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AND

Quarterly Journal of Science.

WITH THE

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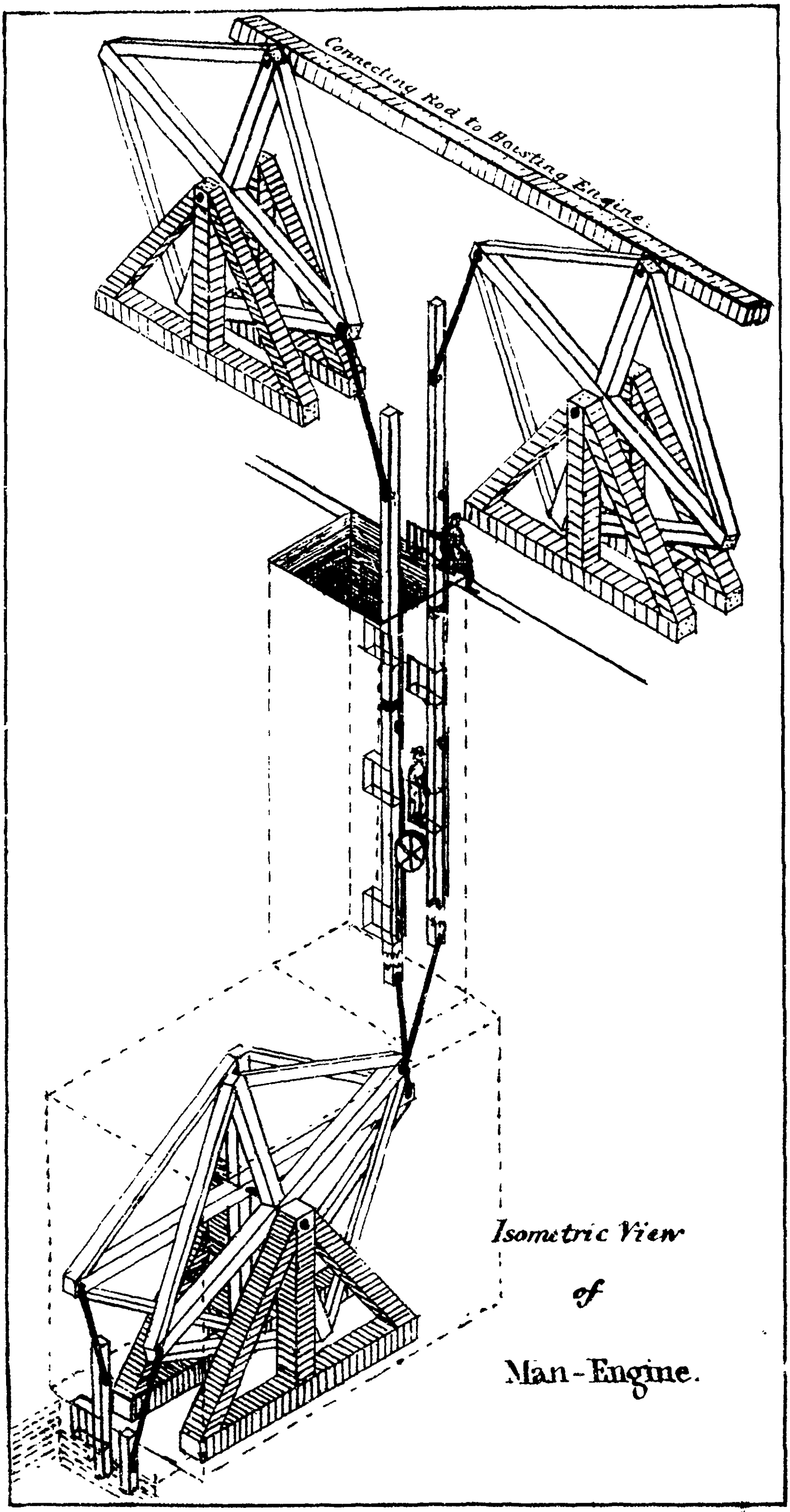
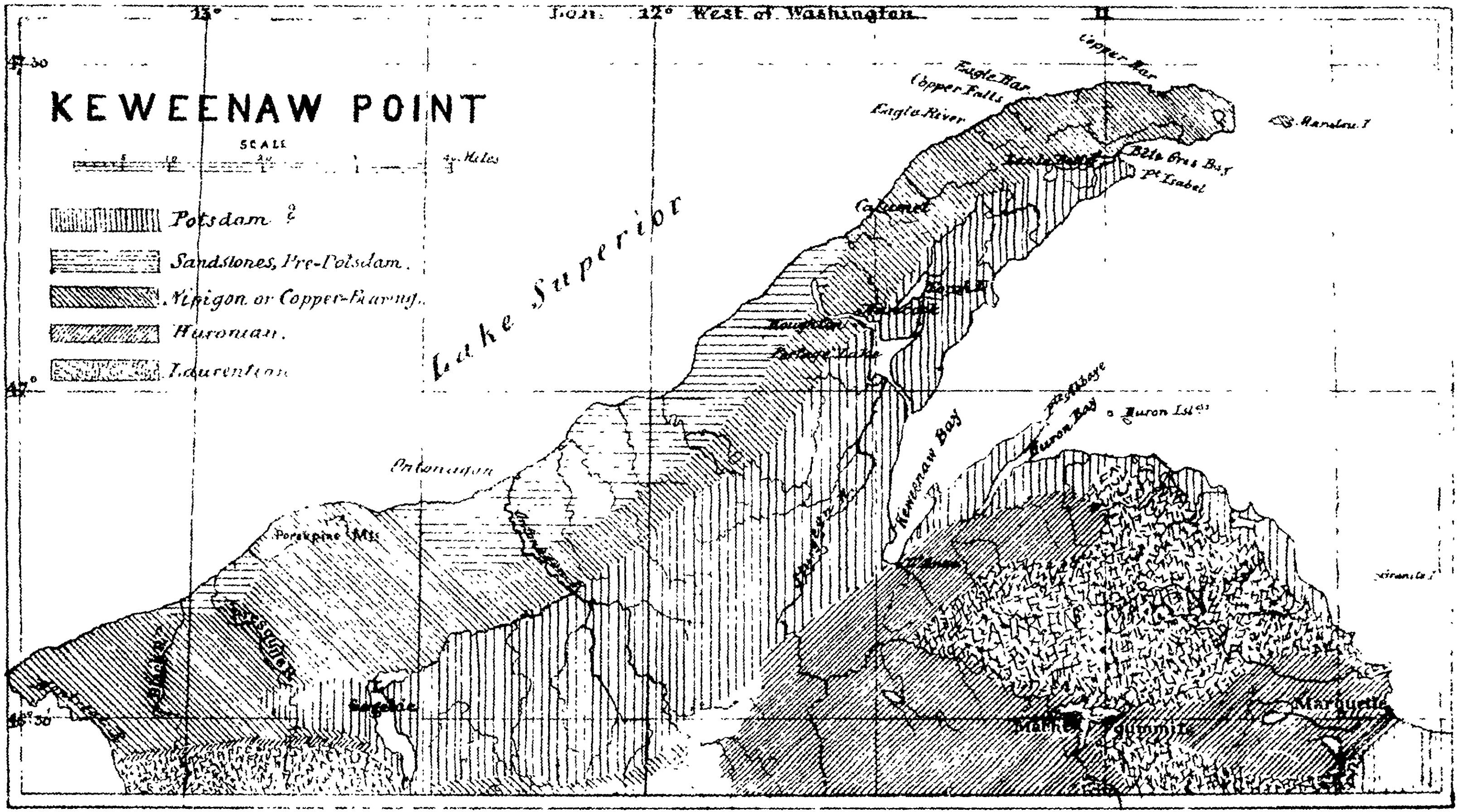


Isometric View of Man-Engine.


KEWEENAW POINT
SCALE
Miles
Potsdam ?
Sandstones, Pre-Potsdam.
Nipigon or Copper-Bearing.
Huronian.
Laurentian
Lon. 12° West of Washington
13°
11
47°30
47°
46°30
Lake Superior
Copper Har
Eagle Har
Copper Falls
Eagle River
Calumet
Houghton
Portage Lake
Bête Gris Bay
Pt. Isabel
Keweenaw Bay
Huron Bay
Huron Isl.
Ontonagon
Porcupine Mts
Marquette

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

ON THE NIPIGON OR COPPER-BEARING ROCKS OF LAKE SUPERIOR, WITH NOTES ON COPPER MINING IN THAT REGION.*

By Joseph William Spencer, B. A. Sc., Min., Eng.

I.—Prehistoric Mining and Early History.

The existence of copper on the shores of Lake Superior has long been known. Before the historic period of America, many localities had been wrought to obtain this useful metal, which was prized more highly than gold by the Aborigines who used it for ornaments rather than for useful implements. These earliest miners are supposed to have belonged to the age of the Mound Builders further south. They are known by the remains of their mining operations alone. They appear to have visited Lake Superior only in summer, as no traces of winter habitations, burial places, or other evidences of winter occupancy have been left. The most recent date assigned to their visits is variously estimated, from the growth of trees over their waste heaps of rocks, at a period of 300–600 years ago. Of all the copper mines that have been opened and worked in modern times in this region, it is said that none have been discovered which have not borne evidences of former operations. These ancient workings generally consist of pits, excavated sometimes to a depth of fifty feet or more. In some instances, horizontal galleries have

* Illustrated with specimens, and read before the monthly meeting of the Montreal Natural History Society, February, 1876.

been drifted for 30 or 40 feet, and to these there have sometimes been sunk second pits or winzes for ventilation purposes. The piercing or drifting into the rocks was accomplished by heating them to a high temperature with large fires, and then suddenly cooling the rock with water, thereby causing them to crack. The greater advancement in the mining art is displayed in the Evergreen Range, in Ontonagon County, while farther north and on Isle Royale their skill appears to have been somewhat more primitive. In some instances, the aboriginal miners have left large blocks of copper at the bottom of their pits, as unmanageable. In the old Minnesota Mine, one of these masses, weighing seven and a half tons was found at the bottom of their workings, raised on skids, with the branches battered off. Numerous stone-hammers, wooden-shovels, wooden-bars, pieces of hides, bark vessels, a few copper implements, and other rude appliances have been found in their workings. The most common of these are the hammers, which are oval boulders of *diorite* or *granite* having sometimes one groove, or even two grooves around the centre, to prevent the straps that fasten the stone to the handle from slipping. The hammers weigh from two or three to more than fifty pounds. All the copper implements that have been found were beaten into their present forms and were not made by casting the molten metal.

After the *Stone-hammer People* left this region to return no more, the shores of Lake Superior seem to have become untenanted for a time by man; but when the early Jesuit missionaries visited the lake 250 years ago, they found the south shore thinly peopled by Chippewa Indians. The old men at this time stated that that tribe had recently migrated, and having been driven westward, settled about Lake Superior, as this region was unoccupied.

La Garde appears to have been the first of the Jesuits who mentioned the existence of copper about Lake Superior, its occurrence he recorded in a work published in Paris in 1636. Thirty years later Claude Allouez noticed the native copper which, in small masses, the Indians regarded as gods. Again, in 1721, De Charlevoix described some of the copper deposits, and the superstitious reverence paid to the metal by the natives. Owing to the representations of Captain Jonathan Carver, who had visited Lake Superior in 1765, an English Mining Company was formed, which commenced operations in 1771 on the Ontonagon River; but these were abandoned the following year.

Between 1819 and 1841, several American exploring expeditions were sent out by the government; but the first of these that could be considered scientific was begun in 1831 by Dr. Houghton, State Geologist of Michigan. His report in 1841 drew the attention of capitalists to this region, and it was not long before the development of the mineral wealth about Lake Superior was begun.

II.—Geology.

This paper is largely the result of personal observations during parts of the last two years, while engaged in geological and mining operations among the copper mines on Keweenaw Point and elsewhere. I have consulted the reports of the Canadian and Michigan Geological Surveys, and I also acknowledge indebtedness to L. G. Emerson, M.E., for having pointed out many geological phenomena,—the knowledge of which would otherwise only have been gained by much longer study of the region. In this paper, too short for more than a general idea, I have endeavoured to point out the most striking scientific features, and to correlate the knowledge of the Copper-Bearing Series, as it has been obtained on both the north and south shores of Lake Superior.

*a.—Geological Distribution.**—The deposits of the geological formation known as the Nipigon or Copper-Bearing (formerly Upper Copper-Bearing) Series is peculiar to Lake Superior. On the south shore of the lake, they skirt it from the extremity of Keweenaw (more correctly Keewainona) Point in the Upper Michigan, south-westwardly for 150 miles into Wisconsin. The exposed breadth varies from 4 to 15 miles. This region is considered the type of the formation, as it is best known. Topographically it consists (in part) of two ranges of hills known locally as the Greenstone or North, and the South Ranges. The North or true Mineral Range rises to heights of 400–700 feet, and slopes gradually to the north-westward, till it underlies the lake or (in places) a more recent formation. In the upper part of Keweenaw Peninsula, this has a breadth of about two miles. The south-east side of this range terminates in an abrupt declivity, the face of which consists sometimes of an almost vertical wall 200–300 feet high. The South Range varies in height

* See Map.

from 600 to 800 feet above the lake, and is more generally covered with iceberg drift deposits. The intervening valley with various rivulets is often very picturesque, having on one side the bolder hills pierced with deep gorges, while on the other there is the moulded contour of the higher southern range. In many places the hills enclose pretty lakelets, while an occasional peak towers to a considerable height above the range. Here and there, throughout the "Happy Valley," active mining villages, and the remains of those long since deserted, are to be seen side by side.

The Copper Bearing Series forms a broad belt to the west of Lake Superior extending from Fond du Lac to Thunder Bay. A large portion of Isle Royale is made up of the rocks of this formation.

According to Professor Robert Bell, of the Canadian Geological Survey, the Copper-Bearing Series of rocks on the North Shore is most largely developed in Nipigon Basin, including Black Sturgeon River, and the shores of Nipigon, Black and Thunder Bays. The deposits in this region extend for 170 miles northward from Lake Superior, and the greatest breadth is about 80 miles. Lake Nipigon is situated in the eastern portion of this basin. Owing to this wide distribution Professor Bell has proposed the name Nipigon Series for this peculiar geological formation, it being more suitable than the old provisional name of Upper Copper Bearing Series. These rocks are described by Sir William Logan, and Mr. Macfarlane, and more fully in the recent reports of Professor Bell to Mr. Selwyn, the Director of the Canadian Geological Survey.

The same rocks occur in patches eastward of Nipigon Bay, and also on Michipicoten and other islands. It is probable that when this wide-spread region is better known, many localities will be found to be of as much economic value as those rich mineral deposits on the south shore of the Lake.

b.—*Lithological Structure.*—Lithologically the copper-bearing series of rocks is peculiar, and consists of alternate beds of igneous and sedimentary deposits, the former predominating. *Diorites, melaphyres* (altered trap-pean rocks) and *amygdaloids* form the group of igneous rocks, and *sandstones, conglomerates,* and some *argillaceous seams* make up the group of sedimentary origin.

The *diorites* are composed of *hornblende* and *labradorite* or else *oligoclase*. The texture varies from that of fine grained *aphanite* to coarsely crystalline and in some the structure is porphyritic, large crystals of triclinic feldspars being present. When exposed the rocks weather so as to leave knobs of lustrous hornblende. In some places the tendency is to a columnar structure.

The larger portion of the formation consists of trappean rocks, called *melaphyres*, and true *amygdaloids*, the one graduating into the other. The term *melaphyre* was used by Dr. Hunt, and applied by the Geological Surveys of Canada and Michigan to the numerous trap-like rocks, having the pyroxene or hornblende matter replaced by a ferruginous chloritic substance, besides some other compound silicates. The texture of these rocks varies from a fine grained and compact to coarse and sub-crystalline condition passing through every step. The *melaphyres* generally graduate into the overlying *amygdaloids*, but sometimes the lines of demarcation between the different beds are quite distinct. The color of the rocks is different shades of green, or else brownish or reddish. The rocks are tough owing to the undecomposed feldspar, yet they are easily scratched as the hornblende has been replaced by soft chloritic earth.

The *amygdaloids* are only *melaphyres* in which the alteration has gone further, and having the cavities filled with the products of the decomposition of the original rocks, or else with other substances introduced by infiltration. The amygdules vary in size, and commonly consist of ferruginous *chlorite*,—called *delessite*,—above referred to as a component of the *melaphyres*. *Calcite*, *quartz* and various *hydrous silicates* are often largely deposited in the cavities. The color of the *amygdaloids* is generally some shade of green like that of the *melaphyres*, both rocks containing much iron, which is sometimes present as minute grains of *magnetite*.

According to Macfarlane the analysis of a coarse variety of melaphyre gave:

Delessite,	46.36	
Labradorite,	47.43	
Pyroxene or Hornblende	5.26	
Magnetite,	0.95	
		100.00

The composition of the delessite, he gives as follows :

Silica,	31.78	
Alumina,	15.47	
Ferrous Oxide,	28.87	
Lime,	9.64	
Magnesia,	4.37	
Water,	9.87	
		100.00

The amygdaloid consists of

Delessite,	38.00	
Labradorite,	62.00	
		100.00

Among the silicates occurring in the amygdaloids are *Epidote*, *Prehnite*, *Laumonite*, *Analcite*, *Datolite*, *&c.* Besides these, *Heulandite*, *Chabazite*, *Apophyllite*, *Stilbite*, *Natrolite*, *Leonhardite*, *Mesolite*, *&c.*, are obtained from the fissure veins.

The *conglomerates* are principally composed of brown felsitic pebbles, often with small imbedded crystals of triclinic feldspars. Occasionally the pebbles are bright flesh red, derived from minute crystals of feldspar of that color. Sometimes the pebbles are of amygdaloidal trap. The matrix is generally dark brown having a texture from sub-crystalline to almost a compact vitreous mass. In some localities the pebbles contain no free silica, while in others the rocks are almost jaspery. The cement is fine grained, and is either siliceous, chloritic, epidotic, cupriferous particles, or else it consists of the comminuted material of the pebbles. As noticed by Pumpelly, the amygdaloidal conglomerates can often be traced over several miles, as the filling of different beds is sometimes uniform over a considerable distance. The felsitic and jaspery pebbles of certain conglomerates appear to have been derived from Huronian rocks, which were exposed somewhat beyond the limits of the igneous overflows during the period of time under consideration.

The *sandstones* are usually of a brick red color, although some of the beds are light yellowish. The sediments of which these rocks are made up has been principally derived from the material of the conglomerates. The beds have frequently a slaty character, the argillaceous material being derived from the decomposition of the feldspars. Some of the beds, as at Copper Falls, show their shallow water origin, as they have ripple and rain drop markings, and mud cracks. The limits of the sandstone strata are usually well defined, although some of the beds seem to be united with the overlying melaphyres, as if the porous sand stone had been permeated by the liquid trap which has since been converted into the melaphyres.

On the north shore of the Lake the variety of the sedimentary rocks is somewhat greater. As shown by Bell, to the above list may be added dark massive argillites, and flaggy black shales, having the mass divided by numerous vertical joints, red shales, red and white dolomitic sandstones, reddish compact limestones, and red and yellowish-gray marls.

c.—*Geological Structure.*—The typical series of the copper-bearing rocks on the South Shore has a great development, having an average width of six miles. It is more than 150 miles long, and its thickness, as shown by the Geological Survey, is not less than 15,000 feet, or nearly three miles. The greatest thickness is to the northward. The range of hills, made up of the deposits of the Nipigon or Copper-bearing Period, has a trend of about N.E., while the dip is N.W., at angles varying from 60 to 25 degrees, flattening out to the north-eastward. The lapse of time occupied for the deposition of so much material must have been very great. During all this time there were long series of submarine volcanic eruptions, which, occasionally ceasing to act, permitted the abrading forces to be forming the pebbles which were deposited in the shallow seas to form what are now the intercalated beds of conglomerates and sandstones. A gradual subsidence was going on while the seas were getting filled with so much igneous and sedimentary matter. The deposition of the sandstones was comparatively rapid, and the time was insufficient for the bleaching of the red rocks by decomposing organic remains, if they were present. The whole series, made up of alternate layers of igneous and sedimentary rocks, has its respective beds conformable, although the individual members are not uniformly deposited. Thus the Allouez Conglomerate can be traced for thirty miles from Portage Lake north-eastward, having a thickness of 15-20 feet at the Allouez and Central Mines, a distance of 15 miles apart, while at the Phœnix Mine, between the two others, the stratum is represented by a thin clay seam, a few inches thick.

Again, the great *Diorite Bed*, which has a thickness of 1,200 feet at the Phœnix Mine, thins out at a distance of about twelve miles to the south westward of this mine, while it extends a long distance to the north-eastward. This large development of diorite consists of various beds having thicknesses varying from 10 to 400 feet, and characterized by rocks of various textures.

Thus we see that the gigantic forces at work, building up and carving out a monument of a long age, were not equally potent. The surfaces of the beds of sandstone in many places were sculptured before the succeeding deposits of igneous matter.

The relative position of the melaphyres and amygdaloids is nearly constant; the former compact rocks being at the base, pass gradually through the various stages till the upper beds become perfectly amygdaloidal. The different beds vary in thickness from a few feet to more than 150 feet, and have the lines of demarcation between them often quite distinct. The change from the compact traps to the amygdaloids is probably due to the structure of the deposits rather than to the greater and more recent internal changes or metamorphoses, as the upper beds of the original trappean overflows would incline to a more vesicular structure than those subjected to a heavier pressure at a greater depth.

Along the lower waters of the Eagle River, a section of the Cupriferous series is exposed for a distance of more than two miles across the formation. It was measured by the Michigan Geological Survey, and more than 160 beds were plotted. This together with the section of Portage Lake region may be summed up as follows, in descending order, having a vertical thickness of:

Conglomerates and *sandstones* dipping under the lake, but of which there is an exposure of,	2,500 feet.
45 beds of *melaphyres*, *amygdaloids*, *conglomerates*, and *sandstones*—there being 10 beds of the sedimentary rocks with an aggregate thickness of 400 feet, reaching to the "Ash Bed,"	1,500 "
45 beds of *melaphyres*, and *amygdaloids* with some thin seams of *sandstone*,	1,400 "
18 beds of *diorites*, beneath which is the representative of the *Allouez Conglomerate*,	1,200 "
60 beds of *melaphyres* and *amygdaloids* reaching to the (recently discovered) supposed representative of the *Calumet Conglomerate*,	1,200 "
Melaphyres, *amygdaloids* and a number of beds of *conglomerates* and *sandstone*, extending from the *Calumet Conglomerate*, to the base of the series,	7,700 "
Total thickness of the Copper-Bearing Series on Keweenaw Point, as far as known,	15,500 feet.

On the north shore of Lake Superior, the Nipigon or Copper-Bearing Series is represented by a similar intercalation of igneous and sedimentary rocks. These deposits are divided by the Canadian Geological Survey into two groups which are not conformable. The Lower Group, called by Hunt the Animikie, is somewhat different lithologically from the lower members of the series on the South Shore, as it is largely composed of conglomerates, cherty layers, some dolomites, and massive black shales with occasional beds of trap. In some of the beds carbonaceous matter has been found. The Upper Group contains some dolomites and limestones which are not present on Keweenaw Point. The Lower Group of the Canadian geologists occurs principally to the north-west of Lake Superior, while the Upper Division lies to the north and east of the lake. According to the measurements of Bell and Macfarlane, in different places, the Nipigon or Cupriferous Series, on the Canadian side of Lake Superior, attains a thickness of 13,000 to 16,000 feet, including upwards of 2,000 feet of conglomerates. In the Nipigon Basin this formation attains its greatest thickness about the middle and southern portions, while to the northward it thins out. The trend is northerly. The deposits are sometimes nearly horizontal, and seldom is the dip greater than 15-20 degrees, although in some places the strata are thrown up at high angles. Thunder Cape and very many of the hills on Nipigon, Black, and Thunder Bays, are capped by thick deposits of trappean rocks, which are deposited almost horizontally, resting unconformably on either the Lower or the Upper Group of the Copper-bearing or Nipigon Series. The wrinkled structure of the trap rocks indicates the different directions of the igneous overflows. The material of these eruptions, according to Bell, had a north-westerly direction on Thunder Bay, while on Isle St. Ignace they were to the north-eastward, and to the east of the lake Sir William Logan showed them to have had an easterly direction. Everywhere, on leaving the great lake basin, the Nipigon deposits thin out. Numerous trap dykes traverse this formation on the North Shore, but on the south side of the lake they do not appear to pass higher than the Huronian Series, while the veins are filled with metamorphosed aqueous infiltrations, or with the *débris* of the adjacent rocks.

Both on the north and south shores of Lake Superior, the beds of the Nipigon Formation are considerably faulted. Between the Phœnix and Central Mines on Keweenaw Point, there is a horizontal dislocation of 400 feet, being equal to a downthrow of 200 feet. At Portage Lake the faulting amounts to over 700 feet horizontally. The effect of this fault has been to weaken the country, and since denuding agencies have made an excavation across Keweenaw Peninsula, having a depth of six or seven hundred feet through the Range. The lower portion of this valley is now occupied by Portage Lake.

Bell has suggested that the igneous eruptions occurred within the present basin of Lake Superior. This was probably the case, and what is now the bed of the lake was the scene of action for some gigantic submarine volcanoes, which piled up two and a half or three miles of solid rocks. The axis of the great eruptions appears to have been somewhere between Keweenaw Point and Nipigon Bay, where were the thickest deposits, whence the material flowed all around, having a radius of 150–200 miles. It is probable that the great basin of Lake Superior, which is one of aqueous denudation, is due to the great weakening of this region by the numerous dykes and faults belonging to the Cambrian or Pre-Cambrian Ages, arising from the many channels of eruptions during those Ages; for while the crystalline Laurentian, Huronian, and some of the Nipigon Series of rocks, have withstood so persistently the denuding agencies of countless Æons, we find in the centre of them, the largest or one of the largest lake basins on our globe; and that the former scene of the greatest disturbance is now covered by the deeper waters of the lake.

d.—*Geological Age of the Nipigon or Copper-Bearing Series.*—The Geological age of these rocks has long been an open question, as recourse to organic remains cannot be made. Nor is it probable that future researches will unveil many fossils, as the conditions of the seas were totally unfavourable to life. At each eruption all organisms would tend to be destroyed. The red sandstones also indicate, at least, a scarcity of vegetable existence, and then the time elapsing between each period, when the sedimentary deposits were forming, were occupied by long successions of volcanic eruptions. However, in one of the sandstone beds, near the top of the Cupriferous Series, over which the Eagle River flows, and near its mouth, a Mr. Uren found an obscure fossil, but as he stated to me, he cared not for palæontological remains and consequently gave it to another gentleman, who was not scientific. Dr. Sterry Hunt also mentioned the possibility of the existence of some sponges in Michipicoten Island. I know of no other evidences of life during this period, unless the carbonaceous matter in the Lower Group of the Series on the North Shore points in this direction. Consequently it is stratigraphy and lithology that must disclose the venerable age of these interesting deposits.

Pumpelly has recently shown that the Cupriferous and Huronian Series appear to be conformable, both in dip and strike, for a distance of 30 miles from the Montreal River, on the borders of Wisconsin, to Lake Gogebic—dipping northward at angles of from 50 to 70 degrees. This is the only known exposure of their junction on the South Shore. On the North Shore, Bell has ascertained that the Nipigon Series is unconformable to the Huronian in some places, while in others it rests on the upturned edges of the Laurentian. Again the great horizontal trap overflows, which cap so many hills north of Lake Superior, are uncomformable to the other beds of the series. These capping trap beds are not present on the South Shore.

The western side of the range, forming the backbone of Keweenaw Peninsula, is overlaid by sandstones similar to those of the Cupriferous Series and apparently conformable to it. Eastward of this range the shores of Lake Superior are skirted by a narrow belt of red sandstones and shales, dipping according to Pumpelly at angles varying from 5 to 15 degrees towards the lake basin. Over these red sandstones, the country east of the mineral ranges is covered with light colored sandstones, often friable, which are deposited horizontally, and are supposed to belong to the Potsdam Period. They contain no fossils themselves, but are overlaid by other rocks, containing a few organic remains, which have been referred to the Calciferous or Chazy Formation; and these are overlaid by the fossiliferous Trenton deposits. The sandstones, on the east side of Keweenaw Point, overlie the Huronian deposits, and in many places contain pebbles of that series. It is not known if the Cupriferous rocks any where intervene between the sandstones and the materials belonging to the Huronian Age; but the western border of the sandstones abut against the upturned edges of the copper-bearing range, which dip away from them at angles varying from 40° to 60°. By some it has been urged that the line of junction, between the igneous and sedimentary formations, represents the plane of a gigantic fault, in which case there has been a down-throw whose vertical depth would equal three miles or more. Near Houghton, there are some isolated patches of sandstone, which overlie beds of melaphyre, and contain numerous pebbles both of melaphyre and of Cupriferous Conglomerate, consequently showing their subsequent origin. As pointed out by the Geological Survey, the Copper-Bearing Rocks were greatly sculptured before the deposition of the sandstones; as there are places where the old hills were denuded leaving cliffs 200 feet high, having formed the old shore line, along which the Potsdam (?) deposits were being made.

The lithological characters of the Cupriferous Rocks resemble those of the Permian and Triassic Periods. As shown by Delesse, Naumann, Macfarlane, Bell and others, no rocks of similar lithological structure occur in any other part of the known world belonging to an older period than the Carboniferous or the Permian Ages. Now, if the Huronian Formation had been thrown into its present position, or nearly so, before the deposition of the Cupriferous Series, and the horizontal sandstones east of the range did not bear evidences of a subsequent origin, (although only in a few small isolated patches are they known to overlie directly the Copper-Bearing Formation), then there would be no stratigraphical grounds whatever for the determination of the age of the rocks under consideration, and we could only look to their lithological structure as a means of solving this interesting question. Again, Macfarlane points out the trachytic character of some of the rocks of this series which are situated on Michipicoten Islands, and this resemblance to modern volcanic products, which are not known to exist elsewhere in the Nipigon Series, might point to a comparatively recent date.

But the most recent investigations on the South Shore, made by Pumpelly and Brooks, go to shew that the Huronian Series, in part, had not been uplifted to any extent before the deposition of the Nipigon or Copper-Bearing Rocks, as the two formations are conformable, and tilted together at high angles, while at no great distance from their junction, the Huronian is also contorted and overlaid by the horizontal Potsdam (?) sandstones. As we have seen the range was sculptured before the deposition of the sandstones, and the more recent origin of the latter rocks appears to be additionally confirmed by the isolated patches near Houghton containing Cupriferous pebbles.

If the ancient Mineral Range on Keweenaw Peninsula were not an old shore line (of which there are numerous indications), but a gigantic fault, then we should expect to find the deposits of the Nipigon Period, between the Huronian and subsequent sedimentary rocks farther east along the south shore of Lake Superior, but this is not the case. The trend of the rocks on Michipicoten Island is very nearly the same as that on Keweenaw Point, although they dip in the opposite direction. From this difference in direction of dip, and from the deep water between the Point and the Island, I would infer that the old Cupriferous Range was much weakened and broken between these two places, and subsequently was easily swept away by denuding agencies, leaving this deep portion of the lake basin.

The south-eastern portion of the Lake Superior Basin does not appear to have been covered with the deposits of the Nipigon or Cupriferous Series but to have been excavated along the junction between the Nipigon Hills to the northward (which have nearly been swept away) and the softer sedimentary rocks to the south.

From the foregoing we see that part of the Huronian Series had not been upturned before the eruptions of the Nipigon or Cupriferous Age became general. It is probable that the dynamical agencies, which were exhausting themselves by covering up the Huronian sea bottoms to the south with igneous matter, were also at work upheaving the older rocks to the north—inferring that the eruptions began somewhat earlier to the southward of the series. This view is strengthened by the fact that the earlier beds of this formation on the North Shore are mostly made up of sedimentary deposits derived from the waste of the older crystalline rocks, with only an occasional trap overflow—the record of some extraordinary eruption.

The Huronian and Cupriferous Series were elevated together, having the greatest upheavals to the south, where the beds were lifted to angles of from 50 to 70 deg., while toward the north the inclination is comparatively low. Now this fact, with the absence of the great capping traps to the southward, together with their unconformability to the older beds of the Copper-Bearing Series to the north of Lake Superior, would tend to show that the seat of volcanic eruptions moved northward, and ended there later than to the south, while the upheaving forces were acting in the opposite direction. The last upheaval to which the south shore of Lake Superior was subjected, probably occurred shortly previous to the deposition of the Potsdam sandstones.

From all the foregoing we conclude that the Nipigon or Copper-Bearing Series belongs to a period newer than the Huronian, and although the first to follow, it is not a continuation thereof. The evidences point to its being older than the Potsdam, and consequently the deposits appear to have been made in the Lower Cambrian Age of Europe, and probably the Nipigon Formation is nearly, in point of time, the American representative of the Longmynd of Wales.

c.—*Occurrence of Copper.*—Unlike other copper-bearing regions, this formation holds its deposits in the metallic state. Although the metal seems to be scattered through the whole formation in minute quantities, yet for mining purposes it occurs only in certain beds and veins where a long process of concentration has been going on, and perhaps is still in progress. The beds in which copper is deposited in workable quantities are those of amygdaloid and conglomerates through which the metal is distributed in minute grains and small masses. Paying quantities are usually confined to the upper five or ten feet of the beds, and the proportion of the metal is more or less constant, although it apparently traverses them in zones.

The greater porosity of the upper portions of the trappean rocks afforded more favorable conditions for the decomposition of the pyroxene or hornblende, and the subsequent formation of the ferruginous chlorites, and admission of other substances, as well as the copper concentrated by means of aqueous infiltrations and subsequent deposition by chemical or electro-chemical processes. As a proof of electrical action, I refer to some recent experiments for the Telegraph Company, by which it was found that there were frequent electrical currents traversing the Mineral Range, which often altered their courses, to the annoyance of the operators, until the source of trouble was discovered.

To the south of Lake Superior numerous veins traverse the Copper-Bearing Series. These Marvine divides into three groups; the two principal systems being more or less transverse to the beds: "the one trends from N. 15° W. to N. 25° W., with nearly vertical dips, but to the westward; the other, N. 16° E. dipping nearly vertical, but to the eastward; and the third trending with the formation, but with a steeper dip." The first system is faulted considerably, while the two other systems are scarcely known to be. The veins are filled with infiltrated matter principally, although masses and fragments of the adjacent beds are enclosed. Much of the vein fillings is *green earth*, *calcite*, often much *laumonite*, *datolite*, &c. In these the copper usually occurs both distributed in small grains, and in masses sometimes weighing many tons. One solid mass of copper was obtained in the old Minnesota Mine, which weighed about 450 tons, being 47 feet long, 18 broad, and 9½ in thickness, requiring 14 months in order that it could be cut into portable pieces. This formerly profitable mine is in a vein belonging to the third system, but the more successful mines are in the veins belonging to the first system. Often between the large masses there is much poor rock, and although often richer than the beds, the percentage in long workings is less, as the deposits are more uncertain.

Though many beds and veins are known to contain copper, it is generally limited to certain portions, where valuable deposits are found, and veins often side by side, or in continuation, and of the same age, are found not to be of equal value. Mines averaging only one and a half per cent. of copper of all the rock taken out can be made to pay well; even from the celebrated Calumet and Hecla mines, the ingots of copper only amount to one twenty-fifth of the rock treated. As the profitable mines are scattered so widely, and also the great veins and cupriferous beds occurring on Keweenaw Peninsula, it is doubtless that time will reveal an inexhaustible supply of the metal. When a large amount of capital will have been expended in researches on the Canadian side, probably no inferior results will be obtained, but at the present little more than the wide existence of cupriferous rocks is known.

However, the structure on the Canadian side of the Lake is not quite like that on the south side, and as remarked by Bell, the metalliferous beds are confined mostly to the Upper Groups of the Series. Throughout the amygdaloids on the Canadian side of the lake there are intrusive masses of traps in the Upper Group. The dykes are of *greenstone*, *porphyry* or *syenite*, and these often stand in relief, being weathered with more difficulty than the country rocks. Numerous fissure veins also occur of more recent origin than the dykes. Of both, there are two systems, the one coinciding with the range of the rocks, while the other set is at right angles to the first; and the series of cracks seems to be constant even throughout considerable areas. The transverse veins, on Thunder Bay, are north-west and south-eastward. As on the South Shore, the Upper Group has many amygdaloidal veins with fragments of the country rock and dark green chloritic matter, sometimes slickensided — a structure common in Keweenaw. The veinstones are often quartz or calcite, or sometimes barite or fluorite. Laumonite in many places is most abundant, as it is on the South Shore. Sulphides, which seem to be almost absent in Keweenaw, are quite common on the Canadian side; as sulphides of copper, silver, iron, zinc, and lead, besides nickel, cobalt, molybdenum, uranium and arsenic.

Many other minerals occur on both sides of the lake, especially in the veins traversing the region under consideration. Besides the native copper on both sides of the lake, *malachite*, *chrysocolla*, *melaconite* and *cuprite* are found. Some years since a large pocket of *melaconite* was found at Copper Harbour, but the workings were abandoned. The *cuprite* or red oxide of copper usually occurs in small quantities in the sandstones and conglomerates, and I believe one or two beds of this ore have been found which contain as much as four per cent. of copper. *Whitneyite*, *Domeykite*, besides the various *hydrous silicates* mentioned before, as well as the sulphides just referred to, have also been found; silver, gold, and lead in vein formations have attracted considerable attention. Native silver occurs associated with the metallic copper, being deposited in a pure state on the latter metal. The two metals are not alloyed, and their contact surfaces are perfectly distinct; the silver, usually in arborescent forms, projects from the copper.

Recently, there has been considerable excitement over some silver-bearing veins which are situated in the Copper-Bearing Formation in Ontonagon County. The prospects of these are said to be encouraging.

The temperature of the rocks in which the copper mines are situated is low, and at a depth of 1,440 feet, it is scarcely higher than at the surface. Mr. Emerson made some experiments on this subject, by taking the temperature of the water which percolates through the rocks, entering the mines at different levels. He found that the average temperature at different places was not far from 60° Fahr. The cause of this low temperature may be attributed to the fact that the region of Lake Superior, which was so long subjected to igneous influences, and to great contortions of the earth's crust, has had very long ages during which it has parted with its heat, and this has not been raised in recent geological times by the bending of the various strata.

III.—Notes on Copper Mining in the Lake Superior Region.

Under this head it is proposed to notice briefly the art of mining as it has been applied to the Native Copper Mines of Keweenaw Peninsula, and to give a short sketch of the financial condition of the industry.

Ordinary blasting powder is almost entirely used. Nitroglycerine and dualin have been introduced, but several accidents having occurred, their use has been abandoned. One of the most fatal of these accidents was at the Phœnix Mine, resulting in the death of two mining captains and four other men. This explosion took place in the office of the captains, while some men were mixing the dualin with ordinary blasting powder, as the mixture was usually fired with fusees and not by electricity. There was a quantity of dualin cartridges in the building when the accident happened, and although the concussion was so great as to throw them several hundred feet, to the top of a high cliff, many were afterwards picked up unexploded. In some places, dualin was found unsuitable for blasting, as the action was such as to bring down too much waste rock in certain directions, but elsewhere it has rendered good service.

As noticed before, the copper is obtained from beds and veins. The beds which are worked dip at various angles from 26° (at the Copper Falls Mine) to 56° (at the Quincy), while the dip of the veins is usually greater than 73°. In almost all cases the shafts follow the inclinations of the beds or veins, changing with their variations of dip; and in only a few instances are the shafts perpendicular or straight throughout their whole depth. Some shafts have been sunk without any engineering skill whatever, and after thousands of dollars have been wasted, have been abandoned, and others sunk at great expense, this being more economical than to straighten those that were so crooked. The best work of engineering skill about Lake Superior is at the Phœnix Mine, where an additional shaft was required. The workings are on the side of a hill capped with a great thickness of greenstone, and it was found that it would be less expensive to sink a shaft at a low inclination, beneath the great bed of diorite, than to sink one perpendicularly through it. The mine is on a fissure vein having a hade varying from perpendicular to 17°, and down which an old inclined shaft had been sunk for 500 or 600 feet, so crookedly as to become useless. Under the charge of Mr. L. G. Emerson, M. E., a new shaft was begun in the hanging wall at such an angle with the direction of the vein that it would be only a few feet from each level, with which it was afterwards connected—the vein-stuff and walls disintegrating very rapidly on exposure to air and moisture. This was sunk with a dip of 35° 55′ to a depth of 1300 feet (still being sunk), having a width of 8 and a length of 14 feet, costing without machinery, $76,000. The work was accomplished in 18 months, as several parties of men were being employed on different sections. The result was a perfectly straight shaft, now used for hoisting on one side, while on the other there is a stairway. The required timbering is very heavy in parts of its course.

The sections of the shafts are usually from 7 by 12 feet to 8 by 14 feet, and divided in two parts, one for hoisting and the other for ladderways or pumps, excepting in those where *man-engines* are constructed. All the large mines have two or more shafts, but some have as many as nine or twelve, besides adits where practicable. The galleries or levels are usually 10 sometimes 15 fathoms apart (vertically), connected by occasional winzes for ventilation, and for other purposes while the mines are being opened, and are usually about 7 feet high and 5 feet wide, being traversed by iron tram-ways, leading to the shafts.

The mining is almost always by overhand stoping, and in some cases the old stopes are completely filled with the broken waste rock.

All the material from one level to the next is removed, excepting what may be required for pillars, or may be too poor to be taken out, as the metal occurs in zones, often enclosing large areas of rock which would be unremunerative ; and some times even when two or three consecutive galleries have been driven for a long distance, the poverty of the rock compels large portions of the mines to be abandoned.

In most cases the drilling is done by hand—one man striking and another turning the drill, or else two men striking alternately where the rock is hard. However, in several mines machine drills are used, especially in stoping—the motive power being compressed air carried down by pipes from the surface, and having a pressure of 60 pounds per square inch. Recently diamond drills have been introduced into the copper mines on Lake Superior for exploration purposes; one being used in the Quincy Mine at a depth of 1600 feet for sectional examinations, in place of the expensive cross-cutting. When we consider that none of the native copper mines (except the Calumet and Hecla) yield an average of two per cent of metal for all the rock broken, and also the great expense entailed in sinking and drifting through much poor rock, the only way to keep the mines successfully in operation is to open up two or three year's galleries ahead of the work, in order that when one remunerative area is exhausted, another may at once be ready for stoping, and thus a very considerable item in the annual expense of mining is expended without any immediate returns.

Sometimes the hanging walls are so strong that only pillars, at considerable distances apart, are required to support the roofs. But in 1872, a sad accident occurred on the *Ash-Bed* at Copper Falls. The pillars which had been left in part of the mine were insufficient, and a portion of the roof having an area of 200 by 300 feet fell, killing six or seven men, and entrapping others for several hours till released. However, this catastrophy could scarcely have been unexpected, for the pillars had been slowly but surely crushing and scaling off for more than a year, besides giving more recent indications. Seldom do large masses fall without giving warning, but the lives so exposed to danger come to be held cheaply, and work is often pursued in spite of everything, till either an accident happens, or at last prudence compels the dangerous parts to be abandoned, or the miners to be protected as much as possible. For this purpose I have known the openings to be completely filled with crib-work of timbers, at a very considerable expense.

The workings of the veins and beds seldom exceed a width or height of from six to ten feet, although the seams sometimes widen to twenty feet or more. The wider veins are often poor in copper, while in the beds, the metal is usually confined to the upper portion of the amygdaloids or conglomerates. The veins have generally well marked walls, sometimes slickensided, while the metallic portions of the beds do not usually have their limits well defined, or at least their foot-walls, and the metallic zones sometimes leave their primary direction and wander off into the lower parts of the beds.

The timber required is sometimes gigantic, and many of the *stulls* (or posts) have a diameter of more than three feet, and a length of 20 to 40 feet in places. In some of the mines the rocks, although hard and tough in mining, disintegrate very quickly on exposure to air and moisture, and temporary timbering is required to protect the men while they are placing the permanent timber and lagging. Such is the Phœnix Mine, which in some places does not require any blasting, for when water is thrown on the face of work, the rock slowly begins to crack and scale off. In such cases when stoping is begun in any place along a gallery, the work is pushed on as rapidly as possible without pausing (except during Sundays which are not observed in the Rocky Mountain mining regions), the slopes being filled in as the work ings ascend, leaving only *mills*, down which to throw the copper rock to the gallery below, whence it is conveyed to the shafts. But in many of the mines, or in portions of them, the galleries and shafts require little or no timber. Skips are now almost invariably used for hoisting, although a few kibbles may still be seen. Down the shafts inclined railways are constructed with T rails, which weigh from 12 to 18 pounds per yard, and having gauges varying in different mines from 4 to 4½ feet wide. The skips are made of heavy boiler plate, each weighing from one and a half to two tons, and having a capacity for two tons of rock. Some skips empty from the bottom, but usually their loads are dumped from the top, and in order to be self-acting, the back wheels are very broad (8 inches), so that when the conveyance arrives at the surface, (the rope being secured by a long iron handle, fastened at each side of the car near the horizontal axis of gravity) the fore wheels pass into a groove or break in the track, while, on the broad back wheels, the bottom of the car continues to ascend on the tramway, and thus upsetting, the skip dumps its contents into a car just below, ready to receive and convey them to the rock-house. The rock from the locality of work on each level in the mine is conveyed in other cars to the skips into which it is dumped. Wire ropes are almost entirely used, although hemp ropes are still to be seen. The sizes of the wire ropes employed are from one to one and a half inches in diameter, for the average load of four tons, the larger size being used in the deeper mines, some of which, down the inclines, are 1500-1800 feet deep. The foot walls are boarded and furnished with rollers, on which are carried the ropes, which, when properly cared for, can safely be expected to last 18 months. In one shaft that I know, the ropes had been used as long as possible, and broke twice each of them after a use of 29 months. At Portage Lake, from the Quincy Rock-House to the Stamp Mill, there is a descent of nearly 500 feet in a distance of half a mile, the steepest grade having an inclination of 14° ; two full cars having a weight of 8 tons are run down an inclined tramway by gravity, and bring up two empty cars of half that weight, these trains of cars being connected by wire ropes over a drum at the summit of the hill. The rope, which is one inch in diameter, has been subject to constant use for 12 years, and although it has broken once (from accident) it is not yet worn out. The ropes which are not galvanized are always kept well tarred to prevent them from rusting. The transportation between the shaft, rock-houses, and stamp mills is also by various other contrivances than the one just mentioned. Sometimes when the railroads are not too long and nearly horizontal, the cars are attached to stationary engines by endless ropes, or again they are sometimes drawn by locomotives, by horses, or, where the distance is short, man-power is used. The car attached to endless ropes is so arranged that it dumps its contents,—this being accomplished by means of two small wheels near the back part of the box of the car, which project, so that when it passes a station near its destination, it runs up an inclined plane lifting the back end and causing the front to open.

The transportation of men in the mines is a subject of interest. Ladders are usually placed in each shaft. A stairway is used in the incline shaft of the Phœnix Mine, while in another shaft of low inclination at the Central Mine, the miners are transported by a car capable of carrying 25 men. At this mine, some years ago, 13 men were riding up in a skip, when the rope broke, and the accident resulted in the death of 10 men, the other three escaping, as the skip was thrown from the track and jammed, instead of going all the way to the bottom of the shaft. The officers are very strict in order to prevent the men from risking their lives by riding in the skips. In some of the deeper mines, as the Quincy, Pewabic, Cliff, Calumet and Hecla, *man-engines* have been constructed at very great cost. The longest of these is in the Quincy Mine,* built down an incline shaft of 54° to 56° dip, to a depth of about 1450 feet. This contrivance con-

* See isometric view of man-engine.

sists of a pair of rods made of Norway Pine eight or nine inches square, the pieces of timber being 20 feet or more in length, and joined together by strong iron plates till the rods are 650 to 700 feet long; below this depth to that of 1450 feet there is another similar pair. At distances of ten feet apart platforms are placed, so that when they come opposite to each other, and there is a temporary pause, the men on those of the one rod step across to the platforms on the other, constantly ascending or descending as desired; the platform being only large enough for two men to pass. At the surface each rod is connected to adjacent ends of two gigantic bobs or walking beams, each of 30 feet in length. These two bobs are connected together by a strong wooden shaft, and are attached to the steam-engine gearing and worked so that the ends (two or three feet apart) have a reciprocating movement of ten feet; consequently any force tending to pull one bob down (as the rod loaded with men) will tend to lift the other (or the unloaded rod). Now the two rods are thus balanced, and in order to lift men from the mines, only the amount of steam to overcome their weight and the friction of the machine is required. This is the principle, but in practice the rods which come to weigh many tons, must be further balanced, and also the friction existing between them and the inclined foot wall must be relieved. About every twenty feet apart there is a pair of flanged wheels attached to the rods and moving on rails, while at every 50 or 100 feet there are permanently attached grooved wheels, over which pass wire ropes or chains attached to both rods, and thus the dead weight of each section is locally balanced, and the upper part of the rods and the bobs are not subjected to an almost breaking strain. Again, by means of the break in the continuity of the rods above noticed additional equilibrium is given to the whole contrivance; for here the rods of the lower half of the *man-engine* are attached to another set of bobs at the opposite ends to those to which the upper set is attached; and thus when the rods are completely loaded the men on the upper 700 feet going in one direction tend to balance those on the lower 700, going in the same direction, and only the friction of the parts has to be overcome by the steam, besides the great weight of each rod being broken into two parts. The *man-engine* makes four strokes per minute, there being a pause at the end of each. The whole construction is very costly, but it is the best means of transporting the men to and from the workings; for although cars may run up very quickly even from a great depth, yet but few can ascend each time, while with the *man-engine* a constant line of men is ascending, and a mine can thus be cleared of 200 to 500 men more quickly than by other means. Moreover if the machine breaks it cannot fall more than 10 feet, or perhaps not at all.

Almost all the steam engines in the Lake Superior Copper region are high-pressure and are attached, either directly to the winding drum, or else have friction gearing.

Most of the copper mines are comparatively free from water, and what does find its way into them is chiefly from the surface, or from the upper levels. Consequently the pumps—which are *plungers*—are relatively small, and the expense of working is inconsiderable. The plungers are usually placed at every 200 to 300 feet apart, with cisterns, and so the great pressure of the columns of water is avoided, and the cost of construction of stronger pipes much reduced. In some of the mines the lower levels do not of themselves contain enough water for mining purposes.

As noticed before, the mines are cool, and out of the leading draughts of air, have an average winter and summer temperature of 60° Fahr. Artificial ventilation is seldom resorted to, unless it be to change the current of air in a shaft from downcast to up-cast. Most of the mines have adits or shafts of unequal height, and sufficient air naturally circulates, as long as the connections are good. In winter, doors require to be placed in some of the passages, the currents of air becoming too rapid, as the difference of temperature at the surface and in the mine is very great, the thermometer at the surface sometimes indicating from 30° to 47° below zero.

When the rock brought to the surface is taken to the rock-house, it is hand-picked, and the poorer portions rejected. After the larger masses are broken up by steam-hammers, the whole of the cupriferous rock is put through Blake's rock-breakers and crushed to a small size, after which it is sent to the stamp mills. The larger pieces of copper that can be detached from the rock by hammers are cleaned and shipped as *barrel-work*, but they usually contains as much as ten per cent. of gangue. Under the stamp the rock is crushed in presence of water, and washed through sieves having holes a quarter of an inch in diameter. The fine material is washed down into hydraulic separators called *jiggers* (Collom's or Sherman's Patent). The principle of these jiggers is that there is a piston box divided into two compartments connected with others in which there are sieves, and over these the water laden with powdered rock flows. A downward sharp motion is communicated to the pistons which forces the water to rise up slightly through the sieve-boxes, on which the heavier and coarser material has settled, thus loosening it. By this means the finer particles of the heavier rock and copper pass through the sieves into the compartments below, whence they are washed down and are farther separated on other sets of jiggers. But the larger portion of the finer rock is carried off the sieves with the over flow of water. By continuing this operation a mineral of 70 to 88 per cent. of copper is obtained in small grains. The refuse from the jiggers is worked over on *percussion-tables* and in *tossers*, or else on convex or concave (English) *buddles*, by means of which an additional quantity of fine copper is saved. At best 20 to 40 per cent. of all the copper is lost in the concentration, the larger loss being caused by the particles of metal being more or less flaky. For some distance about the stamp-mills the water in the lake below has a copper color, derived from minute particles of the metal held in suspension.

Three different kinds of stamps are used on the Keweenaw Peninsula. The first is the square headed stamp weighing from 900 to 1100 pounds, and falling 16 to 18 inches by its own weight, four heads working in each *battery*, which is capable of crushing 12–14 tons of rock in 24 hours. The second kind is Ball's patent stamp, the shoes of which are oval. Together the heads and shafts weigh from 2000 to 2200 pounds, the whole being lifted two feet and forced down by a high pressure of steam in a cylinder at the upper end of the shaft, and in the meanwhile the stamps are made to revolve. Each stamp is capable of crushing more than 100 tons of rock per day (24 hours). The third kind is the *atmospheric stamp*, of which there are six heads to a battery. To each stamp there are engine fittings just above the shoes, for compressing the air, and all six are attached to cranks on a common shaft. Although each stamp complete weighs only 200 to 300 pounds, the quantity of work done per day is comparable to that accomplished by Ball's stamp under the same amount of steam. The shoes are usually made of white iron, and last six or seven days with Ball's stamp, while with the others they last 21 to 30 days before being worn out. Each of those of Ball's patent is allowed 20 jiggers.

The large masses of copper are usually detached in the mines by blowing down all the surrounding rock, after which they are cut up into portable masses of 4 to 7 tons, by means of chisels less than an inch wide, making long grooves through the masses, after which they are brought to the surface and the attached pieces of rock are removed as far as practicable. The masses of copper together with the concentrated *mineral* are smelted alone in reverberatory furnaces (of which there are seven) at Portage Lake or in Detroit. The slag rich in copper is again smelted with lime, in Mackenzie's blast-furnaces, and afterwards the impure copper (containing iron) is re-smelted in the reverberatory furnaces; and the waste slag from the cupolas retains less than one half a per cent. of copper. Eight to ten-hours are usually required for each charge of 10 to 16 tons of mineral to be smelted; of this time two or three hours are given to poling in order to render the copper tougher.

After the appearance of the report of Dr. Houghton in 1841, and for several years following, a wild mining fever seemed to have been caused by the discoveries in the Lake Superior Region; for at the close of 1845 no less than 61 mining companies were organized, of which 12 had commenced active operations, all expecting to become suddenly wealthy. During 15 months ending with November, 1845, no less than 592 mining locations were granted by the Government to nearly as many persons. Although eventually there were 111 mining companies formed, whose locations spread over the whole length of Keweenaw Peninsula, a smaller number commenced work, as many of them found they had "mining permits" without mineral. Of all those that did begin operations and have since been organized, only nine have paid dividends, and with one or two exceptions these nine have paid handsomely, and now three or four more, after a long struggle, are promising to become lucrative. Some of the failures have been the result of working lodes too poor to pay, and moreover, in the early history of these regions, a great deal had to be learned, as the percentage of copper is small and in a different form from that of any other copper mining region, and the necessarily great economy in working and handling the rock was unknown. So great is the economy now that some mines can win the rock, break and stamp it, concentrate and smelt the copper for $3.50–$3.75 per ton for all the rock broken. Other failures were due to gross mismanagement, and waste of money, whereby not only all the original capital, but also all the earnings have been squandered. Some mines have been worked for 20 years, but, in all that time, only enough copper has been won to keep them open, and now we find nearly a score of mines where work is being carried on but not paying dividends. Since 1845 over 200,000 tons of copper have been extracted, having realized $90,-000,000, and the present annual yield is not far from 19,000 tons. As far as known the assessments on the shareholders have been about $20,000,000, leaving seventy millions more which have been spent in extracting the copper, making improvements, and in paying dividends, by which some of the companies have been handsomely reimbursed. The mining population required to obtain this amount of copper, including the families and those indirectly living by the mines, is nearly 25,000 persons, scattered over three principal centres—Portage Lake, Keweenaw County, and Ontonagon County, besides a small population on Isle Royale.

The Calumet and Hecla Mines, discovered about 14 years ago, are situated 13 miles north of Portage Lake. The original sum paid into the company was $800,000; and since that time $9,000,000 have been paid in dividends. This lode yields 4 per cent. of copper. The Minnesota Mine in Ontonagon County paid $1,700,000 over the original capital paid up, and when nearly exhausted, it was sold for $2,000,000 more. The other mines, which have paid handsome dividends, are the Quincy, Franklin and Pewabic, on Portage Lake; the Cliff, Central and Copper Falls, in Keweenaw County, and the National in Ontonagon County.

Only about 1.15 to 1.25 per cent. of all the rock broken, (or 23 to 25 pounds per ton) at the Quincy Mine is copper; yet by economy and skilful management the mine has paid upwards of $1,800,000 in dividends, while the paid up capital amounted to only $200,000, and about $600,000 more were taken from the winnings to make necessary improvements on the property.

The quantity of copper in the Lake Superior region may be considered inexhaustible. Hundreds of valuable veins, as well as beds, exist, on which no work has been done, and on both sides of the lake many of these are awaiting future development, for which large capital will be required before success can be hoped for. Recently on Isle Royale, promising discoveries have been made. On the Canadian side there have been few attempts at copper-mining, but in the future the lessons learned by our

American friends will be a guide. Yet the metal must be paid for, as riches cannot be picked up in the streets.

On Isle St. Ignace, at Mamainse, Point Aux Mines, and on Michipicoten Island, the copper-bearing rocks particularly resemble those on Keweenaw Point, and appear to be as promising. Some small workings have been carried on on Michipicoten Island, but these have not been sufficiently extensive to more than prove the presence of copper in considerable quantities. In a report of Dr. T. Sterry Hunt to the Quebec and Lake Superior Mining Association, he speaks very strongly as to their probable value, and from my own experience in the various copper mining localities on Keweenaw Point, and the comparative value of such cupriferous rocks of Michipicoten Island as I have seen, I look forward to the time when the development of these Canadian mining localities will also be none of the least important of those in the Lake Superior region—already the richest copper mining region in the known world.

Appendix.—After the former part of the present paper was in print, Principal Dawson kindly referred me to a paper of his published in 1857, relating to the cupriferous series in the region of Maimanse, on the North Shore of Lake Superior.

Although written at an early date in the history of geological knowledge in that region, I was struck with the descriptions of the rocks under consideration, and could almost have imagined that he had a section of Keweenaw Point before him, so similar is the lithological and geological structure in this locality to that on the South Shore; and I think the evidence quite sufficient to prove the rocks both here and on Michipicoten Island to be a continuation of the same part of the formation as is exposed on Keweenaw Point. Moreover, Dr. Dawson considered the proofs in the Maimanse region sufficient to establish from stratigraphical grounds that the Copper-Bearing Formation was intermediate between the Huronian and Potsdam (or the St. Mary's) Groups; which proofs have not been found further west on the Canadian Shore.

Again, the same writer points out the comparatively superficial volcanic character of the rocks of the Cupriferous Formation, while those of the Huronian have a deep-seated origin

At Maimanse aboriginal workings have been found, and several years ago a shaft was sunk to a depth of twenty-seven feet, from which three tons of copper were taken, one mass weighing 600 pounds.

NOTES UPON THE SUPERFICIAL DEPOSITS OF ONTARIO.

By D. F. H. Wilkins, B.A., Bac. App. Sc.

Since the publication of the *Geology of Canada* in 1863 and the valuable papers of Prof. Chapman, Ph. D., L.L.D., of Toronto, in 1859 in the Philosophical Magazine, and in 1860 in the Canadian Journal, several interesting facts have been discovered regarding the superficial deposits as far as they have come under the writer's observation in a few localities in Ontario. Thus at Port Rowan, near Long Point, Walsingham Township, Norfolk County, we have the following facts revealed.

First.—As to the succession from below upwards.

(1). An unknown thickness of blue calcareous Erie clay, generally free from boulders and containing in its upper layers a few leaf-impressions, apparently of the birch, the maple, the elm and the poplar. The maximum thickness of this is said to exceed five hundred feet, this thickness having been bored through in 1866 in the vain hope of finding oil. As, however, the soft gray marls of the Hamilton formation must occur about this locality, Port Rowan standing nearly over the line between it and the underlying Corniferous, it is possible that some of these marls may have been penetrated.

(2). About two feet of quicksand.

(3). Twenty feet, on an average, of brown calcareous clay, stratified, as also is (1), and destitute even of leaf-impressions. It contains very many rounded Laurentian, (both Upper and Lower,) and Huronian, fragments and angular fragments of the Corniferous limestone holding its characteristic fossils.

(4). About a hundred and twenty feet of stratified, lacustrine sand, often containing grains of magnetite. It is almost destitute of boulders and pebbles.

Secondly.—As to the distribution of these. In proceeding eastward from Port Burwell to Port Rowan the sand is seen to lie at the surface, and in one or two places along the line of the stage-road, is seen reposing upon the clay. In Bayham Township, Elgin County, about three miles north-east from Port Burwell, a large bed of bog iron ore is found on the property of the late A. McLennan, Esq., of Port Rowan. North from Port Burwell to Tilsonburg, the brown clay is said to be met with near Vienna, occupying the hollows. At lot 17, Con. I. Houghton Township, on the farm of Mr. George Fuller, were found, some years ago, the remains of a mastodon, viz: two teeth, a femur and some tarsal bones. They were discovered two feet from the surface in a swamp. Near here, about a quarter of a mile west of the Village of Clear Creek, the clay (3) escapes from under the sand and constitutes the soil in the south part of Walsingham Township. The line subdividing the clay from the sand crosses the Town-line between Walsingham and Houghton Townships about two and a quarter miles due north of Lake Erie, or a little north of the Second Concession line in Walsingham Township. The sand occupies a breadth of about two miles along the second Concession line and advances in a tongue or spit ending N. 70° W., diminishing to a quarter of a mile in width at Concession B. and thinning out near Port Royal, on the west side of Big Creek. The sand is met with again on this line about five-eighths of a mile west of the Walsingham plank-road, and here has a breadth of a mile. Between these two places and beyond the mile eastward just mentioned, it recedes to the third Concession and disappears on the "Three-quarter Town Line" in their localities one a mile north of the other, the latter being near the second Concession. The line crosses the Charlotteville "Townline West" at the second Concession of the latter township, and ending eastward, appears on the lake, on a hillside on the south-west bank of Barnum's Creek, near Turkey Point, Long Point Bay. On the fourteenth Concession of Walsingham Township, a mile east of the Plank Road, is a workable bed of stratified gravel, and near the fifth Concession on the Plank Road is a lenticular bed of poor limonite twenty feet in thickness. It has been worked over an area of fifteen acres and is employed for the manufacture of pigments. It may also be mentioned that there are two dunes or hills of blown sand, containing so much magnetite as to perturb the compasses of passing vessels if they approach too near the shore. They are three hundred feet high, and occur half a mile south of the "Lake Shore Road" in Houghton Township, about six miles east of

Port Burwell, and fourteen miles west of Port Rowan ; they are immediately uyon the lake shore. The Township of Charlotteville is occupied almost altogether by sand, as is also Woodhouse. In Charlotteville, near Normandale, are several thousand acres of blown sand, the only vegetation upon which consists of a few stunted grasses, the *Phlox subulata*, *Viola cucullata* and *Polypodium vulgare*, and some scrub oaks and dwarf pines. These "oak plains" as they are called, are perfectly valueless for agricultural purposes. On page 185 of the *Geology of Canada*, 1863, will be found a notice of the bog iron ore beds of this township.

Proceeding to North Norfolk and South Oxford it is found that the sand is here at the surface. It is unstratified and in Windham, Burford, Townsend and Oakland Townships it also seems to be unstratified and *to have been derived entirely from the subærial* denudation of the Oriskany sandstone and Corniferous limestone. In Middleton Township, Norfolk County, the sand is met with also and in some localities in the former township sratified gravel. A somewhat peculiar feature—the dead forest—is met with in Dereham, Middleton, Bayham and Malahide Townships. In the summer of 1845 the pine trees in this region all died. Near Waterford in Townsend Township stratified gravel is met with, while further north, both south and north of Brantford the Erie clay is seen to re-appear. It is not only seen in a brickyard south of the town, but also north along the cutting of the Harrisburg and Brantford Railroad which was completed in 1871. At both localities the layers are contorted and corrugated. In Walpole Township, especially at Jarvis, the brown clay occurs at the surface.

Proceeding eastward from Paris the sand overlies the blue clay and forms the "plains" of Brantford Township. From near Rosebank along the Governor's Road east nearly to Lynden, the brown clay appears, and in the valley of Fairchild's Creek is seento be stratified, and to overlie the stratified blue clay. Near Troy in Beverly Township the calcareous blue clay is met with, stratified and overlaid by the stratified brown clay and sands. Thus this brown clay is apparently the stratigraphical equivalent of the stratified brown clay at Port Rowan. On the second con cession of Ancaster Township the clay contains calcareous concretions and is here, about lot No. 7, overlaid by the sand. The sand is met with to lot No. 23, when the clay re-appears for a short distance. Approaching the edge of the Niagara escarpment the gravel ridge is met with which is the watershed dividing streams flowing into Lake Ontario on the north from those flowing southwest to the Grand River. This watershed rises in Binbrook Township, Wentworth County, not far from the Grand River and trends N. W. to Copetown, Ancaster Township, through Binbrook, Glanford and Ancaster Townships. It then sweeps round the head of the valley and trends north-east. It contains great numbers of boulders of Hudson River or Cincinnati age of the lithological character given on page 212 of the *Geology of Canada*, 1863 ; at the same time it holds few, if any, Medina Clinton or Niagara remains, and is stratified.

The valley at Hamilton, Ont., is occupied by Medina red shales and sandstones. The iron in upper layers has been deoxydised by organic matter prior to the deposition of the stratified sand thereon, and the blue calcareous clay is evidently wanting. This is seen abundantly at different localities along the edge of the marsh near the Toronto branch of the Great Western Railroad, immediately east of the eastern city limits on the main line of the G. W. R. R., and towards Dundas west of the city. The Medina shale, is otherwise unchanged in appearance, showing *that the change is due to organic matter only.* The beautiful valley now occupied by Burlington Bay is, as Mr. J. W. Spencer, Bac. App. Sc. has shown, protected by two sand-spits in which beach structure and wind drift structure are plainly seen. These are rudely parallel, the western one being called Burlington Heights and reaching a hundred and fifty feet in height, marking of course an ancient lake-level. A still more ancient margin can be observed, and is very distinctly seen at Dundas. West of Dundas to Copetown, the valley is occupied with hummocks of sand and clay, the latter underlying the former. A ridge of gravel leaves Burlington Bay on the north shore and trends north-eastward crossing the Toronto branch, of the G. W. R. R. half-a-mile east of Waterdown Station. Near the G. W. R. R. bridge on the west bank of the Twelve mile Creek, near Bronte Station may be seen a bed of gravel occupying a hollow in the Medina sandstone.

The valley of Burlington Bay at Hamilton was formed as shown by Mr. Spencer by the erosion of several streams, though the primary form of the valley is doubtless due to the fact that the strata of the Niagara group fold over an anticlinal, and that hence the valley would occupy the crown of the arch, *cœteris* *paribus.* The stream referred to drained an ancient lake, known to the "oldest inhabitant" as the Beverly Swamp. This occupies a space of ten miles from south to north (Concession IV. to Concession XI.) and from the town-line west of Beverly through Beverly, 'West and East Flamboro' inclusive E. to W., "Crook's Creek" flowing from this evidently contributed most to the formation of Burlington Heights. The swamp is crossed by several gravel ridges or eskers, with an E. and W. strike. They are stratified and average a hundred feet in height, containing large numbers of rounded boulders of the underlying Guelph limestones. Niagara *débris* is, as Mr. Spencer says, almost unknown among the boulders and pebbles of all the deposits in the south western part of the Western Peninsula of Ontario.

North of Beverly in Puslinch and Guelph Townships, and as far west as Colborne and Goderich Townships, numerous other eskers are visible, some having a N. W. and S.E. strike, some N. and S. S (*e .g.* Smith's Hill, Colborne Township, and a parallel ridge a mile east,) and some E. and W. Between the eskers the country is often swampy. The eskers are all stratified.

Except the striæ in Beverly and Barton Townships there is no evidence of either glacial or iceberg action near Hamilton, Ont. Several new exposures have been made visible in the Guelph limestone of Beverly since the visit of the Geological Survey officers. One of these, half a mile north of Con. V. and north of Rockton, near to one of the gravel ridges mentioned in the second paragraph above showed striæ N. 70° W. while at Rockton, two miles away, the striæ were N. 79° W. on the roadside. At Sheffield *three* sets of striæ occur, the most ancient being N. 75° W., then N. 75° E. and N. 40° E. Near Troy are two sets of striæ N. 76° W. and N. 70° E. running North of Rockton a mile north of the first exposure are striæ N. 70° E.

NOTE ON THE GEOLOGY OF THE LABRADOR COAST.

By D. F. H. Wilkins, B.A., Bac. App. Sc.

During the past summer a flying visit paid to a few localities on the Labrador Coast enabled the writer to assert that what has been alleged by Mr. Richardson of the Geological Survey, concerning the stratigraphy of the Laurentian rocks between the Bersimis and the Saguenay Rivers, is generally true concerning the rocks further north-eastward, at least at the few places visited. The Lower Laurentian gneisses and diorites are invariably fractured and cleaved in all directions, and intersected by several fissures and some trap dykes, with a, generally speaking, north-easterly strike. The stratification lines are very often so obscure that it is almost impossible to say whether the rocks are metamorphic or eruptive. On these are superposed unconformably the Upper Laurentian gneisses and norites with hyperites, and in one locality, a bed of micaceous sandstone, all dipping at moderate angles, lying in synclinals having, so far as examined, dips ranging from 26° 10′ to 63° 26′ and an E. and W. to N. 45° W. strike.

Thus at Little Mecattina River outlet, Upper Laurentian, red-weathering, gray hyperyte in a bed two feet thick, overlaid by four feet of whitish gneiss with a dip N. 70° W.$<$49° and strike N. 20° E., is seen to repose, at low tide, upon the underlying red gneiss of Lower Laurentian age. At Baie des Moutons, eighteen miles north-east of this, Lower Laurentian firm, coarse-grained, red gneisses appear, intersected by cleavage-planes and fissures, and fine-grained, red, granitic veins, the older set having a strike N. 47° E. and intersected by the newer set which strike N. 87° W. A fine example of a trap dyke can be seen from the ocean at Schooner Bay, three miles north-east of Baie des Moutons. Its strike is apparently N. 50° E, and its maximum thickness is six feet, diminishing to three feet. At the mouth of the river St. Augustine, about fifteen miles from the mainland, on L'Isle aux Sables occurs the bed of micaceous sandstone already referred to. It is tender and friable, brownish-grey in colour, and lies in a synclinal with a N. 45° W. strike.

The dip on the south side of the beds, where it is more friable than on the north, is to the N. E.<61°, while on the north side it is to the S. W.<58°. At L'Isle du Lac Salé about three miles nearer the shore, the Upper Laurentian rocks are seen to lie in a synclinal striking N. 10° W. and dipping N. 80° E.<63° 26' on the south-west side, and S. 80° W.<54° on the north-east side, about four miles across the strike. They rest upon black diorites and consist of twenty-nine feet of grey norites and thin red gneisses overlaid by gneisses which are mostly concealed by vegetation. The bed of micaceous sandstone referred to is intercalated between an unknown thickness of white gneiss below and about a thousand feet of reddish gneiss above.

NEW AND INTERESTING INSECTS FROM THE CARBONIFEROUS OF CAPE BRETON.

By Samuel H. Scudder, of Cambridge, Mass.

Dr. J. W. Dawson has placed in my hands a piece of carboniferous shale from Cape Breton, containing remains of several insects. The best preserved and most interesting is the abdomen of a larval Dragon-fly. Odonata, both mature and in their earlier stages, have previously been found in the Jurassic beds of Solenhofen; wings and fragments of other parts have also been found in the English Lias, and a specimen, which may be an odonate larva, has been figured by Brodie from the Oxford Clay. No true Odonata, however, have been discovered so low as the carboniferous formation, unless the obscure fossil, thought by Goldenberg to be possibly a Termes,* may properly be referred to this group.

In the last edition of Dr. Dawson's Acadian Geology, however, I have described (p. 387) the wing of an insect, *Haplophlebium Barnesii*, which certainly bears some striking resemblances to the Odonata, and of which it is not impossible that the present fossil may be the larva.

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* See Dunker and Meyer's Palæontographica, iv, pl. vi, fig. 8. Subsequently (Vorw. Faun. Saarb. 12) Goldenberg refers this definitely to the Termitina, under the name *Termes* (*Calotermes*) *Hageni*.

The abdomen of the specimen (fig 1) is nearly perfect, and presents a ventral aspect, portions of the flanks of the body may

Fig. 1.

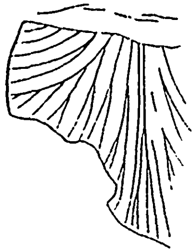
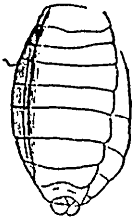


Fig. 2.



be seen on either side; upon the left side in direct continuity with the ventral segments and very distinctly, especially since this region is darker colored than the other parts of the abdomen. The limitation between the ventral and pleural portions is sharply defined on this side by slight ridges, showing that in life these parts were abruptly limited, while the margination of the extreme border of the fossil shows that, as in living odonate larvæ, the dorsal was again separated from the pleural region of the abdomen by a distinct bend. The abdomen is elongate-ovate, devoid of any armature, composed of nine segments, the ninth obscure and bearing a pair at least of rounded lobate pads of considerable size, but not as in recent Odonata, pointed at the tip. The second to the fifth segments are shorter than the others; the posterior edge of all the segments is straight, excepting that of the seventh, that is gently convex, and that of the eighth, which is strongly and roundly excised; that of the ninth appears also to be regularly concave. The entire entire length of the abdomen is 13.5^{mm}, and the width of the fifth or broadest segment 6.5^{mm}, counting only the ventral portion; the appendages are 1^{mm} long.

It is impossible to say to which group of Odonata the fossil belongs. The Agrionina, are, however, unquestionably to be excluded. It seems to be most probably one of the Libellulina, and may be provisionally placed in the old genus Libellula (which formerly contained all the Odonata) and bear the name *Libellula carbonaria.*

Accompanying this interesting fossil is a frond of Alethopteris and two fragments of wings of cockroaches. One of the latter is too insignificant to be worth noticing, but the other is sufficient for determination, and may be called *Blattina sepulta* (fig. 2).

It appears to be nearly allied to *B. carbonaria* Germ., but differs from it in some important particulars. It is very imperfect, a portion of the outer border being the only part of the margin which is preserved, but most of the disk of the wing is present; probably the entire wing measured nearly 15mm. in length; the fragment that remains is but 6.25mm long and 5mm broad. The anal nervure is no more deeply impressed than the others, rather regularly curved, and itself emits several branching and simple shoots from its posterior border; the anal field (and apparently also the middle field) is covered with very frequent cross-nervules, *not represented in the figure*; the branches of the middle field appear to be not very closely crowded, distinctly less so than those of the costal field.

The fossils were obtained at Cossett's Pit, near Sydney, Cape Breton, by Mr. A. J. Hill, C. E., from "near the horizon of the Millstone Grit," as I am informed by Principal Dawson.

ON A COLLECTION OF PLANTS FROM BRITISH COLUMBIA, MADE BY MR. JAMES RICHARDSON IN THE SUMMER OF 1874.

By G. Barnston.

The collection of which the present paper is a catalogue can scarcely fail to be of interest to the botanist in Canada, as it is probably the first brought to Montreal from that distant portion of the Dominion.

Forty-three of the species are from the vicinity of Victoria, the capital of Vancouver Island, and some of them give evidence of the near approach to the genial climes of Washington and Oregon Territories, those picturesque regions whence many of the floral beauties which adorn the gardens of the wealthy both in England and in this our own land were originally obtained.

McLaughlin's Bay (or Bella Bella) on Campbell Island, a Hudson Bay Company post and Indian village, is the next locality, and has furnished forty-seven plants to the collection. The latitude of this place is about 52° 10′ north, and the longitude is about 128° 10′ west of Greenwich; but the flora would seem to indicate that the temperature during the summer months is about the same as at Montreal.

The remaining localities from which specimens were obtained are Gardner's Channel, Kamino River and Mountain, Kitimat Inlet and River.

These rocky and deep inlets represent fully two degrees of latitude; but, at least along the lower elevations skirting the shores, afford the same flora throughout. About forty species were collected on them, not including about fifteen repetitions of plants found at the first mentioned localities. To them may also be added eight or nine grasses gathered in the Kitimat country.

Out of one hundred and twenty species about thirty pertain strictly to the Western flora, and are not known to occur east of the Rocky Mountains; the rest, however, may be met with east of the mountains in various localities, some on the prairies or along their borders, and others in the wooded regions. Five or six species may be classed among the sub Arctic plants, viz., one *Menziesia*, two *Andromedas*, *Saxifraga Aizoon* and *S. æstivalis*. It may be remarked that the *Andromeda cupressina* (Hooker) which occurs among the Kamino plants and which is apparently confined to the mountains of the Pacific slope, is closely allied to, yet essentially different from, the *Andromeda tetragona* of Baffins Bay and the Arctic coast. The latter was the plant upon which Dr. Rae relied for fuel when he wintered in the Esquimaux country at Repulse Bay.

The botanists of Montreal should feel greatly indebted to Mr. Richardson for this contribution to their knowledge of the Pacific coast flora, and for his still untiring assiduity in the pursuit of scientific objects; the more so as botany is not the particular branch of science in which he is officially engaged.

LIST OF SPECIES.

Near Victoria, Vancouver Island, May 1st to 10th.

Ranunculus recurvatus, Bong. Hooked Crowfoot.
R. occidentalis ? Nutt. M. S. S.
Delphinium Menziesii, De Candolle.
Cardamine angulata, Hooker.
Capsella bursa pastoris, Linn. Shepherd's Purse.
Viola rotundifolia, Michx. Round leaved Violet.
" *cucullata Ait., var. cordata.*
Cerastium arvense, Linn. Field Chickweed.
Claytonia alsinoides, Sims. (= *C. Unalaschkensis*, Fischer.)
Calandrinia Menziesii, Hooker.

Cytisus sarothamnus, Linn. The Broom. Naturalized.
Trifolium microdon, Hooker & Arnott., (fide Macoun).
Psoralea argophylla, Pursh. In its early state.
Lathyrus venosus (Muhl.) var. D. (= *L. pubescens*, Nutt.)
" *decaphyllus*, Hooker.
Potentilla nivea, Linn., var. G. (= *P. hirsuta*, Vahl.)
Ribes spectabilis, Pursh.
Ribes sanguineus. Pursh.
Saxifraga integrifolia, Hooker.
" *ranunculifolia*, Hooker.
Thaspium pinnatifidum, Gray.
Seseli leiocarpum, Hooker. (*Peucedanum*, Nuttall.)
Plectritis congesta, Hooker & Arnott, var. *B. multiflorum*.
Bellis perennis. Linn. European Daisy. Introduced.
Helianthus multiflorus, Linn. (Or *H. decapetalus*, Linn., var. *multiflorus*.)
Achillea tomentosa, Pursh.
Armeria maritima, Willd.
Dodecatheon integrifolium, Michx.
Trientalis latifolia. Hooker.
Aphyllon uniflorum, Torrey & Gray. One-flowered Cancer-Root.
Mimulus luteus. Pursh. (= *M. guttatus*, DeCandolle.)
Ilysanthes gratioloides, Bentham. (=*Lindernia dilatata*, Michx.)
Veronica serpyllifolia, Linn. Thyme-leaved Speedwell.
Castilleia hispida, Bentham. (M. S. S.)
Myosotis Chorisiana. Hooker.
" *fulva*, Hooker & Arnott.
Rumex acetosella, Linn. Field or Sheep Sorrel
Arethusa bulbosa. Linn.
Corallorhiza Mertensiana, Bong.
Smilacina stellata, Desf.
" *bifolia*, Ker.
Erythronium grandiflorum, Pursh. var. *B.*, *albiflorum*.
Brodiea congesta, Smith.
Fritillaria lanceolata, Pursh.
Uvularia puberula. Michx. (= *U. lanuginosa*, Pers.)

From Campbell's Island (locally known as Bella Bella,) May 26th.

Caltha natans, Pallas.
Arabis hirsuta, Scopoli.
Drosera rotundifolia, Linn. Round-leaved Sundew.
" *longifolia*, Linn.
Claytonia alsinoides, Sims. (= *C. Unalaschkensis*, Fischer.)
Geum macrophyllum, Willd.
Rubus odoratus. Linn. (Purple Flowering-Raspberry.)
" *obovatus* ? Hooker : or *pedatus* ?
Amelanchier Canadensis, var. botryapium. (Shad-bush. Service-berry.)

Ribes bracteosum, Douglas.
Heuchera micrantha, Douglas.
Cornus Canadensis, Linn. (Dwarf Cornel. Bunch-berry.)
Sambucus pubens, Michx. (Red-berried Elder.)
Viburnum pauciflorum, De La Pylaie.
Vaccinium uliginosum, Linn. (Bog Bilberry.)
Arbutus Menziesii, Pursh.
Gaultheria procumbens, Linn. (Creeping Wintergreen.)
Kalmia glauca, Ait. (Pale laurel.)
Ledum palustre, Linn
Pinguicula vulgaris, Linn. (Butterwort)
Trientalis arctica, Fischer.
" *latifolia*, Hooker.
Gentiana Douglasiana, Bong.
Spiranthes cernua, Rich.
Smilacina bifolia, Ker.
Erythronium grandiflorum, Pursh : var.
Eriophorum polystachion, Linn.

FOG ROCKS, MAY 28TH.

Potentilla villosa, Pallas.

GARDNER'S CHANNEL.

June 1st. *Claytonia alsinoides*, Sims. (= *C. Unalaschkensis*, Fischer.)
Carex Barrattii, Fischer.
" 3rd. *Thaspium atropurpureum ?* (Or *Sanicula Menziesii*, doubtful.)
Potentilla anserina, Linn. (Silver-Weed.)
" 4th. *Ranunculus cymbalaria*, Pursh. (Sea side Crowfoot.)
Actæa rubra, Bigelow. (Red baneberry.)
Lonicera involucrata. (Herb. Banks.)
" 5th. *Aquilegia formosa*, Fischer.
Amelanchier Canadensis, var. *botryapium*.
Aralia racemosa, Linn. (narrow leaved variety.)
" 7th. *Smilacina racemosa*, Desf.
" 9th. *Saxifraga aizoides*, Linn. Yellow Mountain Saxifrage.
" 10th. *Campanula rotundifolia*, Linn. (Harebell.)
Gaultheria procumbens, Linn.

KAMINO RIVER.

" 15th. *Lupinus polyphyllus*.
Rosa fraxinifolia, Bork.
Saxifraga æstivalis, Fischer. (= *S. heterantha*, Hooker.)
Bulbiferous.
Stachys ciliata, Douglas.
Gentiana saponaria, Linn. (Soapwort Gentian.)
" 16th. *Andromeda cupressina*, Hooker.
" *polifolia*, Linn. Kamino Mountain.
Kalmia glauca, Ait.

June 17th. *Menziesia Grahami*, Hooker. (An ? var. M. *empetriformis.*) Stigma exserted.

" 17th. *Lathyrus maritimus*, Bigelow. Gardner's Channel.

" 18th. *Lonicera involucrata.* (Herb. Banks M. S. S.)

CLIO BAY.

" 21st. *Corydalis glauca*, Pursh. (Pale Corydalis.)

Tellima grandiflora, Douglas.

Dodecatheon intergrifolium, Michx.

Glaux maritima, Linn. var. (Sea-Milkwort.)

Erythronium grandiflorum, Pursh. Var. A : minor.

Tofieldia glutinosa, Pursh, var. *purpurea*. (Like *T. coccinea.*)

Panicum dichotomum, Linn.

KITIMAT.

July 1st. *Cornus stolonifera*, Michx. (Red-osier Dogwood.) Inner Harbour.

Andromeda cupressina, Hooker. Near snow.

Kalmia glauca, Ait. Kammo Mountain.

Pyrola secunda, Linn. (One-sided Pyrola.) Inner Harbour.

Menyanthes trifoliata, Linn. (Buckbean.)

Polygonum viviparum, Linn. (Alpine Bistort.)

" 2nd. *Tiarella trifoliata*, Linn. Kitimat Village.

Thaspium ? atropurpureum, Nuttall. (Or *Sanicula Menziesii* : doubtful.)

Achillea tomentosa, Pursh.

" 15th *Brassica campestris.* Wild Turnip. Introduced.

Claytonia perfoliata, Donn.

Epilobium angustifolium, Linn. (Great Willow Herb.)

" *opacum*, Lehm.

Sanicula Menziesii, Hooker & Arnott.

" *bipinnatifida*, Douglas.

Heracleum lanatum, Michx. (Cow Parsnip.)

Plectritis congesta, Hooker & Arnott. Var. B.

Antennaria margaritacea, R. Brown. (Pearly Everlasting.)

Hieracium. Undetermined.

Eriogynia pectinata, Hooker. *Spiræa pectinata* of Torrey.

Pedicularis ornithorynchus ?

Luzula campestris, var. (= *L congesta*, Lej.)

Agrostis scabra, Willd. (Hair Grass.)

Calamogrostis Canadensis, Beauv. (Blue Joint-Grass.)

Festuca microstachys, Nutt.

Hordeum pratense, Huds.

Aira danthonoides, Trin.

Hierochloa borealis, Rœm & Schultes. (Vanilla or Seneca Grass.)

Phalaris arundinacea, Linn. (Reed Canary-Grass.)

A VISIT TO PORT BLAIR AND MOUNT HARRIET, ANDAMAN ISLANDS.

By Lieut.-Colonel George E. Bulger, F.L.S., F.R.G.S., C.M.Z.S., Etc. Late H. M. 10th Foot.

In the Bay of Bengal, between the 10th and 14th parallels of north latitude and the 92nd and 94th degrees of east longitude, lie the beautiful tropic islands of the Andamans, known to us since the Indian mutiny chiefly as a penal settlement, but latterly painfully associated in our minds with the mournful tragedy enacted there on the 8th February, 1872.

The Andamans proper consist of four large islands and a multitude of smaller ones, mostly covered with luxuriant forest, and almost everywhere locked in a fringe of coral, which in many places forms extensive reefs, usually so steep and sudden as to be most dangerous of approach. The three largest, called respectively North, Middle, and South Andamans, are only separated from each other by narrow straits, which are not navigable at low water; and hence they commonly bear the one general designation of Great Andaman, in contradistinction to Little Andaman, the name given to the southernmost of the four, which is divided from the others by the broad, deep channel of Duncan Passage.

The larger islands of the group are said to possess many good harbours and anchorages, as well as an abundance of fresh water,* but very little is known about them, as they are not often visited, chiefly, I imagine, in consequence of the danger of their coral reefs and the inhospitality of their inhabitants, a woolly-headed, savage race, whose origin has been for some time, and is still, a puzzle to ethnologists.

Nature has everywhere scattered her beauties over this region with a lavish hand, and some of the smaller rocks and islets are lovely as a fairy dream, counterparts of those bright creations of poetic fancy which Tennyson has drawn for us in 'Locksley Hall.'

"Larger constellations burning, mellow-moons and happy skies,
Breadths of tropic shade and palms in cluster, knots of Paradise,
Never comes the trader, never floats an European flag,
Slides the bird o'er lustrous woodland, swings the trailer from the crag:
Droops the heavy-blossom'd bower, hangs the heavy-fruited tree—
Summer isles of Eden lying in dark-purple spheres of sea."

* Rosser and Imray's "Sailing Directions."

Many years ago* the Honourable East-India Company formed a settlement at Port Cornwallis, a noble harbour of the north island, but it was soon afterwards† abandoned on account of its extreme unhealthiness, and, since then, until the establishment of the present penal colony at Port Blair, where the interest of the group is now centred, the Andamans were left to the unrestrained dominion of wild and unfettered nature.

The approach to Port Blair‡ from the northward is very charming—the vessel threading her way through the blue waters of Diligence Strait, with a chain of picturesque islands upon one side, and the so-called mainland on the other;—all more or less covered with a dense, rich forest, which is usually of the grandest description, and remarkable for the conspicuous, straight stems of its lofty trees. Every summit and every headland seems crowned with these vegetable giants—every valley and ravine is choked with an impenetrable network of thronging branches and irrepressible climbers, and even the very bays and creeks are brilliantly green with the vivid foliage of the mangrove.

During the passage of this exquisite channel, fresh views of the magnificently forest-clad shores are incessantly revealing themselves to the delighted gaze of the traveller—each one wilder, brighter and more fascinating than the last, until their attractions culminate in the superb beauty of Port Blair itself, which is, perhaps, one of the loveliest bays in the whole world. It is a large, irregularly-shaped inlet at the south eastern end of the Great Andaman, indenting the coast to the westward, and then bending downwards to the south. Within its boundaries are most of the settlements of the colony, but the chief station is the little island of Ross, which lies athwart the entrance of the harbour, and, notwithstanding its small size, contains nearly all the principal public buildings, including the church, Government House, and the barracks.

To the westward of Ross, at a distance of rather less than three miles, is another smaller island called Chatham, where a proportion of the convicts are quartered; and, about the same distance further to the southward—still within the encircling arms of the beautiful sound—the chief prison of the station is reached. It stands upon Viper Island, and is most carefully guarded—a highly necessary precaution, for it contains the very

* 1791. † 1796. ‡ Formerly called Port Chatham.

worst criminals from all parts of India. There are two thriving settlements on the mainland, nearly opposite to Ross, which are known respectively as Haddo and Aberdeen, and several other smaller villages are being established at suitable points further away. On the northern shore of the bay, is Hope Town, and, overlooking this, the sanitarium of Mount Harriet.

The scenery of the long and somewhat tortuous inlet is very attractive throughout its entire distance of seven miles, but its beauty is chiefly due to the presence of a rich and magnificent virgin forest, which, until lately, robed every portion of the visible earth in its vicinity with one living sheet of perennial verdure. Now, however, this glorious jungle has begun to fall rapidly before the axe and the clearing-fire, in consequence of its alleged unhealthiness.

At the southern extremity of the bay is Homfray's Ghaut, and thence, a road, two miles in length, extends to Port Mouat, on the western coast. The land, immediately to the north of this road, is low, swampy and thickly covered with mangroves, but, to the southward, a steep, sloping hill-side flanks it throughout. Here are immense quantities of large and handsome ferns, backed by a grand forest of gigantic trees, whose huge stems are profusely draped and adorned by parasitical and epiphytical vegetation of great luxuriance. Port Mouat consists literally of two bays, which are connected with one another by a narrow passage only ninety yards across. The outer one is open to the sea, and affords no shelter, but the other, which is circular in form, has room enough within its spacious lake-like expanse for the whole of the British fleet. The southern portion is very deep, but it shoals gradually towards the northern shore, and, as the water is particularly clear, the coral bottom may easily be seen, as well as thousands of splendidly coloured fishes and gorgeous parterres of sea-anemones, whose vivid hues rival those of the iris itself. On a narrow spit of land projecting from the northern shore and close to the little settlement, is a beautiful avenue of cocoa-nut palms, growing in two rows on either hand. These graceful trees, which were planted in 1866, bore fruit for the first time in 1872.

Ross Island is a somewhat bold and rather picturesque triangular mass of rock, consisting, according to Mr. Ball,* of bluish-grey

* "Journal of the Asiatic Society of Bengal" xxxix. 232.

limestone, with interbedded layers of argillaceous shales, rising at its highest point to 195 feet above the sea, and covering an area of about one-third of a square mile; its length being nearly 1,700 yards, and its greatest breadth—in the centre, where it runs out abruptly into a long projecting point—rather less than the same number of feet. Mr. Ball remarks that, owing to the great inclination of the strata, and other causes, there is considerable risk of destructive landslips; and if some precautionary measures are not adopted, the eventual stability of the island itself may be endangered, by the removal of stones from the face of the cliff for building purposes, and the disintegration of the exposed surface by the sea and other natural influences.

The indigenous vegetation of Ross has almost entirely given place to ornamental and useful plants, introduced from India, the Malayan Peninsula, and the larger islands. Amongst the trees are cocoa nut palms—which have probably been brought from the Cocos, as they do not appear to be anywhere natives of the Andamans proper—oranges and lemons, with other species of *Citrus*; the Bullock's-heart (*Anona reticulata*), custard-apples (*Anona squamosa*), guavas (*Psidium pomiferum et pyriferum*), acacias of two or three kinds, including the fragrant *A. farnesiana*, *Agati grandiflora*, *Cassia fistula*; the Mango (*Mangifera indica*), the Plantain (*Musa paradisiaca*,) and the Durian (*Durio zibethinus*). There are also numbers of small and beautiful trees of *Mesua ferrea*, a noble and gigantic *Calophyllum inophyllum* near the Commissariat office, and, round the coast, occasional fine specimens of the common screw-pine (*Pandanus verus*). Besides these, many flowering plants and a number of so-called weeds, with ten or twelve specimens of grasses, have followed the footsteps of settlement and cultivation, all of which seem to thrive and flourish in the genial climate of this surf-lashed outlying sentinel of Port Blair.

Peacocks of both species (*Pavo cristatus et muticus*), as well as the common Indian crow (*Corvus splendens*), *Estrelda amandiva*, *Acridotheres tristis et fuscus*, and *Palæornis torquatus*, have been introduced since the formation of the colony; but the amaduvats have disappeared, and the prevailing form of *Corvus* now seems to be *C. andamanensis*, though *C. culminatus* is also found.

Various genera and species of fishes—many of them brilliantly coloured—are abundantly represented in the blue waters of the bay*; and rare and beautiful creatures constantly reward the researches of the malacologist, even on the shores of Rose itself; but my personal experience does not extend to either of the branches of natural sicence which include these denizens of the deep, and I must refer those desirous of information on both points to papers scattered over the Journals of the Asiatic Society of Bengal, and Surgeon-Major Day's article on the Fishes of the Andaman Islands, in the Proceedings of the Zoological Society of London for 1870.

The sea was curling up into white-lipped wavelets one day in the beginning of November, 1871, when, accompanied by a brother officer, I crossed the bay *en route* to Mount Harriet, a hill overlooking the harbour, and easy of access from Hope Town, which is a little native village situated in a cove to the westward of Perseverance Point, and nearly opposite to the settlement of Chatham. As we left the jetty at Ross, the dark nimbus clouds which had obscured the morning began to break and give place to a fairer sky, and ere we had completed half our voyage, the truant sun peeped out upon us, and shed such a magic light around, that the superb land-locked inlet, with its

* The following note may perhaps be interesting as evidence of the rapacity and numbers of sharks in these waters. It is condensed from an account written by a brother officer, whose veracity and accuracy are both unimpeachable.

"The Andaman fishing expedition which you enquire about took place, as you know, during our short sojourn in Port Blair in October, 1871; and my companions were five convicts—all natives of India. I had great difficulty in pursuading the official in charge of these men to allow me to accompany them, and it was only on my promising not to ask them to return before the proper time that he acceded to my request. We left Ross about eleven o'clock in the forenoon, and went, in the first instance, to a small settlement upon the main island some few miles to the north-west, where we remained about three-quarters of an hour. It was a pretty little spot, but as the boatmen went ashore and left me to take care of the canoe, I was unable to explore it; and, indeed, the surf was so great that I do not think I could have landed with any degree of comfort. Thence we proceeded to the fishing-ground, about twenty miles further north, which we reached about 4 p.m. In this vicinity, we remained the whole night and part of the next morning—changing our position occasionally when we found the sport getting slack. The weather during the day was fine and pleasant, but about sunset the wind rose, and the night subsequently proved rather rough and stormy—much to my picturesque islands and wooden shores, seemed all aglow with gold and amber, while the white breakers dashing over the coral reefs, and gathering force and grandeur at every fresh breath of the sea-breeze, lent such an additional charm to the rich green forest, still dripping and sparkling with pendent rain-drops. that the scenery attained an almost ideal beauty, impossible to describe—so soft—so fresh—so glorious.

" —— That earth now
Seem'd like to heaven, a seat where Gods might dwell
Or wander with delight."

The distance across the bay is rather more than three miles, and it was about eleven o'clock when we landed at Hope Town, on the still unfinished pier, which scarce three months later earned such a melancholy celebrity by the assassination of Lord Mayo.

After a short delay at the village, until the servants arrived with our supplies of food and other impediments, we commenced the ascent by a very good bridle-road of thirteen furlongs in length, which climbs easily and pleasantly through a beautiful virgin forest to the Commissioner's bungalow upon the summit of

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discomfort, for the heaving and tossing motion made me ill, and, as there was no room for me to stretch my legs, I suffered terribly from the cramped position which I was obliged to maintain for nearly thirty hours. We did not get back until 3 p.m. the next day, and the canoe was so small and crank, that I was confident we should not have accomplished the voyage in safety, if the boatmen had not been plucky fellows and thoroughly up to their work. I believe all the other fishing parties returned to the shelter of the harbour before it grew dark. We shipped so much water that one of the men was constantly employed in bailing, and even then, we narrowly escaped being swamped. We used ordinary deep-sea lines, and the bait consisted of bits of fish. Those which we caught were from 18 to 24 inches in length, and weighed perhaps between 8 and 14 pounds. I believe they are called cocoa-nut fish, but I regret to say, I knew nothing further about them. Our take would have been very great, had it not been for the sharks, which, in many instances, robbed us of our captives by taking them off the hooks, while they were being hauled in, and leaving nothing but the heads. This was done so deftly and expeditiously too, that the monster's snap was sometimes hardly perceptible. I was so faint when I got back, owing to sickness, the miseries of my awkward position and want of food—plantains and papaws being the only provisions we had with us—that I could scarcely stand."

the hill, 1,185 feet above the level of high tide. Nothing can be more charming than this pathway, winding, as it does, amidst the profuse and irrepressible vegetation of the tropics, and vocal with the many strange and singular sounds with which creation speaks in these voluptuous latitudes. Noble trees of great height and remarkable for their huge buttressed trunks, stand all around like mighty sentinels, and cast grateful shadows from their green canopies of foliage over much of the ascent, tempering the heat and affording shelter to hundreds of gay and often sweet-voiced birds and marvellous insects, which make their home amidst these vast storehouses of nature; while clinging to the giant stems and round the great spreading arms of the patriarchal trees, are myriads of parasitical and climbing plants, rejoicing and luxuriating in the moist warm climate, which though almost free from the oppressive sultriness of the calm regions, possesses much of that fervent life-giving humidity so characteristic of the equatorial zone.

It is not the least of the attraction of this delightful roadway, that in its immediate vicinity a beautiful brook comes dashing down the mountain-side from a perennial spring near the summit, and after a sparkling and rapid journey, falls into the bay near Hope Town.

Escaping a drenching shower on the way by the opportune occurrence of a sheltering rock, we reached the summit of the hill in due course of time, and, taking possession of the Commissioner's house, regaled ourselves with cool draughts of magnificent milk, which appeared to be the only purchasable article within reach, notwithstanding that a considerable portion of the extensive clearing round the bungalow was devoted to the cultivation of vegetables of different kinds. Other houses, inferior in size and aspect to that which we had temporarily appropriated, combined to form a sort of village in this charming locality, which seemed to rejoice in a most cool and pleasant climate, and afforded us such a view as is rarely seen even in the tropics. The panorama unfolded by our elevation embraced a vast extent of sea and land, including Rutland Island and Macpherson's Straits, as well as some of the lofty elevations of the North Andaman, including the Saddle Mountain, which is visible at sea sixty miles away, and estimated to 2,400 feet in height. Almost below us lay the beautiful harbour of Port Blair, with its various rocky islands, and stretching away to the southward, the forest-fringed lagoons leading to Port Mouat.

Mr. Ball, whose interesting paper on the geology of the vicinity of Port Blair* I have already quoted, states that the principal rock of Mount Harriet is a coarse yellowish-green or grey sandstone. apparently very absorbent of water; also that close to the top of the hill the sandstone appears in vertical beds, but that on the ascent the rocks are much obscured by humus.

During the alternations from gloom to sunshine which the moving clouds so frequently created, the effects of light and shade upon the extended landscape open to our view were exceedingly beautiful, and sometimes so wonderfully rapld and complete as to be almost startling. In a single instant it seemed as if the forest changed from a brilliant combination of vivid greens to a solemn and uniform, heavy-looking, almost blue tint, while perhaps, after the lapse of a few seconds, it would suddenly reveal itself again in all its former sunny brightness. The luminous play upon the water under these conditions, though perhaps not quite so striking, was even more lovely still,—now presenting to our gaze a sapphire sea, and anon passing quickly to chrysoprase and emerald, to flash back upon us next moment with an intensity of blue rivalling the deepest azure of a southern sky.

There were scarcely any flowers in bloom, excepting orchids. which seemed to be chiefly representatives of various species of *Dendrobium*, but they were all out of reach, and I did not procure a single specimen. Many of the trees were unknown to me, but in the forests I recognized a few that I was familiar with; amongst which were *Dipterocarpus lævis*, *Mesua ferrea*, and *Pterocarpus dalbergioides*. There was also a tree with brilliant and red decaying leaves, so like *Terminalia catappa*, that I have no doubt of its having been *T. procera*, as mentioned by Mr. Kurz;* an *Acacia* in tolerable abundance, and a *Lagerstrœmia;* also in the lower and denser forest extending down to the beach, *Sterculia fœtida* and a gigantic *Dillenia*, which was probably *D. pilosa* of Roxburgh. I met with no tree-ferns of any kind, and scarcely any palms, excepting a prickly climbing *Calamus*, which was very common, while the great pendulous lichens, such as I have seen adorning the damp forests of the eastern Himalaya in profuse quantities, were altogether absent. *Pothos scandens*, however, another characteristic plant of the moist Himalayan woods, was everywhere plentiful and luxuriant. Mangroves

* J. A. S. B., xxxix. p. 231.

abound in some places, fringing the shore with their brilliant green foliage and growing upon them. One of my friends found large quantities of *Orchidaceæ*, chiefly species of *Dendrobium* and *Pholidota*.

Of birds, we obtained specimens of a beautiful parrakeet (*Palæornis nicobaricus*) which seemed very abundant, but generally kept well out of reach of shot in the upper branches of the great trees; of the peculiar-looking black woodpecker (*Muelleripicus Hodgii*), and some of the Indian green imperial pigeons (*Carpophaga sylvatica*). We saw also a good many bulbuls (*Otocompsa jocosa*) and sunbirds (*Nectarinia pectoralis*); a *Pericrocotus*, which was most probably *P. peregrinus*; and a few others which I failed to identify. A small collection, however, made by a brother officer on Mount Harriet, and in the forests stretching downwards to the sea-beach, furnished me with the following species:

Palæornis erythrogenys, Blyth; *Centropus andamanensis*, Tytler; *Macropygia rufipennis*, Blyth.; *Chalcophaps indicus*, Linn.; *Osmotreron chloroptera*, Blyth; *Pericrocotus peregrinus*, Linn.—*Pericrocotus flammeus*, Forster; *Loriculus vernalis*, Sparm.; *Irena puella*, Lath.; *Oriolus andamanensis*, Tytler; *Merops quinticolor*, Viell; *Myiagra Tytleri*, Beavan; *Alcedo asiatica*, Swains; *Todiramphus collaris*, Scop.; *Picus andamanensis*, Blyth; *Edolius malabaricus*, Scop.

After a most delighful sojourn of some hours on the summit of the hill, the lengthening shadows warned us to retrace our steps. But before we reached Ross Island the soft obscurity of evening was fast settling down over land and sea.

"Now nearly fled was sunset's light,
Leaving but so much of its beam
As gave to objects, late so bright
The colouring of a shadowy dream;
And there was still when day had set
A flush that spoke him loth to die—
A last look of his glory yet,
Binding together earth and sky."

ON THE MOLLUSCA OF THE POST-PLIOCENE FORMATION IN ACADIA.

By G. F. Matthew.

[From the Annals of the Belgian Society of Malacology (Société Malacologique de Belgique, Tome IX, 1874.)]

As an introduction to the immediate subject of this paper it may not be out place to give a brief outline of the chief characteristics of the Post-Pliocene Formation in the North-eastern part of North America.

Two writers, eminent both in America and Europe, have given much time to the study of this formation. Dr. J. W. Dawson in his writings on this subject, published in this Journal, and in a synopsis entitled "Notes on the Post-Pliocene of Canada," Montreal, 1872, gave a full account of the beds and of the organic remains which they contain, in the Province of Quebec. Dr. A. S. Packard of Salem, Massachusetts, has also devoted much time to the study of Surface Geology, chiefly that of Labrador, and of the State of Maine; and has published the result of his observations in the Memoirs of the Boston Society of Natural History, vol. I. part II.

While these authors have discussed the phenomena of the Post-Pliocene in the region to the west and north of Acadia, but little attention has been given to this country itself. My object in this paper is to supply this deficiency in part, by mentioning a few facts bearing on the distribution of the Mollusca which the Acadian beds contain; both in relation to the depth of the sea in which they flourished, and their geographical range now, as compared with their distribution in Post-Pliocene times.

The history of this period in North-eastern North America opens with the movement of enormous masses of ice over the face of the country from north to south. At every point where the solid rocks are laid bare, deep and regular striæ or scorings attest the universality and great power of this attritive force. Dr. Dawson holds to the theory that these grooves, and the "Boulder Clay" which lies at the base of the surface deposits, are due to the action of water-borne ice, carried southward by a strong polar current; while Dr. Packard boldly advocates the view that the phenomena are due to the movement of a continental glacier of vast thickness and weight, which descended southward across Canada and New England. So far as my own observations go, it seems to me quite impossible to explain all the phenomena of the Drift or Post-Pliocene period in Acadia upon either of these two theories taken alone: both glacier and ice-berg have had free scope and course here, but to describe fully the results of their presence would swell these preliminary remarks to undue proportions. Suffice it to say that the period opened with the operation of that powerful agent—ice—which gave rise to the drift striæ, and the boulder-clay; and that the marine life of the epoch was extremely scanty.*

The Boulder-clay is universally distributed in Acadia, being found near the tops of the highest hills and throughout the whole extent of the country. It is a deposit which so far as we know is without stratification, and consists of an intimate mixture of sand and clay, in which innumerable *striated* blocks and fragments of stone are imbedded: these stones have been transported southward, and the majority, in the southern part of New Brunswick, may be traced to ledges of old rock not more than ten or fifteen miles north of the places where they are now found.

Throughout a great part of the country the Boulder-clay is overlaid by another deposit which has been denominated "modified drift" from the fact that the materials of which it is made up are derived from the Boulder-clay and have been sorted and rearranged by water. It is well developed in the valley of the St. Lawrence River, where Dr. Dawson divides it into the Leda clay and Saxicava sand. A threefold division of the formation would be more appropriate in Acadia, for in this country the Leda clay is separated from the Boulder-clay by stratified sand and gravel beds, enclosing *smoothed* boulders: in its lower part this arenaceous group has irregular beds of Boulder-clay alternating with the sandy strata; but the mass of it is distinguished from the typical Boulder-clay, by the absence of clay, the roundness and smoothness of the stones, and the well marked stratification. No trace of organic remains has yet been found in this group, and the arrangement of the beds in many places is such as to indicate that they were deposited in waters of considerable

* Dr. Dawson affirms the presence of *Portlandia glacialis* in true "Till" or Boulder Clay on Murray Bay River in the Valley of the St. Lawrence.

depth traversed by a powerful ocean current. It would appear, therefore, that when these beds were deposited the Acadian region was submerged, and that a resistless current from the icy regions of the Pole flowed over it, sweeping the finer parts of the Boulder-clay from the exposed hills and ridges to more profound depths in the ocean, and heaping up the coarser materials into "horsebacks" (escars) "moraine ridges" and mounds, depending for their direction and form upon the position of submerged elevations along the sea-bottom. Similar conditions now prevail in certain parts of the North Atlantic Ocean, where there are wide tracts of the ocean floor covered with sand, having scattered stones and boulders, and which in like manner are swept by strong currents flowing from the Polar regions.

I would suggest for these Acadian beds the name *Syrtensian*, as indicating their composition and the conditions under which they were formed. Dr. Packard has used the same term in a different sense; viz: as a name for the *fauna* of a sub-arctic type which characterizes the fishing banks off the coast of New England.

Beds of the kind I have described above would appear to underlie the Leda clay in the broad plain of the St. Lawrence; for in Dr. Dawson's section of the modified drift at the Glen brick-works near Montreal, he gives a thickness of twenty feet of such beds beneath the Leda clay at that place. A similar sub-stratum to the Leda clay is to be found along the Atlantic coast of the United States as far south as Massachusetts Bay, as appears from the figured sections and text of Dr. Packard's memoir; and it is clear from the writings of Prof. C. H. Hitchcock and others, that this part of the Post-Pliocene is similarly constituted as far south as Long Island Sound.

The Syrtensian beds of Acadia graduate upward into Leda clay when the latter is present. This group consists of finely laminated clay beds with thin partings of sand, near the coast; but among the hills of the interior it is chiefly made up of sand and clay in alternate layers, and in nearly equal proportions. In certain limited tracts away from the coast the group contains only sand beds. Among the hills of the interior, organic remains are but seldom met with in the Leda clay, but on the lower levels near the coast a variety of fossils have been exposed by the wearing of the clay banks along the shores of the Bay of Fundy, and in cuttings along lines of railway. Among these may be mentioned bones of a seal and a whale, teeth of a large mammal, various crustaceans, echinoids, worms, corals and sea weeds, besides the molluscs which it is my purpose now to describe.

In the following list I have noted the bathymetric and geographical range of most of the species named, and added further remarks upon any peculiarities which seemed worthy of mention. The zones of depth referred to in this catalogue are *Littoral*—the space between high and low water marks; *Laminarian*—from low water to a depth of fifteen fathoms; *Coralline*—the depth from fifteen to fifty fathoms. For the vertical range of species given in this paper I am in most cases indebted to Dr. Stimpson's catalogue, "Shells of New England." The Bay Chaleur shells were collected by Mr. Robt. Chalmers.

The localities indicated by letters are—R. C., River Charlo, B. P., Black Point, R. B., River Benjamin, T. R., Tatagouche River—all on Bay Chaleur; St. A., St. Andrews and Oak Bay, St. G., St. George, St. J., St. John, in the Bay of Fundy.

Neptunea tornata, Gould.—Recent, Arctic seas to the Gulf of St. Lawrence.—Fossil R. C., R. B., St. A. Not common either in the Bay Chaleur or Bay of Fundy deposits. Another species of this genus *N. decemcostata*, which though now living on the coast has a more southerly range than *N. tornata*, has not been found in the Leda clay further north than Brunswick, Maine.

Sipho Kroyeri, Möller.—Recent, Arctic seas to Gulf of St. Lawrence.—Fossil, R. C., B. P., St. A.? Rare in these places.

Buccinum undatum, Linn.—Recent, Greenland to Massachusetts Bay.—Laminarian to Coralline.—Fossil, R.C., R. B., St. J., St. A. In the deposits on the Bay of Fundy this species is much more common than the succeeding *buccina*; but on Bay Chaleur shells of the other species are equally numerous.

B. tenue, Gray.—Recent, Arctic seas to the Gulf of St. Lawrence.—Fossil, B. P., R. C., St. J. Much less abundant than *B. undatum*.

B. glaciale, Linn.—Recent, Greenland to Gulf of St. Lawrence.—Fossil, B. P. Rather scarce.

B. Gröenlandicum, Chemn?—Recent, Greenland.—Fossil, T. R. I am not sure that this species is correctly referred, the specimen (sent to me by Rev. C. H. Paisley) is more ventricose than that figured by Dr. Dawson; the upper part of the whorls is also less tumid.

B. Donovani, Gray.—Recent, Newfoundland and northern seas.—Fossil, B. P. Rare. A single shell with the characteristic ridge on the lower whorl.

Lacuna neritoidea, Gould.—Recent, Nova Scotia to Long Island Sound.—Littoral to Laminarian.—Fossil St. J. Rare. I mention this species on the authority of Dr. A. S. Packard.

Lunatia heros, Say.—Recent, Labrador to Long Island Sound, but scarce to the South of Cape Cod—Littoral.—Fossil, R. C. Two small insymmetrical individuals shewing the result of dwarfing like a shell of the same species collected at Quebec by Dr. Dawson.

L. heros, Say? var. *Chalmersi*. A specimen from Benjamin River received from Mr. Chalmers. If of the species *L. heros*, it is a strongly marked variety. It is proportionately much higher than the typical form; the whorls are more tumid, and the spire more elevated; the lower part of the pillar lip, which in *L. heros* is thin below the umbilical opening, is in this specimen thickened and rounded; the umbilical opening is smaller than in Say's shell, and there is a strong ridge on the upper margin of the last whorl, next the suture. The length of the spire in specimens of *L. heros* collected in the Bay of Fundy, when compared with that of the aperture is as 1 to 4½ or 5; but in some from Mingen River on the south coast of Labrador the proportion is 1 to 3⅝: and as the ratio in Mr. Chalmers shell is 1 to 2⅓ it is probably a high northern variety of this species. Length 1⅝ inch, breadth 1¼ inch.

Natica affinis, Gmelin (*clausa* B. & Sow.)—Recent, Greenland to Massachusett's Bay.—Corralline zone.—Fossil, R. C., R. B., T. R., St. J., St. A. Common in Bay of Fundy deposits, but more plentiful in those of Bay Chaleur.

Bela turricula, Montagu.—Recent, Gulf of St. Lawrence to Massachusett's Bay.—Coralline.—Fossil, R. C., B. P. Rather small and not common.

Bela harpularia, Couthouy.—Recent, range as in the last species.—Laminarian to Coralline.—Fossil, same localities as last. Infrequent.

Pecten Islandicus, Chemnitz.—Recent, Greenland to Long Island Sound.—Laminarian to Deep Sea Coralline.—Fossil, St. John. Plentiful at one locality.

Pecten tenuicostus, Mighels, (*Magellanicus*, Lam.)—Recent, Labrador to Massachusett's Bay.—Laminarian to Coralline.—Fossil, St. John. Rare.

Pecten tenuicostatus var. ? A shell resembling this species in form and sculpture occurs at St. John. It is thicker than the ordinary form of the species and has fainter striæ.

Yoldia sapotilla, Gould.—Recent, Labrador to Long Island Sound.—Coralline—Fossil, a single valve at Black Point. This is not the variety of *Y. limatula* Say, reported by Dr. Dawson from the clays of Rivière du Loup, for it agrees in all respects with *Y. sapotilla*, and has hinge teeth which are excavated on their outer side.

Portlandia glacialis, Gray (*Leda truncata*, Brown).—Recent, Arctic seas.—Fossil, R. C., R. B., T. R., St. J., St. A. This is the most abundant shell in the great mass of the Leda clay along the shores of the Bay of Fundy, but is infrequent in the deposits on the south side of Bay Chaleur. The abundance of this shell in the clays of the St. Lawrence Valley led Dr. Dawson to denominate those beds "Leda clay." *P. glacialis* becomes dwarfed and scarce where the deposit called the Leda clay is sandy.

Leda minuta, Fabricius.—Recent, Greenland to Nova Scotia —Coralline.—Fossil, B. P. and St. J. Rare. Our specimens are shorter and more pouched than those collected at Rivière du Loup by Dr. Dawson. The shells from Bay Chaleur are of the variety *complanata*.

Leda pernula, Muller.—Recent, Arctic seas to Long Island Sound—Coralline.—Fossil, R. C., B. P., T. R., St. G., St. A. —The varieties *tenuisulcata* and *buccata* are common at the localities on Bay Chaleur; but both there and on the Bay of Fundy the former is the more common shell; while in speci mens from Rivière du Loup var. *buccata* prevails.

Nucula tenuis, Montagu.—Recent, Greenland to Casco Bay, Maine.—Coralline.—Fossil, common on Bay Chaleur at the localities named. Not yet found on the Bay of Fundy.

Nucula expansa, Reeve.—Recent, Arctic seas to the Gulf of St. Lawrence. Common at St. John with *Portlandia glacialis*, and occurs at St. George and St. Andrews. Only one valve from Bay Chaleur (Jacquet R.)

Modiolaria discors, Linn. ?—Recent, Labrador to Massachusett's Bay.—Laminarian.—Fossil at Black Point, one valve; too imperfect to determine the species but resembles this one in form.

Mytilus edulis, Linn.—Recent, Greenland to Long Island Sound —Littoral.—Fossil, R. C., R. B., St. J., St. A. Common in upper beds of the Leda clay at St. John; and is plentiful on Bay Chaleur where var. *elegans* is common.

Cryptodon——sp. ?—Fossil St. John. Rare. Specimens of a Cryptodon quite different from *C. Gouldii*, Phil., are to be found occasionally in the starfish beds of Duck Cove: it is near *C. flexuosus* of the British seas, but differs in being more tumid, especially toward the beaks, and these are more sharply curved at the points than those of the British species named. The furrow extending from the beak toward the posterior margin of our shell is much narrower than in *C. flexuosus*; and the ridge dividing it from the ligamental border is correspondingly narrowed and sharpened. There is a faint ridge descending from the beak to the base of the anterior border, and between it and the lunule, the concentric wrinkles of the epidermis are stronger. Shell thin and fragile. Epidermis pale yellowish brown.

Kellia suborbicularis, Montagu.—Recent, N. Europe, (Nova Scotia and Massachusett's Bay, Gould.) Fossil at Black Point. Rare. A small shell, which agrees with the figure and description of this species in Gould's Invertebrata of Massachusetts.

Serripes Gröenlandica, Chemnitz.—Recent, Greenland to Massachusett's Bay.—Coralline.—Fossil R. C., R. B., T. R., St. J., St. A. Recent individuals from Mingen River, Labrador, are double the size of our largest shells from the Post-Pliocene. Shells from the clays of the Bay of Fundy are thin and fragile.

Cardium pinnulatum, Conrad.—Recent, Gulf of St. Lawrence to Long Island Sound.—Laminarian.—Fossil, St. J., St. G. Rather plentiful in a few places. These shells, especially the larger ones, are more angulated than the recent individuals from Massachusett's Bay figured by Dr. Gould.

Astarte arctica, Möller, var. *lactea* ?—Recent, Greenland to Casco Bay, Maine.—Fossil at St. Andrews where it is infrequent. This is the largest of our Astartes; it is wider than *A. semisulcata*, Gray, and possesses a beak which is nearer the anterior margin and more acute.

Astarte compressa, Linn.—Recent, Greenland to Labrador.—Fossil at St. Andrews. Infrequent. This is intermediate in form between the last and the following species; it is a deeper, higher and thinner shell than *A. lactea*.

Astarte Banksii, Leach.—Recent, Greenland to Nova Scotia.—Fossil at St. John. This species has more prominent beaks than the last, and the anterior border is arched inward more deeply at the lunule.

Spisula solidissima, Chemnitz ? var. *Acadica*.* Recent, Labrador to Long Island Sound.—Littoral to Laminarian.—This form is from the higher clay beds at St. John ; and in ponderosity, form of the cartilage pit, position of the beaks, and shortness of the lateral teeth, approaches the European *S. solida*. It may be an arctic variety of *S. solidissima*. Height 1⅜, length 1⅝.

Macoma fusca, Say, var. *Gröenlandica*.—Recent, Greenland to the Bay of Fundy.—Littoral, the variety Laminarian (to Coralline ?) Fossil, R. C., B. P., T. R., St. J., St. A. A small rough variety abounds at Lawlor's Lake near St. John, in a bed which appears to belong to the Saxicava sand, but a larger and smoother form is the most abundant at Bay Chaleur; the latter recalls *M. solidula* of Europe, but is distinct. *M. Gröenlandica* still lives in the deeper waters of the Bay of Fundy, and in the sand-flats along its shores *M. fusca* abounds.

Macoma calcaria, Chemnitz.—Recent, Greenland to the Bay of Fundy.—Coralline.—Fossil, same localities as the last species, but while that (on the Bay of Fundy at least) is confined to the Saxicava sand and upper part of the Leda clay, this one ranges through the whole of the latter deposit.

Pandora (Kennerlia) glacialis, Leach.—Recent, Arctic seas to the Gulf of St. Lawrence.—Fossil at St. John. Frequent in the starfish beds at Duck Cove. It was first referred to *P. trilineata*, Say., from which Dr. Dawson says it is quite distinct.

Lyonsia arenosa, Möller.—Recent, Greenland to Nova Scotia.—Fossil with the last species.

Lyonsia Norvegica ?—Recent, Arctic seas.—Fossil with the last two species, and more common than *Pandora glacialis*. From *Lyonsia hyalina*, Conrad., this shell differs in being more ventricose, somewhat higher, and in having no radiating furrows, though in some individuals there are obscure radiating lines. I have not seen *P. Norvegica* and therefore am not sure of the identity of our shell with it.

* N.B. I find that this shell agrees very closely with specimens of *S. truncata*, Mont. received from England, and differs chiefly in the shortness of the lateral teeth and in having a more oval outline. It may be an exotic.

Mya truncata, Linn., and variety *Uddevallensis.*—Recent. Greenland to Massachusett's Bay.—Littoral to Coralline.—Fossil, R. C., B. P., St. J., St. A. Frequent. The long form occurs in the clays at St. John, but the variety is more prevalent.

Mya arenaria, Linn. and var. *acuta.*—Recent, Greenland to Long Island Sound.—Littoral.—Fossil, R.C., B.P., T. R., St.J., St. A. I have found this species only in the Saxicava sand. It is now one of the most abundant molluscs on our coast. The variety which is probably Say's *Mya acuta*, is distinguished by being markedly ovate in form : it is inflated and expanded in front, and the posterior slope from the hinge is much straighter than in the typical form. The variety is by far the most abundant shell in the Bay Chaleur clays, but the Myas of the St. John beds are of the ordinary form. It may therefore be conjectured that the var. *acuta* is of northern origin.

Saxicava rugosa, Linn., and var. *arctica.*—Recent, Greenland to Long Island Sound.—Littoral to Coralline.—Fossil, R.C., B. P., T. R., St. J., St. A. This very variable species is more abundant in the deposits of the St. Lawrence Valley and Bay Chaleur, than in those of the Bay of Fundy. In going south from the St. Lawrence R. the more regular forms, such as *S. rugosa* and *S. pholadis*, increase in number, and the distorted varieties *S. arctica, S. rhomboides* and *S. hiatella* decrease. For instance in a collection made at Rivière du Loup, for which I am indebted to Dr. Dawson, I find all but two are distorted forms; in Mr. Chalmer's collection from Bay Chaleur the irregular ones still predominate, and two-thirds of the shells would fall into the varieties *arctica*, &c.; but in the shells collected from the Bay of Fundy clays, this proportion of distorted to regular forms is reversed ; at St. Andrews one third only are of arctic types ; and of those collected at St. John, only one-fifth. In the specimens of this species sent to me by Dr. Packard from Brunswick, Maine, all the shells are regular, but one has the beak at the anterior fourth of the valve.

Lepralia hyalina, Johnston, Leda clay, St. John.

Membranopora pilosa, Johnston, Leda clay, St. John.

Cellepora pumicosa, Ellis, Leda clay, St. John.

In this list there are more than thirty species of mollusca, a number large enough to enable us to draw inferences, imperfect though they may be, regarding the depth of the sea in which these creatures lived. As I have not visited the Bay Chaleur and am not informed of the exact horizon in the Post-Pliocene deposit of that district, from which the shells recorded in the above catalogue were taken, I am unable to say whether there is a regular gradation from deep water forms in the lower beds to littoral species in the higher, as in the Bay ot Fundy, or not: and it will be possible to speak only in general terms of their bearing on the question of the depth and temperature of the sea on the northern confines of Acadia during Post Pliocene time. In the clay-beds of the Bay of Fundy with which I am more familiar, there are proofs of a progressive shoaling of the ocean along this coast during the period named. The lowest beds are a compact clay, which is either red or grey, according as it is derived from the red rocks of the Carboniferous area, or the grey slates, &c., of the region west of it. This compact clay contains very few organic remains, and these are chiefly shells of *Portlandia glacialis.* At St.John it graduates into fine dark colored clay which varies in tint from dark grey and liver-brown nearly to black, according to the amount of organic matter disseminated through it; and here the shells of *Portlandia glacialis* abound. This portion of the clay contains beds of black sand from one to three inches thick, holding *Ophioglypha Sarsii*, *Pandora glacialis*, *Lyonsia Norvegica?* *L. arenosa*, *Cryptodon* sp.? and other shells, none of which indicate a less depth of water than that of the Coralline zone. These dark beds are in turn overlaid by other red clays which differ from the lower red clays in being of a browner hue and having numerous intercalated beds of brown or grey sand; these clay beds while they contain *Balanus crenatus*, *Portlandia glacialis*, *Nucula expansa*, &c. of the lower horizon, have in addition such species as *Buccinum undatum*, *B. tenue*, *Mya truncata*, *Macoma calcaria*, *Saxicava rugosa.* A somewhat shallower sea is indicated by the occurrence, at St. John, of clay beds holding *Mytilus edulis* and *Cardium pinnulatum:* while a still further withdrawal of the ocean is shown by the contents of the sand beds which cover these clays; these appear to be the equivalent of the Saxicava sand for they contain shells of *Mya arenaria* and *Macoma fusca.*

While the change from deep-water forms to those of the immediate sea-shore, gives clear proof of the progressive shoaling of the Post-Pliocene sea in this region, it does not show whether this change was a gradual one, or was brought about by sudden and repeated elevations of the land. The mode by which the shoaling of the Post-Pliocene sea was effected is explained, however, by the existence of terraces at several levels on the land near the coast. The change of level was, it would seem, accompanied by rapid elevations, separated by intervals of rest, and the amount of these periodic changes of level can (with certain allowances for the peculiar tidal phenomena of the Bay of Fundy) be estimated with an approach to accuracy. Any indentation of the shore line along the coast where sediment could accumulate subject to the wash of the waves, would have sand flats extending to the lowest limit of tide, and in the Bay of Fundy, where the rise and fall of the tides is very great, such flats would have a slope seaward of twenty or thirty feet: if such a plain were lifted above the sea level and terraced by the action of the waves, the resulting terrace would vary between the limits indicated. This is found to be the case near St. John, where the first terrace rises to the height of fifteen feet above the sea. The next, which is much more conspicuous, varies from forty to sixty feet; and can be seen to be composed of the three subdivisions of the modified drift; viz. Syrtensian beds, Leda clay and Saxicava sand. A third terrace begins at the height of about 100 feet and extends to 120 feet. The surface layers on this terrace are coarser than those of the last and consist of stratified gravel and sand. Another terrace of similar material was observed at a height of 150 feet, and a fifth at 300 feet. Terraces at this height are very gravelly, quite irregular, and cannot always be distinguished from Syrtensian ridges. As those ancient sea-borders are a memento of the rise of the land in Post-Pliocene times, so the composition of the Leda clay in the Southern Highlands of New Brunswick, furnishes a criterion whereby one can judge of the depth of the sea during the whole period occupied in its deposition. In these hills many of the valleys are cut down nearly or quite to the sea level; and while they are partly filled with modified drift, the neighboring hills are covered to a greater or less degree with Boulder-clay. Leda clay forms a notable part of the modified drift in these valleys, and rises up on their slopes to a height of 200 feet or more. Very instructive sections of these deposits on the east-side of the Nerepis and Douglas valleys in Queen's County were made in grading the track of the E. and N. A. Railway: here, where several small streams come off the hills on the western side of the valley, the whole thickness of the "Leda clay," where these streams cross the railway track, presents a succession of *sand beds*; but in tracing these beds in the cuttings along the track of the Railway north or south from the channels of the brooks the sand becomes more and more interlaminated with clayey layer until at length the deposit resumes its normal aspect. It thus appears that when the Leda clay of these valleys was laid down, the tops of the neighboring hills were above water, and as the current from the brooks was sufficient to drive off all the muddy sediment in the waters of the Leda clay sea, at their mouths, the depth of the sea above its present level could not have greatly exceeded 200 feet.* The structure and composition of the beds laid down at this period among the southern hills corroborates the result of an examination of the vertical range in the species of shells which the corresponding deposit at the coast contains.

Another fact revealed by the examination of these fossils which bears upon the probable depth of the Leda-clay sea is the indication given by the localities of the fossils enumerated in the preceeding list, of a geographical division into two groups, in one of which the species have a more arctic range than the other. Thus on the Bay Chaleur a number of arctic *Buccina* occur of which only one, *B. tenue*, has been recognised in the Bay of Fundy; and while *Nucula tenuis* abounds at Bay Chaleur it has not been found in the clays of the Bay of Fundy, where its place is supplied by *N. expansa.* On the other hand several species of the present Acadian marine fauna, such as *Lacuna neritoidea*, *Cardium pinnulatum*, and *Pecten tenuicostatus* occur in the Post-Pliocene of the Bay of Fundy, but have not been found in a fossil state on the Bay Chaleur, though now they are plentiful in its waters. This marked contrast in the grouping of the Post-Pliocene shells of these two bays, cannot be accounted for by differences of latitude alone, but seems rather to have been caused by the existence of a barrier to the free intermingling of the waters of the Bay of Fundy with those of the Gulf of St. Lawrence—a barrier such as would still exist were the intervening country depressed to a depth not exceeding one hundred and fifty, or two hundred feet.

* I have other facts bearing upon this point which will be presented in a future article.

These considerations relate chiefly to the depth of the sea in which the more highly fossiliferous part of the Leda clay was deposited, but other considerations indicate that the higher parts of the Leda clay were formed in shallower waters. I have mentioned on a preceding page that the dark colored clays abounding with organic matter, and containing shells which indicate the depth of water above named, are overlaid at St. John by reddish clay with sandy layers. Just above the "Falls" of the St. John River in Fairville these upper clays may be seen to rest upon eroded beds of dark clay, and at other points they rest directly upon the tough red clays. This group of beds, which contains fossil shells of the Laminarian zone, appears to have been laid down when the land had risen to within one hundred feet of its present level, and may be denominated the Upper Leda clay. It, together with all the older portion of the clay deposit, suffered denudation preparatory to the deposition of the Saxicava sand, a group consisting of grey, buff and brown sand, occasionally capped or underlaid by gravel beds; and which from the occurrence in it of littoral species only may be regarded as a tidal deposit.

[To bring all the known facts relative to the Post-Pliocene deposits in this region into harmony, it appears necessary to assume that at the beginning of this age, Acadia and the neighboring portions of the American continent were elevated to a height of several thousand feet above the sea, and that the extensive plateau thus formed was bordered on the south by deep oceanic waters. Such a change in the relations of sea and land (accompanied perhaps by similar movements under other meridians in the Northern Hemisphere) would lead to the formation of a *glacier zone* across New England and Canada, facing a sea open to the influx of heated waters from the equatorial regions. As glaciers formed in this way would receive accessions to their mass on the southern side only, they would bear with immense weight upon the coast line, and (supposing that the earth's crust possesses a certain amount of plasticity) would have a tendency to depress it beneath the sea, causing at the same time a corresponding elevation of the interior region. As the coast-line sank from this cause, the *glacier-zone* would gradually travel northward, seeking the rising land, and in the deep waters in front of its southern margin, mud and stones swept off the land by the moving ice, would be deposited. Such a deposit would resemble the Boulder-clay, and might contain the remains of a few organisms capable of withstanding the extreme temperature of an icy sea. The neighboring land would for a time protect this deposit from the action of arctic currents, but as the gradual retrocession of the coastline to the north continued, the polar current would begin to act upon the sea-bottom, and sweep off the finer materials to greater depths in the ocean: deposits formed under these circumstances would resemble the Syrtensian beds.

From the recession of the glacier zone to the north a further result would follow: the land relieved from the pressure would rise again; submerged ridges would come near the surface of the ocean and shut off the polar current; and in the quiet seas and shallow, sheltered sounds and bays thus made, deposition of fine sediment like the Leda clay would proceed. As a final step in the process of re-elevation the sea bottom would reach the tide level, and sand banks and flats of material like those of the Saxicava sand would be formed.]

Following this interpretation of the phenomena of the Post-Pliocene period in Acadia (especially for the Bay of Fundy shores) the history of its marine life would be in brief as follows:

Original Drift.

Boulder-clay.—Depression of the present land beneath the ocean about 2000 to 1000 feet—Life meagre and entirly of arctic forms.

Modified Drift.

Syrtensian beds.—Depression about 1000 to 500 feet. Present coast line in the Deep-sea-coralline zone. Life probably sparce. Strong ocean currents.

Lower Leda Clay.—Depression for the tough (lower) clay 500 to 200 feet: for the dark (upper) clay 100 to 200 feet. Present coast line in the Coralline zone. Life in the older beds a few deep water species; in the newer an abundance of marine life.

Upper Leda Clay.—Depression 100 to 60 feet. Present coast line in the Laminarian zone. Life, fossils less abundant than in the last; the waters subject to greater disturbance.

Saxicava Sand.—Depression 40 (or less) to 60 feet. Present coast line in the Littoral zone. Life, molluscs all of shore-loving species.

Report on the Geology and Resources of the Region in the Vicinity of the Forty-Ninth Parallel, from the Lake of the Woods to the Rocky Mountains. By George Mercer Dawson, Assoc. R.S.M., F.G.S., Geologist and Botanist to the Commission; addressed to Major D. R. Cameron, R. A., Commissioner. Large 8vo., pp. 379, with numerous maps and illustrations.

In this volume Mr. Dawson has given us in a very clear and thorough manner the result of his explorations while acting in the capacity of geologist and botanist to the Boundary Commission. We have not space in this number for lengthy extracts, but the following from the prefatory note addressed by Mr. Dawson to the Commissioner will serve to give an idea of the character and scope of the work:—

"In undertaking single-handed the care of Natural History work in connection with the Boundary Commission, it was obvious that in attempting too much it might happen that nothing should be well done. I therefore decided to give the first place to geology; and in that field to endeavour to work out as far as possible the structure of the country, and to make illustrative collections of rocks and fossils, rather than to amass large local collections at the expense of general information. Such time as could be spared from the geological investigations has been devoted to collection and work in other departments; and in this Report the results are presented, elaborated in so far as the time at my disposal would allow, and supplemented also by several valuable notices of the collections in special departments, by gentlemen whose names are elsewhere stated.

"The field work, in extent, has directly covered a region, stretching from the Lake of the Woods, on the east, to the Rocky Mountains on the west, and lying in the vicinity of the forty-ninth parallel, which here forms the International Boundary. In time it has extended over two seasons, those of 1873-74. Owing to the vastness of the region covered by the operations of the survey, much of the period actually spent in the field has been necessarily employed in more or less arduous, and often almost continuous travel. * * * * * *

"The main geological result arrived at is the examination and description of a section over 800 miles in length across the central region of the continent, on a parallel of latitude which has heretofore been geologically touched upon at a few points only, and in the vicinity of which a space of over 3'0 miles in longitude has—till the operations of the present expedition—remained even geographically unknown.

"In working up the geological material, I have found it necessary to make myself familiar with the geological literature, not only of the interior region of British America, but with that of the western portion of the United States to the south, where extensive and accurate geological surveys have been carried on. It has been my aim to make the region near the boundary line as much as possible a link of connection between the more or less isolated previous surveys, and to collect by quotation or reference, the facts bearing on it from either side. In this way it has been attempted to make the forty-ninth parallel a geological base-line with which future investigations may be connected. The matter contained in the special preliminary report on the Lignite Tertiary formation, published last year, has in this final report been included, in so far as necessary to complete the general section on the line."

PUBLISHER'S NOTICE.

COMMENCING with Volume Seven, the Natural History Society of Montreal has arranged to give to each of its Annual Subscribers a copy of the 'Canadian Naturalist' without additional charge.

The Magazine is issued four times a-year as before, but the parts consist of 60 pages only. The volume of 480 pages will thus spread over two years, and as the former price of three dollars has been retained, it is now quoted "per volume" instead of "per annum." Those who are not members of the Society will thus obtain the Magazine at precisely the same price as heretofore, viz. three dollars for 480 pages.

☞ The Editor of this Journal is responsible only for such communications as bear his name or initials.

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