably extends up river a number of miles. Its average direction is about south southeast, corresponding with the course of the lower part of the river. Currents which ran transversely to its main direction have eroded it greatly in places previous to the deposition of the later stratified formations which cover it up on the eastern side to a considerable depth.

The southern extremity of this kame projects into the Bay in a bluff and exhibits a very interesting section of the deposits. The ridge is here 150 yards wide and about 40 feet in height above the beach. Like the Restigouche kame it is composed of loose sand and gravel containing water-worn pebbles, none of them exceeding a foot in diameter. At first sight I was much puzzled with the discovery of marine fossils in the upper part of what was apparently the true kame deposits; but a closer examination soon showed me that the fossils were embedded only to the depth of from 5 to 10 feet on both flanks, and that the central portion, comprising the principal mass of the ridge, was unfossiliferous. It was seen too that while this unfossiliferous portion consisted of loose materials without clay, the fossiliferous strata held the pebbles and shells in a compact gray paste. *Saxicava rugosa*, *et* var. *arctica*, *Mya truncata*, var. *Uddevallensis* and *Macoma Grœnlandica* were the principal species observed, the first-named being the most abundant.

The occurrence of fossils in this peculiar situation suggests the question whether these shells were entombed here while the upper part of the kame was being deposited, or were they mingled with portions of it which were worked over by the sea subsequently, during the Leda clay period, when the kame became submerged. The latter seems the probable view, but the subject in my opinion, requires further investigation.

To the east of the kame occur heavy deposits of fine stratified marine sands, underlaid still farther eastward by stratified clay, reddish above and blue or dark colored below, containing marine fossils of the above-mentioned genera, and others. These marine deposits extend to the mouth of the Little Cascapedia River, three miles distant, forming terraces and concealing from view all the older formations.

A small glacier confluent with the Baie de Chaleur ice sheet, probably occupied the valley of the Cascapedia during the glacial epoch, and to its melting may be due the floods which produced the sand and gravel ridge just described. But, while attributing the formation of kames to rivers flowing over dissolving glaciers and transporting material which had accumulated on their surfaces to lower levels, the relation of such deposits to the drainage systems indicates that, in this section of the country at least, such glacial rivers have not been independent of the present water courses. The Restigouche kame is just such a deposit as the Restigouche itself would have formed were it to debouch from the hills through the Eel River gap, at a level of 125 to 150 feet above its present channel, carrying *detritus* to the flat country below; and in a similar manner the Cascapedia kame might have originated from the action of that river. We can hardly conceive of these river valleys being filled with floods of water 125 to 150 feet above their present courses however, hence it is supposed that ice to that depth occupied them, and that the rivers flowed over its surface, laden with *débris* in sufficient quantity to form these ridges.

Some of the physical conditions necessary to the formation of these deposits, therefore, apart from the theory of their glacial origin, seem to be: (1), a considerable drainage area, affording probably a large flow of water independent of that supplied by the melting of the ice sheet; (2), a region sufficiently elevated to cause the waters to descend with great velocity; and (3), level, or comparatively level areas near the base of the hills, causing a slackening of speed in their flow and a deposition of transported material. At a greater distance than 12 to 15 miles from the elevated tract the kames disappear, and no traces of them have been observed in the flat district to the south. This cannot have arisen from lack of material to form these ridges, judging from the quantity of *débris* of a similar character found along the rivers and in terraces; but the physical conditions necessary for their development do not seem to have been favorable on the low level tracts.

GENERAL CONCLUSIONS REGARDING THE GLACIATION OF THE BAIE DE CHALEUR DISTRICT.

From facts adduced in my paper on the glacial phenomena of this region, I endeavored to show that a local glacier of considerable magnitude had once occupied the depression of the Baie de Chaleur and estuary of the Restigouche, spreading to some extent over the district bordering these waters on the south, and that the different courses of the scratches found there, proved that it had been controlled in its passage eastward by the contour of that depression. The additional data obtained during the past summer, both in regard to glacial striæ and transported material all tend to support the conclusions then reached. The average course of the Restigouche estuary is east northeast; the course of the western half of the Baie de Chaleur is east southeast or west northwest, and of its eastern half nearly east northeast or west southwest. With these bearings the glacial striæ indicate a tolerably close correspondence. The glacier seems to have moved eastwardly from the highland area in the northwest of

New Brunswick, and from the Notre Dame Mountains. It was probably made up of several smaller confluent glaciers, one flowing down the Restigouche valley from the highland regions on that river, another down the Metapedia valley from the Notre Dame Mountains, and a third down the Cascapedia valley from the Shickshock Mountains, besides others of lesser note, all coalescing in the Baie de Chaleur basin. In the list of striæ given in the Geology of Canada (1863), pages 890-92, scratches are noted as occurring on Kempt road, near Metapedia Lake, with a course of south 80° east. Metapedia Lake is about 50 miles from the junction of the Metapedia river with the Restigouche. The particular exposure of these striæ is not stated, but it is probable they have been produced by the glacier which occupied the Metapedia valley. No striæ were detected by me in any part of the Gaspé peninsula that I have visited, but the kame at the mouth of the Cascapedia, already described, may be considered evidence of a local glacier once having occupied the valley of that river.

The Baie de Chaleur ice-sheet must have overspread a portion of the Carboniferous area to the east and southeast of Bathurst, passing over it probably in a northeasterly direction. Although I did not detect any striæ on the sandstones between the Nepisiguit and Miramichi, so far as I examined them, yet the presence of numerous boulders of granite and other rocks scattered over the surface, which have been derived from the metamorphic belt to the west, may be taken as evidence of their transport by ice moving in the direction indicated.

At Weldford Station, on the Intercolonial Railway, which is about 75 miles south southeast from Bathurst, scratches occur on the Carboniferous sandstones having a course of nearly north by east or south by west. A considerable surface of rock was laid bare in this vicinity during the construction of the railway, exposing well defined striæ. They are noteworthy as showing probably the general course of the ice-sheet which passed over the flat expanse of the coal measures of the Province—Weldford being near the centre of this extensive triangular shaped area. These striæ occur on a low water shed between the valley of the St. John and the Straits of Northumberland; the Richibucto, running northeasterly from this point into the Straits, and the Salmon River southwesterly into Grand Lake. The height of the water shed is stated to be about 275 feet above sea level.

These striæ, if produced by a continental glacier, would show its normal course in this part of New Brunswick unaffected by inequalities of surface, as there are no elevations within many miles on either side by which it might be swerved. From their position on the flat ledges, it was impossible to tell from a hurried examination, in which direction the ice moved, whether northward or southward. It is probable, however, that these striæ have been made by a local glacier, and that its motion from this point at least, was southward or southwestward, perhaps along the Salmon River valley towards Grand Lake. But I would not be surprised if indications of ice having moved in a contrary direction are found in the northeastern part of the Province as at Bathurst. One thing appears certain, at all events, viz., that the striæ at Weldford have been produced by a different body of ice from that which occupied the Baie de Chaleur valley.

In concluding this part of my subject it may be stated that so far as my observations have extended in the northern part of the Province I find no evidence of the passage of a continental sheet of ice over that region from north to south. There is evidence that the land was covered down to the present sea level by a glacial mantle of considerable thickness, exceeding in narrow valleys 1000 feet, but, in general, much less on level surfaces. This covering probably existed as snow and ice and not as one solid massive ice-sheet, the ice, when formed, becoming local glaciers. These glaciers descended the nearest slopes, seeking the lowest levels, till they debouched into the sea, or formed one large local glacier in the Bay of Chaleur basin. The courses followed by these local ice sheets conformed almost invariably in detail to the present surface features of the district, not varying far from those of the river valleys. Glacier action of this kind seems to be sufficient to account for all the observed glacial phenomena, if we except the transportation of some foreign boulders which may have been carried about by floating ice.

During the occupation of this region by an ice covering it probably stood somewhat above its present level.

STRATIFIED MARINE CLAYS (*Leda Clays*).

Stratified clays holding marine fossils in abundance are met with all around the Baie de Chaleur, forming a considerable portion of the soil of the area skirting its waters, especially near the mouths of rivers, and they have also been traced along the banks of streams some distance from the coast. In the Restigouche valley they are found as far up as the mouth of the Upsalquitch containing shells of *Mya* and *Macoma*, but have not been detected on the higher lands of the interior. These clays, which, so far as I can judge, are equivalent to the Leda clays of the St. Lawrence valley occur usually as thin fragmentary sheets in the greater part of the district under examination, but at the mouths of the Nepisiguit, Tattagouche and Jacquet rivers, and some other places, they form local beds of considerable extent and depth. In cuttings along the Intercolonial Railway, sections of these clays were exposed during its construction, and excellent facilities afforded for studying them and collecting the fossils embedded therein. In some of the thicker beds, as at Tattagouche and Benjamin rivers, there are evidently upper and lower clays, such as have been recognised by Mr. Matthew in the south of the Province, and by Dr. Dawson in the St. Lawrence valley. The lower division is sometimes a finely laminated blue clay, the laminæ not distinctly visible, and it is usually without pebbles. In other places it is a stiff, dark gray, or brown clay, more or less pebbly and unfossiliferous. The upper division is generally a gray or brown clay, with the higher strata occasionally bluish or black, and prolific in fossils. It likewise contains pebbles and a few scattered boulders, and there are numerous proofs of its upper surface having been eroded by currents, and in some parts perhaps by tidal waters previous to the deposition of the overlying stratified sands. In many places, however, no well marked division between upper and lower beds has been detected, and the differently constituted clays graduate into each other and appear to have been closely consecutive in formation, their color and composition depending largely upon the nature of the rock-formation or drift beds whence they were derived. For example, at the mouths of rivers running through a limestone district blue calcareous clays prevail, while reddish clays are invariably met with in districts in which red Lower Carboniferous sandstones occur. In localities where the clays overlie kame deposits they are so thickly packed with boulders and material derived from the latter as to be scarcely distinguishable were it not for the contained fossils.

The entire thickness of the Leda clays, upper and lower, where they have their greatest development, as in the neighborhood of Bathurst, is about 75 feet, and on the banks of the Tattagouche

River they attain a greater elevation than elsewhere in the district, rising to a height of nearly 100 feet above sea level. Their vertical distribution, however, must exceed this considerably, for in many places they are seen sloping down beneath the waters of the Bay, as for instance, at Charlo and Jacquet Rivers, and the mouth of the Great Cascapedia, where a tough blue or blackish clay is exposed at ebb-tides, enclosing fossils in abundance.

The marine fauna embedded in the Leda clays of the Baie de Chaleur is largely of an arctic type. Some years ago I made a collection of shells from these beds, which was submitted to my friend Mr. Geo. F. Matthew, of St. John, who published a list of them in one or two papers relating to the Post-Pliocene of the Bay of Fundy region.* I here reproduce the list:

Saxicava rugosa, Linn.
" var. *arctica*; abundant.
Mya truncata, Linn; scarce.
" var. *Uddevallensis*; common.
M. arenaria, Linn.
" var. *acuta*. Say; abundant.
Macoma calcarea, Chemnitz.
M. Grœnlandica, Beck; common.
Serripes Grœnlandicus, Chemnitz.
Kellia suborbicularis, Montagu; rare.
Mytilus edulis, Linn; scarce.
" var. *elegans*; common at Benjamin River and Black Point.
Nucula expansa, Reeve; very rare.
N. tenuis, Montagu; common.
Leda pernula, Muller, var. *buccata*; very plentiful.
" var. *tenuisulcata*.
L. minuta, *Fabricius*, var. *caudata*.
Portlandia glacialis, Gray.=*Leda truncata*, Brown; not common except at Jacquet River.
Yoldia sapotilla, Gould.
Bela harpularia, Couthuoy.
B. turricula, Montagu; common.
Natica affinis, Gmelin,=*N. clausa*; abundant.
Lunatia heros, Say.
" var. *Chalmersi*, Matthew; rare.
Buccinum Grœnlandicum, Chemnitz?
B. tenue, Gray.

* *Canadian Naturalist*, Vol. VIII, No. 2, also in an article on the Superficial Geology of Southern New Brunswick, Report of Progress, Geological Survey of Canada, 1877-78.

B. glaciale, Linn.
B. undatum, Linn; frequent.
Tritonofusus Kroyeri, Muller.
Fusus tornatus, Gould.
Balanus crenatus, Brug; very abundant.
B. Hameri Ascan; rare.

In the Jacquet River beds the remains of a small cetacean were discovered about 25 feet above sea level in a clay cutting of the Intercolonial Railway. Nearly the whole skeleton was obtained which was sent to Halifax and identified by Drs. Gilpin and Honeyman as that of *Beluga Vermontana*, Thompson. In the Tattagouche clays, Rev. C. H. Paisley found *Eurychinus Drobachiensis*, Muller (*Echinus granulatus*), two species of *Spirorbis* and remains of the eel grass, *Zostera marina* L. and of *Equiseta* in addition to the above. And during the past summer I discovered a portion of the claw of a lobster (*Homarus Americanus* Edw.) at Black Point, Restigouche County, in a situation which made me almost certain it was in the fossil state, as it was embedded in a heap of clay washed out of the side of a railway cut and associated with fossil shells of *Saxicava rugosa*, *Mya arenaria*, *M. truncata* var. *Uddevallensis*, etc. The specimen has a battered, worn appearance too, and looks as if it might be as old as the shells, nevertheless until others shall have been found, I would not care to make any positive assertions about it.

The fossils in the Leda clays of this district are all remarkably well preserved, and many of them occur apparently in their natural situation, especially in the lower clays; but, from the manner in which they are distributed, deep water and littoral species often appearing intermingled in the same beds, their value, as indicative of the depth of water in which they lived, is not to be greatly relied on. Nevertheless some deductions may be drawn from them regarding the climate and temperature of the seas at that period. At Charlo River the shells occur in blue clay, below high-water mark, and a majority of the species are arctic. They probably lived in waters of moderate depth. *Balanus crenatus* and *Saxicava rugosa* are the most abundant forms, but *Leda pernula*, *Tritonofusus Kroyeri*, *Nucula tenuis* are also frequent, especially the last, while *Portlandia glacialis* is rare. The two first mentioned species (*Balanus crenatus* and *Saxicava rugosa*) must have found a congenial *habitat* in these seas in the Leda clay period, as they abound throughout the deposits of the Baie de Chaleur basin. In the Benjamin River beds the littoral species *Mytilus edulis* var. *elegans*, *Mya arenario* and others predominate, particularly in the upper strata, and appear to range upwards into the stratified sands overlying them. *Serripes Grœnlandicus* and one or two species of *Natica* are also common, and the deposits are evidently of shallow water origin. At Black Point the prevailing forms are also such as inhabited comparatively shallow seas. *Mya truncata* var. *Uddevallensis* is common, and a variety of *Mytilus edulis* and *Mya arenaria* likewise occur here in strata graduating into the sands. *Balanus crenatus* is especially abundant, the upper part of the clay being literally packed with fragments of it; and the lobster (*Homarus*) which probably inhabited the Baie de Chaleur in later Post-Pliocene times is apparently to be met with in these deposits. But the presence of several Arctic *Buccina* (*B. tenue*, *B. glaciale*) and *Tritonofusus Kroyeri*, besides *Portlandia glacialis*, *Leda minuta*, *Macoma calcarea* and others indicate colder and deeper waters and climatic conditions, similar to those of high latitudes, in the Leda clay period previous to the existence of these littoral species. It may be stated that the clay containing these fossils at Black Point rests on the flanks of a kame, has a sloping attitude, and is packed with sand, gravel and pebbles derived from it, as is also the formation overlying the clay corresponding to the Saxicava sands. Were it not for the presence of the fossils which can be traced along certain strata the whole might readily be taken as constituting the kame, as is the case at the mouth of the Cascapedia already referred to.

The fossils embedded in the clays of Jacquet River imply deposition in deeper or colder waters than those found elsewhere on the coast, if we are to judge from the occurrence of such species as *Portlandia glacialis*, *Leda pernula* and *L. minuta* of Dawson's lists in considerable abundance and in a good state of preservation. In the upper strata however, *Mya arenaria* and *Saxicava rugosa* come in, in full force. The skeleton of *Beluga Vermontana*, already spoken of, was found here near the surface of the clay.

The deposits at Tattagouche and Bathurst afford typical examples of Leda clays and Saxicava sands, the latter, however, unfossiliferous. Rev. C. H. Paisley published a description of these beds in the *Canadian Naturalist*, Vol. VII. No. 5.

In regard to the conditions of the formation of the Baie de Chaleur Leda clays, it may be stated that at whatever depth of the sea the lower clay was deposited (and it appears probable that it was laid down in waters not deeper than the Baie de Chaleur is at the present day, namely 20 to 30 fathoms), the higher strata bear evidence of having been formed in shallow waters. For, not only has the upper surface of the clay been eroded and channelled by currents previous to the deposition of the marine sands, but the fossil shell themselves in many cases indicate that they were washed about by the sea and thrown together in masses, occurring often compacted two or three inches deep with the valves mostly separated and broken. Occasionally, too, they seem to occupy pockets or holes in the upper part of the clay, and are heaped up sometimes on one side or the other of the larger boulders. The frequent conmingling of deep water and littoral species may thus be accounted for, the sea having washed those from shallower waters into greater depths, and *vice versâ*.

But although the assemblage of shells embraced in the foregoing list does not afford conclusive testimony as to the depth of the sea in the Post-Pliocene period, yet it is of value as showing that the climate and the waters of the Baie de Chaleur region were much colder then than now. The shells imply, indeed, a temperature boreal or subarctic in charater, similar to that of Labrador or the south of Greenland at the present day; nearly all the species mentioned being now found in the seas adjoining these countries at moderate depths. Their occurrence at the Baie de Chaleur may be explained by supposing that the land stood 100 to 150 feet below its present level, thus allowing the cold waters of the arctic current to circulate freely in the southern part of the Gulf and tenant it with such species as are now found only in extreme northern latitudes. But the fact that the fossils are met with chiefly in the beds which have accumulated at or near the mouths of rivers would lead us to infer that the cold fresh waters which must have poured into the bay in great quantities during the time of their existence have had a greater or less effect upon them; and their irregular forms, the strength and thickness of the shells, as well as their abundance are probably due to that and other local causes. The purely arctic fauna of the lower Leda clay may have lived in the Baie de Chaleur before the final retreat of the glaciers.

Since the deposition of the Leda clays the great change which has taken place in the climate of the district has driven these arctic marine animals northwards into the cold seas above mentioned, and their place has been taken up by a more southern assemblage. The only marine shells of these clay beds living in the Baie de Chaleur now, so far as I have been able to ascertain, are *Mya arenaria*, L, *Mytilus edulis*, L, *Macoma fusca*, Gould, which is perhaps identical with *M. Grœnlandica*, Beck, of Post-Pliocene date, *Lunatia heros*, Stimp. and *Buccinum undatum*, *L;* while the following species, the largest proportion of which are of a New England type and do not occur in the Leda clays, so far as known, are now found there:

Cardium pinnulatum, Conrad.
Pecten tenuicostatus, Mighels and Adams.
Mactra solidissima, Chemnitz; abundant.
Modiola modiolus, Turton; common.
M. —— *plicatula*, Lam.
Solen ensis, Lam; common.
Machæra costata, Gould; rare.
Callista convexa, Say; frequent.
Venus mercenaria, Lam; abundant.
Crepidula fornicata, Lam: common.
Ostrea borealis, Lam; plentiful.
Aporrhais occidentalis, Sowerby.
Littorina palliata, Gould.
Tectura testudinalis, Stimp., etc.

A comparison of this list, meagre as it is, with that of the shells belonging to the Leda clays, given on a previous page, shows at a glance the difference between the faunæ of the Post-Pliocene and the Recent periods in the Baie de Chaleur. The amelioration of climate which brought about this change took place along with a rising of the land and a shallowing of the seas around the shores of Acadia. Dr. J. W. Dawson infers, with much probability, that the invasion of Acadian waters by these New England species occurred in the modern epoch. It is a singular fact, ascertained by dredgings made in different parts of the Gulf of St. Lawrence, that that part of it lying to the south of a straight line drawn from Cape Breton to Gaspé, and to which Dr. Dawson has given the name of the Acadian Bay, is inhabited by a colony of marine forms of a southern type (examples of which are found in the Baie de Chaleur) cut off from their relatives on the New England coast by intervening cold waters. To explain this phenomenon, this distinguished geologist concludes that when the land was at its highest level in the modern period—and stood considerably above the height at which it now is—the waters all around the coast of Nova Scotia and Cape Breton were warmer owing to the arctic current being thrown farther from the shore, perhaps outside of the banks, and these marine animals would then emigrate thither from the south and spread themselves into the Acadian Bay. The subsidence which has since set in has caused the arctic current to run more closely to the shores of Nova Scotia and Maine, this southern fauna has begun to retreat, and those species inhabiting the waters surrounding Prince Edward Island and in the Baie de Chaleur have thus become isolated.

STRATIFED MARINE SANDS, SEA-BORDER TERRACES, ELEVATED BEACHES, ETC.

Stratified sands occur almost everywhere within this region and overlie the Leda clays in most places to a greater or less depth. The lower portion of these deposits is probably equivalent to the Saxicava sand of Dr. Dawson, but no fossils have been detected in them, except it is *Mytilus edulis*, var. *elegans*, which, at Benjamin River and Black Point seems to extend upwards from the Leda clay into their lowest strata. These sands attain their greatest development near the mouths of the larger rivers, forming in some places extensive stratified beaches, or with the underlying stratified clays have been sometimes shaped into a series of terraces, the higher, altogether of sand and perhaps gravel, the lower, Leda clay with a sheet of sand occasionally covering them. At Bathurst there is a large area between the harbor and the Tattagouche River, extending westward to the St. Ann settlement covered with these sands, making a terrace 125 to 150 feet above sea level. This terrace or sand flat is the highest in the region and appears to have derived the material composing it largely from the rivers which here empty into the Bay, in a similar manner to extensive sand flats or shoals now in process of formation outside of the harbor. One or two lower terraces are seen in this vicinity, but their upper surface is very uneven and seems to correspond with that of the Leda clay beds, the sands which once covered them having been denuded to that level. Near Jacquet and Charlo Rivers and Nash's Creek are smaller areas of elevated beaches at a less height above the sea, and around the estuary of the Restigouche there are similar formations, especially at the mouths of tributary streams.

The material of the higher terraces is often a fine stratified gray or bluish gray sand, in some places changing to a brown or reddish sand, and near its upper surface containing water-worn pebbles occasionally arranged in layers. In parts of the country where these sands are not arranged in terraces they are stony, and vary in character from a fine quartzose sand to coarse gravel and boulders. Where they are found overlying or flanking the kame deposits they are composed largely of material derived from them, rendering it often difficult to distinguish one formation from the other.

These marine sands have not been observed at a greater height than 125 to 150 feet above the sea, and their extreme thickness does not exceed 50 to 60 feet. They graduate almost imperceptibly into the recent marine sands composing the present beaches and sand dunes.

The terraces in the marine beds of this district are usually three in number, the highest 125 to 150 feet above tide level as already stated, and the two lower at about 70 to 75 feet and 25 to 30 feet respectively. The last two have been formed by erosion of the stratified clays and sands as the land rose. And it would really seem as if their had been a pause at intervals in the upward movement, allowing greater denudation and terrace making along sea borders at certain levels, although these phenomena can, in several places, be accounted for by the looseness or weakness of the strata at these levels, and their compactness or power of resisting erosion at others. A 14 to 15 feet terrace was observed in some of the estuaries, and also others at less heights. The 125 to 150 feet terrace is the most extensive, and seems to be the upper limit of the marine formations on the southern side of the Baie de Chaleur during the Post-Pliocene epoch.

FRESH WATER FORMATIONS, RIVER TERRACES, ETC.

Besides the deposits just described consisting of stratified marine clays and sands, other beds are met with on the higher lands and more especially in river valleys in the interior, which have evidently been formed by the action of water, but bear no traces of marine life. The great bulk of these deposits is sand and gravel, with layers of clay or loam sometimes interstratified, or occasionally in beds of a few feet in thickness sufficiently pure for brickmaking. Along the banks of rivers they form terraces. These terraces are a conspicuous feature of the scenery on the Upsalquitch River and upper Restigouche, but nowhere in our Province are they exhibited on such a grand scale as along the upper St. John between Fredericton and Grand Falls. The material of the highest of these terraces having a flat summit seems to be chiefly sand and gravel, and has a close resemblance to that of the kames. This upper terrace marks the highest continuous flood plain of the river at the close or immediately subsequent to the melting of the ice-sheet of the glacial epoch. The lower terraces (there are generally three or more) have been formed by erosion of the upper or all other terraces of a higher level through the action of the river. And owing to the diminished volume of water as well as to other causes the materials composing these lower terraces are usually finer, with greater quantities of sand varying to loam or clay in places where the river valleys are wide and the current slow enough to permit quiet deposition of sediment. An elevatory movement of the land is not necessary to the formation of river terraces which are beyond the reach of the sea, although by increasing the speed of the currents it may give the rivers greater erosive power. Terrace-making is still going on along our river valleys though apparently at a greatly reduced rate.

This portion of the stratified deposits, that is to say, the upper terraces, or remnants of the highest flood plains of our rivers, has, as already stated, a marked lithological resemblance to the kame deposits and is obviously related to them in origin. The larger boulders often found in the kames do not, however, occur in the terraces. Besides the latter contain clayey strata sometimes near the bottom, not met with in the Kames. But the character of the earth, gravel and stones composing them, their structural arrangement, as well as their height above the present water courses are striking points of similarity, and indicate deposition also from great floods which swept down these river valleys immediately after the retreat of the ice-sheet,—floods so immense as to be out of all proportion to the present streams. What the exact relations are between these river gravels and the kames, however, is a question demanding closer investigation than I have been able to give to it; but evidently the two formations will have to be studied together.

RECENT DEPOSITS, INCLUDING SAND DUNES, MARL AND PEAT BEDS, ETC.

Recent deposits of marine or estuarine origin occur at Bathurst, at the mouth of the Restigouche and elsewhere, and sand dunes or "points," as they are called, of considerable area have been thrown up at Belledune and Heron Island, and appear to be increasing in extent by the addition of fresh material at intervals. These dunes are composed chiefly of loose sand washed up by the waves; and high spring tides often roll over them leaving drift wood on their surfaces. Belledune Point is one of these formations—the largest probably in the region—and juts out into the Bay three-fourths of a mile or more. At its outer extremity it is made up largely of pebbles half an inch to one inch in diameter, while near the bank or shore the material is chiefly fine sand. A submarine rocky ledge runs out here into the Bay a few fathoms under the surface of the water, and this dune is evidently a sand flat thrown up on it as high as the sea is capable of forming sand beaches. Its shape is triangular, and the material composing it appears to have been forced up from the sea bottom at successive intervals on the northeast side of the dune into parallel ridges, their general direction being about northeast and southwest. These ridges are of various widths and elevations, but the oldest or first found are 4 or 5 feet lower than those of more recent date, yet preserve their original shape, although in spots they are covered with a scrubby growth of wood. They are protected from erosion on the northeast by a sandbank thrown up along the run of the dune, which is several feet higher than the earliest formed ridges. A comparison of the heights of all these ridges would seem to indicate a gradual subsidence of the land during the period of their formation.

Little Belledune Point affords proofs of having been similarly formed, except that the ridges extend northwest and southeast. Neither of these sand dunes is near the mouth of any river and hence, as already indicated, the materials of which they are composed must have been washed up by the force of the sea during storms from the shallow bottom surrounding them. On the opposite side of the Baie de Chaleur dunes are in process of formation at Carleton, Paspebiac and other places which are evidently referable to the same cause.

The harbor of Bathurst and the estuary of the Restigouche appear to be rapidly silting up, and great stretches of flats composed of sand, clay and mud are exposed at ebb tides covered with a growth of seaweeds, chiefly *Zostera marina* and *Ruppia maritima*. The old settlers report these basins as getting shallower within the last fifty years, and this fact has given rise to the opinion by some geologists that the land was rising in the Baie de Chaleur district; but the filling up of these estuaries seems to be entirely due to the *detritus* carried down by the rivers.

Near Belledune Point, on the farm of Mr. Hugh Galbraith, there is a peat bog skirting the shore, the seaward border of which is now being covered over with sands washed up by the waves. The peat is 4 to 5 feet in depth and is underlaid by marl containing fresh water shells *i.e. Limnœa*, *Planorbis* and others. Dr. Gesner refers to this deposit in one of his Reports, and says it must have once formed the bed of a fresh water lake. Portions of it are now being converted into salt marsh.

Along the shore to the south of River Charlo and elsewhere within this region are similar beds of peat, which are apparently being encroached on by the sea.

High tides seem also to encroach farther on the land of late years than formerly, eroding the banks and throwing up sand higher than has been known since the settlement of the country. One of these high tides accompanying an easterly storm occurred in October, 1861, and washed away from 10 to 15 feet of the banks on exposed parts of the coast, spreading so much sand and *débris* over the fields along the shore as to render some of them unfit for cultivation since.

These phenomena together with the apparent sinking of the sand dunes referred to would indicate that the region is slowly subsiding since the formation of the peat and marl beds.

I shall conclude this paper with a section of the surface deposits of the Baie de Chaleur district, embracing a synoptical statement of their geological history, so far as known to me, in descending order.

(1) Recent Deposits.—On the coast—sand dunes, estuarine silts, submarine sand flats. In the interior—river intervales and alluvia, peat and marl beds, etc. Life during period of these formations—fresh water shells. Land reaching a height above present level, followed by a gradual subsidence.

(2) STRATIFIED MARINE SANDS.—Saxicava sands. Marine formations were—sea-border terraces, raised beaches. In the interior—river terracing. No fossils of the period in this region. Land rising: marginal marine areas emerging from beneath the sea.

(3) LEDA CLAYS.—Upper red or brown clay, formed in comparatively shallow waters. Contains pebbles and remains of an abundant marine life. Lower Leda clay—blue or dark colored, fewer pebbles and fossils: chiefly arctic species. Waters of moderate depth, probably 20 to 30 fathoms. In the interior—terrace-making along rivers. Land rising. Climate subarctic.

(4) KAME DEPOSITS, and material of river terraces, the latter now seen in the upper terraces. No organic remains. Land probably subsiding, though not far from its present level.

(5) TILL OR BOULDER CLAY.—Irregularly distributed, occurring on borders of river valleys and under lee of elevations. Evidently of glacial origin. Boulders or erratics strewn about which have been transported by ice. No fossils. Greater portion of till, apparently upper till of other regions. Land evidently above the present level.

SURFACE GEOLOGY OF THE REGION ABOUT THE WESTERN END OF LAKE ONTARIO.

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(This Paper is Part II. of the "Geology of the Region About the Western End of Lake Ontario." For Part I., see this Journal, Vol. X., No. 3.)

I.—Introduction.

We have seen in Part I. of the "Geology of the Region about the Western End of Lake Ontario" that a large and varied study may be made out of the exposures of the old rock-formations. In the present portion of the study, it will be found that the *Surface Geology* is not only of local interest, for, from it we are taught many things concerning the vexed subject of glacial geology;—about the origin of the Lower Great Lakes, the terraces and the transportation power of pan or floe ice, besides the physiography of the region before the advent of the Ice Age and especially the causes which combined to form this very picturesque region of Canada.

In Part I, on the Palæozoic Geology, a portion of the surface features were described with reference to the exposures of Palæozoic formations. The present descriptions of topography have reference only to the Surface Geology.

In order to more fully explain the causes which conspired to bring about the present features, it is necessary to wander somewhat beyond the Region about the Western End of Lake Ontario. The descriptions of the topography and a portion of the study of the origin of the Lower Great Lakes have already been published*

* "Discovery of the Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario; with Notes on the Origin of our Lower Great Lakes." By J. W. Spencer, B.A.Sc., Ph.D., F.G.S., King's College, Windsor, N. S. Read before the American Philosophical Society, March 18, 1881, and published in the Proceedings of the Society. The same paper was re-published in Report Q., of the Pennsylvania Geological Survey, with Notes by Prof. J. P. Lesley, the Director. A portion of the paper on the Origin of the Lakes is copied from my Paper on the subject, read before A.A.A.S., Cincinnati, Aug., 1881.

but will here be reprinted with some alterations without quotation marks.

II.—TOPOGRAPHY OF THE REGION ABOUT THE WESTERN END OF LAKE ONTARIO.*

The Niagara Escarpment.—This range of hills commences its course in Central New York, and extends westward, at no great distance south of Lake Ontario. It enters Canada at Queenston Heights, and thence its trend is to the western end of the lake, where, near Hamilton, it turns northward and extends to Cabot's head and Manitoulin island. Everywhere in Canada, south of Lake Ontario, it has an abrupt fall looking towards the northward; but at Thorold and other places to the eastward its brow is more broken than at Grimsby, and westward. At Hamilton the brow of the escarpment varies from 388 to 396 feet above Lake Ontario. About five miles east of Hamilton the escarpment makes an abrupt bend enclosing a triangular valley, down which Rosseaux creek and other streams flow. This valley is about two miles wide at its mouth, and has a length of about the same distance.

About five miles westward of Hamilton the Niagara escarpment becomes covered with the drift deposits of a broken country, or rather ends abruptly in the drift of the region. Above the range, the country gradually rises to the divide between Lake Ontario and the Grand river, or Lake Erie, without any conspicuous features. South-eastward of Hamilton, at a point about five miles from the brow of the escarpment, where the Hamilton and North-Western Railway reaches the summit, the altitude above Lake Ontario is 493 feet. At Carpenter's quarry, two miles southward of the "mountain" brow, at the head of James street, the altitude reaches 485 feet; and near Ancaster the summit is 510 feet above Lake Ontario. From eastward of Grimsby (for twenty miles) to near Ancaster, the escarpment presents an abrupt face from 150 to 250 feet below the summit (having a moderate amount of talus at the base), thence it extends by a more or less steep series of slopes to the plane, which gradually

* The topography is partly represented on map accompanying Palæozoic Geology. Burlington Heights is the spur of land between the Marsh and Burlington Bay.

inclines (sometimes by a succession of terraces), to the lake margin.

On the northern side of the town of Dundas, the abrupt face of the escarpment looks southward, and extends four or five miles westward, until the exposure becomes covered by the drift deposits near Copetown station, similar to the termination at Ancaster on the south side of the Dundas valley, but not by an abrupt ending as at the latter locality. About two miles east of the G. W. Railway station, at Dundas, the trend of the range bends more to the northward, and from this point there is a marked difference in the configuration of the country below the summit. The range, after extending beyond Waterdown, turns still more to the northward and passes near Milton and Limehouse station (on the G. T. Railway), and thence extends to Georgian bay. The height of Copetown above the lake is 502 feet. On the west side of Glen Spencer it is 409 feet, and eastward of the same gorge, the highest point is 520 feet (Niagara limestone coming to within four feet of the surface). At Waterdown the altitude is over 500 feet (?) and at Limehouse the brow of the range (though only the lower beds of the Niagara limestones occur) is 810 feet. Farther to the northward the country rises until it reaches an altitude of 1462 feet above Lake Ontario, or 1709 feet above the sea, near Dundalk station, on the W. G. & B. Railway. The features of the surface of the country above the highlands north of Dundas are much more varied than south of Dundas valley. As the trend of the escarpment turns northward around the end of the lake, the face of the slope looks towards the eastward.

*Basin of Lake Ontario.**—As is well known, Lake Ontario consists of a broad shallow (considering its size) basin, excavated

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* The various Canadian railways and canals, whose elevations are referred to sea level, take Lake St. Peter as the datum. This represents high tide in the St. Lawrence River. The elevation assigned to Lake Ontario is 235 feet (by the Grand Trunk Railway) and 232 feet, according to different Canadian authorities, (above Lake St. Peter). The U. S. Lake Survey places Lake Ontario at 246·91 feet, and Lake Erie at 573·60 feet above mean tide. The Welland Canal places Lake Ontario at 326·75 feet below Lake Erie (which is now generally acknowledged to be 573 feet above mean ocean level). Therefore in all future references to elevation above mean tide, I have taken Lake Ontario at 247 feet.

on the southern margin out of the Medina shales, and having its southern shores from one to several miles from the foot of the Niagara escarpment. The Medina shales form the western margin (where not covered with drift) to a point near Oakville. From this town to a point some distance eastward of Toronto, the hard rocks are made up of the different beds of Hudson River epoch; while the soft Utica shales occupy the middle portion, and the Trenton limestone the portion of the Province towards the eastern end of the lake.

The country at the western end of the lake consists of slopes gently rising to the foot of the Niagara escarpment, noticed before. Sometimes this elevation is by terraces, and again by inclines so gentle, as between Lake Ontario and the foot of the escarpment at Limehouse (on the G. T. Railway) where the difference of altitude above the water is more than 700 feet, without any very conspicuous features.

At the western end of the lake, the two shores converge at an acute angle. At about five miles from the apex of this angle is the low Burlington beach, thrown across the waters in a slightly curved line, which forms the western end of the open lake. Burlington bay, thus formed, is connected with the open lake by a canal of the same name. This beach is made up of sand and pebbles (mostly of Hudson River age), and is more than four miles long, but nowhere is it half a mile wide.

No mean depth of Lake Ontario can be fairly stated. For geological purposes it has no mean depth, because it is simply a long channel with the adjacent low lands covered by back-water.

West of the meridian of the Niagara river the lake is evidently filled with more silt than eastward, as we find that the bottom slopes more gradually towards the centre, where the mean depth (increasing from the westward) of the channel may be fairly placed at 400 feet below the present surface of the waters. In this section of the lake, the average slope from both shores may be stated at 30 feet in a mile. At a short distance east of the 78th meridian, the character of the lake bottom changes in a most conspicuous manner. Here we find a deeper channel which extends for more than ninety miles, having an average depth of about 90 fathoms or 540 feet, with, in some places, a trough about 600 feet deep, generally near the southern margin of the

90-fathom channel. Here and there is a deeper sounding—the deepest being 123 fathoms or 738 feet. The long channel, surrounded by the 90-fathom contour line, is situated at a mean distance of not less than twenty miles from the Canadian shore, whilst its southern side approaches in some places to within six miles of the American shore, with which it is parallel. This 90-fathom channel varies from three to twelve miles in width. Its broadest and deepest portion is south of the Canadian peninsula of Prince Edward's County.

The mean slope of the lake bottom, from the Canadian shore to this deep channel just pointed out, may be placed at less than twenty-five feet in a mile, with variations from twenty to thirty feet in that distance. The mean slope from the New York shore line to the 90-fathom channel may be placed at sixty feet in a mile, but varying generally from fifty to ninety feet. On examination we find that the greater portion of this slope belongs to a belt which descends much more rapidly than the off-shore depression.

That the southern side of Lake Ontario has a submerged series of escarpments or one moderately steep and of great dimensions, is manifest when we come to study the soundings. In fact, if the bed of Lake Ontario were lifted out of the water, this submerged escarpment would be more conspicuous than the greater portion of the present one, known by the name of the Niagara. In many places the descent from the table-land above the Niagara escarpment is no more precipitous than the slopes of the submerged Cambro-Silurian (Hudson River, in part, if not throughout the entire length) rocks, with its sloping summit, in part crowned by a gently sloping surface of Medina shales. Nearly north of the mouth of the Genesee river, we find that within a single mile the soundings vary from forty-three to seventy-eight fathoms (between contour lines). This gives a sudden descent in one mile of 210 feet. As the soundings are not taken continuously to show to the contrary, most of the change of levels may be within a few hundred yards.

In the region of these soundings the deepest water outside of the 78-fathom line is 84 fathoms, whilst from the shore to the 43-fathom sounding the least distance is four and a half miles, thus giving the greatest mean slope of the lake bottom at sixty feet in a mile, before the escarpment is reached.

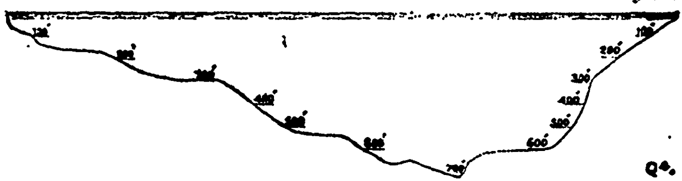
An excellent series of soundings can be studied in a line nearly northward from Putneyville, N. Y.:

Distance from Putneyville.			Depth of Sounding.		Slope from previous Sounding.
0.5	miles.		42	feet.	
1.0	"		72	"	[illegible] feet per mile.
1.75	"		126	"	72 " "
4.125	"		246	"	50 " "
5.0	"	Face of the escarpment.	372	"	144 " "
6.0	"		582	"	210 " "
7.0	"		624	"	42 " "
10.0	"		642	"	6 " "
12.0	"		738	"	48 " "

Fig. 1.

Section of Lake Ontario from Point Peter Light, Ontario, to Putneyville, N.Y.

Pt Peter. *Distance 49 miles.* *Putneyville.*



From this table it will be seen that in a distance of less than two miles the slope of the escarpment is the difference between 582 and 246 feet, or 336 feet as actually recorded. At Hamilton, the Niagara escarpment is only 388 feet above the lake, which is two miles distant, whilst the present slope at Thorold is spread over nearly twice that distance. That this escarpment is not local is easily seen. For a distance of over forty miles, from near Oswego westward, it plunges down 300 feet or more in a breadth varying from less than two to three miles. Eastward and westward of this portion of the lake this submerged escarpment can be traced for nearly one hundred miles, but with the portion deeper than the 70-fathom contour having more gradual soundings, as the base of the hills either originally had a more gradual slope, or the lake in its western extension has subsequently been filled with more silt.

Although we have not soundings made very close together, yet the admirable work of the United States Lake Survey is more than sufficient to prove the existence of a continuous escarpment which has an important bearing on the Preglacial geography of the region, and on the explanation of the origin of the Great Lakes themselves.

The soundings do not show a conspicuous escarpment after passing westward of the meridian of Niagara river, partly on account of the sediments filling this portion of the lake, and partly because the lake in all probability never had its channel excavated to so great a depth as farther eastward.

Attention must be called to the fact that the depth of the Niagara river is 12 fathoms near its mouth, but that the lake around the outlet of the river has a depth not exceeding four fathoms with a rocky bottom.

Another escarpment at the level of Lake Ontario, now buried, was discovered by the engineers of the enlargement of the Welland canal, according to Prof. Claypole (Can. Nat. Vol. ix. No. 4). When constructing No. 1 lock, at Port Dalhousie, it was found that at its northern end, there was an absence of hard rock which formed the foundation of its southern end. Rods more than 40 feet long were pushed into the slimy earth without meeting any hard rock bottom. This discovery will be noticed in the sequel.*

Basin of Lake Erie.—The exceedingly shallow basin of Lake Erie has its bottom as near a level plane as any terrestrial tract can be. Its mean depth, or even maxima and minima depths from its western end for more than 150 miles, scarcely varies from 12 or 13 fathoms for the greater portion of its width. The eastern 20 miles has also a bed no deeper than the western portion. Between these two portions of the lake the hydrography shows an area with twice this depth (the deepest sounding being 35 fathoms). This deepest portion skirts Long Point (the extremity, a modern peninsula of lacustrine origin), and has a somewhat transverse course. An area of less than 40 miles long has a depth of more than 20 fathoms. The deeper channel seems to turn around Long Point, and take a course towards Haldimand county, in our Canadian Province, somewhere west of Maitland. The outlet of the lake, in the direction of the Niagara river, has a rocky bottom (Corniferous limestone.)

The Dundas Valley and adjacent Cañons.—We may consider that the Dundas valley begins at the "bluff" east of the Hamilton reservoir, and extends westward, including the loca-

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* See Report of Chief Engineer of Canadian Canals, 1880.

tion of the city of Hamilton and the Burlington bay, at least its western portion. With this definition, the width at the "Burlington heights" (an old lake terrace 108 feet above present level of the water) would be less than five miles. At a mile and half westward of the heights, the valley suddenly becomes narrowed (equally on both sides of its axis of direction, by the Niagara escarpment making two equal concave bends, on each side of the valley, whence the straight upper portion extends, the whole resembling the outline of a thistle and its stem), from which place it extends six miles westward to Copetown, on the northern side; and three and a half to Ancaster, on its southern side. The breadth between the limestone walls of this valley varies somewhat from two to two and a half miles. The summit angles of the limestone walls on both sides are decidedly sharp.

Dundas town is situated in this valley, its centre having a height of about 70 feet above Lake Ontario, but its sides rise in terraces or abrupt hills—many rounded and resembling *roches montounées.* On ascending the valley we find that between the escarpments are great ranges of parallel hills separated by deep gorges or glens, excavated in the drift by interglacial and modern streams. This rugged character continues until the summit of the Post Pliocene ridges have a height equal to that of the escarpment. As the gorges ascend towards the westward, they become smaller, until at some distance south-west of Copetown and Ancaster, the divide of the present system of drainage is reached. Some of these streams have cut through the drift, so that they have only an altitude above the lake (which is seven miles distant) of 240 feet, while the tops of the ridges immediately in the neighborhood are not much less than 400 feet high, though they themselves have been removed to a depth of about another hundred feet, for the drift has filled the upper portion of the valley to the height of 500 feet above Lake Ontario. Even to the very sources of the streams, the country resembles the rivers of our great North Western Territories (or those of the Western States), cutting their way through a deep drift at high altitudes, which is not underlaid by harder rocks, showing deep valleys rapidly increasing in size and depth, as they are cleaning out the soft material, and hurrying down to lower levels—a strong contrast to the features in most other portions of our Province.

On the southern side of the Dundas valley, a few unimportant streams, mostly dry in summer, have worn back the limestone escarpment, over which they flow, to distances varying from a few yards to a few hundred, making glens at whose head in spring time some picturesque cascades can be seen. At Mount Albion, six miles east of Hamilton, there are two of these larger gorges, whose waters, after passing over picturesque falls, 70 feet high, and through glens several hundred yards in length, empty into the triangular valley noticed before. On the northern side of the Dundas valley, besides small gorges with their streams comparable to those on the south side, there are several of much larger dimensions; for example that at Waterdown, six miles north of Hamilton. Still larger is Glen Spencer which has a *cañon* half a mile long, 300 feet deep and between 200 and 300 yards wide at its mouth. At the head of this is Spencer falls, 135 feet high, and joining it laterally there is another *cañon*, with a considerable stream flowing from Webster's falls, which, however, is of less height than the other. The waters feeding these streams come from northward of the escarpment, and belong to a system of drainage different from those streams which flow down through the drift of the Dundas valley, and are of much greater length. At the foot of Spencer falls, the waters strike the upper portion of the Clinton shaly beds. The Falls are two feet deeper than twenty years ago. Yet the stream is small, and makes a pond below in the soft shales. But this difference in height does not represent the rate of wearing or recession of the precipice. but only the removal of a little *débris* at the base. That the stream is much smaller than formerly is plainly to be seen, for at present it has cut a narrow channel, from ten to fifteen yards in width, above the falls, and from four to six feet deep on one side of the more ancient valley, which is about 50 yards wide and 30 feet deep, excavated in the Niagara dolomites.

The surface of the escarpment on both sides of Glens Spencer and Webster presents a peculiar aspect. That on the north-eastern side has a maximum height of 520 feet above the lake. On the same side, a section, made longitudinally, shows several broad shallow glens nearly a hundred feet deep crossing it and entering Glen Spencer. The surface of the rocks is glaciated, but not parallel with the direction of the channels. On the south-western side of the same *cañon*, we find that a portion of the thin beds of Upper Niagara limestone have been removed. This absence is not general, for it soon regains its average height of about 500 feet.

Dundas Marsh.—The eastern end of the Dundas valley contains a large swamp, nearly three miles long, with a breadth of about three-fourths of a mile, known in the early settlement of the country by the name of Coote's Paradise.

This marsh was formerly connected by a small rivulet with Burlington bay, but this was subsequently closed by the G. W. Railway, when the cutting of Desjardin's canal through Burlington heights was completed. Into this marsh all the drainage of the Dundas valley is deposited, causing it to fill up at the rate of one-tenth of a foot per annum.

Burlington Heights.—Across the eastern end of the Dundas swamp and some of its branches, are the Burlington heights, varying from a few hundred yards to nearly a quarter of a mile in width, and over 100 feet in height, which have been an old beach, at a time when the lake level was at the same elevation, for we find that a lake beach extends along the flanks of the escarpment, both eastward and northward for a considerable distance at the same level. This is mentioned here as forming a most conspicuous terrace, and as changing the physical character of the western extremity of Burlington bay, and the outlet of the Dundas valley. Various terraces and beaches are found, both at lower levels, and also fragments at higher altitudes along the side of the "mountain," until some attain a height of 500 feet above Lake Ontario.

The Grand River Valley.—The Grand river of Ontario rises in the County of Grey, not more than twenty-five miles from Georgian bay. Thence it flows southward, and at Elora the river assumes a conspicuous feature. Here it cuts through the Guelph dolomites to a depth of about 80 feet and forms a *cañon* about 100 feet in width with vertical walls. At this place it is joined by a rivulet from the west, which has formed a tributary *cañon* similar to that of the Grand river itself.

The country in this region is so flat that it appears as a level plain. Farther southward the river winds over a broader bed, and at Galt the present river valley occupies a portion of a broad depression in a country indicating a former and much more extensive valley. In fact, the old river valley existed in Preglacial times, for the present stream has re-excavated only a part of its old bed at Galt, leaving on the flanks of one of its banks (both of which are) composed of Guelph dolomites, a deposit of Post Tertiary drift, in the form of a bed of large rounded boulders mostly of Laurentian gneisses. The country for four miles south of Galt is of similar character, forming a broad valley, in which the present river flows. At this distance from Galt the river takes a turn to the south-westward; but at the same place, the old valley appears to pass in a nearly direct line with the course of the present bed (before the modern turn is made to the westward). As this portion of the valley now entered has not to any extent been cleaned out by modern streams, it forms a broad shallow depression in the country extending for a few miles in width. Yet, it is often occupied with hills composed of stratified coarse gravel belonging to that belt, which extends from Owen Sound to the county of Brant, and called by the Canadian Geological Survey "Artemesia gravel."

It is through a portion of this valley that the Fairchild's creek flows. Many streams derive their supplies of water from the Beverly swamps, and feed the Lindsay creek, which empties over Webster falls and flows down Glen Spencer through the Dundas valley to Lake Ontario.

The G. W. Railway at four miles south of Galt enters the Grand river valley and continues in it or its branches as far as Harrisburg, though the deeper depression is near St. George (a short distance west of Harrisburg). After leaving what I consider its more ancient bed, south of Galt (unless the country between the present bed and Fairchild's creek was an island), the Grand river flows southward to Paris and Brantford, having a deep broad valley. At Paris, Nith's creek enters the Grand river from the west, and has a valley almost comparable in size with that of the latter at this town. At Paris, the Grand river cuts through the plaster-bearing Onondaga formation. Similar rocks appear at various places along the river, where the stream has cleaned out a portion of one side or other of its ancient valley.

Between the elevated plateau (of nearly 100 feet close to Lake Ontario) south of Brantford and that rolling country of equal height near Harrisburg, the alluvial-covered plain of from 400 to 460 feet above lake Ontario, more than ten miles wide, may be considered as a portion of an ancient enlargement of the great river basin.

At the Great Western Railway crossing east of Paris, the bed of the river has an altitude of 495 feet above Lake Ontario, whilst at Brantford it is 398 feet above the same datum. From Brantford the river winds through a broad valley, with a general easterly direction to Seneca, where the immediate bed is about a quarter of a mile wide, flowing near the southern side of a valley, more than two miles wide.

At Seneca the bed of the present river course is 365 feet above Lake Ontario, or only 37 feet above Lake Erie. Eastward of Seneca, the river continues to have its broad valley as far as Cayuga, where the hard bed of the river is below the surface of Lake Erie.

From Seneca to Cayuga the direction of the river is nearly south, but at the latter place it abruptly turns nearly to the eastward, and in a short distance it passes to a flatter country and flows over Corniferous limestone. After a sluggish flow, it enters Lake Erie (passing through a marshy country) at Port Maitland, more than fifteen miles in a direct line from Cayuga.

The Grand river valley (75 feet deep) is more than two miles in width and bounded by lateral elevations of 440 feet above Lake Ontario, or 113 feet above Lake Erie; and farther by boundaries; on both sides, of 160 feet above the latter lake.

At Dunville, a few miles from the mouth of the river, piles were driven to a considerable depth without reaching hard rock. The margins of the valley are small, composed of either the more or less shaly Onondaga rocks, or Corniferous limestone. In the meanderings of the river from one side of the valley to the other, it occasionally crosses spurs of earthy Onondaga limestones, but the character is not such as to preclude the possibility of an adjacent buried river channel. At most, all the waters that could come down the Grand river, even with an increased pitch of the country, and a larger precipitation of moisture would scarcely be able to more than excavate its present bed. The country on either one side of the river or other is remarkably broken within the limits of the valley, but beyond it is equally remarkable for its level surface. This broad peculiar valley bears a strong contrast to that of the upper portion of its course (as at Elora) where the *cañon* could have easily been excavated by the present stream if sufficient time were given.

Returning to the valley of Fairchild's creek, we find the stream principally flowing in the former bed of the Grand river, abandoned a few miles below Galt since the Ice Age. This creek crosses the Great Western Railway at a level of fifteen feet below the crossing of the Grand river, at a few miles to the westward. Again, the Fairchild's creek crosses the Brantford and Harrisburg Railway at an altitude of 397 feet above Lake Ontario, or a little below that of the Grand river at Brantford, although it empties into it a few miles east of the city just named. Fairchild's creek is now of moderate size meandering through the drift for a width of two miles. This drift is stratified clay.

Country between the Grand River and Dundas Valleys.—The watershed between these two present drainage systems is at only a short distance south-west of Copetown, and the distance in a direction from the Fairchild's to the Dundas side of this divide is less than seven miles, with an average altitude of less than 480 feet. The highest point that I have levelled is 492 feet above Lake Ontario. On receding westward from the divide, the country gradually descends to the Fairchild's creek. The region between the divide and the Grand river is traversed from north-west to south-east by a considerable number of streams, all with relatively large valleys, cut in the drift, since the present system of drainage was inaugurated in interglacial or modern times.

The country from Jerseyville (about 465 feet above lake) slopes gradually to the Grand river, from six to eight miles distant to the southward.

On examination, it may be seen that the country is too high to permit the Fairchild's creek or Grand river, as they are at present situated, to flow over the height of land into the upper portion of the Dundas valley. As referred to before, the Niagara limestone forming the summit of the escarpment at Ancaster and eastward has a height of about 500 feet. These beds dip at only about 25 feet in a mile (to about 20 degrees west of south) and are not generally covered by a great thickness of drift, but in many places are exposed on or near the surface. Westward of Ancaster these limestones are nowhere to be found, but the country is only covered with drift. At a short distance west of this village, we find streams flowing north-easterly and easterly with very deep valleys in the drift, indicating the absence of the floor of limestone to a depth of over 220 feet below the surface of the escarpment. On going westward we find that the streams have not cut to an equal depth, but are still running deeply through drift.

On reaching the divide west of Ancaster village, we find that the valleys, excavated out of the drift belonging to both the Dundas valley and Grand river drainage, inosculate at an elevation of about 400 feet above Lake Ontario, thus showing the former connection of the basins more than 100 feet below the rocky flows which surround them. Even in this depressed area wells are known to reach 60 feet in the drift without meeting with solid rock.

On the northern side of the Dundas valley the escarpment after reaching Copetown is buried by the drift. Although the line of buried cliffs recedes somewhat to the northward of the Great Western Railway, yet there are occasional exposures, as at Troy and other places in Beverly and Flamboro, where the underlying limestones come to the surface. At Harrisburg the limestones are known to be absent for a depth of more than 72 feet, as shown in a deep well in the drift.

In the town of Paris one well came upon hard rock at 10 feet below the surface, whilst another at 100 feet in depth, reached no farther than boulder clay. This last well must have been in a buried channel of Nith's creek, as outcrops of gypsum bearing beds of the Onondaga formation frequently occur near the summit of the hills. From what has just been written, it is easily seen that the Niagara limestones are absent from a more or less horizontal floor (which is over 500 feet above the lake, on both the northern and southern sides of the Dundas valley) which continues from Dundas westward to near Harrisburg, where it meets a portion of the Grand river valley. But almost immediately west of Ancaster we find streams running northward at right angles to the escarpment, and cutting through drift to the depth of almost hundreds of feet. In fact, if we draw a line from Dundas to northward of Harrisburg (a mile or two), and another from Ancaster southward to the Grand river, we have two limits of a region where the limestone floor has been cut away from an otherwise generally level region. The southern side of this area is the southern margin of the Grand river valley, between Seneca and Brantford, and the western boundary is composed of Onondaga rocks east of Paris (which perhaps forms an island of rocks buried more or less in drift).

Additional proofs may be cited. About a mile south of Copetown a well was sunk to the depth of 100 feet before water was obtained. At two miles south-east of the same village there is a small pond only 240 feet above Lake Ontario, or more than 260 feet below the neighboring escarpment. This is in drift. Again, at a mile north of Jerseyville, the country has a height of 465 feet, with a well in the surface soil to a depth of 40 feet. A small rivulet flows in a valley a few hundred yards south of the last named well which has a bed 435 feet above the lake. At about a mile west of Jerseyville, the altitude is 468 feet with a well 52 feet deep. Again, at about two miles west of the same village, near the county line, the altitude is 460 feet, with a well 57 feet deep. About a mile north of the last named station is a ravine 436 feet with the adjacent hills forty feet higher, and rising in a mile or two to about 500 feet. All these wells are in the drift. From exposures near Ancaster, it appears that the unstratified drift has not an altitude of 400 feet. And as we know that some of these superficial beds are stratified clay, and over most of the country just described not a boulder is to be seen, neither on the surface nor in the material taken from the greater portions of the wells, it is probable that the water is only obtained on nearing the more porous boulder clay below. It has also been noticed that two wells, at least, are 100 feet deep before reaching water, therefore we may fairly place this as about the inferior limit of stratified superficial clays. It will be seen that westward of the meridian of Ancaster there is an area of over 100 square miles, where the Niagara floor is known to be removed everywhere to a depth of 100 feet, and in its eastern portion to more than 260 feet, and still nearer Lake Ontario to a measured depth of more than 200 feet below its waters.

III.—THE BURIED RIVER CHANNEL IN THE DUNDAS VALLEY AND ITS EXTENSIONS.

That the Dundas valley is that of an ancient river valley now buried to a great depth with the *débris* produced in the Ice Age, becomes apparent on a careful study of the region. However, until a key was discovered the mystery of its origin was found to be very obscure. My own labors at studying this region may fairly be stated as the first systematic attempts at the solution of the present configuration of the western end of Lake Ontario and the adjacent valley. Assertions have been made that it was scooped out by a glacier, but this wild hypothesis was only a statement made without any regard to facts.

From the description of the topography, given in section II, of this paper, it will be seen that the apparent length of the rock-bound valley is six miles with a width of over two miles; then it widens suddenly to four miles (with concave curves on both sides) after which it gradually increases in width as it opens into Lake Ontario. The direction of the axis of the valley is about N. 70° E. The summit edges of the rock-walls on both sides are sharply angular and not rounded or truncated. This angularity is not due to frost action since the Ice Age, to any extent, as is shown by the character of the talus. The rocks of the summit are frequently covered with ice markings, but I am not aware of any locality where they have been observed as being parallel with the true direction of the valley, but on all sides one can observe them (sometimes at only small angles of less than 30 degrees) making conspicuous angles with its axis. One exception may be made to this statement. On a projecting ledge of Clinton limestone, at Russel's quarry, near Hamilton, at a height of 254 feet above the lake, and 134 feet below the summit of the "mountain," after the removal of some talus, I observed that the surface was polished, but with scratches so faint that they could scarcely be compared with those of fine sandpaper on wood; and the direction, if determinable, was parallel with the overhanging escarpment. There are many tributary *cañons*, which are evidently of greater antiquity than the Ice Age, which could not have excavated by the present streams, and are at all sorts of directions compared with the striated surface of the country.

The topography of the lower lake regions precludes the idea of a glacier flowing down the valley to the north-eastward. Again, as the direction of the ice was towards the southwest, the waters from the melting glaciers could scarcely flow up an escarpment many hundreds of feet in height. Even if the Niagara escarpment did not exist elsewhere, the non-parallelism of the striæ, and edges of the escarpment with their angular summits, is sufficient to prove the non-glacial origin of the valley in the hard limestone rocks. Moreover, at the eastern end of the narrower portion of the valley, there are two concave curves facing the lake, which of necessity would have been removed if such a gigantic grinding agent had been moving up the valley.

This glacier-origin of the valley being an absolutely untenable hypothesis, I sought for some fluviatile agent capable of effecting the present configuration of the region. At the time, no idea occurred that even the great valley of the present is only a miserable remnant of one of gigantic proportions obscured by hundreds of feet of drift. The question arose, could Lake Erie have ever emptied by this valley? This suggestion did not hold its ground for any length of time, because the present levels are all too high. Near Galt, the traces of the true origin first presented themselves. A branch of the Great Western Railway extends from Galt southward for about four miles in the valley of the Grand river, after which, without making any important ascent, it passes into the broad older valley, described above as that in which Fairchild's creek now flows. After a careful examination of the region, and of the railway levels, I came to the conclusion that this was an old buried valley. It then became apparent that if the Grand river had occupied the site of the Fairchilds's creek, that the latter probably flowed down the Dundas valley, and that the Grand river, being one of the largest of the rivers of Ontario, might have been a sufficent cause for the great excavation at the western end of Lake Ontario. Having procured all the levels that bore on the subject which were available, it became necessary to connect several places myself by instrumental measurements, which work was accomplished with the aid of Prof. Wilkins. As the whole floor of Niagara limestones is absent, as has previously been shown, the proof that the ancient Grand river flowed down the Dundas valley was completed, and of this discovery there was published a local notice in August, 1880. Significant and interesting as this fact was, relative to the change of systems in our Canadian drainage, a still more important issue was involved. When taking the levels between the Dundas valley (modern) and the Grand river, it was found that the whole calcareous floor was removed from a basin several miles in width, and that all the wells were sunk to a considerable depth in the drift before water could be obtained. On glancing at the map it will be seen that the Grand river from Brantford to Seneca meanders through a broad course, which in its ancient basin is several miles in width, but that from Seneca the valley is narrower, and the course of the stream more direct, as far as Cayuga. At Seneca the valley is two miles wide, and seventy-five feet deep. Also the bed of the Grand river at Seneca is in drift which is only 37 feet above the lake into which it now empties, as has been pointed out in the section.

Having observed the connection between the Dundas valley, Grand river and Lake Erie, it dawned on me that I had established the knowledge of a channel having a very important bearing on the surface geology of the lake region. It now became apparent that Lake Erie had flowed through the Grand river valley reversed, to a point west or north-west of Seneca, and thence by the Dundas valley into Lake Ontario; also that the upper waters of the Grand river, previously discovered as passing down the Dundas valley, were really tributary to the outlet of Lake Erie, and joined it somewhere south of Harrisburg; and that the basin between the Brantford (and the Grand river of to-day) and the Great Western Railway, at Copetown, formed an expanded lakelet along the course of the ancient outlet of Lake Erie, scooped out of the softer rocks of the Onondaga formation before noticed. As the waters excavated a bed in a deeper channel, of course this lakelet would become an expanded and depressed valley, such as we often see amongst the hills of drift.

Fig. 2.

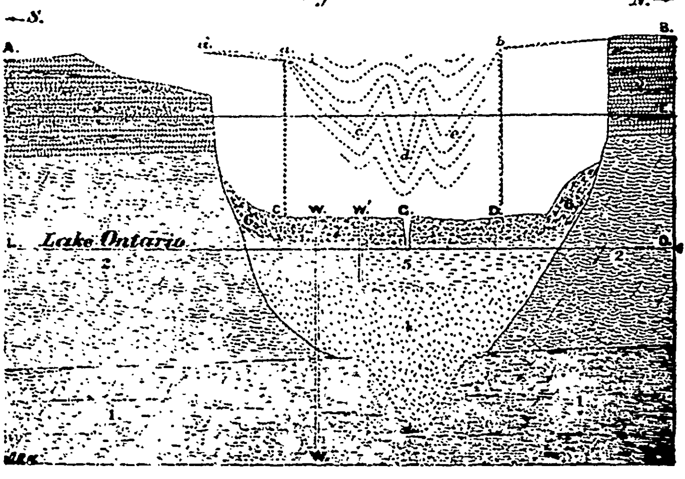

Fig. 2.—1. Hudson River formation; 2. Medina shales; 3. Niagara and Clinton dolomites with some shales. A, C, D, B, modern valley at meridian of Burlington heights; a, C, D, b, modern valley at meridian of Dundas; a, c, d, e, b, sections across, deeply excavated in beds of streams in western part of the Dundas valley; 4. Boulder clay filling ancient valley; 5. Erie clay; 6. Talus from sides of escarpment; 7. Old beach, 108 feet above lake at Burlington Heights; G, Desjardin's canal leading from Dundas marsh to Burlington bay; W, W, well at Royal Hotel, Hamilton; W', another well at Dundas; L, O, level of Lake Ontario; L, E, level of Lake Erie. Horizontal scale, 2 miles to an inch; vertical scale, 400 feet to an inch.

at a short distance westward of Dundas. Possibly the Grand river divided and flowed around an island, the western side of which is occupied now by the town of Paris. At any rate, Neith's creek, at that town, formed a large tributary to the river then flowing down to Lake Ontario.

From a careful study of the broad valley of the lower portion of the Grand river, it becomes apparent that it was a portion of the outlet of Lake Erie, which passing to the region of Seneca village, turned towards the Dundas valley, although the present river exposes shaly Onondaga rocks, occasionally as it approaches the margins of the old valley.

Again Mr. Carll has shown that the Alleghany drainage passed near Dunkirk into the Erie basin at a place just opposite to its outlet, as indicated by the present writer.

Much of the Dundas valley is underlaid by stratified Erie clay, which is known to extend to a depth of 60 feet below the surface of Lake Ontario, according to Dr. Robert Bell. In the upper part of the valley, streams have exposed some deposits of unstratified clay filled with angular shingle, derived from the thin beds of limestone forming the upper portion of the Niagara formation. In the eastern portion of the valley, the Erie clay is overlaid unconformably by brown Saugeen clay or loam (stratified). In the upper portions of the valley the hills are capped by brown clays or sands. But along some of the hillsides excavated so deeply in the drift, we find old beaches resting unconformably on boulder clay.

Near the centre of the city of Hamilton, in the wider portion of the Dundas valley, a well was sunk to the depth of over 1000 feet. This well revealed a most interesting fact. Though known to me several years ago, I did not apply it until recently to its true bearing, since discovering the origin of the Dundas valley. Mr. J. M. Williams sunk this well, at the Royal Hotel, in Hamilton. He told me several years ago that he had to sink through 290 feet of boulders, before coming to hard rock, thus causing the outlay of a large sum of money in excess of his calculations. Unfortunately this well-record has been lost by fire. At that time the fact was so fresh in his memory (improved by the extraordinary cost of the well) that his statement could be relied on, being experienced in well-borings. The mouth of this well is 63 feet above Lake Ontario, and therefore the hard rocks are absent for a depth of 227 feet below the lake surface. See section, Fig. 2.

As the valley is five miles wide at this place, and as the well is only about one mile distant from its southern side, it becomes apparent that the valley in the centre must have been much deeper. Moreover, if we produce the southern side of that portion of the valley, which is over two miles wide, we find that the well is less than a quarter of a mile away from it. Now if we connect the top of the Medina shales (240 feet above Lake Ontario) with the base of the drift in the well, and produce it to the centre of the valley, it would indicate a central depth of over 500 feet. At the base of the drift there are nearly fifty feet of Medina shales, below which are the Hudson River rocks (more or less calcareous and arenaceous, mixed with the shales). This harder formation along the bed of a river would be less extensively removed by aqueous action than the overlying Medina shales, especially as the pitch of the waters would be much lessened. This graphic method of calculation seems as perfectly admissible here as it does in determining other constants of nature. However, I have placed the estimated depth in the section at about 70 fathoms below the lake surface, which depth is perfectly compatible with the soundings of the lake at no very great distance to the eastward. Even this depth gives only very gentle slopes from the sides of the river valley. It should be remarked that Burlington bay is excavated from stratified clays in places to a depth of 78 feet. But this water is silting up comparatively quickly.

Now we have seen that the deep excavation in the Dundas valley and westward is cut through more than 250 feet of Niagara and Clinton rocks, mostly limestone, and to a depth in the Medina shales, so that the total known depth of the *cañon* is 743 feet, but with a calculated depth in the middle of the channel of about 1000 feet. This depth for a *cañon* is not extraordinary for Eastern America. In Tennessee there are river valleys excavated to a depth of 1600 feet. And in Pennsylvania Mr. Carll reports others to be equally deep.

Again, this Preglacial river explains the cause of the present topography of the western end of Lake Ontario. The drainage by this river swept past the foot of the submerged escarpment of Lake Ontario described in preceding pages, until it reached the meridian of Oswego.

With such an outlet, and with the ancient Grand river valley buried by greater or less depth, we have an easy solution to the problem of the drainage of Lake Erie. Moreover the present barrier between the lakes may have quite probably been increased by local elevation of the land as we find the indications pointing to the Dundas valley being along the axis of an anticlinal of less than one degree of dip.

Attention has been called in this paper to the deepest portion of Lake Erie being southward of Haldimand county, and about the end of Long Point, and extending transversely towards the Pennsylvania shore.

So far, our remarks have been applied to Canada. If we turn towards the American shore, we will see that the observations made there go very strongly in support of what has been written.

Several years since Dr. Newberry, Mr. Gilbert, and others, called attention to the deeply buried valleys of the Guyahoga, Chagrin, Grand, Maumee and other rivers in Ohio, which emptied into Lake Erie much below their present levels. The Cuyahoga has its channel buried to a depth of 228 feet below the surface of Lake Erie of our time, whilst the deepest water in the neighboring portion of the lake is less than a hundred feet.

In Report III, of the Pennsylvania Geological Survey, issued in November, 1880, Mr. John F. Carll published excellent maps of the Preglacial drainage of that State and the neighboring portions of the adjoining States. This report on the Preglacial rivers is the result of five years' labors in the oil regions, and many of Mr. Carll's results have been derived from the facts made known by the borings for the mineral oil.

Besides calling attention to the very deep valleys of erosion amongst the mountains, Mr. Carll has shown that in the oil regions the river valleys are frequently filled with drift to a depth of from 200 to 450 feet. In fact nearly all the present rivers flow over beds deeply filled with drift. The map of the Preglacial drainage shows that the upper waters of the Alleghany emptied by the Cassadaga river, reversed, into Lake Erie, near Dunkirk, and had for tributaries many other streams now flowing southward; for example the Conewango. These streams drained an area of 4000 miles, which now sends its surplus waters to the Ohio river. The French and other rivers now emptying southward from the Conneaut basin, emptied in Preglacial times into Lake Erie, westward of Erie city. Again, the Chenango, Connoquenessing, Mahoning and other tributaries of the Beaver river (itself now emptying into the Ohio) flowed northward, by the Mahoning river, reversed, into the state of Ohio, to near the sources of the Grand and Cuyahoga rivers. Hence Mr. Carll did not continue its course, on the map, but from the study of the levels and character of the country, as described by the Geological Survey of Ohio, I have connected it with the Grand river of Ohio, as represented on my map. In addition to this drainage I have pointed out the probability* that the Mahoning and upper Ohio, with the Beaver (reserved), Mahoning (reserved) and Grand (of Ohio) rivers formed a nearly straight valley, from the western side of the mountains of Virginia to Lake Erie.

Thus we find three large areas now flowing southward formerly emptying into Lake Erie basin.

The deepest portion of Lake Erie is between these ancient river mouths and the ancient *débouchement* of the Erie drainage by the Grand river of Ontario, as described in these pages.

Thus we have shown a consecutive system of drainage of the former waters of the buried channels into Lake Ontario, and thence running along the foot of the submerged escarpment of the latter lake to its eastern end, receiving the Genesse and other large rivers along its course.

Not only is the Dundas valley a deeply buried channel, but nearly all the streams that enter Lake Ontario are flowing over more or less deeply buried channels.

Origin of the Lower Great Lakes.

All of the chain of Great Lakes of North America are excavated principally out of the more or less shaly almost horizontal rocks of the various basins. They are all valleys of erosion (excepting perhaps, a portion of Lake Superior.) The erosive action of the atmospheric agencies would tend to wear the country into undulating basins,—for only such are the bottoms of the great Lakes. It is true that slight geological undulations may have determined the position of the lake-basins. The basins of Lakes Michigan, Huron and Ontario, especially, are traversed by long sub-lacustrine valleys resembling those of large rivers, and bounded by escarpments, which rise abruptly several hundred feet high. The description of the lake beds—the probable Preglacial outlets of Lakes Superior and Michigan (discharging their waters to the Mississippi valley); the outlet of Lake Huron

* See Proc. Am. Phil. Soc. XIX, 108.

(at least during a portion of its history) across the southwestern counties of the Province of Ontario, and entering the Erie basin somewhere between Vienna and Port Stanley; as well as a former outlet of Lake Erie into Lake Ontario, have been discussed somewhat fully in my paper published in the Transactions of the American Philosophical Society, already referred to. In order to keep nearer to the present subject of study, I will confine my remarks on the "Origin of the Lakes," to that of Lake Ontario, for the other lakes give corresponding testimony.

Dr. Newberry prophesied that an outlet for Lake Erie into Lake Ontario would be discovered near the Welland canal. This outlet in an unexpected position I have discovered, and in a position which explains more perfectly the cause of the topography of Lake Ontario than any that could have been discovered forty miles to the eastward.

When was the advent of such a drainage system for this continent? Some of our American friends, who have advocated the sub-ærial and fluviatile origin of the lakes, have placed it back to the Devonian Age. About the commencement we know nothing. It would be safer to place it after the Palæozoic time, for probably some portions of the Province of Ontario were covered with carboniferous deposits, as well as Michigan and Ohio, which have subsequently been removed by denudation.

Excavation of Lake Basins. Having seen the course of the Preglacial drainage, let us ask how the broad lake troughs could be excavated. Let us look at Lake Ontario.

The river coming down the Dundas valley flowed originally near the out-crop of the Niagara limestones, elevated by geological causes long ago. The direction of the stream was parallel to its trend. On the one side were the soft Cambro-Silurian shales, geographically higher, geologically lower; on the other (southern) side, the Niagara limestones, beneath which were the soft Medina shales until these were worn away in part. As the shaly rocks were removed and the limestones were undermined, the NIAGARA ESCARPMENT was produced. How far these limestones have receded towards the present face and summit of the slope, is a question yet to be decided. As the waters sunk to a lower level a second escarpment was produced (the one noticed at Port Dalhousie, at the present lake level). Afterwards the Hudson River shales (with some hard rocks) were pierced whilst yet there were capping Medina shales, forming the surface of the country between the river and the limestone escarpment.

All this presupposes the continent at a higher level (at least 600 feet). During some portion of the tertiary times, at least the eastern portion of the continent must have stood a thousand or twelve hundred feet higher than at present, as indicated by the soundings in the St. Lawrence river (near the mouth of the Saguenay), in the New York Harbour and off the mouth of the Chesapeake Bay.

The rate at which the upper lakes was excavated would depend partly upon the rate of the excavation of the Dundas valley and its extensions through the limestone, at first by a slow abrasion, and the solution of the carbonate of lime by the carbonic acid held in the water, and afterwards by the undermining of the hard rocks on the removal of the Medina shales.

(To be continued in our next.)

NATURAL HISTORY SOCIETY.

PROCEEDINGS FOR SESSION 1881-82.

The fifth meeting was held on Monday evening, Feb. 27th—the President in the chair.

On motion of Mr. Marler it was resolved that Dr. Johnson and the Recording Secretary be a Committee to draw up a petition for presentation to the Dominion Government for a general increase of grants to scientific institutions in Canada.

The Cabinet-keeper exhibited seven mounted birds, recent additions to the museum, viz.: *Alcyon Australis*, *Nestor productus*, *Carpophasa Novæ Zealandiæ*, *Porphiris speciosus* (2 specimens), and *Anthochaera coriculata*.

The gentlemen proposed for membership at last meeting were elected. The following gentlemen were proposed for ordinary membership:

Charles Gibb.	W. J. Buchanan.
A. E. Duncan.	Alex. Ewan.
C. F. Smithers.	Harington Bird.

Major Latour proposed as an honorary member M. le Comte de Sesmaisons, Consul-General of France.

Mr. Chas. Robb, C. E., then read an interesting paper on "The Geology and Natural History of the Island of St. Ignace, Lake Superior." The part of this paper concerning the geology of the locality in question appeared in Vol. X., No. III of the "Naturalist."

Principal Dawson then exhibited some interesting post-pliocene fossils, and gave a brief review of a recent essay by Dr. A. J. Von Wœickoff on the Glacial Period. This review will be found in full at page 181 in preceding number of this Journal.

The sixth meeting was held on 27th March, the President in the chair. After reading of minutes, Dr. Edwards and Mr. Muir were authorised to arrange for meetings of the Microscopic Club in the Society's Rooms.

The gentlemen proposed at last meeting were duly elected members of the Society.

Dr. Edwards then addressed the meeting on the "Cornwall Water Supply," giving results of his analyses of a number of samples of water from various sources in and around the town of Cornwall.

The Recording Secretary then read an abstract of a paper on "The Surface Geology of the Baie de Chaleurs Region" by Mr. R. Chalmers.

The paper appears in full in this number of the "Naturalist."

The President directed the attention of members to a large specimen of fresh-water sponge found by R. J. Fowler, Esq., in a mill dam at Scotswood, P. Q., and presented by him to the Society.

The seventh meeting was held on April 24th, the President in the chair.

It was decided to grant the American Association for the Promotion of Agricultural Science the use of the Society's Rooms for their meetings, to be held on the 21st and 22nd August.

Mr. W. F. Ferrier was proposed for ordinary membership.

Recent donations to the Museum, consisting of mineralogical specimens from W. F. Ferrier, Esq., and a Brazilian monkey from Mr. Papineau, were exhibited.

Mr. J. T. Donald then presented a few "Notes on Titanic Iron." He stated he had examined a large deposit of this substance in the Laurentian country, north of St. Jerome, in the parish of St. Agathe des Monts. The ore rested upon Labradorite rocks. It contained 27.6 per cent. titanic acid and 41.92 per cent. metallic iron.

The President exhibited a remarkable inscription, consisting of the letters J.C., M.J.F., with certain religious emblems, which had been engraved on the bark of a beech tree and overgrown by a great number of annual layers of wood. It had been observed in splitting the tree for firewood. The specimen was the property of Mr. A. Oswald, of Belle Rivière, Two Mountains, and had been sent by him for exhibition at the request of Mr. J. R. Dougall. In a botanical point of view the specimen is a rare and remarkable example of the manner in which wounds on the bark of an exogenous tree may be grown over and concealed. It also showed the possibility of an inscription being perfectly preserved in the interior of a tree when entirely concealed by subsequent layers of wood and bark.

The President called upon Dr. Edwards to explain to the meeting the general forms of microscopes and their illumination, which that gentleman did. Dr. Edwards also stated that the object of asking the members of the Microscopic Club to attend the meeting was to see what instruments there were in Montreal, because there would be a Microscopic section in the American Association meetings.

The remainder of the evening was spent in inspecting with the microscopes Natural History objects of different kinds.

ANNUAL MEETING.

The annual meeting was held on the evening of May 18th. the President in the chair.

THE PRESIDENT'S ANNUAL ADDRESS.

The President, Principal Dawson, first delivered his annual address to the members of the Society. He said :—

The present session, I believe, completes the half century since the incorporation of this Society, though its actual foundation dates from the year 1827. At the annual meeting before last, Major Latour gave you an interesting account of its various exertions within that time for the advancement of Canadian science, and which have not only steadily promoted our national growth in this respect, but have led to the institution of great public departments which may be said to have outgrown the Society itself. At the last meeting our attention was directed to the propriety of extending to the American Association for the Advancement of Science an invitation to hold a second meeting in Montreal after the lapse of twenty-five years. In this we have been happily successful. The invitation tendered by this Society has been unanimously and cordially accepted, and we hope on the 23rd of August again to welcome the *élite* of the scientific men of the United States and Canada to the hospitalities of our city. A large and influential local committee has already been organized, and has commenced its labours with that zeal and public spirit which ever characterizes the action of the citizens of Montreal in such matters. The meeting held here in 1857 was one of the most successful up to that time, and it is hoped that the meeting of 1882 may have a similar character. We must remember, however, that the American Association has grown to a much larger body than it was in 1857, and that correspondingly large demands will be made upon us, while correspondingly large benefits may be expected, more especially in the stimulus which will be given to science and scientific arts and industries. In connection with the latter result, not only will there be discussion of the latest results and improvements in the mechanical and chemical arts that depend upon science, but there will be meetings at the same time of the Society for Promoting Agricultural Science and of the American Forestry Association. In prospect of the approaching meeting we are also gratified with the fact that several eminent scientific men from Great Britain and the continent of Europe have responded favourably to the invitation sent by Dr. Sterry Hunt, the chairman of the Local Committee, and we hope that the presence of numerous savants from abroad will be a characteristic feature of the meeting. Montreal is, I think, to be congratulated on the prospect of another meeting here of the great Scientific Congress of this continent. Those who remember the meeting of 1857 know that benefits flowed from it to this city, the results of which still remain, and I trust that those of the approaching meeting will be on a still greater scale.

The session which closes to-night, whether we reckon it as the fiftieth or the fifty-third, may be characterised as a quiet and uneventful one. We have sensibly felt the removal of many of our most active members, caused by the transference of the officers of the Geological Survey to Ottawa. On the other hand we have had an unusual accession of members from the city, and it is hoped that this will not only enlarge the basis of support of the Society, but that some of our new members will contribute original work to our meetings. In connection with this it should be the study of the Council in the next session to endeavour to give added interest to the monthly meetings, so as to bring out a larger attendance of members and to create more lively discussion.

The papers read in the past session may be arranged under the heads of Chemistry, Geology and Natural History.

In Chemistry we have had communications from Dr. Baker Edwards and Mr. Donald on several practical subjects, more especially on analysis of waters used for household purposes, on certain resins imported into Montreal for the manufacture of varnishes, and on the composition of those titaniferous products which are associated with the Upper Laurentian Rocks.

In Geology the most important contributions were that on the recent remarkable discoveries of fossil fishes in the Devonian rocks in the Baie de Chaleur by Mr. Whiteaves, that by Mr. Charles Robb on the geology of the Island of St. Ignace in Lake Superior, and that of Mr. H. M. Ami on the fossils of the Utica Slate. There were also additional facts and conclusions respecting the Post-pliocene formations brought forward by Mr. Chalmers and by the writer.

In Zoology we had an interesting contribution from Dr. Osler, in which he noticed three species of fresh water *Polyzoa* which have been recognized in the Province of Quebec. Under this head we may also place the notice at one of our meetings of the specimen of a whale exhibited in the city, and which appears to be *Balœnoptera musculus* a well known species, though one we rarely have so excellent an oportunity to inspect. We may also notice here specimens of larvæ and of animal preparations exhibited to us by Mr. Muir and other friends in the evening devoted to microscopic work.

Botany has scarcely appeared this session at our meetings; and for this reason I will close with a notice of the remarkable inscription preserved in the interior of a beech tree and exhibited to the Society by Mr. W. Oswald, jr., of Mill Farm, Belle Rivière. The inscription which consists of religious initials and emblems, enclosed in an ornamental border, has been made on the bark of a beech tree about four inches in diameter. The tree had subsequently grown to the diameter of more than two feet, and had covered the inscription with 160 rings of growth, a fact ascertained through the kindness of Mr. Oswald by sawing off a slice of the trunk. Yet the inscription was perfectly perserved, and was recovered in all its integrity when the tree was cut up for cordwood. Many objects buried in exogenous trees by their annual growth have been obtained in this and other countries; but this is a very rare instance of the perfect preservation in the inner layer of an old tree of an inscription made on the bark, and its recovery after the lapse of more than a century and a half. The forests of the world must contain many strange records of this kind, though they are brought to light only by very rare accidents.

In conclusion, the Society is to be congratulated on the improvements made in its collections and building in the past year, and I trust that with God's blessing its second half century may be found, when its history comes to be written by some future President, even more successful and useful than that which has passed away.

Mr. G. L. Marler then read the

REPORT OF CHAIRMAN OF COUNCIL.

As chairman of Council it is my duty to report that during the session now closing your Society has received the large addition of 125 members. The usual course of Sommerville Lectures, six in number, was delivered to large and appreciative audiences.

The Museum was open to the public each evening for one hour before the commencement of the lecture. It is estimated that not less than 2000 persons visited the Museum on these evenings.

The subjects of the lectures with the names of the lecturers were:

1882.

Feb. 2nd. Mountains and Valleys. Principal Dawson, C.M.G., F.R.S.

Feb. 9th. The Lungs and Air Passages in relation to Health and Disease. T. Wesley Mills, M.D.

Feb. 16th. Edible Fruits, their Composition, Preservation, and Causes of Decay. J. T. Donald, B.A.

Feb. 23rd. The Microscope and its Revelations. J. Stevenson Brown, Esq., assisted by Wm. Muir, Esq., with his Oxyhydrogen Microscope.

March 2d. Alcohol and its Physiological Effects. F. Buller, M.D.

March 9th. Notes on a Recent Trip to Europe. T. Sterry Hunt, LL.D., F.R.S.

The thanks of the Society are due to the gentlemen who delivered these lectures which were eminently successful, the lecture hall on each occasion being more than filled.

Your Council has also to report that an invitation to the American Association for the Advancement of Science was forwarded by a deputation of your Society which was cordially received and the invitation accepted. The citizens of Montreal were then called together in your rooms to form a series of committees to prepare for the reception of this Association in a fitting manner. The use of your building has been placed at their disposal, and considerable progress has since been made by the various committees. Your Council cannot allow it to pass without recording the fact that the American Association for the Advancement of Science have chosen for their President Principal Dawson.

During the past year the Society held a field day at Montebello in conjunction with the Ottawa Field Naturalist's Club. This meeting was one of the most successful ever held by your Society, and the Ottawa Club expressed its complete satisfaction.

Your Council hope that many other field days in connection with the Ottawa Club may take place in the near future.

Your Council cannot omit this opportunity of thanking Mr. Papineau for the kind and generous manner in which he received the two societies, throwing open his splendid grounds and art gallery for their benefit.

REPORT OF THE TREASURER.

As Treasurer of the Society, Mr. Marler presented the following report and financial statement.

Your Treasurer is happy to report that the debt which has so long rested on your property has been paid off, also that 125 members have been added to your list of subscribers.

The building has undergone extensive repairs and alterations necessitated by the erection of houses against the north wall and otherwise.

The amount received from Mr. Thomas for the wall and ground ceded him was more than absorbed in paying for alterations and improvements. Finally, I have to report that your Society is now out of debt, and has on hand a balance of $156.09, and that during the year 3000 persons visited the Museum, three-fourths of the number free of charge.

FINANCIAL STATEMENT.

G. L. Marler, Treasurer, in account with The Natural History Society of Montreal.

from May 19th, 1881, to May 18th, 1882.

Dr.		Cr.	
1881. May 18.		1881 and 1882.	
To Balance on hand	$ 74.54	By Improvements, Alterations, &c	$277.31
" Excursion tickets	33.50	" Excursion	55.40
" Rent of Rooms	535.00	" Wood and Coal	104.00
" Members Fees	290.00	" Gas account for year	84.20
" Entrance Museum	21.90	" Printifig and Advertising	148.16
" Sale of Wall and Ground	204.69	" Insurance (three years)	55.00
" Government grant	700.00	" Petty expenses and repairs	67.82
		" Wages and Salary	293.35
		" Editing *Naturalist*	50.00
		" City Taxes (two years)	241.37
		" City for Water	24.70
		" Hy. Joseph Mortgage	268.00
		" Advertising	30.00
		" Lovell for Directory, &c	4.23
		" Balance on hand	156.09
	$1859.63		$1859.63

Mr. Wm. Muir then presented the

REPORT OF THE CABINET KEEPER AND OF THE LIBRARY COMMITTEE.

This report may be arranged under three divisions.

1.—Work on the Building.

2.—Work in the Museum.

3.—Report of the Library Committee.

1st. Work on the Building.—In consequence of the erection of a dwelling adjoining the north side of the building, three windows were closed up; the two in the Library were covered by bookcases and one in the Lecture-room plastered over. Two new Bird cases have been placed in the Museum. The whole drainage of the building has been remodelled, an entirely new drain put in and connected with the lower drain in Cathcart Street.

2nd The work in the Museum has been of routine nature; the care of the specimens, the mounting and placing of the additions by purchase or gift.

Additions to Museum since June 1st, 1881.

DONATIONS WITH NAMES OF DONORS.

ANIMALS.

Red-winged Blackbirds, *Agelaius phœniceus*, male (2). G. L. Marler, Esq.
Two Grey Parrots, *Psittacus*. Mr. Carpenter.
Flying Squirrel, *Poterimys sabrinus*. Mr. W. F. Ferrier.
Brazilian Monkey. Mr. Papineau, of Montebello, P. Q.
(2) Golden Plover, *Charadrius Virginianus*. G. L. Marler, Esq.
Young Alligator. Mr. Percy Simpson.
Canadian Sponge. Prof. Fowler.

MINERALS.

Iron ore. Madoc. Pres. by G. L. Marler, Esq.
Tourmaline, with quartz and albite. Mount Mica, Paris, Me. W. F. Ferrier, Esq.
Mica. G. L. Marler. Esq.
Magnetic Iron Sand. G. L. Marler, Esq.
Magnetite. Port Henry, N.Y. W. F. Ferrier, Esq.
Precious Green Tourmaline and Rubelite. Paris, Me. W. F. Ferrier, Esq.
Colphonite with Graphite. Willsboro, N.Y. W. F. Ferrier, Esq.
Graphic Granite. Paris, Me. W. F. Ferrier, Esq.
Muscovite. Mount Mica, Paris, Me. "
Graphite. Willsboro, N,Y. "
Carbonate of Lime. Saratoga, NY. "
Lepidolite. Mount Mica, Paris, Me. "
Fibrous Serpentine. Rockland Quarry, P. Q. W. F. Ferrier, Esq.

J. Lorne McDougall, Esq., presented specimens of the following gums used in the manufacture of varnish.

Kowrie.
White Copal.
Pebbled Angola.
Damar.
Manilla.
Angola.
Gum belonging to a species of grass of Australia.
Benguilla, unbleached.
Shellac, bleached.
" unbleached.
Asaphaltum.

LIST OF BIRDS PURCHASED.

Gull, *Larus Argentatus.*
Snowy Owls, *Strix Nyctea* (2).
Grebe, *Podiceps cornutus.*
Plover (young), *Charadrius.*
Spotted Sandpiper, *Tringa macularius.*
Grass Finch, *Emberiza graminea.*
Williamson Woodpecker, *Picus* (2). Florida.
Swallows, *Hirundo Americana* (2).
Black Woodpecker, *Picus.* Florida.
Pheasant, *Tetras.* Texas.
Ducks, *Anas* (2). Texas
Bittern, *Ardea.* European.
Sandhill Crane, *Grus Canadensis*
Horned Scremen. South American.
Long Billed Parrot, *Nestor Productus.* Australia.
Blue Waterhen, *Porphyris speciosus.* Australia.
" " (young).
Wattled Honey Eater., *Anthachaera coriculata.* N. S. Wales, Australia.
Gigantic Kingfisher, *Alcedo gigantea.* N. S. Wales, Australia.
New Holland Green King Don, *Alcyon Australis.* Australia
New Zealand Pigeon, *Carpophasa Nova Zealandiae.*
Snow Bunting (2), male and female. summer plumage, *Plectrophanes nivalis.*

3rd. Report of Library Committee.—Having received a grant of $100 from the Council and gifts of ten dollars each from Messrs. Joseph and Marler, your Library Committee is now about to carry out the suggestion made two years ago—that the periodicals and pamphlets that have accumulated in the Library should be bound. Tenders have been received and the material is being prepared for the binder.

Rev. R. Lindsay donated the following books to the Library:

Petrology. 2 Vol.
Darwin on South America.
Van Rensellier's Geology.
Jamieson's System of Minerology. 3 Vols.
Manual of Mineralogy. By J. Nichol, F.G.S.
Richardson's Geology and Palæontology.
Phillips Treatise on Geology. 2 Vols.

List of books, pamphlets and periodicals received into the Library during the year ending May 1st, 1882.

American Journal of Science.
Anniversary Memoirs of the Boston Society of Natural History. 1830–1880.
Canadian Antiquarian and Numismatic Journal, for the year.
Canada Medical and Surgical Journal. for theyear.
Canadian Entomologist.
Le Naturaliste Canadien.
Statutes of Canada.
Proceedings of the Rhode Island Historical Society. 1881–'82.
Proceedings of the American Philosophical Society. Nos. 106 to 110.
Geological Survey of Canada. Report of Progress. 1879–'80.
Canadian Sportsman, for the year.
Bulletin of the Natural History Society of New Brunswick. No. 1. 1882.
Annual Report of do.
Royal Microscopic Journal. for the year.
Quarterly Journal of Microscopical Science, for the year.
Proceedings of the Royal Geographical Society, London, for the year.
" " Society of London.
" Linnean Society of New South Wales, Sydney. Vol. 6. Nos. 1, 2, 3.
Flora of Essex County, Massachusetts. 1880.
Statistics of the Fisheries of Maine; Smithsonian Institution. 1881.
Report of the History and Present Condition of the Shore Cod Fisheries of Cape Ann, Mass., U.S.A.
American Naturalist, for the year.
Science Gossip, " "
Journal of the Royal Society of New South Wales. Vols. 13 and 14.
Scientific Transactions of the Royal Dublin Society. Vol. 1. Series 2.
Bulletin of the Buffalo Society of Natural Science. 1881.
Contributions from the E. M. Museum of Geology and Archæology or the College of New Jersey. July, 1881.
Bulletin of the U. S. Fish Commissioners.
Annual Report of the Entomological Society of Ontario. 1881.

Bulletin of American Museum of Natural History, Central Park. No. 1. December, 1881.

Transactions Ottawa Field Naturalist Club. 1880–'81.

" Literary and Historical Society of Quebec. 1880–1881.

" of Newcastle-upon-Tyne Natural History Society. Vol. 7. Part 2.

Journal of Cincinnatti Natural History Socieety. Dec., 1881.

Journal of the Royal Geological Society of Ireland. Vol. 6. Part 1. 1880–'81.

Proceedings of the California Academy of Science. June 6th, 1881.

Reports of the Superintendent of Enucation, Province of Quebec. 1877–'78 ; 1880–1881.

Report of the Meteorological Service of the Dominion of Canada. 1880.

Proceedings and Transactions of the Nova Scotian Institute of Natural Science, Halifax, N. S. Vol. 5 ; part 3. 1880–'81.

Proceedings of the Rhode Island Historical Society. 1881–'82.

Transactions of the Academy of Science of St. Louis, Mo., U. S. A. Vol. 4 ; No. 2. 1882.

Annual Report of the United States Survey, By Clarence King. 1880.

Bulletin of the Essex Institute. Vol. 13 ; Nos. 7, 8, 9.

Medicinal Plants in New Brunswick. By Dr. G. M. Duncan, of Bathurst. 1881.

Middleton Scientific Association—Annual Address by the President, Jan., 1881.

Proceedings of the Academy of Natural Science of Philadelphia. Part 3. 1881.

Transactions of the New York Academy of Science. 1881–'82.

Annals of the New York Academy of Science. Vol. 1, No. 14 ; Vol. 2, Nos. 1 to 6.

Annual Report of the Middlesex Institute. 1881–'82.

" " Middletown (Conn.) Wesleyan University. 1880-1881.

Archives Neerlandaises des Sciences Exactes et Naturelles—Société Hollandaise des Sciences, Haarlem.

Neunter Jahresbericht des Westfälischen. Provinzial—Vereins, Munster Pro. 1880.

Zeitschrift der Deutschen geologischen Gessellschaft, Berlin. Vol. 22 ; Nos. 3 and 4. Vol. 23 ; Nos. 1—3.

Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gessellschaft Isis, Dresden. 1881.

Archives Musée Tyler. 2nd Series ; part 1st.

Achter Jahresberichte des Westfälischen.

Provinzial Vereins fur Wissenchaft und Kunst, pro 1879.

Berichte des Hydrotechnichen Comité's, Wien. 1881.

Abhandlungen der Mathematish-physischen classe der Kenigl, class 12 ; No. 20, Nos. 5, 6. Leipzig, 1880.

Verhandlungen des Naturhistorisch-Medicinischen, Zu Heidelberg. 1881.

Nederlandsch Meteorologisch Jaarbock, for 1876 and 1880; Utrecht, 1880–'81.

Defense des Colonies V., Apparition et Réapparition en Angletérre et en Ecosse des Especes Coloniales Siluriennes de la Bohême, par Joachim Barrande. Nov. 1881.

Annals del Museo Nacionale de Mexico. Vol. 2; parts 4, 5, 6.

Meteorologiska Iakttagelser I Sverige, Sweden. 1875, 6, 7.

Ofersight af Kongl, Vetenskaps Akademiens Forhandlingar, Stockholm. 1877—1880.

Bihang till Kongl, Svenska Vetenskaps Akademiens Handlingar, Stockholm. 4 Nos. 1878–'80.

Lefnadsteckningar fver Kongl, Svenska Vetenskaps Akademiens Band 2. Stockholm. 1878.

Bulletins de L'Académe Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Nos. 46, 47, 48. Bruxelles.

Annuaire ditto. 1879.

Mémoires de L'Académie des Sciences, Arts et Belles-Lettres de Dijon. 1880.

Actes de la Société D'Ethnographie, Paris. Vol. 8, Nos. 1, 2 1874–1875.

Anatomia Delle Plante Aquatche. By Filippo Parlatore. Firenze, 1881.

Processo Morboso del Colera Asiatico. By Filippo Pacini. Firenze, 1880.

Clinica Obstetrica. By Ernesto Grassi. Firenze, 1880.

Le Empereur Justinien et Son Œuvre Legistative. Par M. Jules Cauvet. Caen, 1880.

Liste des Griogérides. Par A. Prudhomme De Borre. Bruxelles, 1881.

The Secretary then read the

REPORT OF EDITORS OF "NATURALIST."

The Editors of the "Canadian Naturalist" beg to report that since last annual meeting of the Society, only two numbers of the Journal have been issued. A third, however, will be completed at an early date. Whilst it is matter for regret that it has been impossble to issue four numbers within the year, your editors are pleased to state that in the numbers issued, as well as in that to be issued shortly, the matter is wholly original, and, with one exception, by Canadians.

Your Editors would recommend that the Society appoint them to attend to the distributing of the Journal to subscribers and to those with whom it is an exchange. They would also urge upon members of the Society the desirability of making an effort to secure material of a suitable character for insertion in their Journal.

On motion, the reports were received and adopted, and ordered to be printed in the *Naturalist*.

On motion of Dr. Edwards, the Society resolved to accept the invitation of Mr. Gibb to hold a field day at Abbotsford during June, and a committee was appointed to make arrangements for the visit.

Mr. W. F. Ferrier was unanimously elected a member of the Society.

THE ELECTION OF OFFICERS.

The election of officers was then proceeded with and resulted as follows:—

President—Principal Dawson, LL.D., F.R.S.

Vice-Presidents—Rev. Dr. DeSola, Mr. J. H. Joseph, Prof. P. J. Darey, Dr. T. Sterry Hunt, Major H. Latour, Rev. Canon Baldwin, Dr. Hingston, Prof. B. J. Harrington, and Mr. D. A. P. Watt.

Recording Secretary—Prof. F. W. Hicks, M.A.

Corresponding Secretary—Dr. J. Baker Edwards.

Treasurer—Mr. G. L. Marler.

Cabinet-Keeper and Librarian—Mr. Wm. Muir.

Council—Messrs. Thos. Craig, J. T. Donald, J. Bemrose, Dr. Osler, M. H. Brissette, John S. Shearer, G. Sumner, and J. H. R. Molson.

Library Committee—Messrs. W. Muir, J. Bemrose, J. S. Shearer, and J. T. Donald.

Editor of Canadian Naturalist—Mr. J. T. Donald.

BIOLOGY NOTES.

By Professor Osler, M.D., McGill College.

I.—*On a remarkable vital phenomenon observed at Lake Memphremagog.*

During the first week in September, 1881, the water of the lake presented a peculiar appearance, owing to a number of minute green particles floating in it. In places they were so thickly crowded together that the water was of a deep green colour. Except near shore, they did not float on the surface but were diffused through the water to the depth of several feet. It was suggested to me by a friend that they were pollen grains, but their diffusion through the water and the season of the year seemed against this. They looked not unlike *Volvox globator*, but I have never seen this alga in such profusion. Fortunately, I had my microscope with me and the question was soon settled. Each little green mass formed a gelatinous ball, about one-thirtieth of an inch in diameter and enclosed numerous unbranched beaded filaments and proved to be a Nostoc—*Nostoc minutissimum*—a minute confervoid alga met with in water and in moist places. It is not a very uncommon species in our ponds, the remarkable point is the extraordinary profusion in which it occurred. The *Nostoc commune* is plentiful in the ponds at the Mile End, forming irregular green balls the size of a horse-chestnut.

The *Nostoc foliaceum* also occurs there; it has a membranous somewhat folded frond, usually growing erect on damp clay.

II.—*On the occurrence of Ophrydium versatile.*

This infusorian is met with in many of our lakes, particularly those to the north of the St. Lawrence. Its macroscopic characters are plant-like as it forms irregular greenish masses of a gelatinous consistence and though usually somewhat flattened, they may occur as beautiful globular bodies of a light green color. At Lac a l'eau Claire, in the property of Mr. G. W. Stephens, I found one mass the size of a large apple. On examination the gelatinous substance is seen to be colorless but imbedded in its cortex are numerous greenish infusoria with very extensible spindle-shaped bodies which are anchored by a delicate terminal filament in the matrix. When extended the body measures about one-hundredth of an inch, when contracted it forms an elongated oval. The anterior extremity is blunt and fringed with cilia; a narrow elongated gullet can be seen but the body cavity appears protoplasmic and contains chlorophyl grains and nuclei. The naked eye appearances of this remind one of the *Nostoc* or of the gelatinous masses of the *Palmellaceæ*. It occurs extensively throughout Canada. I have found it in Burlington Bay, the Humber ponds near Toronto, the marshes about Lakes Simcoe, Couchiching and Muskoka. Nowhere have I met with it in such profusion as in Lac a l'eau Claire. In Lake Roberta, near Grenville, I found some very large masses.

III.—*On the distribution of Pectinatella magnifica in Canada.*

I stated in the brief notes in Canadian fresh-water Polyzoa which I read at one of the meetings of the Society last year, that the large Polyzoon above named had not been met with in Lower Canada. Since then I have found it in beautiful masses in Fitch Bay, Lake Memphremagog, and Dr. Harrington has obtained several fine specimens in the North river, near St. Andrews. In Ontario it has been found in Rice Lake in the Humber ponds and in greatest profusion in the Desjardins canal and the contiguous marshes. It is probably widely distributed in quiet ponds and swamps throughout the country, never in the open lake or in very clear water.

(*To be continued.*)

"ON THE RESULTS OF RECENT EXPLORATIONS OF ERECT TREES CONTAINING REPTILIAN REMAINS IN THE COAL FORMATION OF NOVA SCOTIA." BY J. W. DAWSON, C.M.G., LL.D., F.R.S., &c. *Abstract of a Memoir read before the Royal Society, January* 12th, 1882.

The explorations referred to were carried on chiefly in the beds at Coal Mine Point, South Joggins, Nova Scotia; and their object was to make an exhaustive examination of the contents of erect trees found at that place and containing remains of Batrachians and other land animals.

A detailed section is given of the beds containing the erect trees in question, with lists of their Fossil remains. The most important part of the section is the following:—

	ft.	ins.
Sandstone with erect *Calamites* and *Stigmaria* roots	6	6
Argillaceous sandstone, *Calamites*, *Stigmaria*, and *Alethoperis lonchitica*	1	6
Gray shale with numerous fossil plants, and also *Naiadites*, *Carbonia*, and fish scales	2	4
Black coaly shale, with similar fossils	1	1
Coal with impressions of *Sigillaria* bark	0	6

On the surface of the coal stand many erect *Sigillariæ*, penetrating the beds above, and some of them nearly three feet in diameter at the base and nine feet in height. In the lower part of many of these erect trees there is a deposit of earthy matter, blackened with carbon and vegetable remains, and richly stored with bones of small reptiles, land snails, and millipedes. Detailed descriptions of the contents of these trees are given, and it is shown that on decay of the woody axis and inner bark they must have constituted open cylindrical cavities, in which small animals sheltered themselves, or into which they fell and remained imprisoned. These natural traps must have remained open for some time on a sub-aerial surface.

In all twenty-five of these erect trees had been discovered and extracted, and the productive portions of them preserved and carefully examined. Of these fifteen had proved more or less productive of animal remains. From one, no less than twelve reptilian skeletons had been obtained. In a few instances not only the bones, but portions of cuticle, ornamented with horny scales and spines, had been preserved.

The Batrachains obtained were referred to twelve species in all. Of these two were represented so imperfectly that they could not be definitely characterised. The remaining ten were referable to the two family groups of *Microsauria* and *Labyrinthodontia*.

The *Microsauria* are characterised by somewhat narrow crania, smooth cranial bones, simple or non-plaited teeth, well-developed limbs and ribs, elongated biconcave vertebræ, bony scales and plates on the abdomen, and horny scales, often ornate, on the back and sides. They show no traces of gills.

The species belonging to this group are referred to the genera *Hylonomus*, *Smilerpeton*, *Hylerpeton*, and *Fritschia*. The characters of these genera and of the several species are given in detail and illustrated by drawings and photographs, including microscopic delineations of the teeth of all the species, with their internal structure and the microscopic structure of their bones, as well as representations of their cuticular ornamentation and armour.

The Labyrinthodonts are represented by only two species of *Dendrerpeton*, which are also described and delineated.

About half of the reptilian species described are new, and those previously described from fragmentary remains are now more fully characterised, and their parts more minutely examined.

The invertebrate animals found are three species of land snails and five of myriapods, besides specimens supposed to represent new species of myriapods and insect larvæ, not yet fully examined, and which have been placed in the hands of Dr. Scudder, of Cambridge, U. S.

The memoir, consisting in great part of condensed descriptions of the facts observed, does not admit of much abridgement, and cannot be rendered fully intelligible without the accompanying plans, sections and drawings. It closes with the following general statement:—

"The negative result that, under the exceptionally favourable conditions presented by these erect trees, no remains of any animals of higher rank than the *Microsauria*, and *Labyrinthodontia* have been found deserves notice here. It seems to indicate that no small animals of higher grade inhabited the forests of Nova Scotia at the period in question; but this would not exclude the possibility of the existence of higher animals of a larger size than the hollow trees were capable of receiving. Nor does it exclude the possibility of higher animals having lived contemporaneously in upland situations remote from the low flats to which our knowledge of the coal formation is for the most part confined. It is to be observed also that as some of the reptilian animals are represented only by single specimens, there may have been still rarer forms, which may be disclosed should other productive trees be exposed by the gradual wasting of the cliff and reef."—*Nature.*

METEOROLOGICAL RESULTS FOR THE YEAR 1881.

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

MONTH.	THERMOMETER.				BAROMETER.*				†Mean Pressure of Vapour.	‡Mean relative humidity
	Mean	Max.	Min.	Range.	Mean.	§Max	Min.	Range.		
January	10.04	34 9	-13.6	48.5	30.1036	30 658	29.512	1.146	.0601	77.7
February	17.62	44.0	-16.4	60.4	30.1476	30.816	29.184	1.632	.0924	77.2
March	30.10	46.0	9.5	36 5	29.7497	30.308	29.236	1.072	.1366	80.5
April	38.98	74.0	8.3	65 7	29.8117	30 359	29 317	1.042	.1439	58.4
May	57.73	86.1	31.5	51.6	30 0148	30.466	29.703	0.763	.3305	68.6
June	61.04	81 8	38 0	43.8	29.8386	30.177	29.450	0.727	.3348	61.3
July	69 20	93.9	53.7	40.2	29 8418	30.275	29.423	0 852	.4909	69.8
August	69 41	91.1	52.2	38.9	29.9594	30.311	29.487	0.824	.5346	74.5
September	64 06	87.0	42.0	45.0	30.0231	30.349	29.767	0 582	.4639	75.7
October	43.85	74 0	23.0	51.0	30.0621	30.594	29.418	1 176	.2357	75.8
November	32.69	63.2	-5.5	68.7	30.0539	30 621	29.385	1.236	.1615	76.7
December	28 47	44 4	-1 0	45.4	30.0 07	30 657	29.047	1.610	.1418	82.3
Means for 1881	43 599	68.37	18.47	49.89	29.9[illegible]85	......	.....	1.0593	.26106	73.21
Means for 7 years ending with '81.	42.633	...	.....	....	29.9634	.....	.....	... ...	.25691	74.15

MONTH.	WIND.		Sky clouded per cent.
	Mean velocity in miles ⅌ hour	Mean. direction.	
January	12 64	S. W. by W.	57.9
February	11.69	S. W.	62.1
March	12.84	N. W. by W.	75.2
April	12 63	N. W.	44 9
May	10.65	N. E. by N.	60.4
June	9.27	W.	60 7
July	8.06	W.	58.0
August	9.01	W.	57.1
September	9.35	S.	61.4
October	10.97	S. S. W.	65.4
November	12.97	S. W.	74.1
December	13.58	S. W. by W.	73.1
Means for 1881	11.138	W. S. W	62.52
Means for 7 years. ending with 1881	11.086		6 .09

* Barometer reduced to 32° Fah. and to sea level.
† Inches of mercury.
‡ Relative saturation being 100.
The monthly means are derived from observations taken every fourth hour beginning with 3.18 a.m.

The greatest heat was 93.9, on the 10th July; greatest cold was 16.4° below zero on the 2nd of February; extreme range of temperature for the year, 110.3°; greatest range of thermometer in one day was 41.6° on the 14th of January; the warmest day was July 10th, the mean temperature being 82.8°; the coldest day was January 15th, the mean temperature being 8.57° below zero; highest barometer reading was 30.866 inches on 6th of February; lowest barometer reading was 29.047 inches, on 30th of December, giving a range for the year of 1.819 inches; the lowest relative humidity was 22 on April 16th; greatest mileage of wind recorded in one hour was 36, on January 14th; greatest velocity was at the rate of 48 miles per hour, on May 16th.

NOTES.—The sleighing of the winter 1880-81 closed on the 21st of April. There was not sufficient snow at any time during the remainder of the year to form good sleighing. The first snow for the autumn fell on October 5th, but was not appreciable. The first snow fall of more than one-tenth inch was on November 12th. The winter ice-roads were declared impassable on April 9th. The first ice shove occurred on April 10th. The first arrival in port was on April 19th. Auroras were observed on 29 nights. Lunar coronas were observed six nights, and lunar halos on 29 nights. Solar halos on 4 days, and coronas on 2 days.

RAIN AND SNOW FALL DURING 1881.

MONTH.	Inches of rain.	No. of days on which rain fell.	Inches of snow.	No. of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain *and* snow fell.	No. of days on which rain *or* snow fell.
January	r	1	26.5	18	2.70	1	18
February	2.04	5	7.3	11	2.76	3	13
March	0.24	8	39.1	21	4.39	5	24
April	0.41	7	0.4	8	0.48	2	13
May	3.25	21	0.0	0	3.25	0	21
June	1.39	12	0.0	0	1.39	0	12
July	3.31	18	0.0	0	3.31	0	18
August	2.18	10	0.0	0	2.08	0	10
September	1.93	11	0.0	0	1.93	0	11
October	3.80	19	0.1	5	3.81	3	21
November	1.09	14	11.8	13	2.19	4	23
December	3.25	12	4.4	12	3.63	4	20
Totals	22.82	138	89.6	88	31.92	22	204
Means for seven years ending with 1881	27.05	137.6	114.1	85.6	38.51	17.1	206

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