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ON THE SURFACE GEOLOGY OF NEW BRUNSWICK.

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The present paper on the *second group* of surface deposits, is in continuation of one published in the *Canadian Naturalist*, New Series, Vol. 6, No. 1. and devoted to a description of the Drift striæ and Boulder clay in the Southern counties of New Brunswick. Since the former article was written, other facts having an important bearing on the geology of the Glacial period have oeen observed, to which I would refer, before entering upon the main subject of this one.

I. Glacial Epoch.

A careful examination of the direction of the striæ recorded in the table given in my previous article, shows clearly the influence of the contour of the land, even in minute particulars, upon the course of the glacial striæ. I have had an opportunity, during the past summer, of verifying this feature in the action of the striating force; and have observed that the later striæ conform more closely to the minute inequalities of the surface than do the more ancient markings. It is also a general rule that the older courses of glacial lines are much heavier than the later, though not so distinct nor so sharply cut. The greater prominence of the later striæ is due to the obliteration to a greater or less degree of the older set, for the latter are often to be seen only on certain protected slopes of the ledges. In addition to the secondary or distinct set of striæ,—in which is included the great majority of those recorded in the following table—there is not infrequently a third group of lines, lighter and more irregular than the last, and still more obviously affected by the contour of the surfaces over which they are spread. Such variations might naturally be looked for as likely to result from progressive diminution in the thickness of the ice cap as the maximum of density and volume gradually receded to the North.

As an instance of these variations, the striæ under No. 39 of the following table may be cited. This ledge has been uncovered in taking gravel for road-making, and the glacial markings are fresh and sharply cut. The oldest record on the ledge shows that the ice once moved directly, through Beaver Harbour, in a course nearly due South, scoring horizontally the slopes of the ridges by which it is bounded on either side. This southerly direction is that of the striæ on the highest ridges in the Southern counties. The course of the next set of lines shews a tendency in the ice to slide obliquely downward into the harbor; and finally it appears to have moved directly down off the hill into the basin in front. The bearings on this ledge exhibit a change in the course of the moving ice, from first to last, of fully a quarter of a circle. Similar influences may be traced in the striæ of Bocabec Bay, and in the converging lines which enter the upper basin of L'Etang River.

Perhaps the most remarkable locality for these markings is one observed by Prof. L. W. Bailey, last summer, on the west side of Chamcook Mountain, near Saint Andrews (No. 12). This eminence (637 feet high) has on its western side a buttress or lower hill, which overlooks the Sainte Croix valley. The rock is steep and high, and toward its base there is a deep recess cut in the face of the cliff, and extending for some distance along its foot. The ledge which covers the recess overhangs about *sixty degrees!* and upon its under-surface are strong, regular, and distinct striæ, parallel to the direction of the cliff. Below this overhanging rock there is a *talus* of loose blocks of felsite, extending to the base of the hill—about seventy feet lower—where the ground becomes nearly flat, and descends gradually to the Sainte Croix River. For a space of four miles to the west, and an indefinite distance to the south, there are no elevations or ridges which could have brought pressure upon the under-surface of this overhanging rock to groove it; and it was protected from the assaults of icebergs by an extension of the Chamcook range of hills for three miles to the north-west. Here, therefore, if anywhere, the glacier has left a witness of its former presence in New Brunswick.

Second Table of Striæ in Southern New Brunswick.

[These notes are arranged according to the longitude of the places mentioned, from West to East; and, as in the former table, the courses are corrected to the true meridian. I am indebted to Prof. L. W. Bailey for those marked with an asterisk (*); and Mr. R. W. Ells has added those indicated by an obelisk (†).]

No.	Description of the Locality.	Exposure.	Course.
1	Prince William, on E. & N. A. R.R., 3 miles S.W. of McAdam Junction...........	S. (flat)	S. 45° E.
2	Saint David's, Oak Bay, E. side of, opposite S. end of Rogers' Island.............	W.	S. 45° E.
3	Manners-Sutton, S. end of ridge running N.W. from N. end of Oromocto L.! Latest striæ S. 60° E. and S. 40° E..	S.W.	S. 20° E.
4	" Harvey Settlement, road to Lester's Mill. Latest striæ S. 45° E. and S. 55° E..........................	E.	S. 20° E. S. 10° E.
5	" Harvey Settlement, Chapel in. Latest striæ S. 45° E. (few)	S. (flat)	S. 20° E.
6	" Cork Settlement Ridge, one mile N. of Cork Station, valley in front trending E. Latest striæ S. 20° E. (few).	E.	S. 30° E.
7	" Cork Station (foot of Cork Sett. Ridge)	S.W.	S. 20° E.
8	Dumbarton, Wicher Ridge, South slope ..	S.W.	S. 60° E.
9	Saint Croix, Bradford's Cove on St. Croix R. Latest striæ S. 10° E...........	N. (flat)	S. 40° E.
10	" Southward on same shore. Latest striæ S. 30° E...................	flat	S. 10° E.
11	" Shore of St. Croix R., opposite Doucet Island. Latest striæ S. 20° E......	flat	S. 5° E.
*12	" Chamcook Mt., W. end of, on a cliff overhanging about 60°	W.	S. 10° E.
13	" Chamcook Lake, E. shore of, on E. side of a ledge that overhangs 20°. Striæ converge from N.W. on overhanging face	E.	S. 50° E.
14	" Chamcook L., near outlet. High hill on E. and N.E.; flat and open to southward. Older striæ S. 45° E...	W.	S. 25° E.
*15	Pembroke (Maine), W. branch of river...	S.W. (flat)	S. 50° E.
16	Saint Andrews, Chamcook Cove, E. side. Older striæ S. 50° E..............	S.W.	S. 10° E.
17	Eastport (Maine), Broad Cove, *roche moutonné* ledge, descending to.......... On N.E. slope striæ S. 60° E, on N.W. slope	N.	S. 55° E.
18	Saint Patrick, Bocabec Bay, head of. Oldest striæ S. 40° E.; latest S. 10° E.....	S.W. (flat)	S. 20° E.
19	" Near the last (projecting ledge to N.)..	flat	N. 70° E.
20	" Bocabec Bay, end of a low point on E. side of. First striæ S. 40° E.; last S. 5° E.......................... (last striæ on N. side of same ledge, S.)	W.N.W.	S. 20° E
21	" Bocabec L., N. side of. Last striæ S. 35° E..........................	S.W.	S. 25° E.

No.	Description of the Locality.	Exposure.	Course.
22	Saint Patrick, Duncan Road, 1¾ mile N. from Turner's Mill................	N.E.	S. 25° E.
23	" Digdeguash Valley, near N. end of Duncan road. Last striæ N. 70° E.!	E.	S. 30° E.
24	" Digdeguash Basin, in deep narrow valley (course S.) W. of mill at.......		S. 30° E.
* 25	West Isles, Pendleton's Isl'd, N.E. end of.	S.W.	S. 65° E.
26	Saint George, Hill betw'n Piskahegan and Magaguadavic Rivers, N. slope of...	W.	S. 60° E.
27	" Magaguadavic Harbour, Creek S. of...	N.W.	S. 85° E.
28	" Fork of Back-Bay Road, near E. end of LaTête ridge..................	N.W.	S. 50° E.
29	" LaTête Harbour, head of Back Bay, S. side of a swale near road. Last striæ S. 75° E.....................	N.W.	S. 25° E.
30	" L'Etang R., N.W. side of basin at head of. Later striæ S. 80° E...........	N.E.	S. 60° E.
31	" L'Etang R., S.W. side of same basin. Later striæ E!....................	W.N.W.	S. 60° E.
32	Pennfield, L'Etang R., E. side of same basin	S.	S 15° E.
33	" L'Etang R., on ridge S.E. of same basin	N.W.	S. 5° E.
34	" " S. slope of this (N.E.—S.W.) ridge......................	S.	S. 5° E.
35	" " next ridge going south. Later striæ S. 20° E...............	N.W.	S 25° E.
36	" L'Etang R., on E. side of Narrows, (high hill on W. side of the river)..	N.	S. 60° E.
37	" Black's Harb., N. of clay flat on r'd from	S. (flat)	S. 60° E.
38	" Beaver Harb., head of, at tide level, high ridge to S. Older striæ S. 30° E.	N.	S. 60° E.
39	" Beaver Harb., same ridge, S.E. slope of. on a *roche moutonné* ledge, 4x10x30 ft. Oldest striæ S. 10° W.; last striæ S. 80° E.; chief striæ S. 30° E., curv'g to On N. side of ledge are a few last striæ S. 20° E.....................	(S.E.)	S. 40° E.
40	Blissville, Fredericton Junc., E.&N.A.R.R. on ridge one mile S. of..........	N.N.W.	S. 5° E.
41	" Forks of Fredericton and Clones roads.	N.N.E.	S. 25° E.
42	Petersville, Fredericton road, E. side of Stony ridge.......................	N.E.	S. 20° E.
43	" Parish Church, Headline Hill—valleys to N.W., W., and S.................		S. 35° E.
† 44	" Olmville Plateau..................		S. 60° E.
45	Gagetown, Clones, Wilson road. Oldest striæ. S. 35° E. Chief striæ, S. 45° E curving to........................	(S.W.)	S. 40° E.
46	Hampstead, E., of Blue Mt. on slope to Long Lake......................	N.E.	S. 35° E.
47	Lancaster, South Bay Station E.& N.A.R.R. Oldest striæ, S. 10° W.; last S. 15° E.	N.E.	S. 5° E.
† 48	Northfield, Newcastle R., above Yeoman's Bridge......	N.	S. 15° W.

Abyss in the Bay of Fundy.—Finding that the drift striæ along the coast of the Bay of Fundy, in the western part of Charlotte county, did not conform to the course of the rocky ridges, but crossed them at right angles, I was led to examine the contour lines of the bottom of the Bay. Elsewhere, along the New Brunswick shore, the water deepens gradually; but south-east of the islands which shelter and shut off Passamaquoddy Bay, and extending thence along the eastern side of Grand Manan to Briar Island in Nova Scotia, there is a remarkable gulf, in all parts of which the sounding line goes down more than a hundred fathoms. A tongue of deep water extends from it toward La Tête Passage, and other tongues point up the Bay of Fundy. The deeper part of the gulf (enclosed by the 100 fathom contour line) is much wider near the Nova Scotian shore, where also the descent to deep water is very abrupt—especially at the North-west Ledge off Briar Island, where the bottom sinks down to the depth of 100 fathoms, at the distance of a mile and a-half from the shore.

This deep cavity has evidently exercised a controlling influence on the glacier which passed over Passamaquoddy Bay and L'Etang Harbour; for the striæ shew a decided convergence toward it from the land to the W., N.W. and N. of it. This movement was analogous to that referred to in my previous article on Surface Geology, as exhibited by the striæ of Nos. 46, and 47, as compared with 45, 48, 49, 50 and 52 in St. John county.

[I have assumed that the abyss in the Bay of Fundy existed in the Glacial epoch; for without adducing proof that the level of the adjoining land has not been greatly changed since that period, there are strong reasons for supposing that this depression was formed in the Triassic period. It is well known that the whole northern coast of Nova Scotia, as far east as Cape Blomidon, is bordered by a range of volcanic hills of that period; and it has been suspected that the trap rocks of Grand Manan are of the same age. This surmise was confirmed during the exploration of that island undertaken by Prof. Bailey, a few years ago, for the Geological Survey of Canada. Grand Manan is the only part of New Brunswick where any considerable mass of Triassic trap has been found, and the deep submarine trench along its eastern shore would appear to have resulted from the simultaneous action of volcanic forces in New Brunswick and

Nova Scotia, causing the collapse of the earth's crust in the intermediate space. For the same reason, probably, deep water surrounds Isle Haute, an isolated peak of Triassic trap in the Bay of Fundy, toward its upper end: and it is noteworthy that wherever in this part of the Bay, Triassic trap appears upon two opposite shores, holes and troughs exist in the intervening space in the bottom of the Bay. I may add that the regular trend across the bay of the contour lines of 50, 40, 30 and 25 fathoms, toward that part of the Nova Scotian coast where the trap mountains attain their greatest development, is not without significance in this connection.]

II. Syrtensian Epoch.

Under this head I propose to describe a group of beds which rests immediately on the Boulder clay: in the flat country of the interior, they are largely composed of sand, but in the valleys among the Southern hills, and between the ridges of slate in the northern part of Charlotte county, much coarse material is mingled with the sand, and in narrow and confined valleys the deposit is apt to consist chiefly of gravel and to contain great numbers of blocks of stone, and boulders more or less rounded and deprived of striæ. Either these beds are not well developed in other parts of Canada and along the Atlantic seaboard, or their position and origin has been misunderstood. Prof. C. H. Hitchcock includes similar beds with the Leda-clay in his division of the Drift which he calls the Beach and Sea-bottom period, but in this country the known beaches are associated with a later group (Saxicava sand) and his Sea-bottom beds seem to correspond to the Leda-Clay. The gravelly group is not recognized by Dr. Dawson apart from the Leda-clay, probably because it forms but an inconspicuous portion of the Modified Drift in the Saint Lawrence valley. I think, however, that it is recognizable in some of his sections, as for instance that of the Glen brick works, Montreal, Nos. 8, 9, 10 and 11 of the Section.* Also in speaking of the stratified sand and gravel of Nova Scotia,† which he considers to be "newer than the Boulder-clay, and also newer than the stratified marine clays," he describes strata very like our Syrtensian beds.

Dr. A. S. Packard gives sections of some Post-pliocene depo-

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* Notes on the Post-Pliocene Geology of Canada, Montreal, 1872.

† Op. cit. pp. 39 & 40.

sits on the coast of Maine* from which—as for instance that of Gardiner (page 244)—it appears that gravel beds like those of *the surface deposits in New Brunswick lie at the base of the* Modified Drift in that state. In his description of the Eastern Coast of Labrador there are passages which forcibly call to mind the probable condition of our own province when these Syrtensian beds were forming. Speaking of the present condition of this desolate shore he says:—"It is an important fact that the "present contour of the coast from the sea level to a height of "about 500 feet, also extends to at least 50 fathoms, or 300 "feet below the surface of the water. Such we found to be the "fact in dredging for a distance of nearly 600 miles along the "coast. . . . . Again, dredging was carried on off "Henley Harbour (Northern entrance to the Strait of Bellisle) "on a pebbly bottom 300 feet below the surface which formed "the continuation of the same beaches which rose some 200 "feet above the sea level. . . . . . . At the settlement "in Chateau Bay is a remarkably steep beach which ascends "halfway up the side of the hill which is about 500 feet high. "It is composed of very large boulders closely packed in layers, "without any gravel to fill up the interstices, and slopes to the "level of the water at an angle of at least 40°, being the steep-"est beach I saw on the coast. . . . . "This beach, when below the level of the sea, was evidently ex-"posed to the action of the powerful Labrador current which "piled these huge water-worn rocks in a compact mass which "served to resist the waves, while the coarse gravel and sand "were borne rapidly away further out to sea on to lower levels."

This thorough sorting out of all the mud and fine sediment by the action of the Arctic current on the coast of Labrador, is but a continuance further north of the powerful agencies once at work in our own province. I have said that over much of the open plain in the interior of New Brunswick the beds which rest immediately upon the Boulder clay are sandy, and they are there for the most part concealed by beds of Leda-clay: but on proceeding southward and entering the Southern hills, where the valleys are deep and narrow, the cutting power of the current was brought into active play, and gravel ridges and slopes became quite common, and are often a marked feature in the landscape.

* On the Glacial Phenomena of Labrador and Maine, Memoirs of Boston Society of Natural History, Vol. 1, Part 3.

According to their relation to the neighboring eminences, and to the straits and gorges between them, these (now elevated) shoals take varying forms—forms of which there are four principal types, viz.—1st. The *Weather Shoal.* This has been cast down before a hill, or on one or both sides of the entrance to some gorge: it has usually a rounded form sloping gently downward to the plain in front, and often having a hollow behind it, separating it from the solid rock of the hillside. Gravel knolls of this nature may be seen at the falls of the Piskahegan River, Charlotte county, and at the gorge leading from the valley in the S. W. corner of Sussex parish in Kings county to that of the Hammond River.

2d. The *Lee-Shoal.* This has gathered behind hills or the outlets from gorges. Ridges of this kind are quite numerous.

3d. The *Centre-Shoal.* This is an accumulation of gravelly materials formed in the open space beyond a gorge or upon the top and slopes of rocky ridges, either covered with or partly denuded of Boulder-clay. "*Giant Graves*" and *Whale-backs* are of this group: the former being for the most part gravel throughout their whole depth, and comparatively small; the latter having usually a substratum of Boulder-clay.

4th. *Horseback*, Boarsback or Escar. This type of gravel bank usually extends along the top of rounded slate ridges, forming a crest often many miles in length, or it forms a connecting bank between neighboring rocky hills. These long and uniform ridges appear to have been formed at the contact of two branches of the polar current, moving side by side but with different velocities, thus giving, especially in the shallower water at the top of the ridge where their edges meet, the effect of an eddy. There is an endless variety of intermediate forms connecting the four types of gravel ridges, but they are all evidently due to the varied action of the current, now stopped by an opposing hill, and anon rushing swiftly through some gorge and scouring it out to the rocky bottom; or again, at a sudden bend of the valley, rising out of it to course across the adjoining submerged ridges.

To show at a glance the most characteristic of the gravel-ridges the following table—in which all the bearings are corrected to the true meridian—is added.. When two bearings are given the first is that of the northern end of a ridge. One ridge observed by Prof. L. W. Bailey is marked with an asterisk, and those seen by Mr. R. W. Ells by an obelisk.

TABLE OF GRAVEL RIDGES IN SOUTHERN NEW BRUNSWICK.

No.	Description of the Locality.	Kind of Ridge.	Length in miles	Direction.
1	Prince William, 1 mile S.W. from McAdam Junction, at E. end of a granite ridge...	Crescent-shap'd lee shoals and whalebacks.	– –	S. 50° E.
2	Saint James, St. Croix R., W. side of, extend'g from Little Simsquich to Kean's......	Horseback, (two courses)	$1\frac{3}{4}$	S. 30° E. S. 20° E.
* 3	Saint James, E of Canous R., on high land at upper end of Lynnfield Road........	Horseback.	– –	S. 40° E.
4	" On road to Oak Hill, separating Cranberry L. from the sources of Moannes stream, a ridge in two parts separated by a hollow running S..	Whaleback and Horseback.	$1\frac{3}{4}$	S. 50° E. S. 45° E.
5	" On Road to Basswood Ridge, 3 miles south of the last...	A sharp whaleback.	$1\frac{3}{4}$	S. 45° E. S. 25° E.
6	Saint Patrick, valley of the Digdeguash R., a series of gravel knolls and ridges...	Giant's graves, whaleback, weather shoal.	$2\frac{1}{2}$	S. 40° E.
7	" Clarence Ridge, mostly Boulder clay..............	Whaleback.	$2\frac{1}{2}$	S. 35° E.
8	" Morrison Ridge, S. of the last	do.	$1\frac{1}{2}$	S. 40° E.
9	" A lower and flatter ridge S.W. of last, and mostly Boulder clay	do.	$1\frac{1}{2}$	S. 30° E.
10	" W. of Bocabec L., flat topped	Gravel ridge.	1	S. 40° E.
11	Saint George, valley of Magaguadavic, between Pomeroy Bridge and Piskahegan R...	Succession of gravel ridges.	1	about S. 40° E.
12	" L. Eutopia, S. of (parallel but less continuous ridges N. and S. of these)	Whaleback and weather shoal.	$1\frac{1}{2}$	S. 40° W. S. 50° W.
† 13	" Clarenton, S.W. corner, E. of McDougall L...........	Horseback.	$1\frac{1}{2}$	S. 30° E.
14	Pennfield, below Cripp's mill-stream on r'd to Black's Har.	Giant's grave.	– –	W.
† 15	" From S. end of Clear L., along W. side of Popologan R	Horseback.	2	S. 30° E.
16	" S.E. face of Pennfield Ridge S. do. do do.	Gravel plateau.	$2\frac{1}{2}$ $\frac{3}{4}$	S. 65° W. S. 80° W.
17	Lancaster, Musquash R., W. of, on Post-r'd to Lepreau, a flat	Gravel ridge.	$\frac{3}{4}$	S. 45° W.
18	" S. of Musquash Marsh (E. of last)......................	Whaleback.	$1\frac{1}{2}$	S. 55° W.
19	" Musquash Harb., W. of the Narrows	do.	$1\frac{1}{4}$	S. 60° W.
20	" Pisarinco, ridge ending at Negro Head....... flattened	Gravel ridge.	– –	S. 60° W.
21	" Manawagonish, long't reach of the raised beach on the Post-road to Musquash	Flattened horseback.	$1\frac{1}{2}$	S. 50° W.
22	Simonds, Mt. Prospect, top of,	Whaleback.	$\frac{1}{2}$	about S.W. (?)
23	Hammond, crossing Ham'd R. valley above Upham village.	Horseback.	$\frac{1}{2}$	?

General set of Polar current over New Brunswick and Maine.

In the region to which this table relates there are three tracts each characterized by certain peculiarites in the gravel ridges. In the middle tract—which includes the Oromocto Valley and Nerepis Valley—the ridges are short and irregular, owing to the course of the current which here ran obliquely to the direction of the hill ranges; and no ridges are recorded in the table, because they have not so evident a bearing on the general course of the current as the ridges in the other two districts have. In the latter the gravel ridges are much longer and more conspicuous, and approximate in direction to the course of the rocky ridges: but while in the western tract they are directed to the S. E., in the eastern they point to the S. W. They differ also in the kind of ridge which prevails; for while *horsebacks* are numerous in the western district, broader and rounder ridges, *whalebacks*, etc., are common in the eastern, and in the middle tract the gravel banks consist almost exclusively of *lee and weather shoals*.

It will be seen that the western area corresponds quite nearly to the "first tract" of glacial striæ (see page 11 of my former article) and in it the striæ agree in direction with the Syrtensian ridges: but in the eastern district near the coast there is a striking difference between the course of the striæ and the gravel ridges, the two running nearly at right angles to each other. From this it may be inferred that the hills of Southern New Brunswick which during a preceding period formed no serious obstacle to the onward progress of the Glacial ice, had risen sufficiently during the Syrtensian epoch to act as a barrier which turned aside to the right and left the principal volume of the polar current. As a result the minor currents traversing the gaps in these hills in Queen's and King's counties united with the grand current in the Bay of Fundy, and ran along the southern side of the granite hills which extend from Bald Mt. on the St. John River to Red Rock Mt. on the Magaguadavic. This would give to the sea of the Syrtensian period a depth along this coast of from 700 to 1000 feet greater than it has at present. While this may have been the depth in southern New Brunswick, when the principal gravel ridges were in process of formation, indications that the sea bottom underwent important oscillations elsewhere are not wanting. At the lower end of Lake Eutopia, near St. George, in Charlotte county, are N.E.—S.W. gravel ridges extending across a somewhat sunken tract, which has been sheltered from the rush of ocean waters down the Maga'davic valley by the granite hills enclosing the upper end of the lake. On each side of this knot of hills, but especially to the east, gravel slopes and flats have been carried out by the polar current running through the Maga'davic valley, in such a way as to indicate that the S.W. set of the current in the Bay of Fundy was overpowered in this neighborhood by the S. E. current coming through the hills to the North. A similar change in the direction of the current would seem to have taken place at Saint John, for while the course of the later gravel ridges west of that city (at South Bay) is S. 25° W. the older ones point S. 50° W.

This forcing of the current across the Southern Hills of New Brunswick in the latter part of the Syrtensian epoch may have been due to the rise of a submarine barrier at the head of the Bay of Fundy, then a broad strait, diminishing the power of the current running through that passage. Or it may have been occasioned by elevation of the sea-bottom of that period along some meridian west of the Penobscot River in Maine. From Prof. C. H. Hitchcock's report on the Geology of Maine it appears that a N. to S. course marks the gravel ridges in the valley of that river and in the southern part of Aroostook county. In the lower part of the Penobscot valley the ridges tend slightly to the west, conforming to the course of the valley; and I infer from the direction of the roads and streams in Washington county, that the courses of such ridges there approximate to the S. E. course of similar gravel banks and ridges on our own side of the border. There was thus a convergence of the waters of the Polar current (as marked by the Syrtensian ridges) from the centre and western part of New Brunswick toward the mouth of the Bay of Fundy; and apparently a fan-like spreading of the same waters over the high wilderness tract extending through Hancock county, Maine, to Mt. Desert. It may therefore be inferred that as far West as the Penobscot valley this current was turned out of its natural S. W. course and compelled to go S. or S. E.

From other data, collected by Prof. Hitchcock in Maine, it would appear that this barrier was still further west—beyond the valley of the Kennebec River. For it will be observed that the axes of the lake basins and harbours in the maritime tract between these two rivers (the Penobscot and Kennebec) and as far as Portland, have a direction not far from 20 degrees west of south. In this they correspond to the gravel ridges of the lower part of the Penobscot valley. Now these fiord-like harbours and the lake basins cannot have been made by glaciers; for in the report quoted* there is a record of twenty or more courses of glacial striæ, in Penobscot, Waldo, Knox, Lincoln, Kennebec, Sagadahoc and Cumberland counties, which run, on the average, S. 30° E. They therefore crossed these harbours and lakes at right angles. But if it be admitted that these hollows were produced, as were similar troughs on the New Brunswick coast, by the scouring action of the polar current, there is reason to suppose that even as far west as Portland this current was compelled to seek a passage tropic-ward, in a less westerly direction than it would have done, had no barrier been interposed. This obstacle to its flow was probably the White Mountains and connected ridges to the northward of that group of hills.

Typical Localities of Syrtensian Ridges in Southern New Brunswick.

To shew the varied influence of the current in the south-western part of New Brunswick, I add here a brief description of some easily accessible localities near the coast.

Digdeguash River.—On the northern side of the range of hills through which this stream winds its way before entering the sea, there is a valley about two miles wide and seven long, across which runs, in an oblique line, a series of gravel mounds and ridges. They begin in a bank of gravel of the Lee-shoal type, cast down behind the western entrance of the basin on its northern side, near Falls Brook. To this bank succeed a number of mounds of the form known as "giant's graves," one of which is now used as a grave-yard for the church in St. Patrick's parish. These mounds extend along the flat bottom of the valley, in the direction of a large gravel ridge of a rhombic form lying in the middle of the valley. At the mound below that on which the tombstones are seen, and at the large rhombic mound, there are gravel pits in which the Leda-clay beds which fill the bottom of the valley may be seen, rising up on the lower slopes of the gravel ridges. On the flat top of the rhombic mound are two depressions, lined with a clayey soil: of these the more easterly

* Sixth Report on Agriculture, &c., of Maine, p. 260; and Second Report on Natural History and Geology of Maine, p. 378.

and smaller one has a pervious bottom, and the soil is only a heavy loam; but in the other the Leda-clay covering is sufficiently thick and fine to hold a small pond of water. This large mound is, in its turn, connected by other sharp, oval mounds of the "grave" type, with a long gravel ridge extending from the river bank up against the shoulder of a granite hill on the south side of the valley: this ridge consists of two parts imperfectly divided, that part near the river approximating to the whale-back form, and the portion next the hill being a weather-shoal, with the inner end turned down along the flank of the granite hill.

Taken as a whole, this series of knolls and ridges may be regarded as a horse-back built up between currents of different velocities—with this peculiarity, that while at the upper end of the basin the western current was the stronger, at the lower part the eastern current, having a freer outlet, by two gorges through the hills, became accelerated, and drew a part of the western current across the horse-back, cutting it into a number of detached mounds.

The course of this line of gravel knolls across the valley shews that the ocean current which formed them, pursued its southward path almost irrespective of the hills which separate this basin from Passamaquoddy Bay: and as these eminences are as much as 400 feet above the sea, it is clear that the current itself must have covered them to the depth of several hundred feet more; and thus its surface would have been quite 700 feet higher than the present sea-level.

Lake Eutopia.—This sheet of water, which discharges by Maga'davic River, is separated from L'Etang River by a gravel ridge only. The ridge is a compound one, consisting, in its western part, of a weather shoal, resting against a slate ridge, and in its eastern part of a whale-back or central shoal—the two being separated by a shallow depression, due to a light current, which drew across the ridge from the side on which the lake lies. At this locality there are clear indications that the force originating the Drift striæ was quite independent of that which threw up the Syrtensian ridges. The centre-shoal begins back of Reardon's Corner, with a course S. 45° W., and terminates with a point directed S. 55° W., while the connected weather-shoal runs S. 50° W, against the slate ridge. In a hollow south of the weather-shoal, on the road along the west side of l'Etang River are the striæ (No, 30 of the table), running S. 60° E. and S. 80° E.: the course of the striæ and ridges therefore diverge at this place as much as 120 degrees.

Carleton and Lancaster.—The entire independence of the force which produced the striæ, and that to which the gravel ridges owe their origin, is also to be inferred from the relation of the striæ and ridges west of the city of Saint John. Carleton Heights, with the hills along the Narrows and Falls of the Saint John River, formed a lee, behind which several gravel ridges, more or less connected with each other, have been piled up. West of the Heights back of Carleton, a lee-shoal, much worked over by the sea, extends S. 25° W., and is slightly overlapped by a small weather-shoal jutting out from a lower hill beyond. Sandy flats back of Sand Cove separate this hill from another weather-shoal, which rises gradually to cover the rounded ridge terminating at Sheldon Point. The western end of this ridge shews a well-defined lee-shoal cut across obliquely by the sea, and exhibiting one of the most instructive sections of the surface deposits to be seen near Saint John. Toward Sheldon point the Boulder clay may be seen resting on striated ledges of Huronian rock; and succeeding the clay westward, are beds of boulders and gravel, shewing by their overlapping layers the action of a westward moving current. The swelling outline of the bank is seen to be due to the thickening of the layers on the axis of the old shoal, and the whole is covered by beds of Leda-clay with characteristic fossils.

These various gravel banks are parts of a series extending along the seashore west of St. John Harbour, and are separated from a more continuous and higher ridge to the North, by a valley filled with Leda-clay and salt-marsh accumulations. The upper part of this higher ridge which has been cut down to a nearly uniform level by the action of the sea, exhibits along its eastward face a distinct raised beach extending for many miles to the westward of Saint John. At two points where the ridge has been cut into in making excavations, the changes which it has undergone may be easily perceived. Originally there was a series of rounded ridges, not unlike those of the southern series along the shore as they now appear, but containing proportionately a much larger share of detrital matter, due to a greater retardation of the current caused by the group of gneissic hills north of Saint John and about the Narrows of the river, than that caused by Carleton Heights. In the hollows between the swelling knolls of this series of ridges, Leda-clay was subsequently deposited, which, although in a few places abounding with boulders and at exposed points sandy, is recognizable by the red color of the mud it contains; and of which in sheltered places it is entirely composed. Ridges and points of pure olive grey Syrtensian gravel project upward into the red deposit, and sometimes through it, where subsequent wave action has worn down both set of beds to a uniform level, and covered them with a sea beach several feet thick, made up of the ruins of both deposits. The size and continuity of this range of gravel knolls, now worked down to a nearly uniform level, has served to protect a third series still further north from the action of the sea. This last row of knolls is connected with the ridge on which the raised beach runs by a cross ridge at the Fredericton road, but elsewhere is separated from it by a deep marshy hollow, which may have been connected with South Bay before this third series of gravel knolls was deposited. In this series there are ridges shewing two courses, one S. 25° W. the other S. 50° W.; the latter are nearly enveloped by the former and are therefore the older. The ridges of the middle row—that upon which the beach runs—also incline greatly to the westward. With regard to either of these courses it may be observed that here, as well as at other points along the coast as far as Pennfield and Saint George, there is a wide divergence between the direction of the gravel ridges and of the glacial striæ *

Petersville. The gravel and clay cuttings along the line of the E. & N. A. Railway in this parish expose clearly the relation between the various parts of the Post-pliocene beds, and throw much light upon the conditions under which the gravel ridges were built up.

There are two gaps in the range of hills which cross this parish—the one, Douglas Valley, which is narrow and at its highest point 200 feet above the sea: the other, Nerepis valley, much broader throughout most of its length, and eroded at its summit to within 300 feet of the same level. Douglas Valley forks in its upper part, but the wider and deeper branch has no opening to the North, being separated from the wide rolling plain

* Compare with striæ of Nos. 32. 33. 37. 38. 39 of Table in first article on the subject.

of Central New Brunswick by hills 600 feet in height. Yet although the western branch at its junction with the eastern is 100 feet higher, the current passing through it in the Syrtensian epoch, was not strong enough to cast the *debris* which it bore along into the lower valley, but the gravel and sand was piled up at its mouth and along the flanks of the hills to the south. The current coming over the hills to the north and sweeping through the closed valley was the more powerful of the two, and kept possession of the main channel after the two united in the lower part of Douglas Valley.

This combined current swept a clean and deep passage through this part of Douglas valley, but was in turn arrested at the valley's mouth by a more powerful one coursing through the Nerepis Valley. Here the arrested current deposited its burthen of gravel and boulders in a triangular, flat-topped bank at Welsford station. The flat area on the top of the bank is diversified with hillocks and holes: it slopes gently to the north, the direction from which its materials came; but much more steeply on the side facing the Nerepis Valley, which is here scooped out to the sea-level. This hollowed part of the Nerepis valley extends downward for nearly three miles from the mouth of Douglas Valley, where a sudden bend and constriction again arrested the current and caused the accumulation of another mass of gravel 150 or 200 feet deep, through which the Nerepis River at a later period cut a channel to within a few feet of tide-level.

On reviewing the relation of the gravel deposits in these valleys to the configuration of the land, observing especially the way in which the banks are built up in and around the gorges by ocean waters which, to produce these results, must have passed over barriers of 400 to 600 feet in height, the conclusion can scarcely be avoided that this was the work of a deep, powerful and elastic current.

Formation of Lake Basins by the Arctic Current.

Since the Polar Current has thrown up these mounds and banks of gravel, it cannot be doubted that it formed corresponding depressions. Just northward of the gravel bank at Weilsford Station, there is a lakelet (Harcourt Lake) exemplifying in miniature hundreds of sheets of fresh water, scattered over the face of the country, which have been produced by this agency. These lake basins have been "*puddled*" *by nature:*

for in all the valleys of this region, there are deposits, varying from 20 to 50 feet in thickness, of Leda-clay, supplying an impervious lining to the hollows left by the arctic current. Such clay beds may be seen at Harcourt Lake, rising up on the slope of the gravel mound near by. By a similar covering of the lower slopes of the gravel banks at South Bay, the Saint John River is upheld, and compelled to discharge its waters through the narrow and tortuous passage terminating in Saint John Harbour. So also the Maga'davic River, but for a similar barrier, would have found its way to the sea, through Lake Utopia and the L'Etang River; for the ridge at the head of this river, described on a foregoing page, shews a clay coating at the foot of the slope on each side. Spruce Lake, near (7 miles west of) St. John, is turned eastward by a bank so low that a few feet of elevation would cause its waters to flow into Musquash Harbour: and the chain of lakes in Loch Lomond Valley, 10 miles east of Saint John, would be drained dry, but for the barrier presented by gravel banks and clay beds at its western end. Finally, the large marshy tract of barren, bog and lake, extending from Cranberry Lake to the basin of the north-west branch of Digdeguash River, is closed at one end by the gravel ridge, No. 4 of the table, and at the other by gravel banks at the mouth of the north-west Digdeguash.

These few instances are referred to, because the places are easily accessible; but I may add that where I have examined the rims of lake basins in southern New Brunswick, I have found very few examples of lakes having rims wholly of rock. In the majority of cases, the shape and position of the lake basins is more readily explicable by the theory of current erosion than by any other: as regards the rocky hollows in which they lie, the lakes, like the fiord-harbours to which I have referred in a previous article, appear to be pre-glacial; but as regards the superficial deposits, post-glacial. It would be tedious to specify instances in support of the latter conclusion; but a study of the region to which these remarks relate, with the aid of a good map, will confirm it.

Tidal Erosion in the Bay of Fundy.

In order that a comparison may be made of the effect of tidal wear in the Bay of Fundy, with the phenomena of the Syrtensian period, I give, in the following pages, the result of an examination of the soundings in various parts of that bay, as shewn in the Admiralty chart. For although an ocean current constantly setting in one direction cannot be expected to produce exactly the same result, in transporting superficial accumulations, as the tides which flow alternately up and down the Bay, the agreement is sufficiently close to illustrate the subject under consideration.

In the Bay of Fundy, the run of tide varies from 2 or 3 knots at its mouth to 7 or 8 knots (!) in the Parrsboro passage near its head. The chain of islands which separate Passamaquoddy Bay from the larger bay, presents, on a small scale, a barrier similar to that which, during the Syrtensian period, separated the ocean waters north and south of the Highlands in Southern New Brunswick. Passamaquoddy Bay has two principal outlets, viz., Quoddy River (salt) and La Tête passage. The rush of the tide through these passes causes a roaring sound which may be heard for many miles; and the whirlpools are strong enough to upset boats and careen large vessels. Both channels are full of deep holes, ledges and pointed rocks. At Quoddy River, the tide passes over barriers having only 15 fathoms at low water; yet within there is 50 fathoms in the narrowest and straightest part, and 30 fathoms where it merges into the shallower waters of Passamaquoddy Bay: in the contour of the 20 and 15 fathom lines, tidal erosion may be traced quite across the Bay, on the Robbinson shore, along which runs the channel that connects Quoddy River with the estuary of Sainte Croix River.

Opposite the La Tête passage, tidal wear on the bottom of Passamaquoddy Bay is even more conspicuous. One would naturally expect to find in this bay the channel of such an important river as the Maga'davic, the largest entering the sea between the St. John River and the United States border; yet no trace of it can be detected beyond the 5 fathom line; on the other hand, the tidal trough which begins inside Passamaquoddy Bay, with a depth of 40 fathoms, may be traced up the centre of the Bay, through the 30, 20, 15 and 10 fathom contour lines. Even the small middle passage between McMaster's and Pendleton's Islands has produced a hollow of 24 fathoms' depth, connecting with that in front of La Tête passage.

Opposite each of the main inlets into Passamaquoddy Bay, beyond the deep water, but immediately in front of these openings, there is a shoal corresponding to the "centre-shoal" described on a previous page, as produced by the ocean current of a former period. And along the straight reach of the northern shore of Deer Island, a channel has been made by the tide, such as the Arctic current produced in Syrtensian times, at many points in the southern counties, where a similar obstacle opposed its onward course.

At Saint John, like results have been produced by the flux and reflux of the tide in the narrow passage by which that river debouches into the Bay of Fundy. Although there is only six fathoms at low water on the reef which causes the rapid ("Falls") at the mouth of the river, such is the force of the current that trenches of 25 fathoms deep below the "Falls," and 33 fathoms deep above it, have been produced.

In the open parts of the Bay of Fundy, especially in its upper half, there are ridges and hollows seemingly produced by tidal erosion. Thus in the centre of the bay, between Quaco, New Brunswick, and Margaretville, Nova Scotia, there is a depression outlined by the 40-fathom contour line, nine miles long and three wide: it lies just between the points of two ridges (outlined by the 30-fathom line) which extend out from either shore. Up in Chignecto Passage also, off Cape Enragé, there is a trough scooped out by the tide, which is outlined by the 30, 25, and 20 fathom contour lines. And furher up the same arm, another, lying in the Cumberland channel, between Peck's Point and Boss Point; this trough is bounded by the 10-fathom line, and through it the tide runs at the rate of four knots an hour.

But it is in the eastern arm of the Bay of Fundy—Minas Channel and Basin—that the scouring action of the tide is most conspicuous. The curve of this arm to the east has thrown the weight of the current on the eastern shore; and there, under Cape D'Or, lies a trough outlined by the 50, 40 and 30 fathom lines, scooped out to a depth equal to that of the deepest part of the bay between St. John, N. B., and Digby, N. S.: yet in the intervening space between St. John and Cape D'or, the soundings shoal to 25 fathoms.

Passing Cape D'or and going further up, the bottom again rises to 25 fathoms, but soon sinks into another trough 40 fathoms deep. This extends to Cape Split, where a sharp barrier reef, rising to within 25 fathoms of the surface, again intercepts the tide. Surmounting this reef, the current again plunges down into a trench 50 fathoms deep, and rushes along through the Parrsboro Passage at the great velocity of 7 or 8 knots where the water is deepest; but slackening to 5 or 6 knots, where, in the more open part of the passage, the soundings rise to 30 fathoms. Here the contour lines, those of 30, 25 and 20 fathoms, take a bilobate outline, corresponding to the two arms of Minas Basin; and at 10 fathoms' depth, this line is tri-lobed, showing the erosive influence of the tide even in the middle of the basin: these three indentations answer to the Cornwallis, Avon, and Shubenacadie Rivers, as will be seen if the shallower contour lines be traced. A similar result of tidal erosion may be detected in Passamaquoddy Bay, where two tongues of deep water reach up from the basin in front of La Tête passage, on the contour line of 10 fathoms, to Hardwood and Hospital Islands.

Conclusions.

Before summing up the results thus far obtained, through observations made on the surface deposits of New Brunswick, it may not be out of place to call attention to the wide difference in composition, etc., between the beds, to the description of which this article has been chiefly given, and the Boulder clay.

The latter exhibits no such indications of the powerful and destructive action of ocean currents, as are everywhere impressed on the Syrtensian beds. It does not lie in stratified beds, like the latter, nor is the clay sorted out, but it still remains evenly distributed through the mass, in company with fragments of stone that show no marks of free attrition against each other. It could not have been exposed to atmospheric action during its accumulation, for, as Dr. Dawson has remarked of this deposit in the St. Lawrence valley, and as may also be seen here, pyritous minerals in the stones of the Drift clay are quite unoxidized, and the stones themselves show no evidence of aerial wear. These considerations preclude us from regarding it on the one hand as a deposit made in places open to the force and sifting action of sea water in rapid motion; and on the other, they are not favorable to the view that these clays were left exposed, on the surface of the continent, to the winds and rains, by the retreat of the glaciers. There remains, however, one explanation of their origin which, it seems to me, meets satisfactorily the conditions of this deposit, viz., that it was pushed into the sea at the submerged foot of the glacier, beneath which it was formed.

The history of the surface deposits in Acadia, so far as I have traced it, might, upon these grounds, be briefly stated as follows :—

1. *The Striæ* mark the formation of a glacial zone across the continent, facing an open sea to the south.

2. In connection with the production of striæ there followed the accumulation of ice on the southern side of this zone, causing a depression of the earth's crust, and producing the slope required to give motion to the glacier covering the Acadian plain,* causing also the *submarine* glacier-foot necessary to account for the nature of the *Boulder Clay.*

3. Recession of the glaciers to the North, consequent upon the continuous sinking of the land at their southern border. This change would result in the widening of the submerged tract, and the admission upon it of the arctic current from the north-east; and would give rise to the formation of the *Syrtensian beds* out of the Boulder clay, the finer material of which, in tracts exposed to the wear of the current, would be carried off to greater depths and more sheltered areas in the ocean.

There is one subject which should be touched upon before bringing these remarks to a close, namely, the time-value of the Syrtensian beds: how will this epoch compare, for duration, with that of the Boulder clay? The gravel and sandy strata of the former group do not present such a thick and uniform coating of detrital matter as the latter, for, although they sometimes rise into ridges of 150 feet high, this thickness is exceptional, and there are large areas where the deposit does not measure more than a score of feet in depth, and many spots which are entirely bare.

But, although the Boulder clay is, on the average, much thicker, there are some considerations which depreciate its value as a time-indicator. Previous to its formation, the eastern part of the continent appears to have been for long ages above the ocean, and the solid rocks, under the influence of a warm and probably humid climate, had been *decomposed to great depths.* In parts of Virginia and North Carolina which have not been beneath the glacier, the gneissic ledges are now softened to a

* See p. 7 of former article on Surface Geology of New Brunswick.

depth of thirty or fifty feet; and a similar condition of the gneissic ledges in Brazil has been noticed by Profs. Agassiz and Hartt, so it may well be admitted that great moving masses of ice, like the glaciers, would have no difficult task in breaking up and pushing into the sea these softened rocks, made loose and tender by the percolating rains of untold centuries. Another cause of the rapid growth of the Boulder clay was that the period during which it was deposited was one of *subsidence*. Whatever mud was poured into the ocean, at the glacier's foot, quickly sank to the bottom in the deep and quiet waters.

In the next period the conditions were changed, and strong currents invaded the submerged ârea. In the preceding epoch, glaciers had ground down the rocks to the hard and compact heart of the ledges, so that, except in the already ex'sting Boulder clay, there was no source from which the roving currents of the epoch could draw for the formation of a new group of beds. Of this old glacial deposit they availed themselves; but, while building up beds out of its coarser materials, they swept off and buried in the depths of the ocean the fine sand and clay. The Syrtensian period was one of *elevation*, and was therefore one of destruction of deposits, rather than of reconstruction and growth, so that the length of time which elapsed may have been much more than the thickness of its beds indicate.

This elevation of the land after the withdrawal of the glaciers, is a phenomenon which occurred in other lands, as well as this. Sir C. Lyell, in his Antiquity of Man (page 243, Philadelphia edition, 1863), adduces proof of the gradual and steady upheaval of the land in Scotland since the ice period. And Professor T. Kjerulf, in his treatise on the Striæ, Glacial formation and Terraces of Norway (Christiana, 1871), also shews that the hyperborean marine fauna was replaced by more southern forms, as the Norwegian land arose above the sea, after the retreat of the glaciers.

It will thus be seen that the theory which I have advanced to explained the conditions of the Post-pliocene deposits of Acadia, is not without support from the glacial phenomena of other lands.

NOTES ON SOME OF THE GALENA OR SULPHURET OF LEAD DEPOSITS CONNECTED WITH THE LAURENTIAN ROCKS OF ONTARIO.

By Henry G. Vennor, F. G. S.

Galena or sulphuret of lead is so often found associated with the crystalline limestones of the Laurentian, that an idea seems to prevail that, like the magnetic oxide of iron, it may specially characterize one or more of these bands. But recent investigations, while furnishing conclusive evidence that such is the case respecting the latter mineral, appear to show clearly the contrary concerning the former. The origin of these two mineral deposits is very different. The magnetic oxide of iron is now proved to exist for the greater part in the form of beds, or interstratified masses, in certain horizons of the gneiss and limestone series; and in a recent Report of the Geological Survey, I have shown that, in Frontenac and Lanark Counties, not less than three horizons of iron ore may be identified, which bear fixed relations to three seperate bands of limestone. The galena, however, does not occur in the form of sedimentary deposits, but always in true fissure veins, which traverse great areas in the Laurentian rocks. Consequently the occurrence of this ore in veins in any of the bands of limestone is merely accidental, or, in other words, is simply owing to these bands in parts of their distribution being crossed by what may correctly be designated as zones of disturbance. It is the object of the present paper to show that these zones are accompanied by great parallel breaks or fissures and displacements of the strata, which traverse the country in straight lines for great distances.

The galena deposits of Lansdowne, Storrington, Loughboro', and Bedford have been long known, and many localities in these townships where the ore has been mined, have been mentioned in the Reports of the Geological Survey. In one of these Reports, for the year 1858, Sir W. E. Logan, in referring to the galena lodes of Lansdowne and Bedford, suggests the probability of their forming a part of the same group as the lead-bearing lodes of Rossie, in St. Lawrence County, N. Y. In this conjecture he was supported by Mr. Thomas Macfarlane, who subsequently examined these lodes, and published a short paper on the Geology of Rossie. (Can. Nat. and Geol., new series, vol. 2., p. 267 et seq.) Beyond these notices, nothing has been published on this interesting and important subject. My own explorations, however, now enable me to state with a still greater degree of certainty, that all the galena lodes belong to a great belt or zone of parallel fissures, which extends not only from Rossie in New York to Bedford, but also to a great but unknown distance beyond, in a general north-westerly direction. These lodes are not of Laurentian age, as they extend up into the Potsdam and Calciferous rocks; or perhaps it would be more correct to state that they extend, at any rate, from the Calciferous, through the Potsdam, into the upturned edges of the Laurentian strata. For we have abundant evidence to prove that these latter rocks had assumed their present folded condition long before the deposition of the former, and consequently at a still greater period prior to the force or forces which have caused so extended a fissuring of strata. It is not so clear, however, whether this force acted from below upwards, or from the Calciferous downwards into the Laurentian strata. Nor is it yet determined which rock is the true source of the ores which now fill the fissures. What evidence we have on these points, however, is instructive. We find, for instance, that the lodes are, in some way or other, connected with the junction or line of contact between the Silurian and Laurentian formations. This contact may be represented, according to Mr. Alexander Murray, "by drawing a straight line from about the middle part of Loughboro' Lake across the heads of Knowlton and Beaver Lakes, to Round Lake in Belmont, a small sheet of water a little beyond Belmont Lake, and then another from Round Lake to the northern extremity of Balsam Lake......... There will, however, be several deviations from the regularity of the straight lines, occasioned by undulations in the more ancient rocks, bringing them occasionally to the surface on the south, while a number of outlying patches of the more recent formations are spread over portions of the country to the north." The junction of these two formations will be more clearly understood by consulting the large colored geological maps published by the Geological Survey of Canada, on which the Silurian is represented by the dark blue color. Along this whole line, and extending northward from it for twenty to forty miles through the Laurentian strata, there occur equidistant and parallel fissures, or great cracks, which probably extend downwards to great depths. The course of these fissures is marked by the occurrence of doleritic and feldspathic dykes, mineral-bearing veins, or where these do not occur, by the abrupt faulting of the strata at numerous points along a number of straight and parallel lines. With these are connected all of the galena veins of Rossie, Lansdowne, Storrington, Loughboro' and Bedford, as well as those in Madoc, Marmora, Tudor and Lake in Hastings County, and Belmont, Methuen, and very probably also Galway in Peterboro' County. Thus the westward extent of this great belt of fissures from Bedford cannot be less than 100 miles, and from Rossie 150 miles. In this distance they traverse a succession of strata of very varied characters, cutting alike the gneisses, schists, diorites and crystalline limestones, and at Ringwood, N. Y., the Potsdam sandstones. Of these rocks, the crystalline limestones appear to exert the most favorable influence on the lodes, as it is in these they attain their greatest proportions and yield the most ore, while in the alternating gneisses and diorites, particularly where these are of a firm texture, they not only narrow, but in many instances are filled with different minerals, such as blende, copper pyrites, mispickel, and more rarely gold, silver, and bismuth. It is this enlargement and improvement of the lodes in the limestones that has given rise to the idea already referred to, namely, that the galena characterizes certain of these bands. The change of mineral contents in lodes of the same age is an interesting and important feature in this connection, but it is one that requires much further investigation.

The direction of most of the galena veins in Lansdowne, Loughboro' *and Bedford*, is *a little north of west and south of* east, but varies from N. 85° W. to N. 15° W. In this same direction run all the lines of faulting and most of the intrusive dykes; but these last run rather by short zig zags than in direct lines. It is an extremely difficult matter to follow out and map any one of these lines continuously through the contorted Laurentian country, but such an attempt was made, and in two special instances succeeded beyond my expectations.

While tracing a number of the faults in Loughboro' and Bedford, one was met with towards the centre of the latter township, which, from its being farther removed from the *overlying mass of the Silurian, furnished more marked features* by which it could be followed. This was traced by abrupt displacements of the strata, from the vicinity of Westport Village, on the Rideau, in North Crosby, through Wolf Lake, in Bedford, to Eagle and Long Lakes, in Hinchinbrooke; thence through Horse Shoe Lake, on the Salmon River, in Kennebec, to and through Kaladar, Elzevir, Tudor and Lake townships, in all a distance of 52 miles. This line of dislocation is accompanied, in Bedford, Tudor and Lake, by numerous parallel galena lodes; in Kaladar and Lake, by lodes carrying the sulphuret of copper, and in one instance, in the last named township, by a lode containing the sulphuret of bismuth in crystalline masses of considerable size. The cupriferous lodes are invariably bounded by diorites, green slates, and chloritic schists, or dolomites, while both the galena and the bismuth are associated with limestones. It is also noticeable that in the localities where the lodes traverse the green slates and chloritic schists, the copper ore is not confined to the lodes themselves, but extends from them along the planes of bedding of both slates and schists, forming bedded cupriferous zones, which can be traced for some distance on the strike of the rocks. These zones, however, do not appear to be of economic importance, nor is the copper ore in the main lodes in sufficient quantity to be worthy of special consideration.

To the south of this first great dislocation, and about ten miles distant from it, a second and similar important break was made out, and traced for some distance in a parallel course, northward of east, towards and through Frontenac County. This runs from the south-eastern corner of Methuen township in Peterboro' County, where its position is marked by Parker's Galena mine, through Marmora, Madoc and Elzevir in Hastings County; thence through the village of Troy or Bridgewater to a position on the Salmon River in Sheffield, about nine or ten miles to the southward of where the first described fault crosses the same river in Kennebec. In this position, the correctness of this line of fault is verified by a fact recorded by Mr. Alexander Murray in his Geological Report for 1852-53, in which he states as follows: "Six miles further down (the Salmon River) it (a band of limestone) was seen below the exit of Long Lake, where it is brought in by a dislocation indicated by a coarse grained quartzo-feldspathic dyke, transverse to the stratification: the mica slate abutted against the dyke on the north-east, and the limestone on the south-west."

Beyond the Salmon River, in an eastward direction, this line of dislocation was not clearly made out, but an extension of it, in all probability, was observed to affect the strata in the northern part of the township of Loughboro', where it is again accompanied by galena lodes. The total distance from Methuen to Loughboro' is about 60 miles.

Besides galena and copper pyrites, gold, silver and mispickel occur in the veins accompanying this dislocation. In Madoc and Elzevir both the once celebrated Richardson Mine and the Barrie Mine are in close proximity to it, and it is probable that the great segregated masses of auriferous mispickel to the west of the "Huckleberry Rocks" in Marmora are due to the same agency. This point, however, requires more detailed investigation. There is little doubt existing in my own mind, that many of the auriferous lodes of Madoc and Marmora are due to the faults, and particularly so where these traverse the dolomites, slates and schists of the Hastings series of rocks. The age, therefore, of these gold deposits is probably the same as that of the galena lodes, namely, as recent, at any rate, as the Calciferous. The source, however, from which the precious metals have been derived cannot yet be satisfactorily determined. I should also notice, in this connection, the occurrence at the Richardson Mine, Madoc, of a black carbonaceous matter or bituminous substance. This was first discovered by Dr. J. Perrigo and myself, during the year 1866, and was subsequently described by Dr. Hunt, in one of his Reports, as Anthracite. This substance is undoubtedly a true part of the lode, and was deposited along with the gold; it is, however, of rare occurrence. Respecting the depth to which these lodes are ore-bearing, little can be said with certainty at present, as there are no shafts or openings deeper than 100 or 125 feet on any of them, by which this point might in a measure be tested; but from what evidence I have been enabled to gather, I agree with Sir W. E. Logan, in a statement made by him respecting the Ramsay Galena lode, that "whatever quantity of ore the lode may carry with it, there is little doubt of its great depth, a depth to which indeed no certain limit can be placed." This statement equally applies to most of the galena lodes examined by me in Frontenac, Hastings and Peterboro' Counties. As to the quantity and constancy of the mineral in these, a word or two may be said. So far, we have abundance of proof that the galena does not extend far into the Laurentian strata, although the lodes themselves undoubtedly extend downwards to great distances. In their greater depths, they would appear either to change in mineral contents or become barren; although this is another of the points which requires further investigation.

Perhaps the largest deposit of galena yet opened up is that on the third lot of the sixth concession of Ramsay. It, however, has not been worked for a number of years, and is now filled with water and debris. This lode does not belong to the same belt or group of fissures as those of Landsdowne, Loughboro' and Bedford, but it is undoubtedly of the same age. It intersects first the Calciferous, next the Potsdam, and finally the Laurentian strata in the same township; but the ore gradually lessens and finally disappears in the older rocks. The bearing of the lode is from N. 45° W. to N. 50° W. and its underlie is, as it invariably is in all the lodes and dykes of the same age, to the northward at a steep angle. It has been shafted to a depth of eight fathoms, and somewhat upwards of thirty tons of galena, averaging 80 p. c. of lead, extracted and sold. This fact has already been mentioned in one of the Reports of the Geological Survey, but I again allude to it in connection with what has just been stated respecting the diminishing of the ore in the downward course of the lode.

The Ramsay lode is accompanied by a displacement of the strata as is the case with those of Bedford and Loughboro'; which fact is particularly mentioned by Sir William Logan, in a foot note to the Geological Report, for 1858, page 51, where after referring to the galena deposits of Wisconsin and Missouri, he says: "The Ramsay ore on the contrary occurs in a true vein, filling a crack connected with a dislocation, and on a late visit to the mine, I had an opportunity of observing a clear evidence of this in one of the walls of the lode (both of which are well defined) in the parallel grooves occasioned by the grinding of the terminal edges of the strata on the opposite sides of the crack when the displacement happened." And further on again in this same Report, in referring to the age of the Ramsay lode, Sir William says: "In addition to the Calciferous sandrock the lode will intersect the Potsdam sandstone and the Laurentian areas beneath, and in this respect resemble the Rossie lodes. Little hesitation can be felt in pronouncing it to be a lode of the same age as these, and the interesting fact is now for the first time shewn, that not only these lodes, but probably all the yet known lead veins of the Laurentian rocks, are newer than at least the Calciferous formation, and possibly than some of the formations above it, thus extending considerably the area in which such veins may by looked for." I need only add that my own observations fully support the view thus taken by Sir William respecting both the character and age of these veins, and that although I have considerably added to the lineal extent of this great group of lodes and collected many further facts relative to their conditions in the Laurentian strata, I can throw but little additional light on their true origin.

As to the future prospects of the Ramsay lode, I may state that little is to be expected either in depth, or in drifting in a north-westward direction, and for two simple but potent reasons. The Calciferous and Potsdam strata, which the lode intersects, are comparatively thin outlying deposits towards the termination of the great mass of the Silurian, which extends for miles to the north-eastward and south-eastward. Consequently at a depth not exceeding 100 feet, a shaft would probably enter the Laurentian gneisses or limestones, probably the former, when the vein might be expected to become unprofitable. The same would happen in drifting on the lode in a north-westward direction, at a very short distance. The only other course then left would be its exploration in a south-eastward direction, if this be practicable, when there is no reason why the lode should not contain as much if not more ore than in the spot where it was first mined. There is perhaps, however, a possibility that higher members of the Calciferous, or immediately succeeding formations of more recent age, may cap over and conceal the lode in this direction. I cannot state decidedly that the ore in this and similar lodes would at once diminish upon entering the Laurentian, but simply that what evidence has been gathered from the condition of the lodes intersecting such strata in other localities in the same township, would point in this direction. On the other hand, the galena lodes of Rossie in St. Lawrence County, N. Y., in the Laurentian, have, to some extent at least, been profitably wrought, and many of the same through Lansdowne, Loughboro' and Bedford in similar strata, appear to be of greater or less promise. Still the fact remains that in the latter localities the lodes are no longer worked, while a number of them have been abandoned as decidedly unprofitable. The Loughboro' mine, near Indian Lake in Loughboro' township, is situated, perhaps, on one of the best tested lodes in this group, and it furnishes us with an example of how the galena may be largely replaced by blende as we descend into the Laurentian strata. In Bedford though galena was found in large masses at the surface of a number of the lodes, it beyond a doubt diminished in depth. Again, in the great series of lead-bearing veins in Tudor, Lake and Methuen in Hastings and Peterboro' Counties, astonishingly large and pure masses of ore were found in many instances immediately at the surface of the lodes, but rapidly diminished in every instance in descending. The shaft of Messrs. Hill & Kershaw in the township first named was in my opinion one of the best tests made in this section of country. It was sunk on a beautifully defined lode, cutting the grey limestone or calc schist of the Hastings series, to the depth of 130 feet, but long before reaching this depth the ore had ceased to occur in remunerative quantity, although the vein continued to descend as well defined as at the surface.

In conclusion then I can only express the opinion that these Galena lodes in the Laurentian system are merely the remnant of lodes which had their greatest development in the rocks of the Potsdam and Calciferous, both of which formations have been extensively removed by denudation.

GEOLOGICAL SKETCHES OF THE NEIGHBORHOOD OF HAMILTON.

By J. W. Spencer, Bac. App. Sc.

The country in the vicinity of Hamilton, Ontario, affords a very interesting field to the geologist. Within a limited distance there are excellent exposures of the upper members of the Medina, as well as of the Clinton, and the lower part of the Niagara formations. These reward the persevering collector with a goodly number of fossils, besides several mineral species. The superficial geology of the region in question is likewise well worthy of study.

The most prominent feature of the Western Peninsula is the Niagara Escarpment (popularly called at Hamilton "the Mountain"), which, crossing into Canada at Niagara Falls, skirts the western end of Lake Ontario, and extends northward to the Manitoulin Islands. The escarpment rises several hundred feet above Lake Ontario, sometimes forming abrupt cliffs, and at others having a more gradual ascent. At Hamilton it is about two miles from the lake, or rather from Burlington Bay, and 396 feet above the bay, or 628 feet above the sea. West of the city it recedes eight or nine miles from the bay, the north side of which it, however, again approaches, forming the valley in which Dundas is situated.

The object of this paper is to give a few facts concerning the strata composing this escarpment in the neighborhood of Hamilton, together with notes on the superficial geology, mineralogy, &c.

The Medina Formation.

This formation has only its upper members exposed at Hamilton, although at Oakville, on the north side of the lake, the lower beds are seen, being underlaid by the Hudson River roc [illegible] whole thickness is estimated by the Geological Survey at 614 feet, of which only about 100 feet of the upper part are seen at Hamilton, and still less at Dundas. The whole formation consists essentially of shales with some sandstones. Near the summit is the "Gray Band," a fine-grained and irregularly deposited sandstone, with a thickness at Hamilton varying between seven and fourteen feet. Above this there are eight feet of impure, slightly calcareous sandstones, in thin beds with shaly partings, and weathering in some cases to a bright red. The gray band, which is extensively quarried, forms an excellent building material, and has also been used for making grindstones.

The shales are particularly poor in fossils, nothing but a few obscure fucoids having been found in them. In the sandstones, however, a few fossils can be obtained, but it is exceedingly difficult to separate them, on account of the hardness of the rocks. Among those which I have found, may be mentioned *Arthrophycus Harlani*, *Palæophycus*, and *Lycophycus*, and of animal remains, *Lingula cuneata*, which is not rare, *Modiolopsis orthonota*, *Murchisonia notoidea* (?), and an obscure coral resembling a *Zaphrentis*. In some places rain marks are common.

The Clinton Formation.

The Clinton formation is exposed along the side of the escarpment, and having the Niagara overlying it, there are but few places where it forms the surface rock of the country. As it approaches from the east, it increases in thickness, and at Dundas is much more largely developed. It has a thickness of 78 feet at this place, consisting of thin beds of calcareo-arenaceous rocks, and some impure limestones, alternating with shales of various textures and tints. During the deposition of these strata there was a constant change in the character of the sediments, as it seldom happened that more than a few inches of the same kind of material were deposited consecutively. The sea was shallow, as is shown by ripple marking, and by quite a variety of worm tracts, as well as by the markings of rain drops. The conditions suitable to life, moreover, were more favorable than in the preceding epoch. Of the fossils obtained here, all or nearly all are likewise found in the Niagara above, and from the material collected at Hamilton it is impossible to separate palæontologically the deposits of the Clinton epoch from those of the Niagara. The Clinton, in its upward extension, has been limited by a hard dolomitic bed, which forms the base of the Niagara formation, and is sometimes known as the " Pentamerus Band."

The most curious fossils of this epoch are two or three species of *Lin ula*, which are of a bright blue colour. They were first discove ed in 1868, by Lieut. C. C. Grant, in the dark brown calcareo-arenaceous beds near the top of the Clinton at the " Bluff" (a cliff about a mile east of the city reservoir), and were associated with numerous specimens of *Modiolopsis*. They appeared for a time to be confined to the one locality mentioned, but recently I have found them near the city. Though bright blue when first taken out, they soon become quite dull.

Several fine varieties of *Buthotrephis gracilis*, and one or two other plant remains are found in the Clinton.

As almost all the animal remains of this formation are found in the Niagara, only a few species, that are less common above, or locally not met with there, will be enumerated, viz.—*Stenopora fibrosa*, *Heliopora fragilis*, *Trematopora fabulata*, *Clathropora frondosa*, *Ptilodictya crassa*, *Orthis lynx*, *O. Davidsoni*, *O. elegantula*, *Athyris naviformis*, *Rhynchonella neglecta*, *R. rugosa*, *Avicula emacerata*, numerous *Modiolopses*, *Cyrtodonta*, *Tentaculites distans*, *etc*. The *Lingula* above mentioned belong principally to *L. oblonga*, *L. oblata* and *L. cuneata*. Col. Grant has found one or two specimens of *Recepticulites*, and a few netted graptoites in the Clinton.

THE NIAGARA FORMATION.

This constitutes the upper portion of the escarpment, and extends over a considerable area, frequently cropping out through the drift. Of the rocks deposited during the Niagara epoch only 63 feet in thickness remain at Hamilton, while at Dundas the formation reaches double this thickness.

The following is a section of the Niagara Formation at Hamilton, in ascending order :

	Ft.	*Ins.*
1. Hard gray magnesian limestone, weathering yellowish, and holding *Pentamerus oblongus*, and in the lower part containing *Lingulæ*, which a few feet below in the Clinton are coloured blue....	1	6
2. Bluish, argillaceous and arenaceous shales, with some bands of arenaceous, argillaceous, or magnesian limestones..........................	21	6
3. Hard magnesian limestone with geodes of calcite, barite, selenite, gypsum, celestite, pyrite, etc.	5	0
4. Thin beds of limestone, in some cases argillaceous, separated by layers of dark bituminous shales, some of which contain graptolites..............	9	0
5. Compact magnesian limestone, known locally as the "Blue Building Beds." Some of the beds weather into pits on the surface, and are separated by shaly partings. Fossils in considerable quantities are found in these beds, especially Trilobites..................................	14	0
6. Gray magnesian limestone, exceedingly cherty, and containing numerous remains of sponges, and reticulated graptolites in places, besides a large number of other fossils..........................	12	0
	63 ft.	0

Although the entire thickness upward from the Pentamerus band is only 63 feet near the head of Wellington Street, it increases to the west, and near Dundas it attains to 127 feet. Eastward of Hamilton it diminishes considerably. The beds are usually irregular in thickness, the thicker bands often in a very short distance splitting up into thin layers, and rendering it impossible to identify the exactly corresponding beds, even over a limited area. Yet, by means of the Pentamerus bed it is not usually difficult to separate the base of the Niagara from the underlying Clinton. The next most noticeable bed is the third member, which is a hard dolomite, and although continuous, varying in thickness from three to six feet. This is extensively quarried, and forms an excellent building material. Some of the argillaceous limestones would doubtless make good hydraulic cement.

Fossils are not so abundant as they are farther east, where the upper beds, which are wanting at Hamilton, are developed. The two most important groups of fossils which have been recently discovered at Hamilton are sponges and reticulated graptolites; the former being found in the cherty parts of the top member of the series, while the latter are found in this as well as in the members below. The cherty beds affording the sponges thin out both to the east and west of Hamilton. Two years ago also, Col. Grant,—who discovered the graptolites three or four years since, and the sponges in 1874—obtained the bodies of certain crinoids, the presence of which had previously been recognized only by the stems or columns.

Besides several plants, some of which are not determinable, the principal fossils that can be obtained at or near Hamilton are:

Receptaculites, *Aulocopina Granti*, and other sponges not yet determined; *Favosites Gothlandica*, *Stenopora fibrosa*, *Zaphrentis Stokesi*, *Diphyphyllum*; *Dictyonema gracilis*, *D. retiformis*, and a number of other graptolites not yet described; *Stephanocrinus angulatus*, *Caryocrinus ornatus*, *Eucalyptocrinus decorus*; three species of starfishes; *Fenestella elegans*, *F. prisca*, *Cladopora cervicornis*, *Phænopora constellata*; *Leptæna transversalis*, *L. subplena*, *Strophomena rhomboidalis*, *S. profunda*, *S. Philomela*, *S. Leda*, *Lingula oblonga*, *L. oblata*, and several other species; *Discina formosa*, *D. tenuilamellata*, *Orthis elegantula*, *O. porcata*, *O. flabellulum*, *Rhynchonella neglecta*, *Pentamerus ob-*

longus, *Stricklandia Canadensis*, *Spirifer radiata*, *S. Niagarensis*, *Atrypa reticularis*, *A. plicatella*, *A. obtusiplicata*, *A. nitida*, *A. nodostriata*; *Avicula emacerata*, *A. subplana*; *Platyostoma Niagarensis*, *Platyceras angulatus*; *Orthoceras Brontes*, *O. undulatum*, *O. virgatum*; *Conularia Niagarensis*, and two undetermined species, one of which is eight inches long, and of which only two specimens have been obtained; *Calymene Blumenbachii*, *Dalmanites limulurus*, *Ceraurus insignis*, *Lichas* undetermined, *Ascidaspis* undetermined, *Bumastes Barriensis*, &c. Besides these, there are a number of others which have not been determined, and many more quite obscure. I have obtained two or three specimens of *Atrypa reticularis* which are interesting, as showing perfectly the silicified spiral supports for the arms.

Superficial Geology.

Between the Niagara Escarpment at Hamilton and Burlington Bay, the Medina shales are covered with drift deposits. The surface rises gradually to the foot of the Escarpment, which is 125 feet above the lake. The next hundred feet of the ascent (vertical) of the slope is at a somewhat high angle, and the material is largely made up of the *débris* of the adjacent rocks, often concealing the whole of the Medina, and in some places part of the Clinton also.

The valley to the west of Hamilton, in which Dundas is situated, is about eight miles long, and five or six miles wide at its eastern extremity. It has been excavated by an ancient river, and in form is V-shaped, the apex being to the west. Much of it is filled with irregular hillocks and broken ridges, which are often separated from each other by deep ravines or by alluvial flats of considerable width. The ridges are composed of blue and brown clays, sands or gravels, some of which are largely made up of the *débris* of the Hudson River formation, with boulders of Laurentian gneisses, and also some remains of the rocks of the immediate vicinity The eastern portion of the Dundas valley is occupied by an extensive marsh, which is separated from Burlington Bay by the "Burlington Heights," which are 107 feet above the lake, and consist of a narrow sprit which is made up of sand and coarse and fine gravel—being part of a former shore-line. This ends abruptly at the north-western part of the marsh, and between the Heights and the escarpment to the north, there is a deep ravine, through which the streams from the Dundas valley flowed into Burlington Bay till after the cutting of the Desjardins Canal. About six miles east of this ridge, Burlington Bay is separated from Lake Ontario by a low beach about half a mile wide, consisting of sand and pebbles—this being the present lake-shore.

In several places, streams have made large deep gorges, through the escarpment, some of which are more than half a mile long and even 150 to 300 feet deep. The largest of these is known as Spencer's Ravine.

In the history of the superficial geology of this region there are three distinct epochs:—during the first, the original excavation of the Dundas valley, which has an area of nearly forty square miles, took place; the second epoch is that of the deposition of the Erie Clay and the partial filling of the valley; and the third is that of the re-excavation of the valley, and the formation of the lacustrine beaches and terraces.

1. *The original excavation of the valley of Dundas* appears to have been effected by means of the denuding action of a river flowing from the west, forming a deep gorge, which widened regularly as it approached the mouth, the part below the escarpment being eight or nine miles in length, while at the mouth the width was about six miles,—the whole somewhat resembling the Niagara River between the Falls and Lewiston. The sides had generally a straight course, broken occasionally by a secondary excavation in the solid rocks. The escarpment seems to have had a higher elevation than at present, as the erosive effects of the river had swept away the Medina formation to a depth of more than 60 feet below the present level of the lake.

2. *The partial filling of the Valley* by Erie clay was not much under 200 feet in thickness, if it was uniformly deposited, as it has a depth of 80 feet at Dundas, and on some of the higher surroundings it occurs more than 100 feet above the present lake-level, according to Prof. Bell. This clay frequently contains boulders, partly of Laurentian age, and partly Palæozoic. It also overlies the Medina shales at Hamilton, and at Burlington Heights is about 60 feet deep, all above, to the level of the lake, having been swept away. The boulders have striated the surface rocks of the Niagara formation quite deeply in some places, the direction of these not being constant; just south of Hamilton they are S. 55° W. This epoch was one of subsidence.

3. *The re-excavation of the Dundas valley*, and the recession of the lake were gradual, as the old shore lines are met with at several different heights. The material of which these old water margins are composed is the *débris* of the Hudson River Formation, which occurs on the north side of the lake, together with some boulders and pebbles of Laurentian age, as well as some material from the Niagara formation; the pebbles of the last being more or less angular, while those of the Hudson River formation are generally oval, and contain numerous fossils, among the more common of which are: *Stenopora fibrosa*; *Lingulæ*, *Leptæna sericea*, *Strophomena deltoidea*, *S. nitens*, *Orthis lynx*. *O. occidentalis*, *Rhynchonella recurvirostra*, *Atrypa Headi*; *Modiolopsis modiolaris* and several undescribed species, *Cyrtodonta Hindi?*, *Ctenodonta*, *Cleidophorus?* *Avicula demissa*, *Ambonychia radiata*; *Cyrtolites ornatus*, *Murchisonia gracilis*; *Orthoceras crebriseptum*, etc.

During the epoch of the subsidence of the waters of Ontario, the streams emptying by means of the Dundas valley re-excavated the valley, and in the deeper parts carried away all the deposits of the Erie clay, except the lower portion below the lake level. The highest ridge showing the old water margin is just north of Dundas, and has an elevation of more than 300 feet above the present lake level; this consequently conceals the lower members of the escarpment to within a 100 feet of the summit. Gravels and sands occur also on some of the ridges south of the town, at a height of over 100 feet, and coincide in elevation with Burlington Heights. Again the same shore line is exposed in the western part of Hamilton, extending to Hudson Street, where it is no longer seen on the surface; but some distance east it can again be traced, following the same contour lines as those of Burlington Heights, which, as has been stated, are 107 feet above the lake. It consists of alternate strata of sand and of coarse and fine gravel, in some places being cemented into hard rock by infiltrated carbonate of lime. Among these shore deposits there is very little of the *débris* of the Niagara formation.

The high and narrow ridge which constitutes the "Heights" was probably caused by the currents of the river flowing from the Dundas valley meeting the waves of the lake beating in the opposite direction; and consequently the coarser materials carried down by the river were deposited along with the boulders, gravels, and sands, from the lake, in the more quiet waters, where the opposite currents of the river and lake met.

The ridge of Burlington Heights is not a moraine caused by the deposition of boulders and pebbles carried down the valley by glaciers and field ice; but the material was brought from the Hudson River deposits on the north side of the lake westward by the waves, or assisted by the action of field-ice drifting on the waters of the lake.

In the excavation through this ridge, during the construction of the Desjardins canal, the antlers of a wapiti (*Cervus Canadensis*) and the jaw of a beaver (*Castor fiber*) were obtained at a height of 77 feet above the lake, while seven feet below, several bones of the mammoth (*Euelephas Jacksoni*) were found.

Farther eastward is the Burlington Beach, the present lake shore, separating the bay of that name from Lake Ontario. This consists of a sand-bar, half a mile wide, extending across the bay, with an opening for the discharge of the waters into the lake, by means of the Burlington canal, which is the enlargement of a former outlet. The pebbles of the gravel are not usually large, and consist mostly of oval Hudson River fragments, together with small ones of Laurentian age.

The streams flowing down tributary ravines, which in several places are deeply cut into the Niagara escarpment, have swept away any of the deposits of Erie clay which may have filled them at a former time. The erosive action did not cease when it had formed the beds of the streams, but is constantly wearing away the soft Medina and Clinton shales, and allowing the harder dolomites of the Niagara to fall, so that the beds of the streams are strewn with masses of rock, the largest of which would probably weigh as much as fifty tons. In some of the gorges calcareous tufas are being formed, and in places mosses, leaves, and fragments of wood are being calcified. Some of the tufa beds have attained a thickness of no less than from one and a half to two feet.

From the different water-margins which exist so much above the present lake shore, it is evident that there has been a gradual recession of the waters, due either to a subsidence of the lake from a deepening of its outlet, or to an elevation of the land. The evidence obtained goes to show that it is due chiefly to the latter cause. During the deposition of the Erie clay, the land must have subsided about 400 feet, and the subsequent re-elevation appears to have been about 300 feet.

MINERALS.

A few minerals can be obtained in the neighborhood of Hamilton. They are not rare species, but still are not without interest. In the thick five-foot magnesian limestone band of the Niagara formation, there are geodes lined with calcite (dog-tooth spar), barite, celestite, selenite, granular gypsum and pyrite; and often the cavities are filled with highly saline waters. Besides these, quartz crystals, chalcedony, galena, blende and sulphur have been found.

Near the junction of the ravines from Webster's and Spencer's Falls, there is a locality where an efflorescence of the following composition is found:

Magnesium sulphate	61.450
Calcium carbonate	19.532
Ferrous carbonate	12.850
Calcium silicate	2.741
Silica	3.427
	100.000

It is evidently the result of the decomposition of pyrites in presence of dolomite.

Mineral waters—both saline and sulphuretted waters—occur in numerous localities. Of the latter class may be mentioned several springs near the Albion Mills, five miles east of Hamilton, which give off large volumes of gas.

MISCELLANEOUS.

CAPTURE OF AN ENORMOUS CUTTLE-FISH OFF BOFFIN ISLAND, ON THE COAST OF CONNEMARA.—On Monday last the crew of a curragh,* consisting of three men, met with a strange adventure north-west of Boffin Island, Connemara. The capture of a cuttle fish sounds little of an exploit. Ordinarily the fish is of small size, a few inches in circumference, with projecting arms, studded with suckers, by which it retains its prey — the body containing a dark fluid, which it emits on being startled, and, blackening the surrounding water, so eludes its enemy. Very different indeed from this ordinary type was the creature in question. Having shot their spillets (or long lines) in the morning, the crew of the curragh observed to seaward a great floating mass surrounded by gulls; they pulled out, believing it to be a wreck, but, to their great astonishment, found it to be a cuttle-fish, of enormous proportions, and lying perfectly still, as if basking on the surface of the water. What rarely enough occurs, there was no gaff or spare rope, and a knife was the only weapon aboard. The cuttle is much prized as bait for coarse fish, and, their wonder somewhat over, the crew resolved to secure at least a portion of the prize. Considering the great size of the monster, and knowing the crushing and holding powers of the arms, open hostility could not be resorted to, and the fishermen shaped their tactics differently. Paddling up with caution, a single arm was suddenly seized and lopped off. The cuttle, hitherto at rest, became dangerously active now, and set out to sea at full speed in a cloud of spray, rushing through the water at a tremendous rate. The canoe immediately gave chase, and was up again with the enemy after three-quarters of a mile. Hanging on rear of the fish, a single arm was attacked in turn, while it took all the skill of the men to keep out of the deadly clutch of the suckers. The battle thus continued for two hours, and while direct conflict was avoided, the animal was gradually being deprived of its offensive weapons. Five miles out on the open Atlantic, in their frail canvas craft, the bowman still slashed away, holding on boldly by the stranger, and steadily cutting down his powers. By this time the prize was partially subdued, and the curragh closed in fairly with the

* These boats are a large kind of coracle made with wooden ribs, and covered with tarred canvas.

monster. The polished sides of the canoe afforded slender means of grasp, and such as remained of the ten great arms slashed round through air and water in most dangerous but unavailing fashion. The trunk of the fish lay alongside, fully as long as the canoe, while, in its extremity, the mutilated animal emitted successive jets of fluid which darkened the sea for fathoms round. The head at last was severed from the body, which was unmanagable from its great weight, and sank like lead to the bottom of the sea. The remaining portions were stowed away and carried ashore, to the utter amazement of the islanders. To quote from 'The Sea and its Living Wonders,' I find it stated that—"Near Van Dieman's Land, Peron saw a sepia as big as a tun rolling about in the waters; its enormous arms had the appearance of snakes. Each of these organs was at least seven feet long, and measured seven or eight inches round the base. These well-authenticated proportions are truly formidable, and fully justify the dread abhorrence Polynesian divers entertain of these snake-armed monsters of the deep. Banks and Solander, in Cook's first voyage, found the dead carcase of a gigantic cuttle-fish floating at Cape Horn. It was surrounded by aquatic birds feeding on the remains. From the parts of this specimen preserved in the Hunterian Collection, and which have always strongly excited the attention of naturalists, it must have measured at least six feet from end of tail to end of tentacles." If the specimens alluded to above are correctly described as "gigantic" and "formidable," well may the capture made at Boffin be regarded as wonderful; and it is owing to the merest chance that the writer became aware of the circumstance, and possessed himself of such evidence as puts the truth of the matter beyond all doubt. Of the portions of the mollusk taken ashore two of the great arms are intact, and measure eight feet each in length and fifteen inches round the base. The two tentacles attain a length of thirty feet. The mandibles are about four inches across, hooked just like the beak of an enormous parrot, with a very curious tongue. The head, devoid of all appendages, weighed about six stone, and the eyes were about fifteen inches in diameter. Doubtless this account may sound exaggerated, but I hold such portions of the fish as are fully sufficient to establish its enormous size, and verify the dimensions above given.—*Thomas O'Connor, Sergeant, Royal Irish Constabulary; Boffin Island, Connemara, April* 28, 1875.—From *The Zoologist*, June, 1875.

Freaks of the Danube.—The disappearance of the Danube between Morhingen and Immindingen, on the frontier of the Duchies of Baden and Wurtemburg, is a curious natural phenomenon. For at least half-a-century it has been noticed that some portion of the water of the river flowed into cavities in the calcareous rocks—Jura limestone—to re-appear again near the town of Aach in the Hobgau; now the whole body of water disappears in the vast cavities which have been formed.—*Athenæum.*

Extinct Wombat.—Among some fossils recently described by Prof. M'Coy, of Melbourne, is an extinct wombat, from the gold-drifts of Victoria. This fossil, called *Phascolomys pliocenus* is of much interest, as having enabled Prof. M'Coy to show that the auriferous deposits whence it was derived, instead of being merely "alluvial," should be referred to the more ancient Pliocene period, thus corresponding in age with the gold-drifts of the Urals.—*Ibid.*

Rat *versus* Octopus.—The aquarium of the Zoological Station at Naples was, last autumn, attacked by a great number of rats, which not only did considerable mischief to the wood work but even caught and devoured a number of the animals kept in the tanks. In an attack on an octopus, however, one of these depredators got by far the worst of the battle, as next morning nothing remained of the four-footed gourmand but the bones and a part of the skin. Though this achievement cannot be compared to the exploits related by M. Victor Hugo, it is interesting as showing that even in captivity a healthy cuttle-fish is well able to take care of itself.—*Ibid.*

Botanical Literature.—The literature of botany, like all other branches of science, is becoming so extensive that the Germans have seen the necessity of publishing an annual record of its progress. Accordingly, a *Botanischer Jahresbericht* is now in course of publication, the first volume, which contains a report of all important papers issued during 1873, having been recently completed. The work is edited by Dr. Leopold Just, Professor in the Polytechnic at Carlsruhe, who is assisted by a large staff of contributors.—*Ibid.*

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NOTE.—Volume VII., containing eight numbers, was commenced in 1873, and extends over a period of two years although dated 1875 on the Title page.