FIG. 10.—*S. Abdenensis*, R. Eth., jun.; left valve, twice nat. size. Same locality.
„ 11.— „ „ „ „ valves partially united along the hinge-line. Same locality.
„ 12.—*Capulus neritoides*, Phill., var. *Simpsoni*, R. Eth., jun.; nat. size side view. L. Carb. Limestone Group, Magazine Quarry, Pathhead, Haddingtonshire. Cabinet of Mr. J. Simpson, Edinburgh.
„ 13.—The same; nat. size, dorsal view.
„ 14.— „ „ view of aperture.
„ 15.—*Orthoceras Brownianum*, R. Eth., jun.; natural size. L. Carboniferous, Ardross, Fife. Cabinet of Rev. T. Brown, Edinburgh. Fig. 15*b*, section enlarged.

II.—ON THE ROCKS OF NEWFOUNDLAND.

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With Notes by ALEXANDER MURRAY, F.G.S., of the Geological Survey of Canada, St. John's, Newfoundland.

WHEN we speak of Newfoundland, we speak of England's oldest and yet almost unknown Colony. When we look at its rocks, we shall find that they also are old, and from the metamorphisms and contortions they have suffered are almost unrecognizable. The first geologist who journeyed round the rugged shores which gird the island, and across the marshes and thickets which cover its interior, was the indefatigable Jukes. For two years he laboured hard, and after many dreary tramps up river-courses, across swamps, and round impenetrable scrub, to the shores of quiet inland rocky lakes, he returned without finding a fossil. The next to prosecute research was Richardson, of the Canadian Survey, who fixed a basis of connexion between the geology of the Island and that of the mainland. He was immediately succeeded by Alexander Murray, a veteran geologist, who, in connexion with Sir William Logan, will always be remembered as the earliest worker who successfully unravelled the tangled knots of the Laurentian system. Mr. Murray has been ten years engaged upon this Survey, and has now placed before us a geological map of the greater part of an island about which we previously did not even know the general topographical details, although it was our oldest Colonial possession.

The formations which have been hitherto recognized are shown in juxtaposition with their English and American equivalents in the table on the next page (p. 252).

A mere glance at this table will show the antiquated rocks with which we have to deal, and suggest a picture of all that is weather-worn and grey with age. A distinguished English geologist, Prof. Judd, after inquiring about the age of the rocks in Newfoundland,

[1] The information contained in the following paper was obtained whilst travelling round and through the island of Newfoundland during the years 1873 and 1874. I visited nearly every bay and cove, and made many journeys into the almost unknown interior whilst twice going round the island. Many specimens, both of rocks and fossils, were collected.

Although I had every opportunity of seeing the island, I must acknowledge the large proportion of material extracted from the early numbers of Mr. Murray's official reports. I also thank Mr. Thomas Davies, F.G.S., of the British Museum, for the microscopic determination of many rocks.—J. M.

[*Table referred to on p.* 251.]

North America.	Great Britain.	Newfoundland.
Lower Laurentian	Laurentian	L. Laurentian.
Upper Laurentian		U. Laurentian.
Huronian	*Cambrian* ?	Huronian.
St. John's Group	Lingula Flags	Primordial Silurian.
Paradoxides Slates		
Lower Potsdam		
Upper Potsdam	Tremadoc Slates	Potsdam.
Lower Calciferous		
Upper Calciferous		Calciferous.
Quebec Group: Levis	Llandeilo Beds	Quebec Group: Levis.
Quebec Group: Lauzon		Quebec Group: Lauzon.
Quebec Group: Sillery		Quebec Group: Sillery.
Quebec Group: Chazy		
Trenton and Bird's Eye Limestones	Caradoc Beds	Bird's Eye Limestone.
Utica Slate		
Hudson River Beds		
Oneida Conglomerate	L. Llandovery Rocks	M. Silurian.
Medina Sandstone		
Clinton Group	U. Llandovery	Clinton.
Niagara Group	Wenlock.	*Niagara* ?
Onondago Group		
Lower Helderberg		
L. Devonian. Oriskany Sandstone	L. Devonian	*Devonian* ?
L. Devonian. Caudagalli Grit		
L. Devonian. Schoharrie Grit		
L. Devonian. Gaspe Sandstone		Gaspe Sandstones.
Mid. Devonian or Upper Helderberg	M. Devonian	
U. Devonian, Portage Group, etc.	U. Devonian	
Lower Carboniferous (Gypsiferous)		L. Carboniferous.
Middle Carboniferous (good coal)	Carboniferous	Millstone Grit.
Upper Carboniferous		

and hearing that the newest were Lower Carboniferous, almost shuddered, and wondered how it was possible to live in such a country.[1]

Laurentian.—Commencing with the lowest member of the series, we have a large exposure of crystalline rocks, which have been identified as being of Laurentian age. This identification is based on the relations they hold to the Lower Silurian rocks which they underlie, and on the lithological resemblances they have to the Laurentian rocks of Labrador and Canada. The limestone bands which belong to the Continental exposures of this series have not yet been found; neither have any traces of organic remains.[2] Both

[1] I cannot see upon what grounds Prof. Judd founds this remark. The valley of the Great St. Lawrence, including the magnificent champaign regions of Western Canada, now called Ontario, is based upon Silurian rocks for the greater part, the highest formation being of Devonian age; the beautiful valley of Strathearn, in Perthshire, is upon Old Red Sandstone; the valley of the Forth, Stirlingshire, is Carboniferous; and a great part of Herefordshire, Monmouth, etc., is Lower Silurian. It seems to me, that the capabilities of a country, for the support of life, depend, not upon their actual position in the geological sequence; but upon the constituents of which they are composed, and the mineral character of the debris which is yielded by their ruins, and spread over the surface; and also in great measure to the degree of metamorphism and disturbance by which they have been affected.—A.M.

[2] The crystalline limestone bands of Lower Laurentian age, so well known in Canada, have not been seen *in place*, in Newfoundland; but I have reason to think they

in the Northern, Southern, and Central parts of the island we have a great display of these rocks, consisting of granite, syenites, gneiss, etc., together with many igneous dykes, some of which are of considerable breadth. From several of these dykes I collected specimens. One of these from Harbour Deep averages at least 25 yards in width. It cuts through a hornblendic gneiss which is traversed by many small veins of quartz, associated with which are small specks of copper pyrites, especially in the vicinity of the dyke. The rock of which the dyke is composed is a melaphyre of a bluish-green to a black colour, and has a splintery fracture. A specimen from one side of the dyke shows some calcite and a little quartz; a specimen from the opposite side is more compact, and is almost an aphanite. Specimens taken from the inner parts of the dyke were not so compact as those from the exterior, and were of a greyer colour. Crystals of a plagioclase felspar, magnetite, and also a considerable amount of apatite, which latter was not seen in the exterior portion of the dyke, are easily recognized. On going to another portion of the dyke, three-quarters of a mile to the south, and taking a similar series of specimens across its breadth, I found that the exterior portions of the dyke had a more slaty character, and the central part, although it still contained the apatite, also contained quartz, which had not been before observed. This particular dyke therefore illustrates that not only may there be differences at different points across the breadth of a dyke, a result which has often before been observed, but also that we may meet with differences as we work along their length.

In the vicinity of St. George's Bay there is a series of labradorite rocks which Mr. Murray has recognized as belonging to the Upper Laurentian. I have also seen specimens of labradorite from High Point, River Exploits, but I do not know how it occurs.[1]

Intermediate Series.[2]—The first series we meet with above the Laurentian is a series which is supposed to be the equivalent of the Cambrian and Huronian, to which it has a great lithological re-

exist to a partial extent in the valley of the great Cordroy River. About thirty miles up that valley I found large angular fragments of white crystalline limestone, with graphite, which exactly resembled the Canadian rocks; and in front of the position they were supposed to occupy the hills are composed of labradorite, which I assume to be of Upper Laurentian age.—A.M.

[1] These are in erratic blocks, more or less water-worn; their source is not known.—A.M.

[2] I object to the term Cambrian, as applied to Huronian, and I introduced the name *Intermediate*, because the system is undoubtedly *intermediate* between the Laurentian and the lowest beds of Primordial strata, holding *Paradoxides*, *Agraulus*, *Archæocyathus*, *Iphidea*, *Agnostus*, *Conocephalites*, *Obolella*, and many other forms typical of the lowest Palæozoic fauna. I have shown that the *Intermediate* or *Huronian* system, must have been worn through by denudation to the very base, previous to the deposition of the beds holding the above-named fauna; as we find them occurring nearly undisturbed overlapping the Laurentian and lower beds of the Huronian. I pointed my evidences out to my old friend and colleague, Sir William Logan, on the ground, who was immediately convinced of the accuracy of my observations. I have also shown that there are some striking lithological resemblances between the *Intermediate* of Newfoundland and the typical Huronian of Canada.—A.M.

semblance. It has been called by Mr. Murray the Intermediate Series. These beds are in the main made up of dark-coloured slates,[1] some of which are fine-grained and cherty, red and grey conglomerates, and various sandstones. There are also some igneous rocks like diorite, quartzite and jaspery bands intercalated in the series.

Considering that there is good reason for believing that these strata are of Huronian age. they are remarkable as containing fossils.[2] The fossils are *Aspidella terranovica*, together with traces of organisms like *Arenicolites*.

At many points in this Huronian Series, which has a great resemblance to the Gold-bearing Series of Nova Scotia, traces of metallic ores have been found. Thus on Terra Nova River an opening has been made on a quartz lode containing copper pyrites, coursing through a chloritic and calcareous rock. A more successful undertaking is, however, to be seen at the La Manche Mine.[3] The ore worked is galena, which is associated with blende, barytes, quartz, amethyst, and calcite, the latter forming the chief portion of the gangue. One side of the lode is bounded by greenstone, or more truly an amygdaloidal melaphyre, in the ground mass of which there is a large quantity of acicular needles of apatite. On the opposite side of the lode we have the black slates of the country, but so hardened that they have the appearance of a siliceous rock.

Primordial Silurian.[4]—Lying unconformably above the Huronian rocks, and distinguished from them by their fossil contents, we have a series of rocks identified by Mr. Murray as the Primordial Silurian,

[1] The type of the system in Newfoundland is in the peninsula of Avalon, where it occupies an enormous area. There are, besides the clay-slates spoken of here, a great mass of pale-green felsite slates, which weather of a dingy whitish colour, with occasional alternating beds of red slate. I have remarked that, except as intersecting veins, lime is very scarce throughout the series as seen in Avalon, and mica almost or altogether absent.—A.M.

[2] The *Aspidella terranovica* and *Arenicolites* are found in the clay-slates, which are pretty high up in the series. They pass immediately below the sandstones and conglomerates of Signal Hill, which appear to be at the summit.—A.M.

[3] Beautiful hand specimens of various ores of copper have been produced from many parts of the distribution, chiefly from quartz veins; but the extent and quantity of the ore, in no case I have ever known, seemed sufficient to warrant the requisite outlay for opening up a mine. Lead occurs in many localities, usually in calcareous veins. The occurrence so frequently of veins of calcite, in a non-calcareous rock, has induced me to speculate on their derivation; which I conceive possibly may have been from infiltration into the fissures of the older rock, from the calcareous overlying Primordial group, now denuded.

[4] I have a very good collection of these fossils from many parts of the island. The formations are distributed in patches; one of the best developments being in Conception Bay, where the relations to the Laurentian and Huronian are most distinctly exhibited. There are also fine developments in Trinity Bay, in St. Mary's Bay, in Placentia Bay, in Fortune Bay, and on the island of Miguelon, from all which places I have made large collections of fossils. The series is recognized in Bonavista Bay, but not so well developed as at the places named above, and I have not hitherto been able to procure any organic remains from them. The base of the series is usually a conglomerate, passing upwards into a reddish sandstone, over which are a set of slates, which are admirably adapted for roofing slates. Mr. Milne's description applies especially to this latter locality.—A.M.

lying as they do at the very base of the Silurian. My last opportunity of seeing these rocks was whilst coasting along the shores of Bonavista Bay, especially in the neighbourhood of Cutler's Head, where they are exposed in cliffs several hundreds of feet in height. The rocks are fine-grained, chloritic, and argillaceous. In many places they are coloured with red oxide of iron. Some of the rocks of this neighbourhood of an amygdaloidal character appeared to be altered diorite.

On the western side of this headland there is a deserted monument of folly in the form of a small quarry, which was vigorously worked upon under the impression that the compact argillaceous-like rock of the cliff was a mass of tin-stone.

Further up the bay conglomerate and more igneous rocks of a chloritic character and rich in kaolinized felspar were observed.

Potsdam and Calciferous.[1]—Still ascending in the series, the next members are those of the Potsdam and Calciferous groups. These are to be seen in the northern and western parts of the island.

The former of these groups consists of dark-coloured slates and conglomerates, containing recognized Potsdam fossils. The series amounts to upwards of 5400 feet in thickness. Penetrating these rocks I found dykes very similar to those I observed before, such as felsites and highly chloritic melaphyres containing quartz.

The Calciferous series, which overlies the Potsdam, is one which presents very different characters to any of the preceding. It is well exposed in the western parts of the island upon the northern side of the Port au Port Peninsula, where it consists of definitely stratified grey limestones rich in fossils,—large *Orthoceri*, Corals and *Maclurea* being very noticeable. These limestones weather into thick columnar forms, divided horizontally by joints, just as if so many huge discs with rounded edges had been piled one above the other.

By the action of the sea and other causes, several caverns have been excavated. Two of these I explored. One was wide and open, and about 70 feet in length; the second, which was narrow and low, was about 130 feet in length. Some of these, on future exploration, may yield remains, beneath the bed of clay with which their floor is covered, which may be of interest in connexion with the study of the modern fauna of the island.

Quebec Group.—At the base of this group we get a vast series of graptolitic shales, amounting to about 4000 feet in thickness. Above these shales we have a large display of serpentines and

[1] The passage upwards from the Paradoxides slates is very well displayed in Conception Bay, where there is no evidence of any want of stratigraphical conformity; but it is difficult to tell in what part of the section the Primordial ceases, and the Potsdam proper begins; a great mass of sandstone occurs at Kelly's Island, and there are alternating sandstones and black shales or slates, which form the largest island in the bay—Bell Island. The whole of these strata hold in greater or less abundance *Cruziana similis*, Billings, *Eophyton Linnæanum*, Torrell, several species of *Lingula*, and other forms which Mr. Billings was disposed to think were of Upper Potsdam type. These strata differ considerably from the beds Mr. Milne quotes, on the north and west sides of the island, which are probably higher measures.—A.M.

diorites about 1000 feet in thickness. As these serpentines and diorites, which represent the Lauzon or middle division of the Quebec group, are, from an economical point of view, perhaps the most important series in the island, I will consider them at greater length than I have the others. Their importance lies in the fact of their being repositories of metallic ores, a character which they bear not only in Newfoundland, but in all our transatlantic colonies and the United States.

In Newfoundland this formation has a considerable development. On the eastern side of the island we see it occupying the valley of Gander River, a great portion of the shores and islands of Notre Dame Bay, and farther to the north in the vicinity of Hare Bay. On the west coast it crops out at many points, as at Cow Harbour, Bonne Bay, Bay of Islands, and Bluff Head. On the south we see it in Despair Bay, and extending northwards up Conne River towards the head waters of the above-mentioned Gander River.

All these districts, with the exception of Gander Valley, I visited, and from various points collected several hundreds of rock and mineral specimens. In the fall of 1874 Gander Valley was explored by my friend Mr. Murray, and to him I am indebted for a collection of rocks from that locality.[1] They consisted of many schists, most

[1] I made a very full report upon the Quebec Group in 1874, the result of my own observations in 1873, and of my assistant's survey by my direction in 1874; to which I beg to refer for my views of the structure. At page 52 of the said Report I have expressed myself thus: "The facts ascertained, as already represented in the description of the coast and river sections on the east side of Port-a-Port Bay, seem to point to the conclusion that the Silurian formations are arranged in a series of sharp anticlinal and synclinal folds, ranging generally about N. 22° E., S. 22° W.; the whole mass of strata having, towards the close of the later deposits or subsequently, been affected by vast igneous intrusion, and become much dislocated by great parallel or nearly parallel faults, the ground trend of which is N.E. and S.W. At the summit of the whole series is a great volume of igneous and magnesian rocks, consisting of various diorites, serpentines, and chlorites, which our evidences seem to indicate to be lapped over the inferior strata unconformably, and to come in contact with different members at different places." In Sir William Logan's investigations in Canada, the great mass of sandstone and conglomerate, displayed so largely at Sillery and other parts of the Gulf of St. Lawrence, were provisionally placed at the summit of the Quebec Group, and as overlying the metamorphic and igneous rocks with serpentines and metallic ores, etc.; but our evidences in Newfoundland seem to point to a somewhat different conclusion—unless, indeed, there may happen to be two great sandstone formations, one of which is absent in this island. The description of the rock of the St. Lawrence applies in nearly every particular to the rock here; but while we find it to succeed the Levis formation with perfect regularity, although with numerous folds and twists, in every case it seems to pass *below* the serpentines, wherever a contact has been seen; and moreover to pass below them unconformably. The Long Point of Port-a-Port Bay contains fossils recognized by the late Mr. Billings as *not older* than the Bird's Eye and Black River, and *may be* near the base of the Hudson River Group; and these strata are comparatively undisturbed; but they are brought down by a fault against older rocks, at the base of which the sandstones are displayed in great disturbance. Having weighed all the evidences with great care, I have come to the conclusion that the great igneous intrusion, of which mention is made in the above extract, must be nearly of the age of the Chazy, or perhaps later; that it has been the metamorphosing agent, and that the altered strata consisting of chloritic slates, serpentines, melaphyres, diorites, etc., belong to a horizon somewhere intermediate between the Chazy and the Hudson River Group.—A.M.

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of which were more or less chloritic; some were, however, argillaceous and slightly calcareous, whilst a few were harsh and splintery clay-slates. Bands of dolomite are here and there intercalated, some of which contain disseminated particles of magnetic or chromic iron, which by decomposition give a rusty appearance to the weathered surface of the rock.

A predominating feature among these rocks are dark-green serpentines, which show traces of actinolite, and some specimens could only be regarded as serpentinized varieties of this mineral. Associated with the serpentine, veins of chrysotile are common. A quartz conglomerate and veins of quartz have also been found. The latter are supposed to contain gold, but what the result of their analysis has been I am not yet able to say. On the whole, the rocks have a green chloritic look, and are magnesian in their character.

Further to the north, in Notre Dame Bay,[1] there is quite an archipelago of islands, the greater number of which seem to belong to the Quebec Group. There are amongst them, however, some granites, porphyries, felsites, diorites, and basalts,[2] to which no particular horizon can be assigned. On Pelly's Island, copper pyrites is found, and mining operations have been commenced in rocks which are dark-green in colour and chloritic in character. On Toulinguet we also find a more or less chloritic series of rocks. On the mainland, upon the north side of the Bay, we meet with massive serpentinous rocks. All of this series have, however, been so altered and contorted that it is difficult to make out their lithological characters, and almost impossible to make out their stratigraphical relations. Along the coast these rocks form bold cliffs, here and there broken by small indentations forming small bays and coves. Inland, they form moderately-sized hills, which are covered with drifted boulders.

The serpentines are dark and light green in colour, some are compact and splintery, whilst others are soft and earthy. When jointed, their partings contain either gypsum or calcite. Chrysotile is also

[1] The confusion and disturbance manifested in Notre Dame Bay is such, that to obtain a structural section is almost impossible; while the total absence of organic remains in the group which contains the metallic ores adds to the difficulty of disentangling the complexities. Our evidences of horizon are therefore of a negative rather than a positive kind; but the circumstance of these altered rocks being succeeded by a group containing fossils typical of a horizon ranging between the upper part of the Hudson's River Group and the Clinton is significant. These upper strata have been found in unconformable contact with the older and metal-bearing formations, and traced from the extreme eastern end of New World Island to the Exploits River. Near the base of the group there is a black shale or slate with *Graptolithus ramosus*, which was followed far up the Exploits River. These fossils Mr. Billings supposed to be types of Hudson River age. The higher beds of the formation were found to contain the following fossils, many of which indicate a period as late as the Clinton:—*Orthis ruida; Rhynchonella; Stricklandinia lens; Modiolopsis; Atrypa reticularis; Strophomena rhomboidalis; Leptæna sericea; Orthis Davidsoni* (?); *Heliophyllum; Zaphrentis bellisriata; Petraria; Favosites Gothlandica; Orthoceras Murchisonia; Bronteus; Encrinites;* and *Pentamerus.*—A.M.

[2] In my report for last year, 1876, I have shown reason for believing that the granites here spoken of are later in date, or contemporaneous with, the Quebec Group; and in my report upon the Exploits, 1871, I have shown that the porphyries and some of the basalts intersect the Middle Silurian. Felsites and diorites occur in strata in the Quebec Group; and also as intersecting veins.—A.M.

to be seen, whilst magnetic iron, and probably also chromic iron, are disseminated through the mass. Enstatite, diallage, and bronzite have also been observed.

The chloritic rocks are sometimes slaty in their character, and sometimes compact and earthy. Very often these rocks are talcose, and in their joints calcareous. Grains of magnetite are to be seen in the mass. Some of them give indications of having been derived from diorites. Associated with this series are a number of rocks which are also, but to a much less degree, chloritic. Amongst them we have altered felsites of a light-green colour, some of which show changes approaching serpentine. There are also others of a green colour, which are tolerably compact, but which under the microscope apparently resolve themselves into a volcanic ash or breccia. In some cases the angular and sub-angular fragments of which these rocks are made up are easily to be recognized. Distinct traces of crystals of felspar are also to be made out.

Amongst these rocks, bands or beds of dolomite are occasionally found, associated with which at Tilt Cove there is an irregular deposit of copper-nickel. It is in the form of small strings and nests. With the chloritic rocks irregular deposits of copper pyrites occur; this has led, in the case of Tilt Cove, to the opening of a large and prosperous mine.

Further to the north, at Terra Nova Mine, a similar series of rocks is to be met with. Here the predominating metallic ore is iron pyrites, which occurs in a band about five feet in thickness.

Although sedimentary rocks are exhibited in the district, volcanic rocks nevertheless predominate and give a character to the whole. That in Silurian times we had volcanos of large extent may alone be inferred from the existence of the extensive beds which I have called volcanic ash and breccia. Since that period, however, the rocks have been so changed in character that it is with difficulty, and generally speaking only with the aid of the microscope, that their origin is to be inferred.

Along the north side of Hare Bay we find a compact splintery grey slate, which at many points holds finely disseminated iron pyrites, which is also sometimes in veins. Near the head of the Bay, at How Harbour, true serpentinous rocks rise conspicuously into high hills, which have generally a bare appearance and a characteristic reddish tinge. Some specimens from this locality had a splintery fracture and a fibrous structure. With the $\frac{1}{4}''$ objective, kaolinized felspar, crystalline grains of hornblende and crystals of magnetic iron were distinctly visible, giving altogether indications of an altered diorite. Other specimens showed a striking likeness to some of those from Gander River Valley, 160 miles to the south.

On the western side of the island, commencing at Bonne Bay, are some very high flat-topped hills, which, from their reddish colour and bare surfaces, are at once to be recognized as being serpentinous. To the south of this, in Lark Harbour, we find rocks belonging to this series of a very undefinable character,—they are rusty, argillaceous, and filled with so many joints that it is difficult to obtain

a fractured surface. However, when one is obtained, the interior of the rock is seen to be chloritic.

Still further to the south, about Bluff Head and Louis Hills, we get a series of weathered amygdaloidal rocks, which may be defined as melaphyres. They have generally an argillaceous smell, and are calcareous, especially in their joints and amygdules. Under the microscope there can be seen, a finely granular ground mass, a much kaolinized felspar apparently labradorite, and sometimes a mineral which brilliantly polarizes, which may be olivine. On the whole, they are like altered dolerites, and all of them have a more or less chloritic look. In places disseminated through the mass there is a bituminous mineral, and very often specks of native copper. These minerals are chiefly found in the more decomposed portions of the rock. Up Louis Brook some true serpentines are to be found, and also a dolomite. Comparing these rocks on the west side of the island with those of similar age upon the east, they only seemed to me to differ in the degree of alteration which they had undergone. And those upon the west in this way tend to confirm the idea of the volcanic origin of the greater part of this series, as exposed in Newfoundland.[1]

Southern and Central Exposures.—In the southern and central exposures of this series, about Bay East River, we get serpentines, chloritic and talcose slates, felsites and micaceous slates. The rocks on the whole having a lithological likeness to the other members of the same series.

Taking a general review of this formation, as presented to us in patches, some of which are more than 100 miles apart, one cannot but be struck with the great lithological similarity which runs throughout the whole. In comparing lists of specimens taken from different localities, it is found that some are almost identical. The rocks everywhere contain serpentines and chlorites, are magnesian in their character, and always contain more or less of some valuable mineral matter like ores of copper. Sometimes their nature is at once to be seen, whilst in other cases it is only with difficulty to be recognized. Everywhere they show traces of having been derived from volcanic rocks, and in all cases the alteration to which they have been subject is similar, and has only differed in amount. Looking at the vast hills which yet remain of these rocks, they appear as relics of large and powerful volcanos which were in activity belching out showers of ashes and pouring forth great streams of lava in Mid-Silurian times.[2]

If this view is a correct one, then there was a period when quiescent, dreary Newfoundland was like a modern Iceland. Since that time, however, great changes have happened, and processes of

[1] I have already alluded to the probable age of the igneous rocks, and to the geological position of the serpentines on the west coast of the island.—A.M.

[2] This view is not improbable, but I am inclined to think, from the undisturbed state of the rocks already spoken of at Long Point, Port-a-Port Bay, that the time of greatest volcanic activity must have been at an earlier date, probably within the Chazy or Trenton periods.—A.M.

degradation have washed away portions of these rocks and divided them in patches; whilst metamorphic action has so changed their character that at times they are hardly to be recognized.

Sillery (St. Julien Sandstones, etc.)[1]—Above the serpentinous and Magnesian series, which has been estimated by Mr. Murray as having a thickness of from 16 to 1700 feet, there is a large series, chiefly composed of black slates and limestones, approximately 3 to 4000 feet in thickness. In these slates, which are well exposed in the northern parts of the island, I have observed both intrusive and imbedded masses of diorite. They are generally of a dark grey or greyish green colour, and in some cases amygdaloidal, the amygdules being filled with calcite. Under the microscope, altered felspar, hornblende and grains of magnetite are generally to be seen.

In Noddy Bay these shales are serpentinous, and contain imbedded nodular masses, which under the microscope resolve themselves into a serpentinized diorite. True serpentine is also to be met with in the same locality. The intrusive rocks of this district would show that the volcanic action continued after the deposition of the upper part of the Quebec Group.

Niagara and Clinton.[2]—The only display of these rocks which has been hitherto recognized is to be found at the head of White Bay, where we have a series of conglomerate, and slates capped with Limestone, altogether 2800 feet in thickness. Owing to the occurrence of a series of faults, some of which may amount to 1000 feet, there has been difficulty in tracing out the sequence amongst the members of this formation. Traversing these rocks there are several large dykes of melaphyre and felsite. One of these latter, at the S.W. end of Sops Island, appears in columnar masses 40—60 feet in height. They are of a pinkish colour, and have a splintery coarse fracture. Their measurements are about 1 foot in diameter, and 20 feet in length. They have generally from 4 to 6 sides. In places they are curved and slightly divergent. The tops of these prismatic-like columns form acute angles with the sides, instead of being at right angles, as is so generally the case. Between these columns strips of greenstone, which under the microscope resolves itself into a melaphyre, may be seen. These felsites are also to be seen further to the north.

On the S.E. side of the island there is a large dyke, which also appears to be a melaphyre, and probably derived from the alteration of a dolerite. It contains many veins of calcite and quartz, and along one side of it a very fair deposit of galena.

[1] In the note on page 256 I have already expressed my views regarding the stratigraphical position of these sandstones. I have visited St. Juliens myself, and Mr. James Richardson, of the Geological Survey of Canada, visited the place where the formation is largely displayed, at the north-eastern termination of the island; but a contact with the serpentinous group was not seen in either case; and I hold to the opinion that it is in consequence of the later group being unconformably spread over the older rocks, that the sandstones are not seen at How Harbour or at Pistolet Bay.—A.M.

[2] Rocks of Middle Silurian age have already been referred to, as having a wide spread in Exploits Bay and the southern parts of Notre Dame Bay. The lithological characters, and some few obscure fossils, also seem to indicate that the series, or a portion of it, extends far up the Exploits and the Gander Rivers.—A.M.

Devonian.—In the vicinity of Cape Rouge and Fox we find a series of plant-bearing sandstones, coarse conglomerates, and reddish-green slates, amounting altogether in thickness to about 3700 feet, which have provisionally been called Devonian, and are apparently the equivalents of the Gaspe sandstones.

Carboniferous.—The Carboniferous is the newest rock formation of which Newfoundland yet boasts. It is displayed in two localities, in both of which it rests upon a Laurentian base.[1] One of these is in the central part of the island, in the vicinity of Deer Pond and Grand Pond, and the other is in the S.W. part of the island round St. George's Bay. Its thickness is about 6400 feet, and it resembles in every way the lower portion of the equivalent formation of Nova Scotia and Cape Breton. In going up any of the rivers which run at right angles to the general strike of the beds, they are seen to consist of red sandstones, shales, greyish limestones, gypsum, and conglomerate. The gypsum is presented at many points in masses like huge cliffs of chalk. At many points where its contact with the surrounding rocks is to be observed, it seems to occupy the position of an intrusive rock,[2] those with which it is in contact being contorted, broken, and turned up against its sides, as, for instance, at the mouth of Kippens Brook. The conglomerate contains fragments of rock and pebbles of magnetic iron derived from the Laurentian Series, and pieces of limestone containing fossils which are undoubtedly of Silurian age. Several seams of coal, one of which is 3ft. 6in. in thickness, have been met with, and many others in all probability remain to be discovered.

In this series I did not observe anything which could be called an igneous rock, nor do I know that any have yet been observed. This fact would lead to the conclusion that it was previous to this time that Newfoundland sank into the tranquil state in which it now exists.[3]

Drift.—Above the Carboniferous we have no other formation but a covering of alluvium, which in many parts of the island, from the striated angular stones it contains, shows undoubted evidence of glacial action. In places this Drift contains shells very similar to those which are still living in the surrounding sea. These, in conjunction with terraces, raised beaches, roche pèrche, etc., tend to show that Newfoundland was at no very remote period below the present level of the sea. The surface of the rocks on which the Drift rests is often roundly smoothed and striated, indicating what may have been glacial action. This so-called glacial action I am, however, inclined to think, from what I have seen in Newfoundland and Finland, is more likely to have been produced by Coast-ice acting in

[1] On the north side of St. George's Bay it rests against Calciferous and Potsdam.

[2] I have tried to account for this phenomenon, which I have repeatedly observed, both in Canada and in Newfoundland, and a suggestion is offered at pp. 18 and 19 of my Report for 1873. The strata of Carboniferous age on the north side of St. George's Bay is almost perfectly flat.—A.M.

[3] Neither have I seen any intrusions of trap in any part of the distribution of the Carboniferous; but the formation is very much disturbed and faulted, both on the south side of St. George's Bay and in the Grand Pond region.—A.M.

a rising area, than by glaciers. (See GEOL. MAG., Decade II. Vol. III. Nos. 7, 8, 9, July, August, and September, 1876.)

Conclusion.—In conclusion I may say that it appears that the rocks of Newfoundland are exclusively old ones, a character which might be inferred from their metamorphosed and generally broken up and contorted appearances. Here and there fossils exist, but they are scarce. In all formations up to the Devonian and Carboniferous, which are the youngest excepting the general superficial covering of Drift, igneous rocks are abundant. During Silurian times there were probably large volcanos, which gave vent to fields of lava, and deposited large beds of ashes. But even these rocks also have undergone great changes, and are now only to be recognized as chloritic and serpentinous masses—a character of metamorphism which seems to be common to many of the formations. An important point about the serpentinous rocks is that they have been already proved to be the receptacles of mineral wealth. In many parts of the country there is the strongest evidence to show that the island has lately emerged from the sea, and during this elevation, for reasons which have in part been previously expressed, we believe that Coast-ice was the chief agent in impressing on the country the glaciated character which it now carries—a view which has subsequently been strengthened by observations on the coast of Finland. Besides the metalliferous wealth of the island, which is in the main confined to the serpentines of the Middle Quebec Group, much may be expected from the Coal-measures. When the value of these two formations becomes fully recognized, we may expect to see the local government stimulated to giving further aid to geological exploration,—explorers will be attracted, the dreary wastes of the almost unknown interior will be penetrated, and something more certain will be learnt about the early history and formation of our long-neglected and oldest colony NEWFOUNDLAND.[1]

III.—WHAT IS A BRACHIOPOD?[2]

By THOMAS DAVIDSON, F.R.S., F.G.S., V.P.P.S.

PART III.

(*With a large folding Table.*)

AFFINITIES OF THE BRACHIOPODA.

For some years past, the serious attention of several eminent malacologists has been directed to the endeavour to determine the

[1] I refrain from more at present, than to make a few general remarks upon Mr. Milne's conclusions in regard to glacial action, and the rise of the land, as I shall probably have something to say upon these subjects at a future time. I think, however, there are evidences to show that there must have been enormous glacial action, probably intermittent; and that the rock-basins of many of the great lakes of the interior, and other phenomena at high elevations in the interior and on the coast, can only be accounted for as the result of such an agency. I also think that the evidences we have, of the rise of the land in *very* recent times, do not show an elevation of over a hundred feet *at most* over the present level of the sea.

My new Geological Map of Newfoundland will probably aid in illustrating both Mr. Milne's and my own remarks. It may be obtained at Mr. Edward Stanford's, 55. Charing Cross.—ALEX. MURRAY.

[2] (*Concluded from the May Number*, p. 208.)