ART. IX.—NOVA SCOTIA GEOLOGY, PRECARBONIFEROUS, LOWER CARBONIFEROUS, &C., RETROSPECT, TO 1859. BY THE REV. D. HONEYMAN, D. C. L., *Hon. Member of the Geologists' Association, London, &c. Curator of the Provincial Museum, Fellow of the University of Halifax, Prof. of Geology, Palæontology & Mineralogy in the Science Department of Dalhousie College and University, and Lecturer on Geology, Palæntology and Mineralogy in the Technological Institute of Halifax.*

"Suum Cuique tribuito."

1859, April 4.—On the "Fossiliferous Rocks of Arisaig." By the author. Trans. N. S. Literary and Scientific Society of Halifax.

This was my *debut* in writing on Nova Scotian Geology. The paper was illustrated by a large collection of fossils from rocks of *supposed Devonian Age.* "Acadian Geology, Ed. 1855, by J. W. Dawson, Esq., F. G. S.

In my paper, I gave the results of the study of these fossils and their comparison with the Upper Ludlow fossils of Wales, so beautifully figured in the plates of Murchison's "Siluria." I was thereby convinced that not only was the *facies* of the *fauna* of the strata near McAra's Brook, Moydart, Arisaig, an Upper Ludlow *facies*, but that many of the forms were identical, and that therefore the containing strata were of Upper Silurian Age.

This was the first step *onward* to our present position. The last step taken by the author of "Acadian Geology," had been in a different direction, as the Arisaig formation had previously been regarded as Upper Silurian. This was also the first recognition of an "English aspect" of the Silurian *Fauna* of Arisaig. 1860; "On the Silurian and Devonian Rocks of Nova Scotia," communicated to the Natural History Society of Montreal, by J. W. Dawson, LL.D., F. G. S. In this paper the Upper Strata of Arisaig are correlated with the "Lower Helderberg" of the United States. Another part of the strata is correlated with the "Clinton." In this work of correlation, Dr. Dawson was aided

by Prof. Hall, the distinguished Palæontologist of the New York Geological Survey. The latter did also good service in identifying certain forms and in describing and figuring others which were new. The Devonian is here also, specially pointed out as occurring at Nictaux. This paper may be regarded as first indicating an "American aspect" of the "Arisaig Series."

They are farther divided, in this paper, into Upper Silurian and Middle Silurian, according to Hall.

1860. On new localities of fossiliferous rocks in Eastern Nova Scotia, communicated to the Nat. Historical Society of Montreal, by the author.

The first locality or rather district is in the County of Pictou. It is traversed by the New Glasgow and Antigonish Road, and has Barney's River as its East boundary and Sutherland's River as its West. The places where the fossils were found are where the road is crossed by two small brooks that run into French River, and another brook that runs into Sutherland's River. In the two first, the fossils were found *in situ*, in the last in boulders, the fossils of the one are identical with Clinton forms of Arisaig as identified and described by Hall, of the other, Upper Ludlow or Lower Helderberg. The Arisaig Clinton forms are, Graptolithus clintonensis—Hall. Strophomena corrugata, &c., the Ludlow forms, Homalonotus, sp., Dalmania, sp., Beyrichia, sp., Chonetes nova scotica—Hall. Crania acadiensis—Hall, &c. Here then we had evidence of the existence of the two recognized members of the Arisaig Series. We shall have occasion to refer to this locality in the sequel.

The second locality is on the N. West side of Lochaber Lake, Antigonish Co. Here we have also two distinct groups of rocks and fossils—one group, which is the upper, has familiar Upper Ludlow forms of Arisaig, e g. Dalmania, sp., Calymene Blumenbachii, Bellerophon trilobatus, Chonetes nova scotica—Hall, and Crania acadiensis—Hall; the lower is altogether strange. The fossils are: Athyris, sp., Orthis, sp., Cornulites, sp., Stenopora fibrosa, and a Cyathophylloid Coral. (Petraia Forresteri, Salter.) The strata containing these are highly altered; they are siliceous, the fossils generally in casts. Some of these, especially

Petraia, are singularly beautiful. Dr. Dawson, in a note to my paper, considered a specimen of this coral as a zaphrentis, not unlike imperfect specimens from the Devonian at Nictaux, and therefore he supposed the Lochaber *Petraia Strata*, to be of *Devonian Age*. A difficulty in the way of this correlation was the evident *stratigraphical* relations of the two series, which showed that the supposed Devonian Strata underlie the Upper Ludlow.

The first locality or district upon re-examination also received a very interesting addition. A section of very unpromising strata, *almost* a clay-bed, on the side of the road near Barney's River, was examined. A considerable number of spherical and oval concretions rolled at my feet. These, when tapped with the hammer, were found to contain beautiful lingulæ, with their phosphatic-calcareous valves, perfect, black, and beautifully iridescent. This was the discovery of my favourite lingula nodule bed, which has since been much extended and elsewhere repeated. This seemed to be the equivalent of the Doctor's Brook lingula shales. The bed at Barney's River is lower than the graptolithus clintonensis strata at the tributary of French River. The construction of a new bridge at this brook led to a recutting of the section already referred to, which enabled me to enlarge my collection of its fauna by the addition of a number of trilobites, Dalmanites, a small *lingula oblonga*, discina; a small orthoceras and a compressed conularia. Other exposures added a large and perfect discina, cornulites and crinoidea. The boulders near Sutherland's River also made additions to the Upper Ludlow fauna of the locality, and I made acquaintance with a "Boulder" to which I shall again refer. Lochaber was also re-examined and important additions were made to its fauna. The series did not receive any addition to its members. The Petraia strata were found to be backed by the Diorite of the Mountain. Several visits were afterwards made to the same locality, which invariably brought additions to the several collections. An old and well known locality, Springville, East River, Pictou Co., was also visited annually, but not much examined until 1860. In this year, and at the memorable time of the Prince of Wales' visit to

Nova Scotia, I spent a month in making a thorough examination; my loyalty could not even induce me to intermit my interesting work. This was the first systematic examination of the district. I examined and made interesting and extensive collections from the higher strata. The fauna here are generally identical with the Upper Ludlow fauna of Arisaig, the coincidence in position and association is very striking. Many new species were also collected. In a mountain, a mile above Springville, I found Clinton strata on the day the Prince of Wales was in Pictou. This was their first recognition here. They were distinguished by the difference of the strata as well as by the fossils.

The fauna which they contained, were two large species of lingula, a discina, a conularia and a new species of homalonotus. Of the last I found two pygidiums, one of them was much distorted. Another specimen had pygidium and thorax, the head being wanting—a most important defect. An intermediate sett of strata is strongly defined especially in its palæontology. The largest orthoceras yet found in Nova Scotia was taken from these strata. Rhynchonella Wilsoni is abundant, so is the genus Strophomena—Atrypa reticularis, and Spirifer crispus, Cornulites is unusually large. It has also its own Homalonotus, different from any of the *four* species that are found in the upper Ludlow of Arisaig and from those occurring in the Clinton. At Moydart, Arisaig, is a set of strata intermediate between the *Clinton* of Hall & Dawson and the upper Ludlow near M'Cara's Brook, having a fauna of like marked character with large cephalopoda. Rhynchonella Wilsoni is abundant, Strophomena in great variety and abundance, Atrypa reticularis abundant, large Cornulites and the peculiar Homalonotus. East River and Arisaig are the only two Districts where this set of strata has been found. The localities and districts thus examined have revealed the thoroughly typical character of the Arisaig Silurian Series extending from Doctor's Brook to McAra's Brook, and at the same time have enabled us to divide the series into distinct members. The Arisaig series in turn has revealed the defects of each, and their comparative importance. At Doctor's Brook we have two members, at Arisaig one, at Moydart two, in all five members, i. e.,

one between the Upper Ludlow and Clinton, and two below the Clinton.

The third locality is Doctor's Brook, about 1½ miles east of Arisaig. Here there is a section of dark coloured shales without any apparent stratification. These were heretofore considered non-fossiliferous. The only thing remarkable in the shales is the presence of concretions. On closer examination, a few *lingulae* were discovered; a large species of *trematis;* a species of strophomena; a cast of a crinoid joint. The lithology of the locality was strikingly different from the Clinton of Arisaig, as well as its few *fauna.* It was regarded as lower than the Clinton.

Having made a subsequent examination of this locality, I happened to examine the stones of a sluice and was astonished to see in them a Lochaber Petraia, and to observe that the stones themselves were like Lochaber slates. I immediately searched for the rocks and found them out-cropping in all directions to the north of the fossiliferous shales, i. e., between them and the igneous rocks which had been referred to in my paper as having elevated and confused the former. These igneous rocks were known as extending to Arisaig Pier, and as having given a southerly dip to the Clinton and Upper Ludlow of Arisaig and Moydart, so that there could be no reasonable doubt that the strata in question were to be regarded as a lower member of the Arisaig series, and that the Lochaber series was an apparently incomplete "Arisaig series." Its mode of occurrence at Lochaber, its lithology and palæontology seemed to give it also an *individuality.*

Not long after I recognized similar rocks in the Marshy Hope part of the Antigonish and New Glasgow road, at the Antigonish and Pictou county line. Here they contained abundance of Petraia, lingulae and cornulites—and a Cyrtoceras. Still farther at the west end of the Marshy Hope, another occurrence of similar strata was observed having abundance of Athyris in casts. This is a genus of Brachiopod eminently characteristic of the Lochaber type. No other member of the Arisaig Series accompanied them. These instances are undoubtedly confirmatory of the individuality of the Lochaber Petraia and Athyris strata.

1860–1. The Band of metamorphic rocks extending from one end of Nova Scotia to the other—from Cape Sable to Cape Canso—which had not been regarded as peculiarly interesting—had now become attractive by the accidental discovery of Gold. The first discovery at Tangier had caused a little local excitement and had ceased to be attractivea; a new discovery in another part of Tangier, renewed the excitement, which henceforth became a *mania*. Soon gold was found in other localities throughout the length and breadth of the metamorphic band. Geologists and gold hunters came to Nova Scotia from all directions. Since Dr. Dawson had gone to Montreal I had commenced below the Coal Fields, and was working downwards, having a kind of a monopoly of the pre-carboniferous formations. I was steadily working at the fossiliferous as consequently interesting, considering that there was "time enough" afterwards to attend to the supposed non-fossiliferous formations. The so-called Lower Silurian fossil—Gold—once discovered could not fail to excite interest. I began to turn attention to the Geology of the Gold Fields. The Great Exhibition of London, 1862, being in prospect, the Nova Scotian Commission engaged to make a representation of the Geology and mineral resources of the Province. Prof. How, D.C.L. of King's College, Windsor, N. S., was also engaged as my associate, with special charge of the mineral department, scientific and economic. At the same time H. Poole, Esq., M. E., was engaged by the Government to investigate the auriferous formation to the west of Halifax, and J. Campbell, Esq., the same formation to the east. I explored a great part of Cape Breton, which I had several times previously visited. Besides making an extensive collection of carboniferous fossils and economic minerals, I made a few interesting Geological observations. I ascertained that the reputed limestones of what is now known as "marble mountain" was marble of various kinds associated with granitoid rocks. I found the rocks at the mouth of Louisburg Harbour and the coast towards Gabarus to be *crystalline*, apparently *Syenites* with *Diorites*. The Baddeck mountains were found to be *Granitic*. Marble in association with Diorites was found at Whycocomah.

In Nova Scotia, I revisited Springville, East River, Pictou and ascertained the approximate position of the Brown Hematite vein, at the same time making a collection of its varieties—fossils were not neglected. As specially directed by the commission, I examined the Geology of the Tangier Gold District. I also examined the singular "Barrel Quartz," or auriferous veins of Waverley, and the sections of the rocks of this band on the Halifax, Windsor and Truro railways.

I was also sent to London to arrange the collections, and to superintend the Nova Scotian Department.

1862. "On the Geology of the Gold Fields of Nova Scotia." By the Author. Communicated by the President, to the Geological Society of London.

(Journal of Geological Society, 1862.)

In this paper I directed special attention to the "Barrel Quartz of Waverley," and the supposed relation of its containing rocks to the sections on the lines of railway. I gave a list of the Gold Fields then discovered, and made some observations on their supposed lower silurian age—directing attention also to the magnificent illustration in the "Nova Scotia Department of the Exhibition."

GREAT EXHIBITION OF LONDON, 1862, NOVA SCOTIAN GEOLOGY.

(Illustrated by the Author.)

This illustration included a large collection of Silurian Fossils from Arisaig and the other places referred to. These were arranged in counter-cases, according to the divisions made, the fossils of each division were arranged in zoological order. Before they were exhibited, I made several visits to the Museum of Practical Geology, Jermyn Street. Examining the collections I found the Upper Ludlow all right—the next—Arisaig and East River, I correlated with the Wenlock Limestone. I found nothing to compare with the Clinton; the Lochaber and Doctor's Brook equivalent were identified with the Upper Llandovery. I afterwards requested Sir Roderick I. Murchison to examine them; he did so, and sent Mr. J. W. Salter, the distinguished Palæontologist of H. M. Geological Survey of G. B., to examine my Silurian collections and to report.

Before examining the collections, he asked me to remove any cards giving explanations or descriptions. When this was done he made first of all a general examination, and then a special examination of the respective groups. The upper he recognized without difficulty, as "Ludlow Tilestone," the next as "Aymestry Limestone," the Clinton, as Upper Ludlow, *repeated;* the upper part of Doctor's Brook was unsatisfactory on account of its poverty in forms, the only form that attracted attention was the *Trematis*, which he regarded as interesting. The Lochaber forms, e. g., Petraia, he determined as Mayhill Sandstone, (Upper Llandovery). The beauty of the Petraia specimens attracted particular attention. He said the species was new and he would give it a name. He asked me to suggest a specific name, I gave that of my most intimate friend Dr. Forrester, superintendent of education in Nova Scotia, and so it was named—Petraia Forresteri, (Salter). Mr. Salter afterwards made other examinations along with other Palæontologists, especially Dr. Anthon Fritsch, of the Imperial Museum, Prague, Bohemia; Dr. F. being familiar with Barrande's great Bohemian "Siluria" and its unparalleled riches of form, gave me valuable aid in the recognition of certain forms which had escaped Mr. Salter's notice, and which had puzzled me exceedingly, e. g., curved Cephalopoda, especially Ascoceras. Barrande, E. DeVerneuil and Dr. Bigsby and Prof. Phillips, also were interested in my collections. They were awarded a *medal* by jury of Class I. Mr. Salter, in the written report which he gave me, divided the "Arisaig Series" as above and identified a large number of forms as English species, and gave the geological structure and sequence in accordance with the supposed palæontological evidence. In consequence of the distance between Nova Scotia and England, in correlating the age of the fauna and formations of the one with the other, he suggests the use of the qualifying adverb "approximately."

It will be observed that there is some difference between Mr. Salter's correlation of the divisions and my own. I was not altogether satisfied with the difference, as I considered it hardly possible that I should mistake in recognizing anywhere, forms so familiar to me as my Arisaig forms. Not presuming to ques-

tion the opinions of an authority so eminent, I revisited Jermyn Street Museum, and was assured that I was not mistaken. Mr. Etheridge, the present accomplished Palæontologist of the Survey, was at the time working among the collections near those in which I was interested. I made him acquainted with my difficulty. He very kindly opened the cases that I might take a closer look at the specimens; at the same time he informed me that the collection which I was looking at was an Aymestry limestone collection, and that the "Wenlock" had to be corrected; of course I was satisfied. Mr. Salter expressed his astonishment that the Wenlock was absent from a fauna so decidedly English as that of Arisaig. There was some difference of opinion between Mr. Salter and Prof. Hall, in regard to certain forms. I did not presume to call the views of either in question on the points of difference; accordingly, in subsequent lists published by me, I name forms according to the opinions of both, so that in these certain forms have two names, e. g. Dalmania Logani, Hall, is Phacops Downingiæ, according to Salter. Graptolithus, clintonensis, Hall, is Graptolithus ludensis, according to Salter. I would observe regarding these two examples, that the difference in the first case is of minor importance as it is merely palæontological, and does not materially affect the main view of the correlation of the group to which it belongs; it is Upper Ludlow or Lower Helderberg notwithstanding.

In the case of Graptolithus clintonensis or ludensis—the difference of opinion was of more serious consequence. It led Prof. Hall to regard the Arisaig group as of Clinton, Middle Silurian age, while it induced Mr. Salter to regard it as of Upper Ludlow, or Upper Silurian of Hall's division of the "Silurian system." There is, however, a peculiar form of the same group which has not been recognized elsewhere on this side of the Atlantic, Grammysia cingulata; Mr. Salter recognized this form which is an Upper Ludlow form in England. This also may have led him to the opinion which he formed.

After the lapse of fifteen years in which I have given no small amount of attention to such questions, I would presume to make a few observations on differences of opinion among Palæon-

tologists on the form in question, with a view to show that any decided opinion of age formed on the occurrence of this Graptolite is altogether unwarranted. The same Graptolite has three synonyms—G. clintonensis, Hall; G. ludensis, and G. priodon, Brown. Salter recognizes the two last as the same, *vide* Appendix to Ramsay's Geology of North Wales, H. M. Geological Survey of Great Britain. It is found as G. ludensis in "Upper Ludlow;" as G. priodon in the "Woolhope Beds;" as G. clintonensis in the "Clinton," N. Y.; as G. priodon in the Mayhill Sandstone, (Upper Llandovery); as G. priodon in the Bala; so that its range in geological time is from the Bala or Lower Silurian to the Upper Ludlow, part of Upper Silurian, so that while the biological importance of this form is considerable, its geological or stratigraphical importance is *very* questionable.

Mr. Salter was led to the supposition, that the Upper Ludlow, with G. ludensis, occupied its relative position at Arisaig, by a *fault.*

1864—"GEOLOGY OF ARISAIG, NOVA SCOTIA." BY THE AUTHOR.

Journal of Geological Society of London.

In this paper, I gave the results of a lengthened and thorough examination of Arisaig, with the aid of the new light of Mr. Salter's examination and report. I directed special attention to the region of the supposed *fault,* and found that the sequence, as well seen in the section on the shore, was perfectly regular, that the supposed Upper Ludlow was certainly older than the overlying Aymestry Limestone of the District, and that therefore the Graptolithus ludensis and the Grammysia cingulata had appeared in Arisaig, N. S., before the Upper Ludlow period. On the strength of these facts, I substituted Lower Ludlow for Upper Ludlow. In the Aymestry, I found a wondrous new fauna, especially the Cephalopods, Orthoceras, Omoceras and Cyrtoceras. I also found heads of the Homalonatus of this horizon, which showed that it was not delphinocephalus, as Mr. Salter had supposed from the pygidium. I also found a new and strange organism, which I considered to be a species of Graptolite. I shall refer to this again. I made my head quarters at Doctor's Brook, as I con-

sidered that there was more work to be done between this and Arisaig, than between Arisaig and McAra's Brook. I followed the black shales with lingula up the Brook, until it met the Clinton—Lower Ludlow, with its characteristic lithology and fossils, and found it underlying the Clinton. From Doctor's Brook, I also followed the black strata along the shore and found them exposed in a cove. Here the concretions showed as at Doctor's Brook abundant, and lingulæ were found in nodules and other concretions. *Cone-in-cone* structure also occurred in masses. I followed it onward to Arisaig Cove, where it was well exposed. Its homogeneous character distinguished it strongly from the Clinton, succeeding at Arisaig Brook, as well as its *cone-in-cone* and other concretions. Fossils appeared to be rare, and I pronounced the band poor in fauna. This was an opinion which I had to modify considerably afterwards. I also found a bed of graptolites in the lower part of its section at Doctor's Brook. I made a large collection from this bed. I regarded this discovery as very interesting on account of the variety of forms and their marked difference, from G. clintonensis or ludensis. I shall have occasion to refer to these again. I also found the Mayhill sandstone division to increase in interest. From Doctor's Brook I followed it along its outcrop to the cove where the black lingula shales were found exposed. Here there was a glorious exposure of vertical strata in striking contrast with the soft coal black ferruginous shales overlying. The brown hard slates have Petraia, sp? (not Forresteri, as at Lochaber) in abundance, internal and external casts, scattered through the strata, showing that the generic name, Petraia, is singularly appropriate. Lingulæ, large black, were of frequent occurrence as at Marshy Hope. These were associated with sandstones replete with Petraia and other forms; in some cases the Petraia were preserved in the hardened rock, the carbonate of lime of the corallum surviving. Lower down the strata contained lenticular beds of Orthis and Athyris, from three to six inches in thickness in the middle. It is only when these beds become weathered that the forms can be distinguished and then they are in the form of internal and external casts. I shall have occasion to notice another locality where

the same forms occur in a similar manner but in a better condition for identification. I found the igneous rocks which bounded the fossiliferous strata on the north, to be a very interesting study, from their exposure being so complete, their aspect so varied, being generally homogeneous, sometimes porphyritic, often amygdaloidal and scoraceous, and frequently ashy, their relation to the associated sedimentary rocks so peculiar, and the effects of this association so striking, especially the conversion of arenaceous strata into porcellaneous rocks, uniform and banded. Mr. Salter advised me to distinguish the respective members by local names. The mode of the distribution of those members made it difficult to act on the suggestion. I therefore adopted an alphabetical division, A, B, B′, C & D. A, Mayhill Sandstone; B, B′ Lower Ludlow; C, Aymestry Limestone; D, Ludlow Tilestone.

1865. Dublin International Exhibition. In the Nova Scotia Department, I exhibited a collection of Arisaig fossils, arranged according to Salter's division. In this were included the principal forms collected since the London Exhibition of 1862. This collection was awarded a medal by the jury of class 1.

1866. "On the Geology of Antigonish County, with a map. By the Rev. D. Honeyman, D. C. L., F. G. S., Membre de la Societé Geologique de France," Hon. Member of the Geologists' Association of London, &c.

In this paper, I correlated B, of the Arisaig Series, with the Hudson River of the United States. Since my previous examination, Prof. Hall's report on the Graptolites of the Quebec of Canada, had made its appearance. This led me to the study of the Graptolites of Doctor's Brook, which were found to be of genera not known to range above the Hudson River, Lower Silurian. Afterwards, however, I found reason to doubt this conclusion, and to refer the group to Lower Clinton? I also correlated certain strata containing copper ore, at Lochaber and Polson's Lake, as Devonian. These strata are non-fossiliferous and seem to succeed the Arisaig, A & D, of the west side of Lochaber Lake, *vide supra*, 1860. I afterwards referred these to the Lower Silurian on lithological and mineralogical considerations. Other

strata, non-fossiliferous, metamorphic and associated with crystalline rocks, were also referred to the Devonian, e. g.. Antigonish Sugar Loaf (mountain), and its N. E. continuation, and also the mountains to the west. These have since been referred to Middle and Upper Silurian on account of their resemblance to certain metamorphic rocks so correlated, underlying the Pictou Coal Fields. The crystalline rocks area, was found after a subsequent and detailed examination, to be much exaggerated on the Geological maps.

1867. Exposition Universelle de Paris, 1867. In the Nova Scotia Department, I exhibited a representative collection of rocks and fossils. Among the rock specimens were auriferous, Lower Carboniferous Conglomerates, illustrating a discovery made by Prof. C. F. Hartt, with argillites representing the underlying auriferous rocks, from which the gold of the Conglomerates had been derived. This collection was awarded a *medal* by the jury of class 1.

This was my first representation of Nova Scotian rocks at International Exhibitions. Before 1867, I had devoted my attention almost exclusively to Palæontology—to the collection of fossils, their study and correlation—to the association of fauna, their distribution and the conditions under which they "lived, moved and had their being." Availing myself fully of my advantages, I made a special study of the Arisaig series of fauna, in order to mark the *first appearance of new forms*, their *culmination* and *disappearance*. When it is taken into account that this field was almost wholly fallow, that its strata are so replete with organisms that they have been exposed for ages to the action of the storms and ice sheets of the Gulf of St. Lawrence, bringing into relief forms on the strata, and lining the shores with fossiliferous boulders, requiring only the application of the hammer to secure forms, new, varied and beautiful, it will be readily admitted that the work was enough to excite monomania, and to exact application. Another consideration was that I was acquiring a branch of knowledge and an intimate acquaintance with a *type* which I was assured would be of infinite importance in future works on the Geology of Nova Scotia.

Yet, other incentives were my facilities through International Exhibitions, of receiving the invaluable aid in the work, by intercourse with the great Palæontologists of England and other countries, of the examination of Museum and Exhibition collections, and the appreciation of my work by international judges. The work of the amateur had become the work of a profession. This change and removal to Halifax, a lithological centre, where fossils in the rocks are hardly recognisable, led to the association of the study of lithology with that of palæontology.

1868. "Acadian Geology," with map. 2nd Edition. By J. W. Dawson, LL.D., F.R.S., &c.

The only part of Acadian Geology which comes within the field of our retrospect is that which relates to the pre-carboniferous Geology of Nova Scotia. This part, of course, is a vast improvement upon the corresponding part of the first edition, both in matter and illustration. The map is elegant and beautifully coloured. In this respect it is a great improvement on the map of 1855. The improvement, however, is often more apparent than real, where pre-carboniferous formations are defined, eg. Between Baddeck and Cape North, I certainly prefer the white of the first map to the blue in the second. The region so coloured was a "terra incognita" in 1855—it is very much so yet, and anything that we do know of it is not in accordance with the blue colouring, as explained on the map. Another example,—on the north side of the Cobequid Mountains there is a continuous blue between the red, which represents the crystalline rocks of the centre of the mountains, and the carboniferous colouring. In the first map there is no such intervention from West Chester road (Amherst road) and westward. The colouring of the last map may be according to theory, the colouring of the first is more in accordance with fact. If required, I can multiply examples of improper colouring, doubtless, however, a great part of the colouring is *only provisional.*

Examining the volume where it treats of the Silurian and Devonian formations, there is only one point which seems to require attention at this stage of our retrospect.

This point is the new division of the "Arisaig series" into

"Lower and Upper Arisaig," a division to which the author seems to attach great importance.

In reference to this I would observe:—

1st—That it was altogether uncalled for.

2nd—It does not seem to serve any practical purpose.

3rd—The division is not topographically accurate.

4th—It disregards Mr. Salter's well established division, ignoring the Aymestry Limestone and Mayhill Sandstone divisions. It also ignores the existence of the extension of the Doctor's Brook shales, which are largely exposed in the Arisaig Cove and at the Arisaig Brook, being here better exposed and having a more numerous and varied *fauna* than at Doctor's Brook.

5th—It only recognizes the Clinton at Arisaig, and the Lower Helderberg near McAra's Brook, Moydart.

6th—In consequence, it seems preferable to consider the whole as *one series*, with five subdivisions, and to regard the whole as Upper Silurian, like Sir R. J. Murchison and Dana, or as Middle and Upper Silurian, like Prof. Hall and E. Billings.

7th—My alphabetical division, which I consider a practical one, has precedence, having been published in 1864. *Journal of Geol. Society.*

I may here state that I have found occasion to use the term Arisaig in its widest sense, "Arisaig Township," for practical purposes, and to adopt for the sake of precision the terms "Lower, Middle and Upper Arisaig," the series under consideration being called "Upper Arisaig."

1868, June—October. I re-examined professionally Arisaig in particular, and Antigonish County generally. 1st, to collect a suite of Arisaig fossils and rocks, for the museum of the Canadian Geological Survey; 2nd, to ascertain the extent and distribution of the Arisaig series. I consequently spent a considerable time among the fossiliferous rocks. It was then that I discovered the richness of the fauna of B at the Arisaig Cove, especially in corals, favosites; trilobites, phacops, stokesii, calymene tuberculosa; crinoidea, graptolites, and brachiopoda, strophomena, atrypa reticularis, &c. In collecting rock specimens, I found that the rocks lying between the Mayhill sand-

stone strata and igneous rocks of the shore, of which Frenchman's Barn and Arisaig Pier were a part, were singularly varied and interesting—some of them being of quartz hardness, others soft and unctuous, easily cut with a knife, and susceptible of a beautiful polish. I also examined the rocks of the Arisaig Mountains, and found a "mountain series" of very perplexing character. Two or three bands of strata led me to imagine that it was a repetition of the fossiliferous series very much affected by igneous action. It had syenites rising to the elevation of 1010 feet, mountain conglomerate—hard as jasper—rising to an elevation of 900 feet, petro-siliceous rocks at 1000 feet elevation; diorites porphyries and slates. I shall have to refer to those again.

I had to modify the supposed great area of crystalline rocks of the published maps, and to limit the exact areas to a mountain here and there, and an occasional outcrop, as I found obscurity everywhere; swamps, table land and forests. Measurements were made wherever practicable, from which maps have been constructed which are in the *Museum portfolio*—unpublished.

October—same year—Arisaig Laurentian.

In the expectation of seeing a fine section of lower carboniferous conglomerates, grits, and a continuation of the conglomerates of Malignant Cove and Cape George, I took to the shore of the Cove. I found sand banks and a shore covered with syenite and diorite boulders, then contrary to all expectation, there appeared, *in situ*, diorites, granitoid and homogeneous, on, on, on, the same, then appeared a loose mass of a mixed character, ophicalcite, then it appears in intercalary beds with diorites, homogeneous and granitoid and hornblende rock. Then succeed very coarse diorites having hornblende in crystals in albite (?) and also granitoid diorites with veins of snow white granular calcite several inches thick and quartz veins, with talc and without. Ophites, ophicalcites, crystalline limestones, petro-siliceous strata, black and hard with quartz veins containing mica. Syenites, red and white with patches of green and red orthoclase, also penetrated by dark coloured veins (diorite ?) and veins of granular calcite, three to four inches thick. A system of calcite and quartz

venation thus pervades and apparently connects the whole. This seems to be the results of *re-metamorphism*. This glorious section extends nearly to the eastern line of "Arisaig Township" —having cliffs lofty and precipitous, overhanging and jutting into the deep, necessitating hard climbing and leaping for onward progress, at the same time stimulating the desire to make extensive rock collections, and restraining it.

The carboniferous band of our maps has totally disappeared and been replaced by crystalline rocks of high antiquity. These rocks extend less than two miles from the shore, so that the area of crytalline intrusive rocks of our maps situate farther south have been obliterated. Our survey has also contracted the Antigonish mountain area of the south and given an interesting carboniferous basin (8 miles wide) having conglomerates on the north and south. Limestone overlying the north conglomerates, and in the middle black and very bituminous shales with abundance of *Palæoniscus* scales, an interesting *flora* and reputed coal beds. I was of course much gratified by making the discovery of this very important series of rocks. In common with others I had taken for granted the existence of the carboniferous band, and considered that all was right with the intrusive rocks—for twelve years—and as there was no expectation of finding fossils in this direction, I did not take any special interest in examining.—"Prove all things!"

Fortunately I was in no small degree prepared for this occurrence. While I was engaged as Executive Commissioner for Nova Scotia at the Exposition Universelle de Paris, 1867, I relieved the monotony of regular attendance by occasionally studying the fine collection of Laurentian and Quebec rock specimens, exhibited in cases by the Canadian Geological Commission, only a few feet distant from the front of the Nova Scotian court, as well as by studying the magnificent specimen of polished eozoonal ophicalcite afterwards presented to M. Daubree, l' Inspecteur general des Mines, for the museum of the Ecole des Mines de Paris. I was therefore able to form an independent opinion of the character and age of the rocks discovered. I had therefore no hesitation in concluding that they were of *Laurentian age*, and I announced

the discovery to gentlemen in Antigonish who had been in the habit of accompanying me to Arisaig and other localities in Antigonish county, and were consequently interested in a matter of this kind.

Not long after, I shewed specimens to Sir W. E. Logan and Mr. Hartley in New Glasgow, when on my way to Halifax. Sir W. said that he considered them to be of *Quebec age.*

1869. In the spring when I unpacked my collections, at Gabriel street, Dr. T. Sterry Hunt examined, chemically and otherwise, choice specimens, especially a beautiful polished specimen of ophicalcite which I had got polished in Halifax. When Sir W. and I were discussing the question, Dr. Hunt made his appearance in the Lapidary's Room, with the polished specimen in his hand, and said that he considered it to be Laurentian serpentine—and expressed a wish to see the rocks themselves—enquiring after the locality. I was gratified at this expression of opinion, by one so well qualified to judge in a matter of this kind. Dr. Dawson afterwards referred to Dr. Hunt's opinion, and said that he considered the rocks to be of Devonian age. Having been occupied in the following summer in investigating the pre-carboniferous formations of the Pictou Coal Field, and subsequently in establishing the Provincial museum and arranging the collections—the question of the age of the Laurentian rocks of Arisaig remained *in statu quo* until 1870.

Laurentian rocks of Nova Scotia and Cape Breton. Proceedings of Institute, January 10, 1870.

Prof. H. Y. Hind had been exploring Cape Breton, up the McKenzie River. In the heart of the "terra incognita" already referred to, he had discovered rocks which he considered to be Laurentian gneisses. He had also been examining the granites of the auriferous band in Nova Scotia, and had discovered that they, too, were gneisses, and therefore concluded that they, too, were of Laurentian age.

In communicating his views to the Montreal authorities, he was informed by letter that Eozoon Canadense had been found in my specimens of Arisaig ophicalcite, and that this was regarded

as conclusive evidence of their Laurentian age. As I had long before, in the winter of 1868, noticed something of the kind and pointed it out to others, I was not at all surprised when Prof Hind gave me the information—and told him the circumstances. He published an account of the matter. This led to a spicy correspondence between Sir W. E. Logan and myself.

Prof. Hind informed me of his intention to go to London to bring his Laurentian discovery before the Geological Society.—He also suggested that I should write a paper on the Arisaig Laurentian and offered to take it with him. I accordingly acted on his suggestion, and addressed my paper to the Secretary, G. S.—Prof. Hind's paper was accordingly communicated to the Geological Society—vide Geological Journal, 1870.

At the meeting following, as announced, my paper was read by the Secretary. In this I described the rocks of the section, and gave my views regarding their age, alluding also to evidence of the supposed *Eozoon*. In the discussion which followed the reading of my paper, Sir W. E. Logan and Dr. Dawson took a part. In the report Dr. Dawson is said to have observed that the *tubulation* of the Arisaig *Eozoon* was different from that of Eozoon Canadense, and that Eozoon of other species occurred in rocks of a different age from the Laurentian, so that existence of this species.—*Eozoon Acadiense*, Dawson, was not conclusive of the Laurentian age of the Arisaig Rocks. Journal of the Geological Society, 1870. I may state that I felt somewhat annoyed at the treatment that my paper received from the Geological Society. In my unavoidable absence my paper was attacked by those who had never seen the rocks described—who had committed themselves to erroneous views which they had considered themselves bound to maintain—and my paper was subsequently printed in the Quarterly Journal of the Society in a *mutilated* form, so as to give Sir W. E. Logan and Dr. Dawson a decided advantage. Subsequently Prof. Hind had an article on the Laurentian Rocks of Nova Scotia and Cape Breton, in the American Journal of Science and Arts. In this article there was a reference to the "Arisaig Laurentian." In another article in the same Journal, Dr. T.

Sterry Hunt claims the credit of having *first* recognized the Laurentian age of the rocks in question, maintaining that it was his expression of opinion that led me to hold this view.

In an article in the same Journal I replied giving facts and references. The question of priority thus received its *quietus*. American Journal of Science and Arts, 1870.

1870–1. Reports of Geological Survey of Canada.

In the Summary Report of A. R. C. Selwyn, F. G. S., Director, page 5.—The Report of the late Mr. E. Hartley, F. G. S., of the Survey: "From the foregoing facts it appears that the Coal measures in Cape Breton are in direct contact with rocks of Laurentian age which I believe had not before been recognized in that region." I may state that their existence here had at least been suspected on the evidence of W. A. Hendry, Esq., Deputy Commissioner of Crown Lands, N. S. He had given an account to myself, before the Paris Exhibition of 1867, of a remarkable series of rocks at the head of St. Ann's Harbour—the district referred to by Mr. Hartley, and a specimen of ophicalcite from the rocks was given to me by Mr. Hendry. This was exhibited in the Nova Scotia Department of this Exhibition. It was noticed as remarkable by Prof. Lesley and Dr. Hunt. Sir C. Wyville Thomson also noticed it, finding in it what he supposed to be *eozoonal* structure. As he appeared to be particularly interested in it I gave it to him. On enquiry he was told that it came from a supposed Devonian formation at St. Ann's, Cape Breton. He afterwards produced it in London, causing considerable excitement among the *Eozoonalists*. The supposed solution of the difficulty was that the Laurentian had been brought up in Cape Breton by a *Fault*. Dr. Dawson would have suggested a difference in *tubulation*, and considered it as an evidence of the Devonian age of the St. Ann's, C. B., rocks, rather than have recourse to the *Fault* supposition.

1870. Nov. 14; Dec. 12, 1871. Feb. 13. Papers on Nova Scotia Geology, by Rev. D. Honeyman, D.C.L., &c. The first two papers are a "record of observations" made since 1855. The only point requiring notice, which has not been referred to in the retrospect, is the correlation with the supposed equivalents in the

United States, of members of the Arisaig Series, which had not been recognized and correlated by Dawson and Hall. Here the metamorphosed series in contact with the igneous rocks (Diorites, is considered to be the equivalent of the "Oneida Conglomerate" —the next—the "Mayhill Sandstone" is regarded as the "Medina Sandstone," U. S. The Doctor's Brook and Arisaig Shales, I have designated "Lower Clinton" (?) and the "Aymestry Limestone" above the Clinton of Dawson, and under the "Upper Ludlow" or "Lower Helderberg," "Niagara Limestone."

One reason that I had for making this change, was the inconvenience connected with the use of the English nomenclature on this side of the Atlantic, where the American nomenclature is in general use. I also adopted Hall's sub-division, Middle and Upper Silurian, which had been adopted by Mr. Billings in the Reports of the Geological Survey of Canada. I had also established classes of Geology and Palæontology in connection with the Provincial Museum, in which Dana's Manual and Text Book are the Text Books. I had, however, in my lectures, to adopt a middle course, as I found difficulties connected with the restricted use of the American nomenclature in consequence of the peculiarities of Nova Scotian Geology, which is decidedly "Anglo-American" in character, our Peninsula being evidently the connection of English and American Geology.

Pre-carboniferous formation of the Pictou Coal Field, Feb. 12, 1871.

In this paper are given the results of a systematic and thorough examination of the pre-carboniferous formation of the Pictou coal field made in the summer of 1869. I measured these pace by pace, collecting rocks and fossils, and defined the whole in a map made from my measurements and observations. *Museum Portfolio.* I re-examined the old "Arisaig Series" of Springville, already noticed above. (1860) I completed the series by adding to it metamorphic strata underlying the fossiliferous Clinton of the former account, I considered these to be additional Clinton, with Mayhill or Medina Sandstone. In these lie the out-crop of the Brown Hematite, long familiar on account of its detached masses scattered around. I examined and measured the great

Diorite succeeding (locally), and on the other side of this, in an elevated position, other metamorphic strata, at the point of contact, coalescing with the Diorite. Above these are slates, non-fossiliferous—Clinton—well exposed in a Brook,—they then became obscure, being covered with forest, the series re-appearing in Blanchard with fossiliferous Upper Ludlow, on McDonald's Hill. We have thus an anticlinal arrangement, having Springville, "Arisaig Series," fossiliferous and metamorphic, on the one side, the Diorite, in the centre; and another Metamorphic and fossiliferous on the other. Blanchard fossiliferous Hematite (Iron ore) was also examined. The fossils—athyris, cornulites, &c., showed it to be on the horizon of the Mayhill Sandstone and Clinton. This age was also inferred from Dalmanites sp. and other fossils in Squire Campbell's marsh. From its position relative to the intervening Diorite, I inferred that the course of the iron bed southerly, would be on the western side of the Diorite mountain. Since I examined the locality, it has been found to be on the same side as the fossiliferous Clinton Strata of Campbell's marsh and their continuation at Ross's, so that the age of the iron bed is unquestionably Clinton, the same as a fossiliferous iron bed of Arisaig. Higher strata of this series are exposed in a marsh, and then above Pleasant valley, on the East River, below the Church and on the Blue Mountain Road, the strata are on the north side of the River. The only fossils found here were *Euomphalus*, in a boulder; the strata are highly metamorphic. In the associated Diorite at Pleasant valley, there is micaceous oxide of iron. This occurs also in joints of the metamorphosed Upper Silurian, on the river side. The last of the Silurians is on the north side of the river, where they meet the Silurian of the south side of East River.

The latter appear as black shales in the bed of the river. Proceeding westward, on the south side of the river, they reappear in a brook at the dam of a saw mill. Farther on, they are again exposed in a brook at Pleasant valley. Still farther on they are well exposed in McDonald's brook.

To the west of this *Brook Section* lies one of the iron localities of this region, "McDonald's specular ore." This lies in the metamorphic Silurian rocks of the section.

In the same brook, at a bridge, I found a section of shales having fossils. These are anticlinal to the other, having a northerly dip, the iron bearing strata having a southerly dip. They contain fossils which seem to be of Clinton age.

We seem thus to have evidence of the Clinton age of the specular iron ore of McDonald's, of the Blanchard Hematite, and the Springville Brown Hematite. Writers on these and similar iron deposits in Nova Scotia generally refer them to the Upper Silurian. It may be excusable, thus to refer *veins*, but fossiliferous *beds* are certainly entitled to be treated in a scientific manner. I have to except Dana's Manual of Geology, where the Blanchard Iron bed is referred to the *Clinton age*. I succeeded in extending the Springville "Arisaig Series," north, to the extremity of Irish mountain. Beginning at the west side of this mountain and coming to the east, I found Upper Ludlow, with characteristic fossils; this extends to the end of the mountain and disappears under the Lower Carboniferous. "Aymestry Limestone" did not appear. In Cross Brook, succeeded Clinton with characteristic fossils, this extends north, in the brook, beyond the Upper Ludlow, and disappears under the Lower Carboniferous. Farther on, Mayhill Sandstones (with Petraia) and Diorite appear, the extension of these northerly appear in Cross Brook; the Mayhill Sandstone disappears under the Lower Carboniferous. I found at the side of the brook, the Diorite in the Lower Carboniferous, some distance beyond the exit of the Mayhill Sandstone. As at Springville, this Diorite is the middle of an anticlinal. On the opposite side, the strata are metamorphic, and apparently non-fossiliferous as at Springville. This band is of considerable width. It extends north and partly terminates on a mountain east of the seeming extremity of the axial Diorite in Cross Brook. A great part passes through McLellan's Brook and forms the steep western side of McLellan's mountain. The Lower Carboniferous sandstones and limestones are now seen in the brook, at the side of the mountain, at the back of the passage. As the mountain tends northerly, the back of the same strata is skirted by L. Carboniferous limestones and strata.

On my return when I descended from the mountain, east of the Coal mines—I found Diorite exposed with L. Carb. conglomerates. This is doubtless a reappearance of the axis of Irish mountain, which might readily be mistaken for a Diorite of Carboniferous age.

About three-quarters of a mile up McLellan's Brook above the junction of the Lower Carboniferous and the Irish mountain strata, Upper Ludlow strata with characteristic fossils appear. These extend up the brook about one-eighth of a mile, and assume the appearance of a syncline, so that, as at Blanchard, we may have here fossiliferous Ludlow above the Irish mountain metamorphic strata. I regard this metamorphic series as *peculiarly interesting. First,* because in its present connection its relation is obvious, as a middle Silurian series—the upper being fossiliferous ; *second,* apart from its present relation on the west side of McLellan's mountain it is hazardous to attempt to determine its age—*as we shall see in the sequel. Third*—It not merely enables us to determine the age of its extension in McLellan's mountain, which has perplexed experienced observers, but also to determine the age of similar metamorphic strata, e.g. in the Sugar Loaf and other mountains of Antigonish County, where their relations to the "Arisaig series" are not so obvious as in the case before us.

The eastern side of the fossiliferous Upper Ludlow syncline in McLellan's brook is the upper member of another fossiliferous "Upper Arisaig" series on the side of Fraser's mountain (McLellan's). Continuing our eastern course through Irish mountain, and crossing McLellan's brook, and ascending Fraser's mountain, we pass through "Clinton strata which are possibly fossiliferous, and then we come to a splendid and extensive outcrop of "Mayhill Sandstone," having a lithology so characteristic that I expected as a matter of course, to find characteristic fossils, and did find them almost as soon as expected; a fine group of *Petraia* and trumpet shaped *cornulites,* chiefly in casts, but also *entire.* These strata are vertical and have a normal thickness of 250 feet. After these came the Diorite and Porphyrite of the mountain summit. On the other side succeeded a broad band of meta-

morphic strata, similar to the Irish mountain metamorphic band. The extension of these Diorites and metamorphic and fossiliferous strata south, constitute the south end of McLellan's mountain (range). The extension north with the Irish mountain contingent, constitute the range northward. In the latter case the fossiliferous "Mayhill Sandstone" becomes interrupted and the Clinton becomes obscure; the Upper Ludlow with its fossils having also passed into the mountain in like manner, becomes obscure. The Mayhill Sandstone disappears a short distance beyond the place where it first appeared, and then it reappears twice or thrice in connection with the central Diorite, non-fossiliferous, but with characteristic lithology, while the Clinton and Upper Ludlow lie hid in the hollow formed by the syncline of Irish mountain strata with the Fraser mountain series.

Towards the northern end of the range—these two disappear beneath the Carboniferous, leaving the opposite metamorphic strata of Fraser's mountain, to continue the mountain by running up against the diorite of Wier's mountain, the end of the range, or passing on the east side of this mountain and on to Sutherland's river falls, and terminating on the other side of this river.

To an observer coming from the Pictou coal field, the metamorphic character of the strata, the course of the dip and the want of fossils, cannot fail in causing perplexity, while to an observer who has followed our course, all must appear sufficiently obvious.

The Carboniferous formation is now seen passing on the north of Wier's (McLellan's mountain) and coming up against the metamorphic rocks of the mountain which we have seen to pass over to Sutherland's river.

The character and age of the metamorphic strata of the lower falls of Sutherland's river seem to one coming upon them from the Carboniferous formation below, even more difficult to understand than even the metamorphic middle of McLellan's mountain.

The strata at Wier's have introduced to another very interesting and also complicated Silurian district, which I have named after the river of which it is the basin. The hard metamorphic strata at Wier's are succeeded on the east by soft Clinton strata having abundance of characteristic fossils; these are well exposed

in a brook which is one of the tributaries of Sutherland's river. This *seems* to indicate the Mayhill Sandstone age of the hard strata at Wier's. At the mouth of the same brook as it enters Sutherland's river in front of the falls, strata appear. These outcrop on the east side of the brook as far south as the New Glasgow road. The section here shows them to be argillaceous strata with very irregular fracture. One cannot certainly recognize in this our old siliceo-argillaceous and arenaceous acquaintance—Mayhill Sandstone. A close search produces two distinct *Petraia*. Can it be that our Petraia is not characteristic of our Mayhill Sandstone after all. Passing along the road eastward, Diorites are observed out-cropping on the left side of the road, a little farther are argillaceous strata. On the right side of the road opposite the Diorite—we find pieces of strata brown in colour and beautifully lined—these when broken shew a bed of lovely casts of athyris and orthis; a core unweathered shows the organisms themselves. Such pieces are abundant. I have not seen anything like them except in McDonald's cove, Mayhill Sandstones between Doctor's brook and Arisaig. This shows satisfactorily that Petraia is in its right place, although the conditions of its former existence seem to have been irregular. To the south, overlying these, are seen argillaceous strata with characteristic Clinton fossils; all therefore is plain. Still farther east, Clinton strata outcrops on the road. Before we come again to Sutherland's river, Diorites are seen off the left side of the road. At McPherson's mill dam and cross roads, strata appear, having Lingulæ. These seem to be of Mayhill Sandstone age, their dip is southerly; on the north side, immediately below the dam, are Grit strata of L. Carboniferous age. These extend down the river until they approach the Falls from which they are separated by Diorite in the River bed. These Grits have the Sutherland's River "Brine Spring." Succeeding the Mayhill Sandstone of the dam and cross roads, are seen at some distance on the road side, clayey strata containing abundance of lingula nodules, the bed, its position, fauna and nodules being the exact equivalent of the lingula bed of Barney's river, and consequently of B. of the "Upper Arisaig

series," these extend to the river shewing black shaly strata dropping its nodules in the water.

Farther south, we come to the outcrop of a Clinton member of another series, which has a metamorphic base on the summit of the mountains, rising on the left, and its upper member, Upper Ludlow, in the river, on the right. In the middle there seems to be an irregularity indicated by the fossiliferous Upper Ludlow strata, seeming to lie above and below the Clinton, and dipping in the same direction, as if there had been a fold with the crown denuded. The Metamorphic strata in the mountains passing on in a S. W. direction, are seen up the river at a considerable distance, crossing it, the lower part, forming the falls at McIntosh's saw mill. The strata outcropping in the river below these falls seem to be metamorphic Clinton, and are replete with quartz veins. This was a reputed Gold Field. Coming farther down the river, we reach a lofty mountain which lies on the west side of the river. The side toward the river is a bold precipice, this section of the mountain has on the south side metamorphic slates, on the north porphyrite. It has something of the appearance of Blomidon in the distance. In the river below this the Upper Ludlow of the series appears with its fossils; these continue to outcrop down the river, making formidable rapids. The exposure is magnificent. There are some minor and apparently detached sections of members of the Upper Arisaig Series, which are referred to in the paper. The last, which I would notice, lies in the mountain east of McPherson's mill. This is an exposure of Upper Ludlow strata dipping northerly at a low angle and having an east and west strike. This is the western extremity of the Upper Ludlow member of the series which is exposed at French river, Barney's river, &c., already referred to. The strata under notice are the probable source of the boulders, which have been noticed as containing Upper Ludlow fossils. We return to East River to notice one or two points of interest. At Springville, in the river, Lower Carboniferous limestone is in contact with the Aymestry limestone, the same is the case at the "Sluice" and in Holmes' Brook, where the water of the brook disappears in summer to re-appear after a subterranean course at the "Sluice."

Farther up the river, south of Blanchard, and near the mouth of McDonald's brook, already referred to in connection with the Specular Iron Ore, Crystalline Pyritous Limestone—marble—of L. Carboniferous age appears in the bed of the river; near this, a little off the road side, on the left, limestone appears in contact with the lowest beds of the Blanchard district, overlying Diorite. On the mountain side of the road to Blanchard, Limestone appears with angular fragments of Diorite set as if in mortar. At Pleasant valley, above the bridge, Limestones form walls on the right side of the River, while metamorphic Upper Ludlow occupy the left side. The Limestone then crosses the river to the left, makes a respectable appearance, and finishes above the left side of the road about a mile farther up, forming a cave. I have thus dwelt at considerable length on this very interesting, instructive and complicated district.

1871. After Feb. 13th, the date of the last paper. Report of the Geological Survey of Canada, 1860–9, received.

1871–2. Two papers, "Being strictures on Logan and Hartley's Geology of the pre-carboniferous formations of the Pictou Coal Field." In Sir W. E. Logan's Report of Survey of the Pictou Coal Field, page 7, read: "No evidence was observed by me, on McLellan's mountain, to show to what epoch these older rocks belong; but masses somewhat similar are noticed by Mr. Hartley on the west side of the East River, in a position where they have been mentioned in his *Acadian Geology*, by Dr. J. W. Dawson, who considers them to be of Devonian age, and on his authority they will be so distinguished.

My papers contained a *resumé* of the part of my paper of Feb. 13th, in which I proved that the rocks of McLellan's mountain referred to are a continuation of the metamorphic Middle Silurian of Irish mountain and Fraser's mountain. The view expressed by Sir W. Logan is antiquated, dating from the Devonian *regime* of 1855.

1872. April 8.—"On the Geology of the Iron Deposits of Pictou County." Author,—*Transactions.*

In the Appendix to Reports on the Pictou Coal Field, Canadian Survey, 1866–9, page 408. Mr. Hartley says, "Several

deposits of Specular ore were examined. These all occurred in a range of metamorphic rocks lying ten or twelve miles to the south of the Pictou coal field. Of the age of their formation, I cannot speak with certainty, but it is probably Upper Silurian. The rocks consist of light and dark green, purplish, brown and black colours, and giving a white streak. The quartzites are sometimes coarsely granular, but as a rule compact and fine grained. This formation appears quite distinct in lithological character from the series which has been described by Sir Wm. Logan and myself as occurring near the Pictou coal field at McLellan's and McGregor's mountains, and at Water's hill, and which are believed, by Dr. Dawson, to be of Devonian age. I made no attempt to obtain fossils in these rocks, nor has any bed been observed likely to contain them at the few localities examined: but it seems probable that the fossiliferous beds mentioned by Dr. Dawson in his Acadian Geology, pp. 568–70, are included in these series. These beds from which a large number of fossils have been collected by Mr. D. Fraser, of Springville, are of undoubted Upper Silurian age."

The fossils referred to by Mr. Hartley, as collected by Mr. D. Fraser, were either from the Upper Ludlow or Aymestry Limestone, or possibly, both, and therefore Mr. Hartley was perfectly right in considering them to be of Upper Silurian age. The position of the Brown Hematite, as ascertained by Mr. Hartley himself, was at Fraser's, in the lower non-fossiliferous part of the series, and could only in a very loose manner be correlated with the upper members of the series.

It was shown that the fossiliferous ore of Blanchard, the only ore which could admit of precise correlation, is of Clinton age, and therefore Middle Silurian, having fossils altogether different from the Upper Silurian fossils referred to, and that the probability seemed to be that all the ores were of Clinton age.

He rather seemed to be astray in regarding the iron bearing rocks as of different ages from the rocks of McLellan's mountain, in regarding the latter as Devonian and the former as Upper Silurian, while they are evidently of the same age, and that Middle Silurian. Mr. Hartley seems to have got rather

muddled in his correlations. Others adopting the same methods will succeed no better.

1872-3.—Nov. 11th.—Notes on the Geology of N. Scotia and Cape Breton. Author,—*Transactions.*

Having re-examined the supposed Laurentian rocks at Arisaig and investigated their relation to the other series, and not yet having had an opportunity of examining an acknowledged Laurentian series, I began to entertain doubts of their Laurentian age. To this was added the fact that the unquestionable evidence of relative position only shewed that they were older than the Mayhill Sandstone and Middle Silurian, and therefore might be Lower Silurian. In this state of indecision I thought it advisable to designate this series "The Lower Arisaig Series," and the other the Upper Arisaig Series, and I began to designate the lower series as Quebec rather than Laurentian. My recollections of the Quebec rock specimens of the Exposition de Paris 1876, and their many points of resemblance to the Laurentian specimens, with the descriptions of both in the Geology of Canada, 1863, led me to adopt this alternative. I may now anticipate and say that this change was only temporary.

The paper before us gives an account of the typical series at Arisaig and the discovery and examination of a series perfectly identical, occurring at George's River, Cape Breton, near the Little Bras d'Or, and underlying the Sydney Coal Field. Every characteristic rock found at Arisaig was found here. The specimens in the two collections in the museum can only be distinguished by the labels. In such a case as this Lithology can be safely trusted in correlation. The intervening distance, also, is inconsiderable.

This discovery was important not only in itself and in its bearing on the Geology of Cape Breton, but we will yet see it having an important reflex influence in the process of the correlation of the type itself.

The rocks in this locality resembling the Arisaig rocks are Syenites, Diorites, Crystalline Limestone, Ophites, Ophicalcites. Arisaig rocks and those of George's River are both in contact with the Lower Carboniferous.

1872. "The History of a Boulder" the Author—*Transactions.*

This Boulder is a large one of those already referred to as occurring to the east of Sutherland's River. In it was a *band* of fossils having Dalmania Logani, Hall. This shewed that it belonged to a rock of the Upper Ludlow period. Its position showed that it had been derived from rocks which outcrop at McBeath's, of Sutherland's River Basin. (Paper Feb. 19, 1871.) In this history allusion is made to the underlying Clinton of French River, the "Lingula nodule bed" of Barney's River underlying the Clinton, and the great band of Mayhill Sandstone discovered up Barney's River, extending eastward and westward on the flanks of the mountains and having the usual Diorite. This Mayhill Sandstone band when discovered yielded Petraia and trumpet-shaped cornulites in abundance, Calymene Blumenbachii, &c. In short a *fauna* nearly as numerous and varied as at Arisaig itself; with Lochaber additions.

1873. "On the metamorphism of Rocks in Nova Scotia and Cape Breton." Author,—*Transactions.* The most important part of this paper is that which refers to local metamorphism.

In my paper "On the Geology of Arisaig," 1864, I directed attention to the conversion of arenaceous strata into Porcellaneous rocks, by means of association with trap. At that time I thought that the porcellaneous rocks were, A, Mayhill Sandstone strata altered.

It so happened that the former appeared where the latter seemed to terminate; the last of the fossiliferous Mayhill Sandstone disappearing before reaching Frenchman's Barn (rock); this porcellaneous rock and similar rock seemed to be a continuation of the A. strata. In 1867, giving due attention to lithology and collecting specimens of rocks, I found near McNeil's brook, east of Doctor's brook, on the shore, trap with porcellaneous rock of quartz hardness associated with a soft rock, unctuous, variegated, easily cut with the knife, and susceptible of a beautiful polish. The same association was afterwards found at Arisaig pier and on either side of Frenchman's Barn. On the east of the barn this soft rock was of a bright orange colour, and connected with another green and brown rock which

I at first mistook for serpentine. The soft rock was afterwards quarried with the expectation of finding it massive and suitable for ornamental purposes. At Doctor's Brook the connection of these and McNeil's was found lying *between* the Mayhill Sandstone—fossiliferous—and the trap ; so that it became evident that this was something *lower* than the May-hill Sandstone. Regarding the May-hill Sandstone as the equivalent of the Medina Sandstone, I considered that this might be the next in order, underlying, and I therefore named it Oneida ; and considered that the rocks in question were Oneida conglomerate metamorphosed by the igneous rocks. It has been suggested by Mr. Selwyn that this may be part of a Lower Silurian series.

The latter rocks are Diorites, homogeneous, amygdaloidal and porphyritic.

The Amygdals with one exception, a small fortification agate, are Calcite.

There is also ash with Amygdals.

The Diorites are of precisely the same character and age, as similar rocks which I found associated with and penetrating Upper Silurian fossiliferous strata in the north of New Brunswick (Dalhousie), and which contained *corals* that had dropped into them before they had cooled and become solid.

I considered that the porcellaneous and other rocks had been acted upon by this igneous rock in the carboniferous period, and thus had local metamorphism superadded to prior metamorphism induced during Upper Silurian and Devonian time.

1873–4. " Geology of the Cobequid mountains," Two papers. Author,—*Transactions.*

These papers give the results of a course of examination of the Cobequid Mountains by crossings from south to north and *vice versa.*

1st.—Through the Intercolonial Railway Section.
2nd.—Great Village to Greenville.
3rd.—Greenville Cross Roads to West Chester.
4th.—Folly Lake and Wallace River.
5th.—Five Islands to Napan.

These are at intervals of 5 and 22 miles.

No. (1.) I. C. R. This Section from Folly River to Greenville station, cuts Triassic, Carboniferous, Middle Silurian, Laurentian, Lower Silurian, Middle Silurian (?) and Carboniferous formations.

(2.) Triassic, Carboniferous, Upper and Middle Silurian, Laurentian, Carboniferous.

(3.) Laurentian, Carboniferous.

(4.) Laurentian, Carboniferous.

(5.) Trap, Triassic, Carboniferous, Upper and Middle Silurian, (?) Laurentian, Carboniferous.

These indicate the same order and succession on the south side of the mountains, with questionable difference; with the exception of the I. C. R. Section all have on the north the *Lower Carboniferous* succeeding the Laurentian.

None of these Sections show an anticlinal arrangement on either side of the mountains like the mountains associated with the Pictou Coal Field. All, with the exception of the I. C. R., show an enormous break on the north side from Laurentian to Lower Carboniferous. There are wanting, Cambrian, Lower, Middle and Upper Silurian, and Devonian. It was observed that the Triassic at Five Islands had a synclinal arrangement, the trap on the south having given part of it a northerly dip. This shows that the trap is intrusive and therefore of *later* formation than the strata. The I. C. R. and the Great Village River Sections show that the lower part of the Triassic have conglomerate, and grits, as well as the lower strata of the Carboniferous. A quarry west of the latter section, shows that the lower member of the Carboniferous, is a limestone. Five Islands Section shows the lower part of the Triassic to be sandstone and of the Carboniferous, a ripple marked clay slate. Great Village river at Londonderry Mines, shows a greater thickness of the metamorphosed or "Upper Arisaig Series" than the I. C. R. The Iron Ores, for which the other is remarkable, do not appear in the I. C. R. Section, and therefore the latter seem to be a very low part of the Upper Arisaig Series.

The Lower Carboniferous on either side of the mountain, are nearly at the same elevation above the level, 450 feet, as shown from the exact measurements of the I. C. R. Section Books; this

shows that they were unquestionably formed on approximate sea levels at the Lower Carboniferous period, and acquired their present position at the same time and by the same causes; that their present sequence is the result of the relative position of the Pre-carboniferous formation at the period when the Carboniferous Strata were formed. Irregularity of sequence here accords with the normal state of things, as regularity is certainly the exception having been only observed where Lower Carboniferous conglomerates are formed on Diorites of supposed Devonian age; some may be induced to account for irregularity of succession here by supposing faults. If this were adopted as a principle, there would be no end of fault finding in Nova Scotia.

We seem to have another approximate sea level on the I. C. R. in the Triassic conglomerate of the second cutting south of the Carboniferous of the Londonderry mine station. The difference between the height of this and the Lower Carboniferous Conglomerate is 150 feet.

Gravels were observed at Folly lake of such a character and in a position which led me to infer that they are *in situ*, being subaërial deposits formed in the Lake at a time when it had a greater extent and a higher level. These were regarded as having been formed in Oolitic, Cretaceous, Eocene, Miocene and Pliocene time.

The Pre-carboniferous formation of the centre and northern part of the I. C. R. Section and corresponding parts of the other courses are treated of in the papers. There are 1st "Lower Arisaig Series." 2nd, Wentworth (Lower Silurian) and Middle Silurian?

That the crytalline rocks of the I. C. R. and other sections correspond with the "Lower Arisaig Series" is evident from their Lithology. Here we have as at Arisaig and George's River, Syenites, Diorites, granitoid and homogeneous Gneisses, Petrosilex, Crystalline Limestones (marbles of Five Islands), and in addition Granites and Porphyries. The Granites are peculiar, especially the Maccan mountain granite. Specimens of similar granite have been brought to me from Cape North, Cape Breton. The Marble of Five Islands does not seem to have serpentine associ-

ated with it,but it has Syenitic gneiss—other evidence of identity follows :—Succeeding the red Syenite of the preceding formation is a mixed Crystalline series, having a width of 8,300 feet. This consists of crypto-crystalline Diorites of various shades of green ; one part has crystals of red felspar ; there are red porphyrie's and banded jaspideous rocks, purple grits, purple conglomerate with enclosed pebbles of scarlet jasper, purple jaspideous rocks and coarsely crystalline Diorites, besides other rocks which it is difficult to characterise. There is here a conglomerate which deserves special mention. It is very coarse consisting of pebbles of Jaspideous rocks of Diorites and Amygdaloids cemented by calcite, some of the Diorite boulders, are Amygdal-porphyritic, the amygdals being calcite and the crystals red felspar. Succeeding there is a closely connected band also mixed crystalline, this has crypto-crystalline diorites and porphyries with fossiliferous argillites and shales, a singular alternation of very hard and very soft rocks ; a similar lithological arrangement is not met with in Nova Scotia. I have assigned the lower part of these to Bala of England or Cincinnati of United States, on account of the character of the *fauna* found in the claystones. In Wales is to be found an arrangement of rocks which very closely resemble that under consideration. Prof. Ramsay's great work " on the Geology of N. Wales," has a wood cut, section Fig. 20, page 90, which might represent the present section. It runs thus—1st, Syenite; 2nd, speckled felspathic and talcose flaggy beds, (Llandeilo and Bala beds); 3rd, Felspathic ashy Conglomerate; 4th, Slate; 5th, Felspar porphyry; 6th, Blue slate; 7th, Felspathic trap; 8th, Blue slate beds. Plate 28, Sec. No. 3, has the following explanation. The syenites, porphyries and greenstone (Diorite) are referred to the *Lower Silurian age.*

This seems to be another *Anglican* coincidence. This mixed crystalline series refers to and throws important light on a similar series at Arisaig, which had no counterpart at East River or elsewhere, and consequently, was a subject of perplexity and misunderstanding. When I surveyed Arisaig, in 1868, I observed in the Arisaig Mountains, what I considered to be an " Upper Arisaig Series" in a much altered condition. Continuing

my Section, No. 2, of 1863—(which commenced with the Trap and Mayhill Sandstone of the Cove west of Doctor's Brook on the N., and ended with the Clinton of the south side of the Syncline, with a succeeding Lower Carboniferous limestone, conglomerate, trap and porphyry, in a small branch of Doctor's brook.)—I found slates succeeding a great Diorite of which the Porphyry of the preceding section is an accompaniment. This is a band of bright red and grey slates of considerable thickness, which at once suggested to me the great band of red and grey slates, on the east side of Lochaber Lake and opposite the fossiliferous Upper Arisaig Series already noticed in that locality. This is the top of the series which contains the copper ores of Polson's Lake and Lochaber, a series which was once regarded as Devonian? On the other side of this slate is also a Diorite, after this comes Quartzites and a Metamorphic band of rocks that weather white and adhere to the tongue; this is the summit of McDonald's mountain, having an elevation of 1000 feet, (Bayfield,) succeeding this, and having an elevation of about 900 feet, I found a Conglomerate, different from any other met with in N. S., it is composed of very *fine* gravel and is excessively hard. The position of it suggested *Oneida Conglomerate.* I regarded it as representing the porcellaneous rock of Arisaig pier, &c. This series is also bounded on the south by the crystalline rocks associated with the Syenite of McNeil's mountain. It corresponds very much in character, and also in relation with the mixed crystalline series of the Cobequids; so that the Arisaig Mountain Series is actually a Lower Silurian Series, intervening between the "Upper Arisaig Series" and the "Lower Arisaig Series," and may appropriately be called a "Middle Arisaig Series." This series having taken the position, at Arisaig, which I had assigned to the "Lower," we may now regard the *latter as of Cambrian age?* or lower part of the Lower Silurian age.

1874–5.—"A month among the Geological Formations of New Brunswick." Author,—*Transactions of the Institute.*

In this paper I gave the results of an examination of the Laurentian, Huronian and Primordial Formations of Saint John. I

found the recognized Laurentian here, an exact counterpart of the "Lower Arisaig series" in Nova Scotia. In some respects it more nearly resembles the series in the Cobequids; in the variety of its Limestones it has a greater resemblance to the typical series at Arisaig and the series at George's River, C. Breton, so that, if there is no doubt of the Laurentian age of the Saint John series, there can be as little doubt of the Laurentian age of the "Lower Arisaig series." The Huronian of Saint John is also very like the "Middle Arisaig series." A *Diorite* associated with the Primordial at Saint John, is perfectly identical with the Diorites of the Bala or Cincinnati of Wentworth, I. C. R. section.

I would here refer to a case which seems to coincide with the views here stated in reference to the Huronian of Saint John and the Middle Arisaig series. In the same summer, not long after I left New Brunswick, Mr. Selwyn, the Director of the Geological Survey of Canada, discovered on the Louisburg railway, between Mira and Louisburg, C. B., a series of rocks which he considered to have a striking resemblance to the "volcanic accumulations of Snowdon and Cader Idris in Wales." I had compared the "Middle Arisaig series" in the Cobequids to the *same*, as represented in "Ramsay's Geology of N. Wales." Mr. Selwyn, from personal knowledge of the Geology of Wales, had come to a similar conclusion regarding the Louisburg rocks. I may also state that Mr. Selwyn had placed the Louisburg rocks in the Huronian division, along with the rocks of Saint John, in the "Centennial Exhibition," Stratigraphical collection of the Survey.

1876.—"Nova Scotian Geology at the Centennial Exhibition."

In my Nova Scotian rock collection, the rocks of the Lower Arisaig series, of Arisaig, George's River, C.B., and the Cobequid Mountains, were exhibited as Laurentian. In the Stratigraphical Collection of the Geological Survey of Canada, the rocks of George's River and corresponding rocks from St. Ann's, C. B., and Saint John, New Brunswick, were in the Laurentian division,—vide Catalogue of the Mineral Department of Canada,—A. R. C. Selwyn, Esq., F. R. S., &c., Director. In Dana's Manual of Geology, last edition, the *Laurentian* and *Cambrian* are included under the term *Archæan*. To this he refers my typical Lower Arisaig.

Canadian Journal, July and August. Outlines of the Geology of Canada. By Prof. Chapman, Ph.D., LL.D., of the University of Toronto.

The author of those outlines having examined the district of Campbelltown, Cape Breton, indicates the rocks underlying the Coal measures, i. e. St. Ann's rock as Pre-silurian, i. e. Cambrian or Laurentian.

Thus by a tedious and indirect process extending over seven years, we have arrived at the same conclusion regarding the age of the "Lower Arisaig series" that I had reached by direct correlation in the course of a day when first examining the rocks, and that Dr. Hunt had arrived at by examining the specimens of the rocks in his Laboratory in Canada.

In these investigations I have also connected the Laurentian of New Brunswick with Laurentian of Nova Scotia and Cape Breton, and therefore with the Laurentian of Newfoundland and the typical Laurentian of Labrador. The name Labrador directs attention to the suite of specimens in the Provincial Museum which the Rev. J. Campbell, now of the Canada mission in India, kindly collected for me, in the harbours of Labrador. I find these of great service in pointing out to students the marks of resemblance between the typical Laurentian and that of Arisaig, Cobequid mountains and Cape Breton.

In the stratigraphical collection of the Canadian Geological Survey, Mr. Selwyn pointed out to me specimens of rocks of supposed Potsdam Sandstone age, from the Little Bras d'Or in Cape Breton. Mr. H. Fletcher, of the Survey, who had discovered these rocks, subsequently pointed out to me the locality. I was astonished and gratified to find that they were from strata on the north side of my Laurentian rocks of St. George's, C. B., strata, which I had *hastily* concluded to be of Carboniferous age, from the arrangements of the formations in a coast section at George's River. Mr. Fletcher found in these strata, Lingulae, Dictyonema, &c., which Mr. Billings considered to be of probable Potsdam Sandstone age. This discovery, besides being important in itself, as of the first Silurian Fossils known to have been found in Cape Breton, is of very

great importance in its relation to the Laurentian rocks of George's River. It does for this series what the Middle Arisaig series did for the Lower and typical Series; it makes the supposition of Quebec Lower Silurian age untenable, and therefore *per se* the Cambrian age probable. The lithology, corresponding with that of the Laurentian of Saint John, now makes its Laurentian age certain. Thus, we have the Cape Breton Series confirming our correlation of the typical series at Arisaig.

I would now observe, what will be readily admitted, that the township of Arisaig is remarkably favoured in the possession of three important (Typical) Series of Pre-carboniferous rocks. In fact, I believe, we are here furnished with the *data* for giving the solution, perfect or approximate, of every problem in Nova Scotian Pre-carboniferous Geology.

I would now take a look at the continuation of the I. C. R. Section in the Cobequids. Succeeding the igneous Conglomerate last referred to, we have, on the north side of the Wentworth station a remarkable section, as follows:—

		feet
	Obscure	
1.	Dark green crypto-crystalline diorites	30
2.	Black soft shale	20
3.	Diorites with shale parting	8
4.	Black shale	56
5.	Black slates and shales, very pyritous, having abundance of fossils, dip 45 N., 5 E.	40
6.	Diorite—pyritous	24
7.	Black slates with shales, dip 41 N., 5 W.	100
8.	Diorites—pyritous	14
9.	Shale	140
10.	Diorite	60
11.	Shale	6
12.	Diorite	30
13.	Shale	10
	Vertical thickness of the whole	615

The report of the discovery of this section and of my opinion that it was a *Lower Silurian* series of rocks made quite a sensation. This was so repugnant to the *grand ideal* of the struc-

ture of the Cobequid mountains,—igneous centre with Upper Silurian sides,—I was informed by authority that I was mistaken, and that the supposed Lower Silurian rocks were of *Clinton* age. Still considering that my views were in accordance with facts and reason, I maintained my position. Transactions, 1873.

From the very beginning I never saw any resemblance between the rocks in question and their fauna, with the acknowledged Clinton of Hall and Dawson, in the "Upper Arisaig series," either at Arisaig or elsewhere in Nova Scotia. This was enough to make me disregard the opinions of authorities in the matter. The only part of *this series* that did suggest itself in connection with the general aspect of the lithology of the section and the *fauna*, was the Doctor's section or B of my "Upper Arisaig Series" which is ignored or slightly favoured by the admission of possibly being a little lower than the recognized Clinton of Arisaig. Lingulæ seemed to be a characteristic feature here as at Doctor's brook, Barney's river and Sutherland's river, and Graptolites, not *Clintonensis*, but more slender in form, and diprionidean forms, diplograpsus and climacograpsus—such forms as caused perplexity in the correlation of the Doctor's brook or B. Arisaig, leading me, in my Transactions, 1865–6, to correlate it with the Hudson river; Palæontologists maintain that these forms do not occur after the Lower Silurian period. A closer examination of the lithology of the section led me to doubt the supposed resemblance and to consider that this was a normal case of *diprionidean graptolite* occurrence and not exceptional as at Doctor's brook, and to regard the series in question as of Bala or Hudson river or Cincinnati age. Its close connection with the preceding volcanic series as well as its lithology and palæontology suggested a Bala resemblance.

The two thus combine to form an almost exact counterpart of the series of Prof. Ramsay's *Section* already referred to. The Graptolites particularly suggest the Hudson River, and one peculiar form which will come under notice, suggests the Cincinnati. The arrangement here thus seems to be peculiarly "Anglo-American." The lithological characteristic of importance, which

suggests an Anglican resemblance is certainly not in the black claystones which, for want of a better term, I call slates in No. 6 of the above Section, neither is it in any of the sedimentary rocks, but in the alternation of Diorites with the strata, and their *seeming* bedded character, as if they were co-temporaneous lava flows. The Diorites are different from the Diorites generally associated with the strata of the "Upper Arisaig series" to which I have already often referred, and shall have occasion yet to refer; the latter are coarser and more solid than the former, they have not the same beautiful lustrous green colour, besides they are always intrusive and have a marked influence in altering the character of the strata in contact. The Diorites of our section are not distinguishable from the homogeneous Diorites of the Laurentian centre of these mountains, and have their exact counterparts in the Huronian and Primordial Diorites of Saint John.

Another lithological peculiarity is referred to in No. 6 of the section, "very pyritous"—the rocks containing the fossils are very pyritous, joints are filled with crystals of pyrite, and the fossils when preserved, otherwise than as casts, are pyritous. Where we have Diorites in contact with the lower members of the "Upper Arisaig series" we occasionally have crystals of pyrite in the latter; two or three times I have found fossils pyritised, but the occurrence does not come into prominence as in the present case.

Mr. Selwyn in his Report,—Reports of the Geological Survey of Canada 1875--6—takes occasion to call in question my Lower Silurian correlation of this series.

He states that Mr. McOuat of the Survey collected 300 specimens from these fossiliferous rocks, i. e. from No. 6 of the Section. He finds the rock containing the fossils to resemble certain rocks of the Ludlow formation of England, and thence infers the Ludlow or Upper Silurian age of the rocks in question, and he informs us that Mr. Billings recognized certain forms in the same specimens which he considers as proving their Clinton or Middle Silurian age. I have more specimens than I would care about counting. Certainly more than 300 specimens out of the 40 feet of strata from which the said 300 specimens were taken; but the greater part of mine having the distinctive *fauna* of

the series were taken from the lower part of the strata, whereas from the description of the rock given by Mr. Selwyn, and the *fauna* by Mr. Billings, the specimens of the Survey were taken from the upper part.

Mr. Selwyn in his lithological comparison ignores the striking lithological features of the section to which I have directed attention, and attaches importance to an obscure characteristic; a character of claystone which may be common to Lower, Middle or Upper Silurian rocks of any country. Mr. Billings' evidence of Clinton age, are 1st Graptolithus, like Clintonensis. 2. Strophomena corrugata. 3. Atrypa reticularis. 4. Lingula oblonga. 5. Rhynchonella Eva. 6. Leptæna transversalis. 1st—Graptolithus Clintonensis. This appears to be first in importance according to Mr. Billings, and to have suggested to him the Clinton age of the strata. From the observations that I have already made upon the synonyms of this *form*, when considering Prof. Hall's and Mr. Salter's correlation of B'. Arisaig, you may see that I have as much reason to assume that the graptolite referred to is Ludensis, or priodon. I therefore assume in accordance with lithology and apparent stratigraphical relations, that this graptolite is *graptolithus priodon* of Bronn and Salter.—Salter's Appendix to Ramsay's Geology,—and may therefore be an evidence of Bala age.

2nd—Strophomena corrugata. This form occurs in the Bala; Salter. It is abundant in the Mayhill Sandstone, Arisaig; it also abounds in B'. slates, Clinton, in C. Aymestry Limestone and in D. Upper Ludlow. The inference is obvious. Its existence does not necessarily indicate Clinton or Bala.

3rd—Atrypa reticularis. I do not find this occurring in Bala of Wales, nor in A. May-hill Sandstone of Arisaig. Its first appearance is in B or Doctor's brook, it does not occur in B' the recognized Clinton. Coarse and fine varieties occur in C. Aymestry limestone; this appears to be its climax at Arisaig and East River; it is also found in D. upper Ludlow. To affirm that a form so persistent may not occur in the Bala would be a hazardous position. However, grant that it does not occur in the Bala and occurs in the Clinton somewhere

it occurs also in B. *under the Clinton* in Nova Scotia, therefore its existence in our Series does not prove that it is *not lower* than the Clinton.

4th—Lingula oblonga. The species is a Clinton form, according to Hall. It does not occur in Nova Scotia Clinton, or B' Arisaig, it abounds in my Lingula nodule bed, B.

It is therefore not a Clinton form in Nova Scotia, and its existence does not prove that our series is not lower than the Clinton.

5th—Rhynchonella Eva. I have tried to inform myself regarding this form. Its specific name shows that it is one of Mr. Billings' own species. I cannot find it described anywhere.

6th—Leptæna transversalis. By referring to Salter, I find that this form occurs in the Bala. Hall does not refer to it as occurring in the Clinton of New York. It is included among his Niagara Limestone forms. It does not occur in any member of the Upper Arisaig Series. It is altogether new to Nova Scotia, and may without *impropriety* be assumed as of Bala age in Nova Scotia.

I think this examination of the supposed antagonistic evidence does not establish the Clinton age of the controverted series, but rather tends to show that it may be older than the Clinton. It is so, at least, Clinton as recognized in Nova Scotia. It will not now take much to bring down the scale. I consider that the lithology added to the palæontology has done this already. I also consider that Diplograpsus and Climacograpsus, a number of monoprionidean slender forms associated with graptolithus priodon, the number and variety of Lingulæ after Lower Silurian types, a great number of forms, new to Nova Scotian Geology, which I have not yet been able to identify, and last of all, the occurrence of Pholidops Cincinnatiensis, Hall, as figured by Meek in his Report of the Geological Survey of Ohio, Vol. I, Part II., Lower Silurian (Cincinnati group), plate Fig. 2, a. b., are sufficient evidence of Bala or Cincinnati age. Add to all this the succession of another group of harder argillaceous strata with crystalline rocks, Diorites and Porphyries. These are ex-

posed in tunnels and sections north of the *Cincinnati strata* just examined. They too are fossiliferous—I found in them one large *Lingula.* Comparative lithology, even with one lingula, would make this Lower Silurian ? giving the place which I was ready until now to assign to the other series. I therefore regard the Bala, Cincinnati or Hudson river age, of the Wentworth, Diorite, Argillaceous and Fossiliferous strata established as satisfactorily as any part of the "Upper Arisaig series." These affixed to the "Middle Arisaig series" seem to make the Lingula flags the conditional upper limit of the "Lower Arisaig series."

1875–6. Superficial Geology of Halifax County, read before the N. S. Institute of Natural Science and the American Philosophical Society, Philadelphia, May 16th, 1876. Author,—*Transactions of Institute.*

This paper contains an account of investigations in the superficial Geology of Halifax, extending over a period of three years. It shows that a very large proportion of the drift material had been collected from the Pre-carboniferous formations of the Cobequid mountains, from the Carboniferous and Triassic on the north side of Minas Basin, from the Triassic of King's County, especially from Blomidon, and from the Carboniferous formation of Hants Co., from the respective distances, 60, 55, and 30 miles.

It also shows that the boulders had been distributed along the Atlantic coast; from N. W. Arm, Halifax Harbour, to Three Fathom Harbour, a distance of about 20 miles. It points out enormous blocks of quartzite that had fallen from the drift bank sections on the shore. These show strikingly the results of rough and hard usage in the course of transportation. The underlying slates, quartzites and granites show extensive numerous and striking, polished, striated and furrowed surfaces, the effects of this transportation. The striation corresponds with the material of the drift in showing that the course of transportation had been from N. to S. It indicates that there had been two courses, 1st.—The course generally indicated in the peninsula of Halifax S. 30 E., to S. 20 E., a course which if extended includes Blomidon and seven or eight miles west of it. 2nd. Striation of

considerable extent at Wellington Station, indicating a course S. 30 W. This course passes at no great distance west of Londonderry Mines. This and the other extended beyond Blomidon to the Cobequid Mountains will include about 65 miles of the mountains N. E. and S. W., from which material has been transported.

The two meeting some way near the Windsor and Truro Railroad Junction, seem to have exerted a reciprocal action so as to convert the two courses into one course S. 5 E. The line of junction of the two seems to pass through Halifax Harbour, hence we have the great drift accumulations, Navy Island, Bedford Basin; George's and McNab's Island in Halifax Harbour; a considerable part of Citadel Hill; and the accumulations of Dartmouth. One point which has to be noticed is this, that the resultant course S. 5 W. formed by the meeting of the two courses, accounts well, especially for the syenitic transportation and distribution from the Cobequids. But in order to meet the case of amygdaloidal transportation and distribution along the shore to Three Fathom harbour, a course S. 20 E., would be necessary. My investigations in Superficial Geology are still in progress (1878).

Centennial Exhibition, 1876. An illustrative Boulder Collection was exhibited by me, in the Nova Scotian contingent of the Canadian Mineral Collection, consisting of Syenites, Gneisses, Diorites and Granites from the Laurentian of the Cobequid Mountains. Amygdaloids with the usual minerals of Blomidon. Two Islands and Five Islands, *e. g.* Agates, Jasper, Chalcedony, Cacholong, Heulandite, Natrolite and Stilbite. From Cobequids: olive coloured Quartzite with casts of crinoid columns. From Hants—Carboniferous Limestones with fossils, Macrodon Athyris, Fenestella, &c. Sandstones with cast of stigmaria and rootlets, Lepidodendron and a calamite. This collection was awarded a *Medal* by the International Judges.

REPORTS OF THE GEOLOGICAL SURVEY OF CANADA, A. R. C. SELWYN, F. R. S., DIRECTOR.

Mr. Fletcher's Map and Report is, beyond exception, the best work that the Survey has executed in Nova Scotian Geology.

It is altogether up to the mark and time. Standing on the "Lower Arisaig" representative, the extremity of Mr. Fletcher's "Boisdale Mountains," an extremity which has been often referred to in this retrospect as "George's River." As far as the mountains appear the Laurentian is seen to extend, having on the right, in direct contact, the Lower Silurian, (Potsdam Sandstone,) with the Lower Carboniferous succeeding, and on the left, as far as the map indicates, the Lower Carboniferous Limestones, in direct contact with the Laurentian — the Carboniferous resting on either is unconformable. This takes us back to the close of the Devonian Period and beginning of the Lower Carboniferous, when the Boisdale, Cobequid, Arisaig and other mountains of Cape Breton and Nova Scotia were humbly raising their heads (lower than now by 470 feet) in the wild waste of waters, having Laurentian or Silurian slopes, where mechanical agencies are forming shingle beaches or sandbeds or Laurentian or Silurian walls, where organic agencies are at work, or organic and mechanical combined in forming clay beds or calcareous deposits—the mechanical products are seen converted into conglomerates, sandstones and claystones, and the organic into limestones. Our retrospect limits our view of this formation which includes the Sydney Coal Fields.

Mr. Fletcher made another very interesting discovery at McIntosh's Brook opposite *Escasomie*, East Bay, on the left side of the Boisdale mountains, and beyond the range of the map in the last Report. Here he found a section having a singular deposit of phosphatic limestone composed almost wholly of the crushed valves of lingula. The Potsdam sandstone on the opposite side of the mountain makes these represent the Upper Lingula Flags of Wales. This is also interesting in its relation to the "Lower Arisaig" of George's river. Making it lower than the Upper Lingula Flags gives it a primordial position, so that it is no longer to be regarded as of *Quebec age*. Palæontology and relative position have lowered it to the Upper Cambrian. We have here to look to the primordial, (Lower Lingula Flags, Upper Cambrian) to lower them to the Lower Cambrian or to the Laurentian, by the aid of lithology. This is all the proof we profess

to give of the Laurentian age of the Lower Arisaig series. *Eozoon* is said to have been found in the Saint John Laurentian. Arisaig and Saint Ann's, Cape Breton have also been credited with *Eozoon;* the question of *tubulation* may make this palæontological aspect still *questionable.* I have no very great objection to allowing the matter to rest here, and to make the "Lower Arisaig series" Laurentian? or Cambrian? or with Dana to call it *Archæan.*

1877, August. Mr. Fletcher kindly sent to me specimens, the proof of another remarkable discovery that he had just made in a reputed carboniferous locality, Marion bridge, Mira river, Cape Breton, *vide Maps of Acadian Geology,* 1st and 2nd editions. The specimens are composed of broken trilobites, making a deposit analogous to the Lingula deposits of East Bay. These trilobites are altogether new to Nova Scotian Palæontology. Those that are distinguishable are *Olenus (sphaeroph thalmus) alatus* Bœck. Salter's Appendix to Ramsay's Geology of Wales—plate 4, fig. 3. The head, eyes and scimitar-shaped cheek spines, are not to be mistaken. Its usual associate *Agnostus* is seen in accompanying black shale.

According to Salter this species of *olenus* is an "Upper Lingula Flag" form. This tends to confirm the correlation of the Boisdale, Lower Silurian, Potsdam Sandstone. Mr. Fletcher will soon inform us of the relation of these to the *Lower Silurian?* or *Huronian* of Louisburg, as the olenus strata seem to be on its border.

1877–8. On the Geology of Annapolis County. By the Author—present No.

The part of this beautiful county treated of in this paper is the S. Eastern, whose pre-carboniferous rocks have heretofore been considered to be of both Upper Silurian and Devonian age.—These contain as is well known beds of Iron ore, fossiliferous and magnetic, which have been considered to be of Devonian age. Granites, Gneissoid Rocks, &c., are also found associated The Granites have been regarded as igneous rocks of Devonian age, and the Gneissoid rocks as Devonian strata metamorphosed by Granitic igneous action. Acadian Geology 2nd Edition. The paper contains the results of a survey of these

made in July 1877. The examination of the strata, and especially of localities having fossils, which are so distributed as to represent the whole field, Silurian and supposed Devonian, shew us unmistakably that the strata in question are Middle and possibly Upper Silurian, or A. and B'. and possibly C. of the "Upper Arisaig series." The Lithology of the A, Mayhill sandstone representative is highly characteristic, being in its lower part exceedingly arenaceous. In whatever part of the field these are prominent we have the usual association of *the East*, Diorites, which elevate, fold, tilt, and metamorphose the strata, converting arenaceous strata into quartzites, tilting the strata or giving them a dip of from 70 to 80, folding or faulting in such a manner as to make the apparent thickness of the strata enormous, and bring up older rocks, so as to make them appear as members of the newer series. In the region where the Diorites occur most frequently, the ores are magnetites. No part of the field has escaped the influence of these Diorites. The fossils have been almost wholly converted into casts, and crystals of Pyrite and Arsenopyrite are added. The fossils of the iron beds are often different from the Arisaig fossils of the east. Still Petraia of the Arisaig species abounds, and the genus Athyris is represented by a greater number of species than the Mayhill or Medina Sandstones of the east. The genus also occurs frequently in the iron beds. The fossiliferous iron bed has its course running indiscriminately through the Devonian and Silurian of Acadian Geology. The genus Strophodonta is represented by two large species. The Trilobites observed are Dalmanites Hausmanni? and Cheirurus? It was remarked as a coincidence that Strophodonta occurs in the same association here as Strophodonta prisca in Oneida County—with iron. The iron deposits in this locality are therefore of the same age as the fossiliferous bed of Arisaig brook, and the fossiliferous bed of Blanchard, East River, Pictou —Clinton age.

Granites.

Where the Middle Silurian approached to or appeared in actual contact with granite it was in no respect different from the same strata in the centre of the area, farthest removed from all crys-

talline rocks. The only effects apparently produced were tilting or confusion of stratification or lifting up. This seemed to be effect of the granite itself being lifted up, so that it was only a secondary agent in the process. This shewed conclusively that the granite is older than the Middle Silurian, and therefore at least of Lower Silurian Age.

GNEISSOID.

The relation of these to the Middle and Upper Silurian showed that they were underlying the Middle Silurian Strata. Diorite intervening between the two separates them, giving where distinctly intervening an opposite dip to the Middle Silurian, away from the Gneissoid, a northerly dip. The distribution and contortion of the Gneissoid, as well as lithological character indicated the age as of corresponding rocks at Halifax. They are often like the familiar *Ironstone* of N. W. Arm, Halifax Harbour. When not pyritous they are like the gneissoid in contact with the granite quarried at the back of York Redoubt. Where the Gneissoid of Halifax have accidental minerals, Andalusite and Chiastolite, the Nictaux Gneissoids have garnets. The phenomena of contact of the gneissoid and granite are similar to the phenomena of Halifax. Gneissoid fragments are seen imbedded in the granite, shewing a softening or apparent formation of the latter, subsequent to the consolidation of the former, and that the Gneissoid strata are older than the granite, *i. e.*, of the early Lower Silurian or the Cambrian. Mr. Selwyn was the first to maintain their Cambrian age. In the Stratigraphical Collection already referred to—the Quartzites, Gneissoid rocks and Argillites of the gold fields are arranged in the Cambrian division.

In conclusion I would observe that at Nictaux as elsewhere the Diorites seem to have been the agent in giving variety of position to the members of the "Upper Arisaig Series." Elevating action seems to have been at the same time generally prevalent, and hence the variety, irregularity and breaks at the junction of the Pre-carboniferous and Carboniferous formations.

The all prevalent Devonian of Nova Scotia, in 1855, is, in 1877, represented by, post Silurian and pre-Lower Carboniferous *Diorites.*