Proceedings and Transactions

OF THE

NOVA SCOTIAN

INSTITUTE OF NATURAL SCIENCE,

FOR

1886-87, 1887-88, 1888-89, 1889-90.

WITH NINE PLATES AND ONE PORTRAIT AND AN INDEX TO VOLS. I-VII.)

VOLUME VII.

HALIFAX, NOVA SCOTIA:
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1890.

ERRATA.

Page 406, line 3, for "Dorothy" read *Elizabeth*.

" " " 4, Elizabeth Willis was a native of Ireland. Dorothy was J. R. Willis' stepmother.

" " in first footnote, for "brother" read *half-brother*.

" 469, line 11, from bottom, for "four" read *three*.

" 470, " 4, for "two more nests" read *another nest*, and for "They" read *It*.

" 472, " 12, from bottom, for "has" read *had*.

" 473, " 15, for "do" read *did*.

For other Errata in this volume, see p. 178.

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D Maclagan

PROCEEDINGS

OF THE

Nova Scotian Institute of Natural Science.

VOL. VII, PART I.

Provincial Museum, October 13, 1886.

ANNIVERSARY MEETING.

DR. SOMERS, *President, in the chair.*

The minutes of last Anniversary Meeting were read and approved.

The Treasurer's accounts were then audited and found correct.

The following were elected members of Council for the current year:

JOHN SOMERS, M. D., *President.*

WM. GOSSIP, *1st Vice President.*

PROF. J. G. MACGREGOR, D. Sc., *2nd Vice President.*

REV. D. HONEYMAN, D. C. L., *Corresponding Secretary.*

ALEX. MCKAY, *Recording Secretary.*

WM. C. SILVER, *Treasurer.*

A. J. DENTON, B. A., *Librarian.*

PROF. GEO. LAWSON, PH.D., LL.D., EDWIN GILPIN, M. A., MAYNARD BOWMAN, JOHN J. FOX, SIMON D. MACDONALD, ANDREW DOWNS, MARTIN MURPHY, C. E.

MR. GEORGE CAMPBELL was proposed an associate member, and MR. HARVEY DOANE and MR. JOSEPH BENNET ordinary members.

PROVINCIAL MUSEUM, November 8, 1886.

ORDINARY MEETING.

WM. GOSSIP, ESQ., *V. P.*, in the chair.

INTER ALIA.

DR. HONEYMAN read a paper "On the Geology of Aylesford, King's Co."

PROVINCIAL MUSEUM, January 10th, 1887.

ORDINARY MEETING.

MARTIN MURPHY, C. E., was called to the chair, in consequence of the absence of the President.

INTER ALIA.

Dr. HONEYMAN read a note "On the *Nautilus* of the Lower Carboniferous Limestones of Brookfield."

He also read notes of an examination by Professor Hall, of Albany, of the Silurian Collections of the Provincial Museum.

PROVINCIAL MUSEUM, February 14th, 1887.

ORDINARY MEETING.

DR. SOMERS, *President*, in the chair.

INTER ALIA.

DR. SOMERS read a paper "On Fungi of Nova Scotia."

DR. HONEYMAN read a paper "On a Collection of Fishes, &c., from the Indian Ocean."

PROVINCIAL MUSEUM, March 14th, 1887.

ORDINARY MEETING.

DR. SOMERS, *President*, in the chair.

INTER ALIA.

Prof. J. G. MACGREGOR, D. Sc., read a paper "On Temperature and Time."

PROVINCIAL MUSEUM, April 11th, 1887.

ORDINARY MEETING.

MARTIN MURPHY, C. E., was called to the chair, in consequence of the President's absence.

INTER ALIA.

A paper was read "On the Carboniferous of Cape Breton," by EDWIN GILPIN, Esq., M. A.

A paper was also read "On Flora of the Bermudas," by PROF. LAWSON, Ph. D., LL. D.

PROVINCIAL ENGINEER'S OFFICE, May 9th, 1887.

ORDINARY MEETING.

DR. SOMERS, *President*, in the chair.

INTER ALIA.

A paper was read "On the tides of the Bay of Fundy," by MARTIN MURPHY, C. E.

A paper was read "On the Geology of Halifax and Colchester Counties, Part II.," by DR. HONEYMAN.

LIST OF MEMBERS.

DATE OF ADMISSION:

1873. Jan. 11, Aikins, T. B., D. C. L., Halifax.
69. Feb. 15, Allison, Augustus, *Meteorologist*, Halifax.
64. Dec. 20, Brown, C. E., Halifax.
84. Mch. 13, Bowman, Maynard, Public Analyst, Halifax.
84. Nov. 10, Campbell, G. M., Truro.
84. Apl. 13, Denton, A. J., Academy, Halifax.
65. Oct. 26, DeWolfe, J. R., M. D., L. R. C. S. E.
86. Nov. 8, Doane, Harvey, Halifax.
63. Feb. 5, Downs, Andrew, M. Z. S. London, Taxidermist, Halifax.
83. Mch. 14, Forbes, John, Halifax.
83. Mch. 12, Foster, James G., Barrister, Dartmouth.
82. May 8, Fox, John J., Halifax.
73. Apl. 11, Gilpin, Edwin, F. G. S., F. R. S. C., Gov.'t Inspector of Mines.
63. Jan. 5, Gilpin, J. Bernard, M. D., M. R. C. S. Lond., F. R. S. C.
65. Feb. 5, Gossip, Wm., *Vice-President*, Halifax.
81. Dec. 12, Hare, A. A., Bedford.
67. Dec. 3, Honeyman, Rev. D., D. C. L, F. R. S. C., F. S. Sc. Lond., &c., *Secretary*, Curator of Provincial Museum, Halifax.
74. Dec. 10, Jack, Peter, Cashier of People's Bank, Halifax.
60. Jan. 5, Jones, J. M., F. L. S., F. R. S. C., Halifax.
82. Apl. 12, Keating, E. H., City Engineer, Halifax.
85. Jan. 11, Laing, Rev. Robert, Halifax.
64. Mch. 7, Lawson, George, Ph. D., LL. D., F. I. C., F. R. S. C., Prof. of Chemistry and Mineralogy, Dalhousie College, Halifax.
81. Mch. 14, Macdonald, Simon D., F. G. S., Halifax.
77. Jan. 10, MacGregor, J. G., D. Sc., F. R. S. C. and E., *Vice-President*, Prof. of Physics, Dalhousie College, Halifax.
72. Feb. 5, McKay, Alex., *Secretary*, Supervisor of Halifax Public Schools, Dartmouth.
85. Oct. 21, McKay, A. H., B. A., B. Sc., F. S. Sc. Lond., Principal of Pictou Academy, Pictou.
78. Nov. 1, McLeod, John, F. S. Sc. London, Demerara.
77. Jan. 13, Morrow, Geoffrey, Halifax.

70. Jan. 15, Murphy, Martin, C. E., Provincial Engineer, Halifax.
79. Nov. 11, Poole, H. S., Associate of the Royal School of Mines, F. G. S. Gen. Supt. of Picton Coal Mines, Stellarton, Pictou Co.
65. Jan. 8, Rutherford, John, M. E., Stellarton, Pictou Co.
64. May 7, Silver, W. C., *Treasurer*, Halifax.
75. Jan. 11, Somers, John, M. D., F. R. M. S., *President*, Halifax.
85. Jan. 12, Stewart, John, M. D., Pictou.

ASSOCIATE MEMBERS.

DATE OF ADMISSION:
81. Nov. 13, Harris, C., Prof. of Civil Engineering, Royal Military College, Kingston, Ontario.
76. Nov. 9, Kennedy, Professor, King's College, Windsor.
82. Mch. 31, McKenzie, W. B., Engineer, Moncton, N. B.
78. Mch. 12, Patterson, Rev. G., D. D., New Glasgow.
84. Apl. 4, Pineo, A. J., Kentville.

CORRESPONDING MEMBERS.

71. Nov. 29, Ball, Rev. E., Tangier.
71. Oct. 12, Marcou, Jules, Cambridge, Mass.
80. June 10, McClintock, Sir Leopold, Knt., F. R. S., Vice-Admiral.
77. May 12, Weston, Thomas C., Geological Survey of Canada.

LIFE MEMBER.

Parker, Hon. Dr, M. L. C., Halifax.

PROCEEDINGS

OF THE

Nova Scotian Institute of Natural Science.

ART. I.—GEOLOGY OF AYLESFORD, KING'S COUNTY, N. S.—By the REV. D. HONEYMAN, D. C. L., F. R. S. C., F. S. Sc., London.

(Read November 8, 1886.)

I HAVE already read notes on the Geology of Wolfville and Kentville, in this same County, and also on Nictaux, in Annapolis County. In the last I encroached somewhat on Kings County. (*Vide* Papers in *Transactions* 1877-8.) These left the long distance of twenty-three miles unexamined. In August last I had an excellent opportunity of interrupting this distance by an examination of a considerable part of Aylesford. My headquarters were at Holmworth—the Rev. B. Musgrave's—through whose assistance I was enabled to make a very satisfactory examination of the district. It was observed that stones were of rather rare occurrence. Red sand is seen on all sides—the *debris* of the Triassic formation. The formation itself is rarely to be seen. On the banks of the rivers are *alluvium* and a *terrace.* Our attention is directed to one large stone. It is basaltic. Its original position was the basaltic rocks of North Mountain, about five or six miles north of its present position. Henceforth similar boulders appear often enough. With these are associated granite boulders, which have come from an opposite direction, from South Mountain, where the granites are to be seen also in position. We now cross the Annapolis River on our way to North Mountain. We proceed eastward until we come to the Ormsby Road. Going along the road, before crossing the railroad, we have on each side sections of a great drift elevation—a "boar's back"—whose trend is in the direction of the valley N. E., S. W. This is chiefly sand; but numerous small-sized boulders are seen falling from the sides of the sections. Some of these are basaltic; others are amygdaloids. These also come from the North Mountain; others are granitic; still others are purplish quartzites. We will find the last come from the South Mountain, as well as the granite boulders. We cross the railroad to the east of the Aylesford Station and proceed towards the North Mountain. Boulders on the road and sides, large and small, are granites, basalts and amygdaloids, &c. Other peculiar ones appear and continue up the sides of the mountain. These are diorites and felsites, &c. In the meantime they are perplexing. They have the aspect of Cobequid Mountain Archaean Rocks. On the mountain side there is seemingly remnants of the Triassic sandstones. We proceed no farther in this direction.

Proceeding from our headquarters to the South Mountain, we cross the Annapolis River and reach the main road. In a small branch of the River, over which there is a bridge, we observe basaltic boulders. Farther on we observe a pile of stones at a barn. These consist largely of basalts. There are a few boulders of granite. Farther on, on the right (north) side of the road, we find embedded in the soil a sizeable boulder of basalt and another of granite. We come to the road that leads to the South Mountain. Going along this we come to the new bridge which has just been built across the Annapolis River, and cross it. On either side of this there is a new road. There is nothing observed but sand and bog. Beyond this we see and chip large boulders of basalt and amygdaloid. Many specimens of the latter, we bagged, on account of the beauty and variety of their zeolite amygdules. There are also abundance of immense granite boulders. We only look at and note these. Approaching South Mountain our attention is turned to boulders of purplish and red quartzites, with quartz veins and masses of gray slates. We ascend the mountain. A very large and beautiful amygdaloid boulder is seen on the left. We examine and chip it. An outcrop of red arenaceous and argillaceous slate is observed crossing the road. We observe its strike. It is N. 80 E., S. 80 W. This is doubtless an extension of the silurian of the eastern and western parts of South Mountain, Wolfville, Kentville and Annapolis County, Nictaux and Moose River, outcrops of similar strata, but of gray colour, continue, as far as the Jackson Road. At the corner of the two roads, and on the latter, are beautiful exposures of glaciated surfaces. We take the courses of a number of these, and find that they are generally S. 30 E., corresponding with striation of Point Pleasant, Halifax. This is the *path* of North Mountain basaltic and amygdaloid boulders, which are still observable. We are now in quest of the Canaan Road. To reach it we proceed westward on the Jackson Road until we reach a cross-road leading south. We proceed along this, observing boulders of granite, basalt and amygdaloid, and reach the Canaan Road. This road was noticed in previous papers, *e. g.*, Nictaux. We are disappointed to find this road—surveyed, but only opened and used here and there. On our left (east) it is only a foot-path ; to the right we walk along. There are houses and fields on the south and forest on the north. Among the boulders we observe and collect beautiful amygdaloids. Coming to the end of the forest on the right, in a clearing with stumps, we observe a towering outcrop of rocks. They are very ferruginous. Chipping them they are seen to be gneissoid, similar to the Halifax "ironstone," and probably of the same age—Cambrian. Returning to the road we observe low outcrops with S. 80 W., N. 80 E. strike. In a clearing on the south we proceed farther southwards. Observing white rock on the high ground we made for it direct. Here was a chief object of our search. Granites in *situ* ; *roches moutonnées* running east and west—the sources of the granite boulders which we have met with so often. With Dana we regard these granites as of Archaean age and of Metamorphic origin. Others regard them as of Devonian age and Igneous origin. *(Vide* our papers *Trans.)* We return. On the north of the granites we have a depression with bog. We cross this by a bridge, reaching the opposite side. We observe an outcrop of bedded rock similar to that noticed on the other side of Canaan Road, near the gneissoid strata. We miss the Diorite dykes, which are of frequent occurrence in Annapolis and Digby. We had been led to expect them by the occurrence of the diorite boulders already noticed on Ormsby Road. Our investigations, however, have been so far satisfactory. Returning to the Jackson Road we take a longer road than that by which we came, and return to Aylesford by Mill Village.

We propose crossing North Mountain to Morden, on the Bay of Fundy. The Auburn Station, according to the railway measurement, is two miles west of the Aylesford Station. The former is on the Morden Road. On this road, about two miles north of the station, we come to the foot of North Mountain. On our way we observe granitic, basaltic and amygdaloid boulders. Of course the occurrence of the two last is as expected. The continuance of the granite boulders is puzzling. On the top of the mountain are abundance of outcrops of rocks. Amygdaloids, amygdaloids, amygdaloids, with gray and red bases. About two miles from Morden we notice the absence of granitic boulders, and we come to a rock with little or no amygdaloid. It is a trap, without the characters of the two former. Reaching Morden, we proceed to the shore to look for a shore section of the rocks of the Mountain. Here we find the amygdaloid, with the other trap rocks seemingly overlying. Near the junction we find the overlying rock, permeated with veins of Zeolites. Out of these we collect many fine specimens. At the point the amygdaloids disappear, and we find ledges of the overlying trap. In these we observe abundance of agates. None of these tempt us. They are destitute of lines, fortification or other. We have not met with basalt *in situ*. Our granite boulders have not advanced thus far. The arrangement of formations from Morden to the south of Canaan Road, in the South Mountain, in descending order, is the Igneous rocks, Triassic, Silurian, Cambrian (?), Archaean, with superficial post-pliocene. Distance thirteen miles.

We go along the line of railway from Auburn towards

Aylesford Station. On the north of the line the usual basaltic, amygdaloid and granite boulders are of frequent occurrence—sometimes singly, at other times in heaps. Large boulders have been utilized in the construction of fences, for supports of poles. The basalts are of the usual kind, occasionally they are olivinetic. The red amygdaloids occasionally have large amygdules of mesolites, beautifully radiating. We collect from these boulders. Our work is interrupted. We resume. Commencing at the Osborne Road, we make another inroad on the South Mountain. Proceeding along the Mill Village Road, we have our boulders, granites, basalts and amygdaloids. At the foot of the Mountain, before reaching the Methodist Church, we find amygdaloid boulders of great size, with equally large basalts and granites. Silurian strata, shales, are also seen outcropping. Outcrops of slates succeed, and boulders. We are now in search of the Canaan Road. Boulders continue, but rocks are obscured. Granite boulders predominate, but basalts and amygdaloids are still plentiful. We reach high ground and commence descent into a valley. Here we notice particularly large amygdaloid and basaltic boulders. The former are deeply embedded in the road. Descending, we observe several sections of metamorphic slates. These and all the strata we have already noticed seem to be destitute of fossils. We reach the Canaan Road and the site of a saw mill. We are informed that the part of the road which connects this with that of our previous examination is only a foot-path through the forest. Going along the road in an easterly direction we observe diorite boulders similar to those observed on the Ormsby Road and the sides of North Mountain. We are interested and search for others. We find the same variety as on North Mountain, and best of all we find the diorite *in situ*. We walk to some distance along the road, observing occasional outcrops of shales and amygdaloid boulders. Finding that we are going in the direction of the strike we return. Before coming to the saw mill we reach a farm, where the Mountain on the south seems to be accessible. Expecting to meet with granites as in our course of a preceding day, we make for the highest ground. Only granite boulders are observed, with occasional amygdaloids. Continuing our course through fallen trees and brush to a distance of half a mile south of Canaan Road, we observe what seems to be the granite *in situ.* Reaching this we find immense masses of granite resting on stratified rock. Several outcrops of these rocks appear farther to the south-east. They are gneissoid rocks similar to those which we observed at Nictaux, and supposed from analogy to be of Cambrian age. Here is a field of grain. On the south is seemingly impenetrable forest. In this doubtless lies the extension of the granite observed to the south of the Canaan Road. We find and return by a cart road, on which are exposed frequent outcrops of the gneissoid and other metamorphic bedded rock, which were not observable on our preceding way. About a quarter of a mile from the Canaan Road and saw mill I reached the dyke of diorite. It seemed to be as wide as the dykes of Nictaux, to which I have devoted special attention in our Polariscopic studies. (*Vide* papers, &c.) Outcrops of slates, &c., occur before reaching the Canaan Road. The arrangement of rocks from North Mountain to our extreme point on South Mountain is: Triassic with dolerites, Post-pliocene drift, recent alluvium, Silurian (South Mountain) with diorites, gneissoid and slaty rocks. Cambrian? Distance nine miles.

These sections correspond generally with those of Nictaux. The only formation that presents peculiarity is the Pleistocene. I have noticed southerly transportation. I expected this, and even a certain amount of northerly transportation; but I was not prepared to find it so extensive or so much northerly. I regard this transportation to be the work of those agencies which formed the valley between North and South Mountain after the glaciers transported the basalts and amygdaloids and deposited them on the South Mountain and Atlantic coast. I therefore would refer this northern transportation and the "boar's back" drift, generally, to the Champlain period.

ART. II.—THE NAUTILUS OF THE BROOKFIELD LIMESTONE.—NAUTILUS BROOKFIELDI, N. SP.—REV. DR. HONEYMAN, D. C. L.

(Read January 10, 1887.)

OUR attention has been particularly directed to this subject by the presentation to the Museum of a fine specimen of this fossiliferous limestone, by J. J. FALCONER, of the Acadia Iron Works. Large quantities of this limestone from the Brookfield quarries, Colchester County, are used at these works in the reduction of the iron ores. Our specimen was happily rescued from the furnace.

It measures 6 x 5 inches; its greatest thickness is four inches. It shows the distinct remains of a dozen *nautili*. The habitation chambers of six individuals are seen upon one side. These are of medium size. Others that we have collected from the same limestones are larger. Those of our specimen measure 2.2 inches along the outer curves. Another of the same size, which is separate and has parts of upper chambers attached, has a girth of 3 and 3.3. The form of the empty chambers is sub-eliptical; the siphuncle is central. This species is very distinct from the *Nautilus avonensis*, Dawson. Of this we have two larger body chambers from the Avon limestones, Windsor. The siphuncle has its characteristic position, *dorsal*. A still more beautiful specimen of the chamber of habitation of this species is from the Brookfield limestones. It is a cast full of the shells of brachiopoda. Its siphuncle is dorsal. It has two lateral ridges; the middle is slightly convex. Our new species wants these ridges and the middle is concave. We name the species, *Nautilus brookfieldi*. The limestones are of Lower Carboniferous age.

Art. III.—Notes of Examination by Prof. James Hall, of the Silurian Collections of the Provincial Museum, —By the Rev. D. Honeyman, D. C. L., F. R. S. C., F. S. Sc.

(Read January 10, 1887.)

Prof. Hall's early contributions to the Silurian and Devonian Palæontology of Nova Scotia have formed the basis of all our accurate knowledge of the subject. In these he described, figured and named characteristic Silurian and Devonian fossils, and assigned them to their proper positions in the Silurian and Devonian systems. He has consequently been regarded as paramount authority on questions relating to this department of Palæontology. Our extensive collections, made since the publication of Prof. Hall's work include almost all the fossils described by him, and a large number still undescribed. Many of these have been examined and characterized by Salter and Barrande, (although not figured or described) and referred to their proper palæontological and geological positions; while others, not examined, have been identified and characterized by myself, and referred to their supposed geological horizons. No small controversy has arisen in consequence of the publication of our views in the Transactions of our Institute and elsewhere. As the end of all our investigations is a sincere desire after truth, I have often wished for what I have at length obtained—a personal examination of my entire collections, as they are now arranged and displayed in our Museum, by an authority to which, as Sir Roderick I. Murchison would have expressed it, "we are all disposed to bow."

I directed attention: I. To a Silurian collection from Cape Breton. This consists of the Brachiopods *Lingulellæ* and the Trilobites *Agnostus* and *Olenus*, or *Sphærophthalmus alatus*. Professor Hall agrees with me in referring these to the "Upper Lingula Flags" of Wales, where the same forms occur, according to Salter,—Appendix to Ramsay's Geology of North Wales. Paper Trans. 1873, Nova Scotian Geology Retrospect, page 485, 1878; Louisburg Past and Present, page 207, 1885. II. A Collection from Wentworth, I. C. R., was next examined. In this Trilobites *Calymene senaria, Dalmanites.* Sp. Graptolites: *Climacograpsus.* Hall, *Linguloe, Pholidops Cincinnatiensis,* Hall, and other *Pholidops, Leptæna transversalis, L sericea, Grammysia,* Sp. *Cyclonema crebristriata* were identified. A supposed *Atrypa reticularis* was discarded. Professor Hall agreed with me in referring these to the Cincinnati or Hudson River and Utica group. *Vide* Trans., 1873. Paper, Nova Scotian Geology, Intercolonial Railway, page 854. Nova Scotian Geology Retrospect, 1878, page 473. "I have assigned the lower part of these to Bala, of England, or Cincinnati, of United States, also pages 478, 481. Attention was also given to my 'Arisaig collection.'" I have divided the Arisaig fossiliferous into members and have designated them alphabetically thus: A, B, (Doctors Brook and Arisaig Harbour). B', C, (Arisaig Brook and Knoydart). D, E, (Moydart). Our collection is designated accordingly—A, B, C, E, E, F. Mr. Salter suggested this. Prof. Hall's attention had been directed to a collection made by Dr. Dawson (Sir J. W.), from B' and D. He identified named and figured certain fossils. B,' was accordingly named Clinton, and D, Lower Helderberg. Salter's attention was directed to a large collection of fossils frem A, B, C, D, E, at London Exhibition of 1862. He designated A, Mayhill sandstone; B, Ludlow; C, Aymestry Limestone; D, E, (upper and lower part) Ludlow Tilestone, identified and named some of the fenils. Mr. Bailly and Sir C. Wyville Thomson examined an addition to the collection at Dublin exhibition, 1865. J. Barrande and E. de Verneuil examined another addition at L Exposition Universelle de Paris, in 1867. Medals were awarded to me for my collections at all these exhibitions. I have referred to this collection and examination in several papers read to Geological Society of London, and Nova Scotian Institute of Natural Science. So much for the past. Our last examination commenced with D and E. We propose to invert the order, and give first our notes on A and B. In my paper "On the Geology of Antigonish County," Trans. Vol. I, Part IV., May 1866. (This paper was written 20 years ago.) We read, page 10 and 9, 'Hall's noble work on the Canadian Graptolites, has led me to consider that there is yet something to be done in the correct determination of the equivalency of the Arisaig group, as the graptolites of B appear to have the *facies* of the Hudson River group, so that A and B may be the Arisaig equivalent of this group. Instead, therefore, of beginning at the Upper Silurian age it may begin with part of the Lower Siluiian, so that in Arisaig A and B are probably equivalent to the Hudson River Group—Lower Silurian." Mr. Salter's opinion that A was equivalent to the May Hill Sandstone of England, which is at the base of the Upper Silurian, led me to connect B and B', and to put an (?) after B'. In my "Revision of the Geological formations of Antigonish County," presented to the Royal Society of Canada and read before the Institute last Session (May, 1886), I was led back to my opinion of 1866, and to regard A and B as Hudson River and Utica Slate. For reasons *Vide* paper, Trans. It is satisfactory to find Prof. Hall now confirming my opinion. He recognizes the greater part of the Graptolites of Doctor's Brook as belong- to his genus *Climacograpsus*. I described to him the best specimen which I unfortunately took to the Museum of the Geological Survey at Gabriel Street, Montreal, and gave to Mr. Weston. This has been lost or mislaid. This was a beautiful and much prized specimen, I described as having the stipe pointed at the lower end, as having 10 notches (cells), alternating on either side, and terminating with about half an inch of the stipe, lanceolate and without notches. Prof. Hall says that this is characteristic of the genus. I next showed him a handful of opened nodules, with beautiful and varied lingulæ from my "Lingula Bed" Arisaig, Barney's River and Sutherland's River, especially at the two last localities, occurring at distances 12 to 14 miles and 20 miles from Arisaig. He considers this a very remarkable bed. Similar linguæ but not in nodules are found associated with *Climacograpsus*, in the corresponding geological horizon, at Wentworth, I. C. R. Attention was next directed to the Petraia of Arisaig A, and Lochaber. Specimens from the latter locality are considered very beautiful. Gasteropoda from A Arisaig, were recognized as *Cyclonema crebristriata.* The first of this Gasteropod which Prof. Hall recognized was in the Wentworth collection.

Trilobites of B, were also examined. *Calymene senaria, Calymene tuberculata,* and *Phacops.*

I would observe that the Arisaig A and B, are my own discoveries. Dr. Dawson having only brought the series down to B' Clinton, of Hall. Vide Geology of Arisaig, by D. Honeyman, Quarterly Journal of Geological Society, 1864.

I also discovered the Wentworth equivalent of A and B. Vide Nova Scotian Geology,—Intercolonial Railway, Trans., 1873. Subsequently Mr. McOuat, of the Geological Survey made collections in this locality. These led to the belief that the formation is of B', or Clinton age. My extensive collection made previously led me to consider "The Wentworth Group," as approximately "Hudson River, U. S., or Bala of England," *Loc. cit.*, page 354. Sir William Dawson and Dr. Selwyn have not examined my collections.

ART. IV.—ADDITIONS TO THE LIST OF NOVA SCOTIAN FUNGI—BY J. SOMERS, M. D., F. R. M. S.

(Read February 14, 1887.)

1. Agaricus (Psilocybe) semilanceatus, Fr. Liberty; Cap.; Psilocybe abundant; growing under Spruce. Pennant, Halifax County.

2. A. Mycena delectabilis, Peck, Aug. 1886; among moss, in damp, peaty spruce woods. Pennant. The diagnosis formed upon Prof. Peck's description of the species; p. 93, Rep. N. Y. State Museum. 1885.

3. (A. Pholiota) radicans, Fr.; on the roadside (Halifax road), Sept. 1886.

4. Lactarius, lignyotis, Fr. A rare but very pretty fungus, its bright crimson surface resembling fine silk plush; growing on turfy soil under spruce. Pennant, Halifax Co., August, 1887. Named for me by Prof. Peck. 'Tis not in Cook.

5. Hygrophorus speciosus, Peck, Willow Park woods. I am doubtful if I have reported this species before.

6. Russula alutacea, Fr. Woods Pennant, 1886.

7. Marasmius terginus, Fr.

8. M. personatus, Fr. Same locality as last.

9. Xerotus degener, Fries; very delicate, shriveling up quickly in dry weather; growing on moss tussocks; Woods Pennant, Halifax Co.

10. Boletus pachypus, Fr. Aug. 1886, as above.

11. Polyporus spumeus, Fr.; 1886, Deal's, Dutch Village, Halifax Co.

12. P. destructor, F. Oct. 1886, on decaying Fir wood. Melville woods, Halifax Co.

13. Hirneola auricula Judae, Fr. Oct. 1886, on dead trunks of White Pine. Same locality.

14. Ditiola radicata, Fr. Rooting diteola on decaying Birch [Bethuula excelsa]. Oct, 1886, Melville Island woods.

15. Vibrissea truncorum, Fr. Golden vibrissa (same as last.)

The past season being very dry, and Fungi being so very dependent upon moisture for their life and well being, I have not been able to find the same abundance and variety of these interesting plants as on previous occasions, therefore my bill of fare is a very meagre one.

ART. V. — ON THE MEASUREMENT OF TEMPERATURE AND TIME — BY PROF. J. G. MACGREGOR, D. SC.

(Read March 8, 1887.)

(Abstract.)

THE object of this paper was to point out the analogy between the so-called measurement of time and of temperature.

The time of the occurrence of any event may be described by the aid of any series of recurring events. The daily passage across the meridian of the first point of Aries may be chosen, for example. In that case the time of the occurrence of an event is described as between the nth and $(n+1)$th transits of this point. To make the description more definite we may use a rapidly oscillating pendulum and describe the event as occurring between the mth and the $(m+1)$th oscillations of the pendulum after the nth transit of the first point of Aries. By thus selecting a series of events occurring with sufficient frequency it is possible to give our descriptions of instants of time as great precision as may be desirable.

It is consequently possible to record the magnitudes of variable quantities (e. g. distances, angles, etc.,) at definite instants, and therefore to compare the changes which the positions of bodies may have undergone in any required interval of time.

To facilitate the comparison of the contemporaneous changes of position or motions of bodies among one another, the motion of some one body is chosen as a standard, and all other motions are compared with it. It is obviously desirable that the moving body chosen as a standard of reference should so move that as many as possible of the laws of the motions of other bodies, when expressed in terms of its motion, should be (1) simple and (2) permanent, i. e., independent of the date of their determination. The selection of such a moving body is rendered possible by the records of astronomers, which extend over more than 2000 years. Their observations shew that if the motions of other bodies are compared with the contemporaneous rotation of the earth relative to the fixed stars, the laws of their motions take forms which are simpler and more permanent than if any other motion be taken as standard. Hence, by common consent, the motion of the earth about its axis is taken as a standard with which other motions are compared.

It is obvious that if the interval of time in which the earth makes a complete rotation were always the same, the laws of the motions of bodies, expressed by reference to the contemporaneous rotation of the earth, would be identical with the laws of their motions, expressed in terms of time. Usually in stating the laws of the motions of bodies it is assumed that the rotation of the earth is uniform, and these laws are expressed in terms of time. But though the terminology of time is employed the laws of their motions are always really expressed in terms of the standard motion.

Recent discussion of astronomical observations * seems to shew that the laws of the motions of heavenly bodies would take simpler forms, and would be more permanent, if the standard motion were that of an ideal earth, rotating so that its rate of rotation would slowly gain on the rate of rotation of the actual earth. If the time of the rotation of this ideal earth be assumed to be uniform, the time of the earth's rotation, i. e., the sidereal day, must be regarded as increasing at a slow rate; and when the sidereal day is said to be increasing, nothing more is meant than that, as time goes on, a greater and greater number of rotations of this ideal earth occur during one rotation of the actual earth. We have no means of knowing whether the time of the rotation of the ideal earth is more or less variable than that of the real earth. But as the laws of the motions of bodies generally are simpler and more permanent when expressed in terms of the rotation of the ideal earth than when expressed in terms of the rotation of the real earth, it is convenient to assume the time of the former uniform and that of the latter variable.

While therefore it is possible to describe instants of time with any degree of precision, it is not possible to measure the interval

* See Thomson & Tait's "Treatise on Natural Philosophy," Part II, p. 830.

of time between two instants, i. e., to compare one interval with another as to magnitude; and when we express the laws of the motions of bodies by reference to time, and thus seem to claim to be able to measure time, we are in reality only expressing the laws of the motions of bodies in terms of the contemporaneous motion of some one body.

The temperatures of bodies may be described by reference to any quantity which varies with temperature, as the volume of a body under constant pressure, or its pressure under constant volume. Thus the temperature of a body is usually described as being the same as that of the mercury in a thermometer when the apparent volume of the mercury has a specified value. Except for the difficulty of making thermometers which are exactly comparable, temperatures may be described in this way with as great precision as may be desired.

It is therefore possible, as it is also important, to compare the changes of volume, pressure, &c., of different bodies, involved in given changes of temperature. Changes of volume, pressure, &c., consequent upon the same change of temperature, may be called co-thermal changes, the term *co-thermal* having the same signification with respect to temperature as *contemporaneous* has with respect to time.

To facilitate the comparison of co-thermal changes, some one such change is chosen, and all others are expressed in terms of it. Usually the change chosen as standard is the change in the apparent volume of the mercury in the ordinary thermometer. And when the laws of the variation of the volume, pressure, etc., of bodies with temperature are expressed in terms of the co-thermal change in the apparent volume of the mercury of the thermometer, the laws of the variation of volume, pressure, etc., thus expressed, are said to be expressed in terms of temperature. They are no more really laws of variation in terms of temperature however than laws of the motions of bodies expressed in terms of the contemporaneous rotations of the earth are laws of their motions with respect to time. When we speak of them as laws of variation with respect to temperature, we assume, for the sake of a convenient terminology, that increments of the apparent volume of the mercury in the thermometer, which are the same fraction of its apparent volume at the temperature, say, of melting ice, are due to equal changes of temperature.

It is found that if we employ thermometers containing different liquids, and compare the changes of volume, pressure, &c., of bodies due to change of temperature, with the co-thermal changes in the apparent volumes of these liquids, the laws of the variation of volume, pressure, &c., thus obtained have different forms, but that if gases, far removed from their temperatures of condensation, be employed instead of liquids the laws obtained have the same form. Hence it is manifestly advantageous that laws of the variation of quantities with temperature should be expressed in terms of the co-thermal changes in the apparent volume of a gas enclosed in a glass vessel.

Sir William Thomson has shown that if the variations of the volume, pressure, &c., of bodies, due to a change from one temperature to another, be compared, not with the co-thermal change in the apparent volume of a liquid or a gas enclosed in a glass vessel, but with the work done by a reversible heat engine, working with its source at the one temperature and its refrigerator at the other, and taking in at the source an amount of heat sufficient to raise the entropy of the working substance by a fixed amount, the laws of the variation of the volume, pressure, &c., of bodies, expressed in terms of the work thus done, will be the same, whatever the working substance of the heat engine may be. Hence it is manifestly still more advantageous that laws of variation with temperature should be expressed in this way. But laws of the variation of volume, pressure, &c., expressed in this way, are no more truly laws of the variation of these quantities with respect to temperature, than those expressed by the aid of the Mercury Thermometer.

In fine, neither time nor temperature can be measured, And when we seem to claim to measure them by expressing laws of the variation of quantities with time or temperature, in terms of time or temperature respectively, we are simply expressing these laws of variation in terms of the contemporaneous or co-thermal changes respectively, of some body chosen as a standard.

ART. VI.—THE CARBONIFEROUS OF CAPE BRETON—By EDWIN GILPIN, JR., A. M., F. G. S., F. R. S. C., DEPUTY COMMISSIONER PUBLIC WORKS AND MINES, AND INSPECTOR OF MINES.

(Read April 12, 1887.)

PART II.

IN my last contribution on this subject I sketched briefly the outlines of this formation as exposed in the Counties of Cape Breton and Richmond. I now purpose following the various subdivisions as they are met in the remaining counties, and to finish with analyses of the coal beds, iron ores, limestones, saline springs, etc., met in the Carboniferous of the Island. These analyses are found scattered in various reports and papers, and are not accessible to the general public, and I may therefore be pardoned for inflicting on you the dry calculations of the analyst.

In finishing the first part of this paper I alluded briefly to the coal field of the River Inhabitants Basin. This district was first reported on by Sir J. W. Dawson, and the results of his survey are to be found in the journals of our Legislative Assembly. Owing to the paucity of exposures and the wooded character of the country, little could be gathered by him of interest to the field geologist.

Some interest was shown in the district at that time, and seams were opened on at Little River, and at Carabacou Cove, and some outcrops exposed on the west side of the river Basin. The mines, which were imperfectly opened, did not long compete with the collieries of the Sydney district and were abandoned. Mr. Fletcher, of the Geological Survey, used every exertion to map out the district with precision, but it proved a difficult task, its complicated structure was rendered less intelligible by the presence of several faults of great magnitude, and scarce a record could be found of the large sums spent in prospecting. It, however, would appear, that, roughly speaking, there is a coal basin extending from Carabacou Cove to Little River, then running in an easterly direction across the River Inhabitants, and sweeping south to the shore of Lennox Passage. Outside this basin are thick beds of millstone grit, but the whole series is interrupted by masses of the Marine Limestone Series, brought, possibly by faults, into curious relations to the coal beds. In fact at Little River it has been suggested by several geologists that the coal is associated with the limestones, and gypsums, a mode of occurrence paralleled I believe in the North of England.

At Coal Brook a seam four feet thick is said to have been found, with several smaller ones in the vicinity. At the Little River Mine the measures are steeply inclined, and apparently form the axis of a narrow basin. They dip at a nearly vertical angle, and present the following section:

	Ft.	In.
Coal	3	0
Strata	154	0
Coal	4	0
Strata	60	0
Coal	3	0
Strata	45	0
Coal	5	0

The upper beds were opened some years ago by the Eastern Development Company, and a few tons extracted. The coal is compact and apparently of good quality, but I have seen no recent analysis of it.

These outcrops have been traced but a short distance as the surface earth is very deep. Their exact relation to the Seacoal Cove seams is obscure, but they may possibly be repetitions on the northern side of an anticlinal. At the latter place quite extensive operations were carried on between 1863 and 1865, but only a few hundred tons of coal were shipped. Mr. Campbell reported that there were several workable seams from three to eleven feet in thickness, all standing nearly vertical. The coal is said to be similar in quality to that of Little River, and to resemble the Pictou coal rather than the more bituminous variety mined in the Sydney district.

It is to be regretted that the records of the thousands of dollars spent in exploratory work in this district have been almost entirely lost. The field geologist, confined to natural exposures and outcrops, finds that the notes of a borehole or of a shaft frequently supply the very information desired to show the nature or dip of an important piece of ground. However, Mr. Fletcher has compiled all that is available above and below ground, and has furnished information of great value to future explorers. From a review of what is known about this district it may be said that there is a strong probability of workable coal seams being found in those portions lying less disturbed than the sections opened at Seacoal Cove and Little River. The fact that an almost continuous winter shipment can be carried on will help to forward the development of any discoveries.

At Glendale, on the upper waters of the River Inhabitants, there is a small isolated coal field, the exact horizon of which is doubtful. If the idea of there being two unconformable series of measures as suggested in Mr. Fletcher's report be adopted, the coal of Glendale and of the mouth of the River Inhabitants may be assumed to correspond, and the limestones of Glendale and Plaster Cove are identical. However, further search into the relationship of the Little River coal and plaster is needed before the structure can be clearly made out. The Glendale coal field as yet boasts of only one seam about 20 inches thick, as reported by Mr. Fletcher, there is said to be another seam about three feet thick underlying it. However, the total extent of ground apparently underlaid by coal is limited, and at present scarcely tempts exploration.

The extent of the Carboniferous of Victoria and Inverness Counties can be readily understood by any one at all familiar with the geography of the island. If a line be drawn from the mouth of the Cheticamp River to the mouth of Middle River the country to the east of it will be found to be almost exclusively occupied by the pre-Cambrian measures, and on the west side are met the Carboniferous with a few outlines of the older measures. The western shore of the Bras d'Or Lake from Baddeck through the Grand Narrows and West Bay to Hawkesbury complete the circuit of the district now under consideration. Its length is about eighty miles, and its maximum width from Mabou to the Grand Narrows about thirty-five miles. It is composed almost exclusively of Carboniferous measures with a few protruding ridges of Devonian and Pre-Cambrian strata. The largest of these ridges forming the Craignish and Whyhogomah hills begins near Plaster Cove, in the Strait of Canso, and runs north-easterly to Whyhogomah; its width at the Strait of Canso being about ten miles, but narrowing to an average of about five miles. Near the Strait of Canso it is largely Devonian, then Pre-Cambrian felsites, etc., are met, followed by the associated crystalline limestones, most generally known in connection with the Whyhogomah iron ores. Scattered areas, small in extent, of felsites and limestones, are met at the head of, and near the eastern shore of Lake Ainslie, and connect with the main body first referred to along the divide between the Margaree and the St. Patrick's Channel watersheds. The highlands of Cape Mabou, and of the Malagowatch Hills, and some small outliers along the north side of St. Patrick's Channel may complete our reference to these pre-Carboniferous measures.

It may be remarked here that throughout Cape Breton the older and harder rocks in ridges of varied size and outline have a general north-east and south-west course, and are higher than the newer carboniferous strata which dip, roughly speaking, away from them, forming wide valleys. The traveller will readily recognize these features in the stern hills of Boiesdale, St. Ann's, Coxheath, Mira, Marble Mountain, etc., as compared with the valleys of the Sydney, Middle and Margaree, as well as of the Dennys and Inhabitants Rivers.

Taking the productive and millstone grit measures together, they are to be looked for on the Gulf shore, and apparently at one time formed a belt continuous, at least from Judique to the Cheticamp River, a distance of about sixty miles. Now they form four narrow strips, separated by the Pre-cambrian of Mabou and by the Lower Carboniferous horizons of Mabou River, Broad Cove and Grand Etang, their width nowhere exceeds three miles, and the largest continuous patch is that lying south of the Margaree River and Chimney Corner.

The Judique district, forming the fifth of the synclinals into which Mr. Fletcher divides the Carboniferous of southern Cape Breton, contains measures of uncertain age. They are largely composed of soft sandstone and marls, frequently gypseous, and carrying small impure seams of coal. They are possibly millstone grit, and are succeeded to the north by the economic coal strata of Port Hood. There has been apparently in the Judique district conditions of deposition permitting the growth of coal plants, and at a small vertical horizon of conditions favoring the accumulation of gypseous and calcareous matter. The section given in the Geological Survey Report, 1879-82, is on this account very interesting. It may possibly be applied at some time to the elucidation of the problems offered in the River Inhabitants Basin.

At Port Hood the exact extent of the coal bearing measures is still unsettled. Two large seams are known—one is exposed at low water, and said to be six feet thick; the other seam crops near the shore, with a dip also toward the Gulf. The following section of it is given by Mr. Fletcher:—

	ft.	in.
Coal with bands	1	5
Slaty band	0	9
Coal	4	2
Total....................	6	4

The seam dips at an angle of 27°, and was opened by a slope in 1865, by the Cape Breton Company. Another slope was driven some distance to the north to win the same seam in a submarine area held by Judge Tremain and others, but was closed in 1878. Formerly a sand bar connected the mainland with Smith Island, but its destruction by the sea ruined the harbour, and any attempts at coal shipping would be attended with difficulty, unless, as has been suggested, a fresh bar could be formed by sinking a row of cribs along the line of the old one. The extent inland of this district is still unknown. The crops of small coal seams have been observed about three-quarters of a mile from the shore; beyond this the measures consist of grey sandstone and shale, having a millstone grit facies.

Mabou.—Mr. Fletcher remarks of this district that there is no difficulty in defining its limits, the two patches at Coal Mines and Finlay Point being sharply interrupted by the gypsum at a distance from the shore, not exceeding one quarter of a mile. These were presumably united at one time, but are now isolated by folding and denudation. The geological survey sections give one seam six feet thick, and a number of thinner ones. Mr. Brown, in his book on the Coal Fields of Cape Breton, now unfortunately out of print, states that on the south side of the first basin the outcrops of four workable seams have been examined. They lie with heavy northerly dips, and are included in about 550 feet of measures. He gives their thickness as follows :—

	ft.	in.
Highest Seam	5	0
Second "	7	0
Third "	14	0
Fourth "	4	0

As there is no good means of shipment at present available, there has been no coal mined here except for local use. No doubt the time will come when these seams will yield valuable returns in their land and seaward areas, Mr. Brown estimating the amount of coal in one square mile at 27,000.000 tons.

Still continuing to the north there is a small patch of Lower Carboniferous at Cape Mabou, but the shore for about three miles further is occupied by Pre-Cambrian rocks. At Port Ban the commencement of the Broad Cove coal field is met. Here it follows the valley of Rankin's Brook for about two miles in a narrow tongue resting on the felsites. Beyond this it widens until a little to the north of McIsaac's Pond it is nearly two miles wide, it then contracts to a narrow point about a mile north of the mines; the total length of the district being about five miles. It is probable that a large part of this district is underlaid by workable coal seams. Their dimensions are best known at the mines of the Inverness Coal and Railway Company, where work has been carried on intermittently for a number of years.

The following general section of the strata has been given by Mr. Brown:—

UPPER GROUP.

	ft.	in.
Coal	3	0
Strata	340	0
Coal	5	0
Strata	100	0
Coal	7	0
Strata	240	0
Coal	3	6

LOWER GROUP.

	ft.	in.
Coal	2	6
Strata	60	0
Coal (said to be)	3	6

In common with all the other coal districts of Western Cape Breton there is no proper shipping place. The coal shipped from the Broad Cove mines had to be lightered to vessels lying in an open roadstead, an arrangement that could not be followed at the present prices of coal. It has been proposed to cut a ship channel across the bar forming McIsaac's Pond, which would give ample dock room. It is questionable how far such a channel would prove permanent, in view of the small volume of fresh water discharged into the pond, and the continued drift of sand along the coast, as the forces laying down the sand bar would resume their work the moment its profile was altered. At Chimney Corner, a few miles to the north, at some considerable expense a breakwater could be built so as to afford shipping facilities, but the frequent employment of a dredge would be required.

Continuing to the north we meet the commencement of the Chimney Corner coal field at Broad Cove Marsh. Here, as elsewhere in the district under consideration, the dividing line between productive and millstone grit measures is obscure. Taking them as grouped together by Mr. Fletcher they form the westward slope of the watershed between the Margaree River and the Gulf, until about half way between the Forks and the mouth of the river, when they come nearly to the river bank and form the south-western shore of the harbour. Out of this district, which is eleven miles long, and about two and a half miles wide on an average, it may be assumed that a strip on the west side about a mile or a mile and a half wide may be assumed to be valuable to the coal miner. Attempts have been made to open a colliery at Chimney Corner, but a breakwater would have to be built before regular operations could be carried on. The following section shows the relative positions of the seams opened here; they dip under the sea, and are of excellent quality:—

	ft.	in.
Thin Seam	1	6
Strata	300	0
Coal	3	0
Strata	88	0
Coal	5	0
Strata	200	0
Coal	3	0

To the north of Margaree Harbour Mr. Fletcher reports that for several miles a narrow fringe of rocks, representing probably the lower beds of the district just referred to, skirts the shore. Thence to the mouth of the Cheticamp River the Lower Carboniferous come to the shore. The Island of Cheticamp is occupied by rocks of the Middle Carboniferous, presumably millstone grit, as I do not know of any reported outcrops of coal seams.

These notes may serve to show roughly our reserves of coal in the County of Inverness, and although they are of considerable value from their quality and extent, the present conditions of the coal trade do not warrant any ground for predicting their early development. Should the older measures in their vicinity yield workable deposits of copper ore and other minerals they may be found useful at an early date. It is of interest to glance at their former seaward extensions. Part of Port Hood Islands and Margaree Island are composed of Middle Carboniferous, and they are the relics of a vast coal field extending for miles under the Gulf of St. Lawrence, and gradually worn away by its tides and currents. Even in historic times we have seen marks of the progress of destruction in the sweeping away of Port Hood Bar, and undermined cliffs at numerous localities.

In the district we are considering, Mr. Fletcher has divided the remaining Carboniferous strata into two groups, on which he remarks:

"Conglomerate—At or below the base of the lower Carboniferous, in several places occur strata, greatly altered by the intrusion of igneous rocks. They frequently resemble the supposed Devonian of the Isle of Madame, but are more probably for the most part Carboniferous, and underlie the Marine Limestone."

The more important and most highly altered rocks of this series, occur at Mabou, Strathlorne, South West and North East Margaree and Cheticamp. They comprise, argillaceous and arenaceous shales, and sandstones and conglomerates with diorites and tuffs. Similar but less highly altered grits, sandstones and conglomerates occur in the ridge between the Baddeck River and St. Patrick's Channel at Middle River, Mabou, Lake Ainslie, Syke Glen, etc.

One band of these measures, begins at Low Point, on the Strait of Canso, and runs to Lake Ainslie in a band about five miles wide. A branch of it running down the West River of Whyhogomah forms the Salt Mountain, and gradually widening occupies great part of the district between Lake Ainslie and the mouth of Middle River, and following the west bank of the Middle River terminates near Loch Ban.

Other isolated patches are met on both sides of Loch Ban, and between the branches of the Margaree. Another irregular band, beginning at the forks of the Margaree, on the east side of the river, follows it down to within a mile of the shore, to which it pursues a roughly parallel course until it ends on the Cheticamp River, about five miles from its mouth, and has for its eastern limits the Pre-Cambrian of the interior and the valley of the lower part of the North-East Margaree. These strata are non calcareous and in great measure must be considered as representing the basal conglomerates which I have referred to as characteristic of the Carboniferous of the Sydney district, while the more altered sections are possibly to be regarded as lower than the commonly accepted dividing line between the Carboniferous and Devonian.

The Marine Limestone formation in this part of Cape Breton presents the same typical features which lead to its easy recognition in all parts of the Maritime Provinces. In the extreme part of Cape Breton it extends from Cape St. Lawrence to Cape North, and nearly joins the exposure of the same horizon at Aspy Bay, which, following the valleys of the Brooks, runs far into the island. At Ingonish, and along the shore from Cape Enfume to St. Anne's Harbour, there is a narrow strip of the marine limestone, which follows the valleys of the St. Anne rivers for several miles until it is succeeded by the Pre-Cambrian felsites. Through St. Anne's this horizon is continuous to Baddeck and connects with the larger exposures of Carboniferous in Inverness County. From Baddeck it follows the valley of the Middle River in a narrow tongue, and connects with the same measures filling the valley of the Margaree and its principal branches. In the opposite direction it extends from Baddeck through the River Denny's Basin into the watershed of the River Inhabitants, and passing between the Malagawatch and Craignish Hills ends on the Strait of Canso at Plaster Cove, and on the Bras d'Or at the head of West Bay.

Another band lying west of the Craignish Hills, and the belt of altered Lower Carboniferous already referred to, runs from Judique to Mabou and passing to the east of the felsitic highlands of Cape Mabou extends to Lake Ainslie. Here it surrounds some outliers of the " altered " rocks referred to above, and continues in the rear of the Broad Cove and Chimney Corner coal district, until it meets the valley of the North West Margaree. Another narrow strip skirts the eastern shore of Lake Ainslie. There are many small isolated patches of these measures along the shores of West Bay, at Port Hood, etc., but they need not be noticed in this brief sketch.

This formation presents everywhere beds of limestone and gypsum, with marl shales, sandstones and grits, of various colours, frequently gray or red.

The gypsum deposits are of every conceivable variety of colour, texture and quality, and frequently extend for miles. They often give rise to saline springs and mark the ground with funnel-shaped holes. The limestones are in equal variety, and at some points carry the fossils characterizing the formation. Little use is made of these minerals, nature having scattered the former everywhere; while a few bushels of the latter meet every requirement of the local architect and mason. The student will frequently notice these measures running in long tongues and spurs beside some brook in large deep valleys of the Pre-Cambrian felsites and syenites, thus bringing into close connection the valleys of three epochs of countless years. There is first the Pre-Carboniferous valley eroded in the felsites. In this was deposited the marl, limestone and gypsum, and finally we have geologic history repeating itself, and a glen worn out in them in their turn by some brook bearing a highland name.

At many points the sub-divisions of the Carboniferous present signs of unconformability, but this cannot be settled in many cases, as there are frequent faults and small undulations, which when accompanied by great erosion, made unequal by the varying resistance of limestone and gypsum, and marl, yields dips of uncertain value. Generally speaking, however, the sequence in passing from north-west to south-east is fairly regular.

No estimate is given by Mr. Fletcher of the thickness of these measures, except in connection with the Port Hood mines, where he has measured one section lying above the gypseous strata, which is 3370 feet thick. Owing to the inter-section of the district by the outliers and ridges of Pre-Carboniferous rocks and to the deposition of the Carboniferous in their hollows, etc., it is doubtful if any exact measure of their volume will be arrived at.

In my next paper I purpose giving analyses of the seams of the various coal districts, and of their ashes, their gas values, etc.; and such information as I can gather about the extent, nature and value of the various beds of iron, copper and lead ores, and of the other minerals of the various sub-divisions of the Carboniferous of Cape Breton.

ART. VII.—GEOLOGY OF HALIFAX AND COLCHESTER COUNTIES —By REV. D. HONEYMAN, D. C. L., F. R. S. C., F. S. SC., &c. (Written, 1883.)

(Read May 9, 1887.)

PART II.

IN this and next paper I intend to adopt the plan of procedure which I proposed in my last paper on this subject—Trans. 1884. As I have already traversed with you the same region in my papers "On Superficial Geology"—*Trans.* 1881. I shall follow the same routes as formerly and with the same associates (the late) W. Sawers Stirling and Joseph Bell, and the Hon. Samuel Creelman.

HALIFAX CITY AND HARBOUR.

In the harbour to the east of Point Pleasant the only outcrop of rocks that appears is a small irregular patch of argillites, on the north end of McNab's Island. This and the other island—St. George's—show only drift accumulations. The argillites of the city cross over to the Dartmouth side, re-appearing below the ferry, and showing themselves on this side as far as the Narrows. Here they pass over from Richmond, I. C. R. Depot, associated with the succeeding quartzites. In Dartmouth the argillites are seen in fine sections at Black Rock, on the harbour, and in the Canal, and in frequent outcrops in the Town and on the Common. They appear on both sides of the First Lake; on the road, at the left side. At the Colored Settlement the argillites are associated with the quartzites and together cross at the top of the lake. The argillites then disappear, the quartzites only appearing as we proceed northward, as on either side of Bedford Basin to the north of Halifax.

ROUTE TO EASTERN PASSAGE.

From Dartmouth to Fort Clarence the only outcrop of rocks apparent is a patch of argillites. These are on the side of the road and on the shore not far from the fort. Not far from the Cross Roads—Cow Bay and Eastern Passage Roads—there are fine exposures of strata from this onward, the last of them extending seaward and forming Devil Island. While the mass of these rocks are argillites I noticed among the first of the ledges a rock of a different character. It seemed to be a quartzite of appearance different from any that I had observed elsewhere in this formation. On applying an acid there was a brisk effervescence. There is about 18 per cent. of calcareous matter in the rock. I have called it a "Calcareo-quartzite," *vide* list in previous paper. The next noteworthy feature in some of the strata is the occurrence of the singular forms that I have noticed as occurring in the rocks below York Redoubt and called "Discinoid" forms. Returning to the Cross Roads, and taking the road to Cow Bay, a glaciated outcrop of argillites was noticed at the Episcopal Church, and a fine exposure in a brook crossed between the church and Cow Bay.

Cow Bay.

There was only drift observed at the Bay. To this attention has already been fully given. Crossing over to the east of the bay, outcrops of rocks were seen. On the shore are interesting ledges. The rocks are generally argillites. Grey ones were observed, singularly hollowed by the action of the waves. These were found to be largely *calcareous* — "Calcareo-quartzite." The existence of these led me to expect fossils. I thought I had succeeded in finding them in a fine exposure of argillites. They were full of "discinoid" cavities, in layer upon layer, lying at right angles to the slaty clearage. My associate, the late W. Sawers Stirling, and I collected specimens. In his collection were afterward found two specimens which were peculiar. One of these has concentric rings such as I have seen in *Discina*; the other is perfectly round and has an eccentric prominence, which I supposed to be the cast of the *foramen*. The finding of these led me to re-examine the rocks with the forms. I did not succeed in finding any resembling the two in question. I have still doubts of their organic origin.

Cole Harbour.

Then I traversed the region N. W. by Cole Harbour, the Lawrencetown and Dartmouth Road, and crossed over to entrance to the Preston Road, to the north of Dartmouth. All was rough and rocky. Quartzites only were observed until we reached the Dartmouth argillites. Quartzites solid. Stratified often in bold sections ; are broken up in wildest confusion.

Lawrencetown Gold Mine.

Again and again the same rough region was traversed by the road from Dartmouth to Lawrencetown. (The "Lawrencetown" Gold Field occurs in this formation in the locality so named. This is one of the oldest of our gold fields and the least productive. A very fine specimen from it was a prominent object in the Government Collection at the Exposition de Paris, 1867.)

Montague Gold Mines.

Proceeding to the north of Dartmouth along the lakes we cross the argillites already mentioned and enter upon the quartzites. At a distance of about 6 miles we come to the road that leads to the Montague Gold Mines. On one occasion we examined these with the Institute, when Mr. Lawson was working there successfully. Vide Appendix to Trans. 1870.

Still later I made a more particular examination with "Wong Kien Shoo." After examining excavations by prospecting, where much quartz had been broken up in search for gold, with apparently unsuccessful results, we came into the line of the old "Lawson Mines." Here we found a number of parallel quartz veins little disturbed. These had been evidently examined without success. The course of these was nearly E. and W. We found considerable excitement by a recent successful search for gold. A fine collection of rich quartz specimens were on exhibition in a miner's house and rich quartz at the Crushing Mill, erected on the old Mines. The vein from which these were extracted was examined and seen to advantage, as the excavation was only to a depth of 9 or 10 feet below the surface. A fine collection from this mine was exhibited at a Halifax Exhibition and elsewhere. The proprietors of this mine sold it for a handsome sum. It was worked for some considerable time afterward with success. I understand that mines are still in operation in this gold field. [Still later there were other remarkable discoveries such as that of the Blue-nose Mine, afterwards called the Albion Mine. Vide Paper Trans. Feb. 1, 1856.]

Waverley Gold Mines (A.)

Proceeding northward we come to the Waverley Gold Mines. I directed attention to these in the paper which I read to the Geological Society of London in 1862—*Vide Quarterly Journal.* This was selected as the subject of my paper, on account of the peculiar character of the quartz veins —so-called Barrel quartz—and its proximity to the fine sections of the auriferous formation on the Intercolonial and Windsor Railroads. Operations in this field were afterwards extended as far as the junction of these roads. Here were situate the German Mines. We leave these mines at present, to return when we shall have noticed the remaining gold mines contained within the bounds of our area of observation.

Old Guysboro' Road.

As formerly when we examined the "Superficial Geology" —Paper Trans. 1881–2—we traverse the Old Guysboro' Road as far as Meagher's Grant. On our way we noticed several outcrops of argillites. One of these is very ferruginous. It is near "Goff's Hotel." *Vide* "Walling's Map of Halifax County."

Meagher's Grant (A.)

Turning toward Musquodoboit Harbour we observed outcrops of argillites and then came to strata of Lower Carboniferous Limestones at "Seaton's Farm." These extend about a mile and are succeeded (geologically preceded) by Lower Cambrian quartzites without any intermediate formations. These quartzites extend to "Gibraltar," about a mile. Altogether unexpectedly we came to and traversed a great band of *granite.* This was unexpected, as it was not indicated upon any geological map, or referred to in any geological work. Surveyors had spoken to me of the existence of granites at Preston, but I was not, until now, convinced of their existence or importance.

Granites (Archæan, Dana.)

This band was crossed after a traverse of 6 miles. It was seen to extend westward to Major's Lake, Preston, and the vicinity of the Waverley Mines. It was found also to reach at least as far as Ship Harbour, thus having a length of at least 25 miles. This lofty ridge of granite has a strike (?) conforming with that of the quartzites and argillites. This band was forthwith defined in my Centennial Map of Nova Scotia and exhibited at the (" Dominion Exhibition," Halifax) of the same year.

Leaving the band of granites we crossed a band of quartzites and argillites and reached the Mail Road, Musquodoboit Harbour. On this road we proceeded eastward to Clam Harbour, observing outcrops of quartzites and argillites and reached Clam Harbour. Here prospecting was in progress and some excitement caused by the finding of gold sights in quartz veins in the rocks of the locality.

Returning by the same road to Musquodoboit Harbour we found some excitement there by the discovery of gold at the east of Chezzetcook Harbor. The specimens exhibited were certainly very beautiful, and according to reliable reports the results realize expectations. [Mines are being worked and the production is satisfactory (1887.)]

From Musquodoboit Harbour we proceeded to Dartmouth. Outcrops of very ferruginous argillites were observed before reaching the road to East Chezzetcook. Beyond at Porter's Lake and Preston outcrops of quartzites were of frequent occurrence. Between Preston and the Dartmouth and Waverley Road there were outcrops of argillites.

MEAGHER'S GRANT (B.)

Returning to Meagher's Grant by the former route, we proceed to the Settlements—LITTLE RIVER and Middle Musquodoboit. At the Cross Roads Lower Cambrian quartzites with

Lower Carboniferous limestones were seen associated. At Little River L. C. limestones were also observed. At Sheriff Archibald's farm, black L. C. limestones with fossils cross the road. At Middle Musquodoboit, on either side of the bridge, interesting sections of Lower Carboniferous strata were examined. On the right side were limestones, having fossil gasteropods and brachiopods with clays, having nodules of crystallized pyrite. On the left side were limestones with clay stones. In the latter were *lens* forms having calcite crystals in the hollow interior. These strata were considerably above the junction of the Meagher's Grant limestones, overlying quartzites. Still all were within Lower Carboniferous bounds.

Middle to Upper Musquodoboit.

Proceeding on the road left side of the river we cross the bridge at the lower part of Upper Musquodoboit, and come to the right side of the river and road to Caribou Gold Mines. I observed Lower Carboniferous limestones of massive character, and Lower Cambrian quartzites associated. They were exposed in the high ground in such a manner as to lead me to expect to find the two in direct contact. On closer examination I found the two so closely connected as to form breccia. Of this *intimate and interesting contact* I secured illustrative specimens for the Museum. Here, as well as at Meagher's Grant, the seas of the Lower Carboniferous Period had a shore and a depth sufficient for the formation and accumulation of thick and solid limestones, and Nova Scotia was very contracted in width. The present distance between this and the Atlantic Coast is only from 15 to 20 miles. Mr. Bell and I proceeded about a mile on the road to the Caribou Gold Mines, which is distant about 6 miles. South of this about 6½ miles are the Moose River Gold Mines.

Gay's River Gold Mines.

Taking the road to Gay's River Settlement we come to Bold Brook and the site of a saw mill (Leck's.) On the side and bed of this brook is a *magnificent exposure* of Lower Cambrian strata. This is the only exposure of consequence. Drift is the only formation noticed in the remainder of the road. Reaching *Gay's River* we turn to the right and travel along the old road, a distance of 4 miles, and come to the *Gold Field* in the County of Colchester. This is a field of very great interest. It is different from all the other gold fields, and as yet stands alone. It was first examined by the late Prof. F. C. Hartt, who determined its true geological position. At first the gold containing deposit was supposed to be a drift. Prof. Hartt recognized the deposit as a Lower Carboniferous Conglomerate. Not being aware of this, I went and made an independent examination, accompanied by the Rev. Mr. McLean. I communicated the results to the Institute in Session 1866—Vide Transactions. I found the deposit containing the gold to be a thick conglomerate overlying Lower Cambrian argillites. I also found that this conglomerate was succeeded by limestones (?) and gypsums, and therefore occupying the normal position of a Lower Carboniferous Conglomerate. I also compared the deposit with the Ovens—the *Lunenburg Gold Field.* Considering that the conditions under which the Gay's River auriferous deposit had been formed in the Lower Carboniferous period were analogous to those of the formation of the gold-bearing of the Lunenburg Ovens, i. e., that the seas of the Lower Carboniferous period by their tear and wear had formed a shingle of and on the argillites and quartzites in the manner of a beech, that the associate gold by its superior gravity had made its way towards the bottom of the shingle, as it is so found in the conglomerate, and that the shingle had been converted into conglomerate by the salts of iron contained in the auriferous argillites.

At the time of examination I obtained interesting specimens of the gold containing conglomerate, which were exhibited in my Geological Collection at the Exposition de Paris, 1867. These excited considerable interest. Prof. T. Rupert Jones received one or two specimens to shew Sir Roderick I. Murchison, as interesting specimens. Subsequently the late R. G. Fraser shewed me a piece of auriferous rock from these mines. On close examination the gold was seen to be in small quartz veins in argillite. The source of the gold was thus made evident. At the Centennial Exhibition, Philadelphia, 1876, H. S. Poole, Superintendent of the Acadia Mine, Pictou, exhibited a collection of gold specimens with associate minerals. In this there were fine specimens of the gold containing conglomerate of Gay's River. One large specimen was particularly interesting. It is a large piece of greenish argillite upon which conglomerate has rested, leaving a small portion of itself and a striking display of small plates and scales of gold. On our last visit to the mines I found that a great amount of work had been done since my previous visit. The slates underlying the conglomerates had also been excavated. I did not find any conglomerate with gold, but I observed in the slates abundance of the *Discinoid* forms, which had attracted my attention on my first visit, and which I have already noticed elsewhere. These forms here are very regular, striking and puzzling. The specimens in the Museum with the gold containing conglomerate readily attract attention. The sea shore of the Lower Carboniferous Period extended to the position of Gay's River Gold Field.

The gypsums associated with the conglomerate are seen by frequent outcrops to extend westward to the neighborhood of the Gay's River and Shubenacadie Road. Beyond this all formations are obscured, except on the old road from Gay's River to Elmsdale. Here frequent outcrops of Lower Cambrian quartzites occur. Beyond the road to Milford these are seen to approach the Shubenacadie River to within the distance of ½ a mile. Before coming to Elmsdale they retreat in the direction of the Oldham Gold Mines, giving place to a large extent of gypsums and gypseous deposits. Near the Enfield Station, on the other side of the Shubenacadie Bridge, on the road to the Oldham Gold Mines, argillites appear. About 2 miles farther we enter the mining region. I visited these in order to examine the position where our rich gold specimens had been found—the specimens which had been purchased by the Government for exhibition at the Centennial Exhibition, Philadelphia. I examined the position with interest. It was in the Oakes' Mine, at no great distance from the road, and very near the surface. I also examined the other mines. Some of these were in operation and others at rest. The conviction was and is that the process which produced our 54 ounces, or $1000 specimens, was capable of extensive production. This is from a scientific point of view.

Returning to Enfield Station, and proceeding along the line of railway towards the Waverley Mines, we find evidence of the existence of gypsums until we approach a creek on the left, where argillites appear in Grand Lake and continue associated with quartzites to the Grand Lake Station. Then we enter upon a broad band of argillites. These only appear in the cuttings. If, however, we take the road from the station and proceed a little distance we will observe in an opening in the bushes to the right a limited and isolated patch of another formation. This is a remnant of Lower Carboniferous Conglomerate, resembling that of Gay's River, with the exception of the seeming absence of gold. This is of considerable thickness and rests upon the upturned edges of the underlying argillites. It reaches to within a short distance of the railway. The glaciation of the argillite surfaces around shows the nature of the agency that has been at work in the isolation of this remnant of the Carboniferous Period.

Proceeding onward by the road or railroad we come to the Waverley or German Mines respectively.

Waverley Gold Mines (B.)

Age and Origin of the Gold.

From this position we proceed to the consideration of the two topics just indicated. The peculiarity of one of its gold deposits led us into a similar discussion 21 years ago. I now consider the questions with the advantage of observation and experience since made and acquired. At that time we knew nothing of the Gay's River Gold Field, and consequently any opinion that would extend the time of production of the gold into the Carboniferous Period might have been maintained. As far as our gold fields are concerned Gay's River Gold Field disposes of this view as altogether untenable. The gold existed in the Lower Cambrian rocks of Nova Scotia *before* the beginning of the Lower Carboniferous Period. How far back in Pre-Carboniferous time is now the question. Another opinion has been advanced, viz., that the gold existed in the Archæan has granite (Laurentian Gneisses) and that the gold deposits are beds derived from these granites with gold, converted into auriferous quartz by the metamorphism to which the strata has been subjected. This makes the auriferous quartz to be of Lower Cambrian age. This opinion has not met with much acceptance. The generally received opinion is that the *lodes* or *beds* are true veins, and therefore formed subsequent to the formation of the strata which contains them.

Our researches in the west—Annapolis and Digby—have led us to the conclusion that the metamorphism of the gold-bearing rocks was chiefly effected previous to the Middle Silurian Period, i. e., during Upper Cambrian and Lower Silurian time, and hence the term "Cambro-Silurian (Lower)" was applied to the rocks in question—Vide Paper Trans. 1884, This view of the age of the gold would still, in a sense, accord with the Murchinsonian view of the Age of Gold, or with another view that gold might be viewed in the light of a "Lower Silurian Fossil."

Thus much for the "age of the gold."

When I examined the so-called "Barrel quartz," 22 years ago, much of it lay exposed by the removal of the overlying quartzite bed. It lay in an almost horizontal position on a soft bed of unctuous green argillite, which much resembled a talcose schist. It lay like a number of branchless hemlock trunks, or as others described it like a "washing board." The miners regarded it as an "overflow" of melted igneous rock, and expected some time to find the vent or dyke. It was never found, and after the "barrels" were removed the mining was done. The general opinion was that the veins were of igneous origin, and came up from the molten interior in the manner of lava. One difficulty in the way seemed to be that the rocks containing the quartz veins had not sufficient solidity to furnish open rents (vents) for the passage of molten material. If the veins had been in the granites the case might have been otherwise. Some of the most important leads have been found to end, e. g., Hattie lead, Wine Harbour, and attempts to find a continuance downwards have been fruitless. There was no passage from the regions below.

I have yet to notice a very interesting locality in Colchester County. On the south branch of the Stewiacke River Cambrian quartzites are observed, having a very interesting gold vein. The quartzites are grey and contain numerous cubical crystals of pyrites. This is traversed by a vein of auriferous quartz, which measures one inch and upward. This vein is crystalline throughout. These crystals are often arranged in *geodes.* One in my possession has numerous long six-sided prisms with pyramidal terminations clear as crystal. Another has crystals with gold projecting from a crystal. There are no fewer than 7 sights of gold in a piece not more than an inch square where distinct crystals are seen crossing and recrossing from either quartzite wall. In another small specimen the vein goes into corners, the gold following. I cannot conceive anything more conclusive in support of the Hydrothermal Theory of the production of auriferous quartz veins. The veins seem to be too small for working.

Additional Observations.

In our extensive collection in the Provincial Museum, which is representative of our principal gold fields, I find a specimen from Wine Harbor, which tends to confirm the view which I am illustrating. This is a piece of quartzite traversed by a quartz vein very rich in gold. This vein is so thin that it can scarcely be measured. It could only have been filled by capillary attraction. I find also several specimens of large size from Isaac's, in which the gold is in *calcite,* having ~~shown~~ rhom (boidal) cleavage.

There seems to be no reason why every quartz vein in our Lower Cambria should not contain gold. Yet it is a fact that only certain veins, even in known gold fields, contain the precious metal.

In the Yarmouth and Digby great coast section there is any number of quartz veins, large and small, exposed in the best manner possible for observation. I have examined them carefully, but this is nothing to what has been done by prospectors. Yet only one vein has been found to be auriferous. This one has a peculiarity which the others do not possess. In the containing stratas there is abundance of arsenopyrite in beautiful crystals. The most productive veins at Montague are well known to have arsenopyrite in abundance. There are two fine specimens in our Museum Collection, which were presented by Mr. Lawson, as very striking. One is an unusually large piece of arsenopyrite, with a large sight of gold in the arsenopyrite. Another is a large piece of arsenopyrite, with the gold spread over it in a striking manner.

Other specimens are from Oldham, presented by Mr. Donaldson ; arsenopyrite rich with gold.

I shall give another illustration from Wine Harbor. Some years ago I went with Judge Henry and examined his mine. A large quantity of quartz was piled up at the top of the mine, which was said to be auriferous, although not visible. Looking about for minerals or other interesting objects among the rubbish, I noticed a piece of stone with a large piece of arsenopyrite. Striking it with my hammer, to break off the specimen, the stone broke into 8 pieces, all showing fine sights of gold. The principal pieces are in the Museum Collection. Specimens from Waverley and other gold mines show the same association of gold with arsenopyrite and other sulphites. When the ~~latter~~ former occur in any quartz vein I generally recommend a search for gold and *vice versa*. Why this discrimination ? I believe is one of the geological mysteries, which it is vain to attempt to elucidate.

ART. VIII. — THE TIDES OF THE BAY OF FUNDY. — By M. MURPHY, C. E., *Provincial Government Engineer. Member of Council Can. Soc. C. E.*

(Read May 9, 1887.)

AMONG the manifold phenomena coming daily within the range of our observations, there are but few more remarkable than the tides which break upon our shores.

In Nova Scotia we can have, really and truly, a general conception of their relative bigness. If we leave Bay Verte, in the Straits of Northumberland, proceed through the Strait of Canseau, follow the Atlantic shore to Cape Sable, and the Bay of Fundy to the head of Chiegnecto Bay, we might, with a well-appointed steam yacht, encompass our coast line, and complete within 20 miles of an entire circuit, inside the short space of 40 hours.

Within that circumscribed limit we would encounter, and might observe, many relative phases of tidal oscillation. Our departure is from a place where the flood tide cannot reach without losing in volume and in force, because of its shelter and remoteness. Our course is through the Strait of Canseau, where prevalent winds arrest the regular tidal flows, and press it forward through a long and narrow channel at irregular times and in fitful directions. Along the Atlantic they are, owing to a more conformable coast line, more normal and periodic, whilst in the Bay of Fundy they are augmented and turbulent. Yet they are all the result of the same tidal wave, which, rising in seas far south, rolls through the Atlantic, and in twelve hours, after passing the parallel of Cape Horn, is found pouring its flood along our shores. During the new and full moon the tides in Northumberland Strait rise from five to six feet; in the Strait of Canseau about five feet; along the Atlantic, from Canseau to Shelburne, six to seven feet. From Cape Sable to Briar Island they are influenced by the Bay of Fundy tides, rising at Briar Island to the height of twenty and one-half feet; and increase as you ascend the bay, until at Chiegnecto they attain the height of fifty feet.

We can walk over the sands or mud flats of the Bay of Fundy, now dry, but in a few hours after comes a rushing torrent, a few hours more and the largest ship afloat could sail over the same ground which we occupied six hours ago. Again the same body of water is drawn back impulsively to again swing forward, and thus maintain its vibrating, rocking motion

To one unaccustomed to the approach of the great waves that daily inundate the bays and basins at the head of the Bay of Fundy, and pour their waters over the adjacent marshes and flats, their first observance is strikingly impressive. I had frequently observed rapid currents rush upwards against streams from the tides of the English Channel, and considered my experience justified a passive recognition of what I might expect from the phenomenal *bore* of this bay; but no,—my conceptions were very vague with regard to their relative magnitude and characteristics. Generally during spring tides, at the periods of the vernal and autumnal equinoxes, the greatest intensity being in the autumn season, attain their utmost pitch.

My first experience in Nova Scotia occurred near the mouth of the Maccan River, a small stream, emptying into Cumberland Basin. I was engaged at the time of low tide examining the foundations of the pier of a bridge, and owing to a bend in the river further down, did not notice its advent, although heralded by a desultory murmur as if proceeding from a distant waterfall. My more experienced companion gave the alarm, and led the way in doing so. To seek higher and drier ground was, of necessity, the work of the next two or three minutes; the water followed close on my heels until I got well up, and before I could pause, look back and take in the aspect. The bore had then passed on, upwards, leaving a veritable newly evolved stream of about fifteen feet deep, following more placidly in its wake; and all this within five minutes. The flood kept still rising, but without further indication of disturbance, until the set of the ebb tide about two hours afterwards. The Maccan is here narrow and shoal, and may be said to be favorable to the rapid growth of the ogre or bore. Further down the river widens and receives easily the tidal wave from Cumberland Basin. As it ascends the stream it becomes more confined and crowded, until, from its own gravity, it rushes swiftly forward—hence the phenomenon we have witnessed.

Out in the Bays of Chiegnecto and Cobequid these flood tides exhibit different forms and phases, varying with the variable contour of the shore. At low tide spurs indicating shallow channels, estuaries and creeks, are conspicuous, with miles in extent of dry flats and marshes, looking as if the sea had altogether retired. Presently, however, the returning flood tide appears in the distance, tumbling and rolling with white breakers abreast. It rushes swiftly forward and digs deep into the red, soft mud, that but momentarily obstructs its advance. It frequently resembles the rapids of a great river, stretching across for miles, with alternating patches less turbulent, where in its path it meets with less resistance. Thus this tremulous tidal oscillation, with breakers tumbling from and over its crest threatening to overwhelm and engulf everything that impedes its progress, moves bodily onward until it reaches the heads of Shepody, Cumberland and Cobequid Bays. The mud flats are soon covered, and the creeks, estuaries and basins are full to the brim,—the *fiat* has been given, "Hitherto shalt thou come, but no further." Immediately the retreat commences, and the waters retire almost as rapidly as they came.

The flood tide carries with it the silt and mud, and deposits its load chiefly in the creeks and on the flats at the head of the bays. As I had a good opportunity of ascertaining the extent of this deposit, and although it is a digression from the subject of this Paper, it may be worth placing on record here. The old wooden bridge that crossed the Avon River at Windsor is being replaced by an iron bridge. The substructure consists of five pairs of steel cylindeis, each tube having an internal diameter of five feet, and are secured to the limestone rock on which they rest. The bottom sections of these tubes stood, when placed in position, from three to six feet above the level of low tides, and were filled with concrete to a height of two feet, above low water. One pair remained thus from the 19th of August until the 19th of December last (1887), just 122 days, when it became necessary to remove the mud or silt that had accumulated or was deposited by the tide within that time, so as to continue the concrete upwards; as the next succeeding section of tube required filling. There was within each tube a depth of 30 inches of fine sand and mud of the same consistency, or just as compact, as the ordinary deposits on the flats at low tide, a short distance down stream from the bridge. Allowing two tides for each 24 hours there would be deposits during each flood tide to a depth of decimal .012 of an inch. The Avon bridge is 10 miles up the river from Mines Basin, there would therefore be a more rapid deposition of the coarser sediments further down. The waves, acting with violence above the level of low tides abrade every cliff and bank within their reach. Exposed sandstone strata here so frequent, and beds of gravel and earth so easily removed are eroded, carried with them and deposited over long stretches of the inlets, flats and marshes. The roots of coarse grasses, striking deep into the muddy banks, bind earth, mud and sediment firmly together, whilst their growth upwards protects and retains the deposits. In this way the land-making process goes rapidly on, until the surface is lifted by the hand of nature to be within the reach of practical reclamation by the hand of man. Thus the dykes "that the hands of the farmer raised with labor incessant to shut out the turbulent waters" drain a rich alluvial soil of great natural fertility, capable of yielding for centuries, without the application of manure, abundant crops of grains and grasses; and in this manner over 43,000 acres of marsh land have already been reclaimed within the Province of Nova Scotia.

Man scarcely begins to realize such productions of nature until he considers the practicability of utilizing them. The early settlers were not slow in recognizing the value of these marshes and the feasibility of their acquisition by dyking.

The currents, too, are considered, studied and applied by the mariner, and made to subserve his purpose in bearing him rapidly along with more unerring precision than the no less phenomenal trade winds. The fisherman also profits by the great height of the tide which, during the flood, comes with its large shoals of such fish as resort to the coast. These remain to feed until the return or ebb tide falls somewhat, and are trapped within wiers of wattles, that are made to run out past their line of retreat. Large quantities of herring, cod and shad thus left dry at low water, are carted tc the smoke-houses prepared and packed in small cases and forwarded to the different markets. Smoked cod and herring from Digby, ("Digby Chickens") obtained in this way, form important items of export.

If we look at the bending of the great waves, as shewn by Whewall's chart of co-tidal lines around the continents of Africa and Europe, they seem to trend very like that sort of refraction which takes place on every shelving shore with respect to the common waves, which, whatever may have been their origin become always, as they spread, more and more, nearly parallel to that of the coast which they are approaching.

The tides result from the disturbing influence of the bodies within the Solar System, which cause a constant changing of the position of the ocean in accordance with their changes of position in relation to the surface of the earth ; but they are not currents, they are merely undulations or oscillations of the ocean, although where obstructed by coast lines they form currents about the coast.

The ocean currents result from the great cosmical force of gravitation, drawing in all directions *from* the centre of the earth opposing terrestrial gravitation drawing *towards* earth's centre; thus forming a system of circulation within the position in which the ocean is held by gravitation without tending to change that position in relation to the surface of the earth ; and these ocean currents would exist, even if the earth were not affected by the bodies of the Solar System, so that currents such as the Gulf Stream have no relation whatever to tidal movements.

The height of the tide is less in mid ocean than along the coast, and is greatly augmented where two coast lines converge. At St. Helena the rise is two or three feet; at the Azores three feet; and on the Atlantic coast of the United States from five to twelve feet. In the Central Pacific the height is from two to four feet. The tidal wave becomes one of great strength where there are narrow channels to receive and discharge the waters. The movement may have the violence of a river torrent, when the entrance to bays is such as to temporarily dam up the waters, until the far advanced tide has so accumulated that it overcomes the resistance and passes on in a body.

"In some cases the whole tide moves in at once in a few "great waves; this happens especially at the mouths of rivers "where there is obstruction from sand bars and other favoring "circumstances about the entrance. The phenomenon is called "an eagre or bore. The most perfect examples are afforded at "the mouths of the rivers Amazon, Hoogley, (one of the mouths "of the Ganges) and Tsien-tang in China. In case of the last-"mentioned river the wave plunges on like an advancing "cataract four or five miles in breadth and thirty feet high "and thus passes up stream to a distance of 80 miles at a rate "of twenty-five miles per hour. The change from ebb to flow, "tide is almost instantaneous. Among the Chusan Islands, just "south of the bay, the tidal currents run through the funnel-"shaped firth with a velocity of sixteen miles an hour. In the "eagre of the Amazon the whole tide passes up stream in five "or six waves, following one another in rapid succession, and "each twelve to fifteen feet high." *Dynamic Geology, Dana.* At St. Malo, near Cherbourg, France, and at Swansea and Chepstow, in the English Channel, they reach the respective elevations of 36 and 50 feet.

We might proceed with the following assumptions:

1. The tidal wave is a wave of translation moving parallel to the coast which it is approaching. (Dr. Whewell, Admiral Fitzroy.)

2. The tides are undulations or oscillations, and form currents when obstructed by coast lines. (Airy, Jordan, Dana.)

3. The currents of the ocean result from cosmical force of gravitation opposing terrestrial gravitation, and from *vis inertiæ,* or a crowding of the water in high latitudes. (Airy, Jordan, Enc.-Brit., Maury.)

4. The heights of the tides are less in mid ocean and are greatly augmented where coast lines converge. (Examples from Dana's Dynamic Geology.)

Referring to the chart before us, it will be seen that the co-tidal lines of Whewell follow and keep nearly parallel with the Nova Scotia coast as we would expect (1), and extend in like order along the shore of Massachusetts.

Our Nova Scotia coast extends its dip or slope far out to sea, and receives the advancing tidal roll, lifting it somewhat by the force of its own forward movement along the incline, until it breaks gently on the beach. A little later on, the same advancing volume sends its flood teeming in like manner along the Massachusetts and New England coast. Along Nova Scotia shore to Cape Sable it runs upward to the beach. Along Massachusetts coast it trends and runs in like manner to Cape Cod. Between these points it passes on without retardation or hindrance into the bay. These capes or prominences mark, respectively, the juncture of the flood tides, where partially arrested and in motion, and the commencement of the rips or rotary currents which they generate. (2.) Sailing directions say: — "The ebb stream across Nantucket shoals begins a short time before the tide has ceased to rise by the shore, and runs in a direction a little eastward of south, with no interval of slack water. It then gradually attains its greatest velocity, in a direction between south and west, after which it slackens, altering its direction a little westward of north. This is the commencement of the flood stream which gradually attains its greatest velocity, changing its direction to between north and east, or contrary to that of the ebb stream, after which it slackens and runs to the southward as before, thus completing an entire circuit in the direction of the hands of a watch. The flood and ebb streams are of equal duration, each running about 6¼ hours, their minimum velocity being about one fourth of the maximum."

Now, let us see how the tides disport themselves at the eastern entrance from Cape Sable to Briar Island. "The flood tide sets from Cape Sable to the north-westward, through the Seal, Mud, Tusket and Bald Islands, at the rate of two or three miles per hour, and in the channels among the islands it increases to four or five miles, thence taking the direction of the mainland it flows past Cape St. Mary, and then N. N. W. to Briar Island."

The times of high water at full and new moon are at Seal Island 9 h.; Tusket Island, 9.33; Yarmouth Sound, 10.9; Cape St. Mary's, 10.30; and at Briar Island, 10.43.

It takes, then, 1 hour, 43 minutes, for the crest of the flood tide to advance between co-tidal parallels drawn through Seal and Briar Islands, representing a distance of 64 miles, whilst the same tidal wave advances across George's shoal, about the centre of the entrance to the Gulf of Maine, and reaches the shore of the State of Maine, a distance of 150 miles in the same time. The flood passes in freely and swiftly at the centre, crowded and tortuous at the sides.

Capes Cod and Sable are the portals of the flood-gate. Around the Nantucket shoals of the former the tide has a whirling motion, and around or between the latter and Briar Island there is the contest between the water pent up or backed by the shore and the water moving swiftly into the gulf in volume, which takes place at every change of tide, or before either force has gained or lost ascendancy; and here in this gulf we have the principal fountains of the abnormal tides of the Bay of Fundy.

About the centre of the opening to the gulf no unusual tidal oscillation is apparent until we cross an imaginary line drawn from Cape Cod to Cape Sable. No sooner have we advanced over the George's bank, and proceeded about forty or fifty miles northerly, than a remarkably sudden rise of tide presents itself, about four feet in fifty miles. Following the shores of Massachusetts, New Hamsphire, and Maine, to Mount Desert, and crossing the bay from thence to Yarmouth, thus completing a circuit around the crescent, which the shore line resembles, we find the time of high water in the Gulf of Maine at full moon and change to be at

Place.	Time—h. min.	Spring—feet.	Neap—feet.
Plymouth Harbour ..	11.35	$10\frac{3}{4}$	9
Boston " ..	11.12	11	$9\frac{1}{2}$
Salem " ..	11.13	11	9
Gloucester " ..	11.02	10	$9\frac{1}{4}$
Portsmouth " ..	11.23	$9\frac{1}{4}$	$8\frac{3}{4}$
Portland " ..	11.17	$9\frac{1}{2}$	9
Bass " ..	11.02	10	..
Mount Desert Island...	10.52	11	9
And on the Nova Scotia coast:			
Cape Sable	8.30	8	$5\frac{3}{4}$
Pubnico..............	9.25	12	10
Tusket Island.........	9.33	13	10
Jebogue..............	10.04	15	$11\frac{3}{4}$

If we extend these observations further south we will find that the times of the spring tides F. and C., from Chesapeake Bay to Sandy Hook occur from 7.51 to 7.21 local time, and that they rise from $3\frac{1}{4}$ at the former to $5\frac{1}{2}$ feet at the latter place. From the western extremity of Long Island to Bridgeport the shore trends easterly, and the tidal wave courses along as well as upon it. The times are 10.12 and 11.11 respectively. Springs rise, 9 to 8 feet; neaps, $7\frac{3}{4}$ to $6\frac{1}{4}$ between these points.

Within the Gulf, as will be seen above, from Plymouth Harbour to Mount Desert it is high water flood tides about the same time. Springs rise from 10 to 11 feet; neaps about 9 feet. We may place this, the American side, as having, say, an abnormal height of from four to five feet. On the other horn of the crescent, from Cape Sable to Chebogue, the times are from 8.30 to 10.04. Springs rise from 8 to 15 feet; neaps, $6\frac{3}{4}$ to $11\frac{3}{4}$, so that we have the abnormal height of tides of 7 to 8 feet on this, the Nova Scotia side, piled up before we enter the Bay of Fundy proper; and here we have the fountain, the beginning, of the Bay of Fundy tidal phenomena.

The problem which is suggested by these observations is not so complicated as it may at first seem to be, since a comparison of the effect is so accessible to observation. The great tidal wave, striking the shore at Cape Cod and Cape Sable, and moving freely inward between these points imparts a whirling movement with a crowded rush around them like the whirl of water at the flood gate, or the piled up rotary ridge in the wake of the screw-propelling steamer. This circling current borne onward marks the advance of the flood tide. If we follow the movement of these accumulations from their sources we find them all converging during influx to the Bay. We quote the following from "Sailing Directions," U. S. East Coast, 1882 (page 4):

"As a general rule, between Nantucket Shoals and Cape "Sable the ebb, or southerly stream, runs to the southward during the first 4½ hours, and the flood, or northerly stream, from "the 6th to the 11th hour following the moon's superior and "inferior meridian passages. The average velocity of each "stream is one knot per hour, being greater in the shallow and "less in the deep water. The times of turning of the flood or "northerly, and ebb streams, correspond with the times of high "and low water respectively at Boston and Portland. Westward "of George's bank the stream runs half an hour later, and eastward of the same, half an hour earlier. Between George's bank "and Nantucket shoals the flood stream commences at 5h. 37m. "after the time of the moon's meridian passage, running for the "first 1½ hours in a N. ½ W. direction, with a velocity of one "knot per hour. For the next 3 hours the direction is N. by W., "at the rate of 1½ knots, and during the last quarter N. by W. 1 "knot."

In regard to the British, East Coast, North America, the Sailing Directions say—(p. 63.)

" Take notice that the flood and ebb tides set fairly N. W. " and S. E., so that in taking the Tusket Passages you will have " the flood in your favor; the ebb, the contrary. Observe also, " that in taking, as we have said the more prudent course to the " southward of Seal Island, and in setting course to the north-" westward, that, if on the ebb, the tide does not catch you on " the port bow, and cause you to bear up to clear the lurcher, " and perhaps compel you to take the Grand Passage between

"*Briar Island* and *Long Island*. into the Bay of Fundy." And in p. 66: "At the south entrance of St Mary's Bay the flood "sets N. E. by N. at the rate of 7 knots."

As in nature everything is repeated when similar conditions occur, we must, by not concealing even what is still imperfectly observed, call attention of future observers to special phenomena. According to my observations, it must not be forgotten that besides the crowding movements of the currents which we have followed so far, movements with very different forces, as for instance, the meeting of currents advancing from opposite directions caused by the tide itself, may take place. Currents of water, like currents of air meeting from various directions, create gyrations and form whirlpools. The celebrated Maelstrom, on the coast of Norway, is caused by such a conflict of streams. The late Admiral Beechey, R. N., in an interesting paper on tidal streams of the North Sea and English Channel,* gave diagrams illustrative of many rotatory streams, a number of which occur between the outer extremities of the channel tide and the oceanic or parent wave, and says—"they are clearly to be accounted for by the streams acting obliquely on each other."

Here in the bell mouth of this funnel or trough-shaped bay, we may again follow with the very simple assumption—that it is by this conflict of currents the water is still more lifted by crowding and rotatory action and continues onward as the flood increases, thus imparting the progressive lifting movement as far as Cape Chiegnecto, a distance of 100 miles. The confluence of these currents setting along converging coasts,—first marked by the tide rips between Briar Island and Mount Desert—impinging obliquely and rolling up the Bay with enormous progressive motion, create a vast force of horizontal translation; and this action is nearly as powerful at a great depth as at the surface. Such a wave, reflected from a rigid body, would produce a hydraulic pressure equal to that due to a little more than double its own height; a roller of 20 feet high would produce a pressure of over a ton per foot.

The tide floods the Bay of Fundy from Grand Manan to Cape

*See Phil. Transactions, Part II, 1851, on Tidal Streams of the North Sea and English Channel.

Chiegnecto, a distance of nearly 100 miles, within five hours; this could not be done from the currents alone. It is the translating movement that effects such performance. It is not an influx altogether, that fills up the Bay during that time—it is largely due to the piling up of the littoral waters within it. The currents seldom exceed ten miles per hour. The tidal wave, if unimpeded, or unobstructed by coasts, would travel round the earth in a lunar day of 24 hours. It is this wave that floods the Bay of Fundy (No. 1) as well as every other tidal bay, bight and recess on our planet.

It has been already said that the wave of translation affects the depths as well as the surface. Here there is very convincing proofs of this. Chiegnecto Bay, Minas Basin and Cobequid Bay are divergent arms, extending northerly and easterly from the head of the Bay of Fundy. The ebb tide nearly empties them, leaving here and there muddy pools and shallow channels. A regular flood tide refills them to a depth of from forty to fifty feet, whilst the mean level between these extremes is just the same as the mean level of the Atlantic Ocean along our shores, where the extremes of tide do not exceed eight feet, and nearly the same as the mean of Northumberland Straits, where they seldom exceed six feet.

But we are afforded an opportunity of giving a thorough practical application to this part of our theory. Referring to the report of the Chief Engineer of Public Works on Baie Verte Canal, Ottawa, 1874, Mr. Page says: "It may at once be stated, that "a daily record of the rise and fall of tides in Cumberland Basin, "was kept from the 13th August to the last day of December, "1870; and during that time there were between the 13th and "31st of August, four days; in September two days; in October "three days; in November one day; and none in December that "the tides did not rise to 86 feet. Between the 13th and 31st "of August there were ten days; in September fourteen days; "in October sixteen days; in November twenty days; and in "December twenty-two days, that the tides did not rise to over "88½ feet.

"Between the 13th and 31st of August, there were fifteen "days; in September twenty-three days; in October twenty-five "days; in November twenty-three days; in December twenty-five "days, that the tides did not rise to over 90½ feet (height of springs "full moon). The new moon spring tides in August, 1870, rose for "three days to, from 92 to 92½ feet; and in each of the following "four months they were for five days from 92 to 94½ feet *above* "*datum.*

"On the 25th of October, 1870, an exceptionally high tide of "96 feet was observed; and on the 5th of October, 1869, the "Saxby tide rose 100 feet above datum."

Mr. G. E. Baillairge, Jr., Assistant Chief Engineer, says in the same report:

"Rise and fall of tides were registered every five minutes "except on Sundays and stormy days; and the rate per hour in "each case is given at the respective dates, stated in tables for "each month. In cases where the daily tidal register is not "complete, the range and rates of the tides are based on those of "the corresponding tides in one of the other months. Night "tides not observed."

"SUMMARY.

Mean tide level of Bay of Fundy.

Year.	Month.	Half tide or mean level for each month.
1870	August.	70.37
	September.	70.41
	October.	70.85
	November.	70.90
	December.	71.01
		353.54
Half tide line or mean level of the sea.....		70.71"

Half tide elevation, or mean level between high and low water referred to datum, which is from 47 to 50 feet below low water Spring tides.*

Baie Verte:

Half tide or mean level of sea 1870 and '71, from August till May 10th was about 71.54. So that the mean level of sea at half tide is just 10 inches higher at Baie Verte than at Cumberland Basin.

It is also well worthy of remark that the Bay of Fundy tides seldom rise to a greater height above the main level of the sea than 22 feet; and the great Saxby tide did not rise to a greater height above the same level than 29 feet.

The tidal wave, then, on its retreat scoops back with it just as much water in depth, below the mean level of the sea, as it carries in with it in its advance above the level.

It would be a great error then, to say that the tides rise in the Bay of Fundy above the level of the sea fifty or sixty feet, because they do not rise more than about half that height above sea level. But it would be correct to say, between the level of lowest and highest water, there is a difference of level of from 50 to 60 feet.

The oscillations of the tidal vertex, or daily elevation of high tide above datum, between tides occurring at full and new moon, and those occurring at the moon's quarters, in the Bay of Fundy, are not, relatively considered, proportional to the difference between the respective heights of springs and neaps in places where those abnormal tides do not occur. The minimum level that was reached by neaps during high tide was about 85 feet above datum, whilst the height of springs seemed to turn about 94, having a difference only of about 9 feet, or say as 9 to 8. The universal law of gravitation when the sun and moon are acting in conjunction, as at the full moon, and when the moon is acting alone, as at the quarters, would be as 9 to 5 nearly. Thus the translating, impinging or crowding

* Care must be taken not to confuse the heights given in the above *datum* with the height above low water. For the convenience of levelling or obtaining levels of surface, the Engineer invariably computes all heights from an arbitrary level taken well down below the lowest point of surface which he calls *datum*, so as to avoid minus quantities in computation. The heights given here are about 50 feet below low water. The height, therefore, above low water for main level of sea will be 20.71 feet.

forces exerted do not give anything like the results equivalent to the initial degree of exertion at work at the entrance to the Bay. It is generally observed that when any unusually high tides occur, such as from prevalent southerly winds, or from causes such as produced the Saxby tide, those extremely high tides will maintain themselves for several recurring oscillations. They seem to swing like a pendulum after receiving a sudden impulsive motion, until after some time they settle again into their normal condition.

The tidal waves of the Bay of Fundy, as well as the waves of the atmosphere, teach us how great mechanical effects can be produced by the concentration of energy or power from small sources. The study of them may not only be interesting but instructive.

APPENDIX.

THE GIANT TRILOBITE OF MOOSE RIVER IRON MINE, N. S.

ATTENTION has again been directed to this interesting crustacean.

From a correspondence with Prof. Vogdes, of Fort Hamilton, New York, the Trilobite which we considered a *new species* and named *Asaphus ditmarsiæ*, seems to have been the first of the family in Nova Scotia to which special attention has been given. It is now over half a century since it was described figured and named. Prof V. has kindly sent me the following description, which is sufficiently convincing and very interesting.

Feb. 1, 1888. D. HONEYMAN.

(Trans. Geol. Soc., Penn., Vol. I, Part 1, Phila,, 1834, P. 37.)

DESCRIPTION OF A NEW TRILOBITE FROM NOVA SCOTIA—by JACOB GREEN, M. D., PROF. CHEM. IN JEF. MED. COL. PHILA.

Asaphus? crypturus, Green.

Cauda acuta, articulis terminalibus obscuris; parte marginali vix membranacea; corpore convexo.

A tolerably perfect fragment of the abdomen and tail of this highly interesting fossil comprised all of the animal which has yet been found. Eleven articulations of the middle lobe, and ten of the lateral lobes are quite distinct. All the costal arches or ribs are smooth and rounded, being without pustulatiæs striæ or grooves. Four of the upper arches of the dorsal, or middle lobe are longer than those on the sides of the body, a peculiarity which is sufficiently decisive to mark the species. Indeed this organization furnishes a striking exception to the generic characters of the Asaphus, as given by Professor Brongniart, who states "that the middle lobe of the abdomen is rarely more than 1-5 the width of the body." But what is more remarkable, and still further distinguishes this animal remains from all other Asaphs, is the epidermal covering which concealed the terminal articulations of the tail. In our specimen there is no appearance of what has been called the membranous development beyond the lobes of the animal, another circumstance which seems to separate it from the genus Asaphus. The body is quite convex, and (page 38) both in breadth and length our fragment measures nearly three inches.

I am indebted to the kindness of Dr. Charles J. Jackson, of Boston, Mass., for this interesting species: it occurs in magnetic iron ore, and was found by Dr. Jackson and Mr. F. Alger during their geological tour through Nova Scotia. Their highly important memoir describing the mineralogy and geology of that part of North America, has been justly proposed as a model, both in its generalizations and its details, to future explorers of those districts of our country which yet remain unexamined and undescribed. According to this memoir, Nova Scotia is based upon granite, although that rock is almost every where covered by more recent formations. A transition slate, with marine organic remains, and containing beds of limestone and rich deposits of iron ore, is very abundant. The iron ore is often beautifully impressed with organized bodies, of which our *A. crypturus* is a fine example. Sometimes one portion of a fossil is found moulded in the slate, and the other portion in the iron ore, thus indicating their contemporaneous formation. Sandstone is next in extent after the slate, and it is said corresponds geologically with the new red sandstone or red marl of England. Dr. Jackson, in his letter which accompanied our fossil, remarks: "I send you a Trilobite from the mines of magnetic iron in Nova Scotia, which exist in the clay slate of Clements, on the Moose River, at Annapolis Basin; also a Terebratula found in the same locality. I beg you to show these specimens to the Geol. Soc. of Penn., and let me know the result of your decisions. The most extraordinary thing connected with these fossils is, that they were found in a magnetic iron ore, the protoxide mixed with the peroxide and clay slate. The walls of the bed are of the same, or nearly the same date with the bed of the ore, for they are filled with terebratulæ."

In a communication recently made to the Geol. Soc., London, by J. Prestwich, Jr., Esq., "On some of the faults which affect the coal field of Coalbrookdale," the author concludes his memoir with some observations on the fossils he procured, principally from the iron stone of the coal measures; among the most remarkable were the remains of some *trilobites*, hitherto undescribed. They were procured from a bed of ironstone in the centre of the coal measures. No description of these animals being to my knowledge, yet given, it is impossible to say what affinities they may have to our *Asaphus crypturus*. Mr. Prestwich, who notices a *Coleopterous insect*, and another apparently belonging to the genus *Aranæ*, which were obtained from the ironstone nodules. The occurrence of these different races of animals in the same formation is certainly a very curious and highly important fact.

PROCEEDINGS

OF THE

Nova Scotian Institute of Natural Science.

VOL. VII. PART II.

PROVINCIAL MUSEUM,
12*th October*, 1887.

ANNIVERSARY MEETING.

JOHN SOMERS, M. D., F. R. M. S., *President*, in the chair.

THE Annual Address was delivered by the PRESIDENT. He pointed out the valuable work of the Institute in collecting facts for future generalizations in Science. He also urged upon members the duty of taking up fields of scientific inquiry hitherto left unexplored in this Province.

The TREASURER'S Account Book and vouchers were presented, audited, and found correct.

The LIBRARIAN'S Report was read, and gave full information regarding the Library. The Report was adopted and referred to the Council.

The SECRETARY was instructed to present to Hon. Mr. CHURCH, Commissioner of Public Works and Mines, the thanks of the Institute for the use of the Provincial Engineer's rooms.

The following were elected Office-bearers and Members of Council for the current year:

President—JOHN SOMERS, M. D.

Vice-Presidents—J. G. MCGREGOR, D. Sc., &c., A. H. MCKAY, B.A., B. Sc., &c.

Corresponding Secretary—REV. D. HONEYMAN, D. C. L.

Recording Secretary—ALEXANDER MCKAY.

Treasurer—W. C. SILVER.

Librarian—A. J. DENTON, A. B.

Councillors—E. GILPIN, A. M., M. BOWMAN, J. J. FOX, S. D. MACDONALD, WM. GOSSIP, M. MURPHY, C. E., GEORGE LAWSON, Ph. D., LL. D.

ORDINARY MEETING, PROV. ENGINEER'S OFFICE,
14th November, 1887.

DR. SOMERS, *President*, in the chair.

Inter alia.

A Paper was read by Dr. HONEYMAN, "The Glacial Geology of Nova Scotia, Theories of Sir J. W. Dawson and T. Belt, Esq."

Mr. A. P. SILVER was proposed a member.

ORDINARY MEETING, PROV. ENGINEER'S OFFICE,
12th December, 1887.

DR. SOMERS, *President*, in the chair.

Inter alia.

PROF. JOHN DUNS, D. D., of New College, Edinburgh, was proposed a corresponding member.

Reported, that MR. A. P. SILVER had been duly elected by the Council.

MR. THOMAS FYSHE was proposed as a member.

MR. A. P. SILVER read a paper "On the Diurnal Lepidoptera of Nova Scotia."

ORDINARY MEETING, PROV. ENGINEER'S OFFICE,
9th January, 1888.

PROF. MCGREGOR, *Vice-President*, in the chair.

Inter alia.

Reported, that PROF. JOHN DUNS, D. D., of New College, Edinburgh, and MR. THOS. FYSHE had been duly elected by the Council.

MR. FARIBAULT was proposed as an associate member.

PROF. MCGREGOR read a paper, "The Elementary Treatment of the Propagation of Longitudinal Waves."

DR. HONEYMAN read a paper on Carboniferous Flora with Spirorbes attached.

ORDINARY MEETING, PROV. ENGINEER'S OFFICE,
13th February, 1888.

MR. MURPHY, C. E., in the chair.

Inter alia.

DR. HONEYMAN read a note from Rev. J. AMBROSE, A. M., "Perforated Stone Implements—their uses."

Also, a note by LIEUT. VODGES relating to "The Giant Trilobites of Moose River Iron Mines, as described in 1837."

MR. HARRY PIERS read a paper, "Studies in the Provincial Museum: 1st Fishes; 2nd, Fish Development."

MR. FARIBAULT was reported as duly elected by the Council.

ORDINARY MEETING, PROV. ENGINEER'S OFFICE,
12th March, 1888.

DR. SOMERS, *President*, in the chair.

Inter alia.

A paper was read by E. GILPIN, M.E., Analysis of Cape Breton Coals.

DR. MCGREGOR delivered an address on "Lockyer's Spectroscopic Investigations of Meteorites."

ORDINARY MEETING, PROV. ENGINEER'S OFFICE,
9th April, 1888.

DR. SOMERS, *President*, in the chair.

Inter alia.

DR. LAWSON read a paper on the "Life History of the Plant."

The appointment of a delegate to the Royal Society of Canada was left to the Council.

ORDINARY MEETING, PROV. ENGINEER'S OFFICE,
14th May, 1888.

MR. ANDREW DOWNS in the chair.

Inter alia.

DR. HONEYMAN read a paper on "The Nomenclature of the Archæan Rocks of Arisaig, N. S., and George's River, C. B."

MR. H. PIERS read a paper on "The Japanese Magic Mirror of the Museum."

DR. HONEYMAN read papers:

1. "Nova Scotian Surface Geology, mapped, systematised and illustrated."
2. "Our Museum Meteorites—Celestial and Terrestrial Teachings—Daubree."

LIST OF MEMBERS.

Date of Admission:

1873. Jan. 11, Aikins, T. B , D. C. L., Halifax.
69. Feb. 15, Allison, Augustus, *Meteorologist*, Halifax.
64. Dec. 20, Brown, C. E., Halifax.
84. Mar. 13, Bowman, Maynard, *Public Analyst.*
84. Nov. 10, Campbell, G. M., Truro.
84. Apl. 13, Denton, A. J., Academy, Halifax.
65. Oct. 26, DeWolfe, J. R., M. D., L.-R. C. S. E.
86. Nov. 8, Doane, Harvey, Halifax.
63. Feb. 5, Downs, Andrew, M. Z. S., London, *Taxidermist*, Halifax.
83. Mar. 14, Forbes, John, Halifax.
83. Mar. 12, Foster, James G., Barrister, Dartmouth.
82. May 8, Fox, John J., Halifax.
87. Dec. 12, Fyshe, Thomas, Cashier Bank of Nova Scotia, Halifax.
73. Apl. 11, Gilpin, Edwin, F. G. S., F. R. S. C., Gov't Inspector of Mines.
63. Jan. 5, Gilpin, J. Bernard, M. D., M. R. C. S. Lond., F. R. S. C.
65. Feb. 5, Gossip, William, *Vice-President*, Halifax.
81. Dec. 12, Hare, A. A. Bedford.
67. Dec. 3, Honeyman, Rev. D., D. C. L., F. R. S. C., F. S. Sc., Lond., &c., *Secretary*, Curator of Provincial Museum, Halifax.
60. Jan. 5, Jones, J. M., F. L. S., Halifax.
82. Apl. 12, Keating, E. H., City Engineer, Halifax.
85. Jan. 11, Laing, Rev. Robert, Halifax.
64. Mar. 7, Lawson, George, Ph. D., LL. D., F. I. C., F. R. S. C , Prof. of Chemistry and Mineralogy, Dalhouse College, Halifax.
81. Mar. 14, Macdonald, Simon D., F. G. S., Halifax.
77. Jan. 10, MacGregor, J. G., D. Sc., F. R. S. C. and E., *Vice-President*, Prof. of Physics, Dalhousie College, Halifax.
72. Feb 5, McKay, Alex., *Secretary*, Supervisor of Halifax Public Schools, Dartmouth.
85. Oct. 21, McKay, A. H., B A,, B. Sc., F. S. Sc., Lond., Principal of Pictou Academy, Pictou.
78. Nov. 1, McLeod, John, F. S. Sc., London, Demerara.
70. Jan. 15, Murphy, Martin, C. E., Provincial Engineer, Halifax.
79. Nov. 11, Poole, H. S., Associate of the Royal School of Mines, F. G. S., Gen. Supt. of Pictou Coal Mines, Stellarton, Pictou Co.
65. Jan. 8, Rutherford, John, M. E., Halifax.
87. Nov. 15, Silver, A. P., Halifax.

DATE OF ADMISSION:

1864. May 7, Silver, W. C., Halifax.
75. Jan. 11, Somers, John, M. D., F. R. M. S , *President,* Halifax.
85, Jan. 12, Stewart, John, M. D., Picton.

ASSOCIATE MEMBERS.

88. Feb. 13, Faribault, E. R., C. E. of Geological Survey of Canada.
81. Nov. 13, Harris, C., Prof. of Civil Engineering, Royal Military College, Kingston, Ontario.
76. Nov. 9, Kennedy, Professor, King's College, Windsor.
82. Mch. 31, McKenzie, W. B., Engineer, Moncton, N. B.
78. Mch. 12, Patterson, Rev. G., D. D., New Glasgow.
84. Apl. 4, Pineo, A. J., Picton.

CORRESPONDING MEMBERS.

71. Nov. 29, Ball, Rev. E., Tangier.
88. Jan. 9, Duns, Prof. J., D. D., New College, Edinburgh.
71. Oct. 12, Marcou, Jules, Cambridge, Mass.
80. June 10, McClintock, Sir Leopold, Knt., F. R. S., Vice-Admiral.
77. May 12, Weston, Thomas, C. Geological Survey of Canada.

LIFE MEMBER.

Parker, Hon. Dr., M. L. C., Halifax.

Art. I.—Glacial Geology of Nova Scotia.—By Rev. D. Honeyman, D. C. L., F. R. S. C., F. S. Sc., &c.

Read November 2nd, 1887.

Although engaged in Geological investigation in Nova Scotia for many years, I may say since 1860, I had found the superficial Geology altogether unattractive until the year 1873. On Her Majesty's birthday of that year, while I was sauntering with a friend spending the holiday, on the shore of Cow Bay, on the Atlantic Coast, 9 miles east of Halifax (*Vide* Admiralty Charts of Harbor), I observed peculiar boulders of familiar rocks. These were different from the bulk of the boulders, which were, quartzites, argillites and granites, derived from Lower Cambrian and associate rocks of the region. The boulders in question were amygdaloids having amygdules of zeolites, e. g. stilbite and heulandite. The only rocks that could produce these in British America is a range of igneous rocks connected with the Triassac Formation that lie north and west of Halifax. These rocks are celebrated for their minerals, which are found in all the American Museums, and of course in the British Museum. The question was asked by my friend: How did these boulders come here? I had seen similar boulders on the Avon Estuary, at Windsor, Nova Scotia, which my friend, Professor How, told me came from Blomidon opposite. This headland is the eastern extremity of the range of rocks already referred to. I suggested that some vessel, which had taken in ballast at the Avon, had thrown them overboard in the Bay, and that they had been *washed ashore by the sea.* Another and better answer was furnished when we came to Osborne Head, on the east end of the Bay. Here amygdaloid boulders were seen falling from the drift of which the Head is formed. Abundance were found on the beach at its foot. In the drift I found a beautiful boulder of moss agate. My associate, Mr. Stirling, also found another specimen of this mineral on the shore at the east side of the Head. Judge James had also found a fine specimen in the preceding year. These abound in veins, in the traps of Blomidon. Still the question was asked: How did the boulders, etc., come to the bluff? Massive boulders of quartzite lay at the foot of the bluff and partly embedded in it. These were striated and grooved in a singular manner. We were thus referred to Point Pleasant, Halifax, especially the well known and wonderfully striated and grooved *rocke moutonneé* at Prince of Wales Tower. *Vide.* Picture in Sir C. Wyville Thomson's Challenger Expedition Volumes. Procuring the Admiralty "Chart of the Coast of North America from the Strait of Belle-Isle to Boston," I located on it our glaciated rock surface. On extending the lines or courses S. 20 E., N. 20 W. and S. 30 E. and N. 30 W. magnetic, northerly, they were seen to pass by Blomidon and over it. Several ruts on the same surface distinctly show that the agency that formed them had moved in a southerly direction. All this seemed very satisfactory. An important problem thus presented itself for solution. As the occurrence of the Triassic amygdaloid rocks was limited in an easterly direction to Five Islands on the north side of the Basin Minas, it was considered that a parallel (S. 20 E.) drawn from Five Islands to the Atlantic Coast would limit the occurrence of the boulders on the shore. There were still other boulders observed occurring in abundance associated with the amygdaloids on the shore and in the bluff. These are syenitic gneisses, syenites, hornblendic granites, diorites, &c. They were at once recognized as of Archæan rocks, whose nearest seat is the Cobequid Mountains. Through these our Blomidon striation line would also pass.

I found, after a course of investigation extending over many years, that Osborne Head is one of a series of heads and less elevated deposits which extend from Thrum Cap, in the mouth of Halifax Harbour, to Three Fathom Harbour, a distance of 16 miles, *Vide.* Chart. In this "Terminal Series" I have found represented by boulders, not merely the Triassic Igneous rocks of Blomidon and the Archæan Metamorphic of the Cobequid Mountains, but also Silurian fossiliferous rocks and Carboniferous, having *fauna* and *flora* from the formations that occur in the region traversed, the transporting agency having levied on every formation that lay in its path, and discharged its freight on and in the Atlantic. *Vide.* List of specimens exhibited in the Nova Scotian department in the Centennial Exhibition, Philadelphia, 1876. Trans. 1877 and 1886. In further illustration of our subject I intend only to record investigations of the present year yet unpublished, while I may incidentally refer to previous records.

COW BAY *revisited*, 1887.

The experience of 14 years led me to expect the finding of new points of interest which had been overlooked at the first. The season being more advanced, the day was beautiful, the sea view charming; the lake, which is separated from the sea by two raised beaches and an intervening terrace, was adorned with fields of white water lilies *(Nymphæa odorata)*, basking in the bright sunshine. Coming to the shore, attention was attracted by an amygdaloid boulder—a traveller from Blomidon. It lies before me in my new representative collection; its colour is dark brown; its amygdules are *heulandite* and *stilbite.* Another distinctive boulder was next observed and added to our collection. This is of Syenitic gneiss from Archæan rocks of the Cobequid Mountains. The distance from Cow Bay to Blomidon is 65 miles. The middle of the Cobequids is 15 miles further. At first I connected associate boulders with Osborne Head. This has its own beach and boulders. Our first discovered boulders and the present came from a low section of Mosher's farm, on which is the road to the shore. This farm is chiefly composed of glacial drift. It is also part of the "Terminal Moraine." I have incidentally noticed a terrace which separates the fresh water lake from the sea. This extends to a considerable distance. Its groves of scraggy spruce afford convenience and shelter for picnic parties. A cart road passes along the middle. It has a ridge of sea-worn boulders next the lake and a large bank of similar boulders next the sea. Shelving in this direction it is succeeded by beautiful sand flats, in which *Echinarachnius parma* abound. The boulders of the ridges and terrace are generally of Lower Cambrian quartzites. Among these, however, we find abundance of beautiful boulders of Archæan syenites, syenitic gneiss, porphyrites, &c., and also Triassic amygdaloids. Out of these we made up our collection of 25 specimens.

Dartmouth Railway.

Several years ago I fully investigated the Glacial Geology of this side of the Halifax Harbor, and recorded my observations in the Transactions of the Institute. As in other parts of the province, a line of railway has been constructed here, which enables me to improve previous work. The great drift accumulations which contribute to the picturesqueness and roughness of the eastern side of the harbour have been exposed more than formerly. Two fine new sections are particularly instructive. We have now three good sections. The first is an old section of the eminence on which Judge James' residence and grounds are situate. This was our chief key to the geology of the moraine previously. The section is near the line of railway, not on it. There was nothing new observed here. It is on the north end of the accumulations. Walking along the railway (S.) we reach Mott's factory. On a field to the south of it, we have the first new section. Here I found abundance of boulders of Archæan rocks, such as we have already named, and several boulders of basalt (dolerite) and an amygdaloid. I took specimens of these to form a new representative collection. The next section south of Troop's wharf is more varied and of looser material than the preceding. A prominent constituent is a coarse red brick clay. This is a section of a beautiful green field belonging to Dr. Parker and others. Here were abundance of the usual Archæan boulders and also Triassic. In the clay I observed, partly projecting, an amygdaloid of grey colour. It was found to be of large size, the remainder of it being deeply imbedded in the clay. Other amygdaloid boulders of various sizes and replete with beautiful amygdules of *heulandite* were also found imbedded in the same clay. Of these I took specimens, leaving the remains for other collectors. The collection from these sections contains 19 specimens. I would here make a remark which is applicable to all the collections. I label the collections from each locality immediately, as it is the only way that I can distinguish them. They are all so much alike. I have also come to regard Triassic amygdaloids and basalts as characteristic (*fossils*) of Postpliocene. accumulations of the "Cow Bay Type."

Point Pleasant.

There is an accumulation of the above character at this Point. This is the site of an old battery which protected the boom which formerly crossed the North West Arm. The shore section of this is renovated every spring by the agencies—frost, thaws and sea-storms. Lying to the south of the Tower glaciation, and being otherwise conveniently situated, it is very frequently visited and levied upon. Thus the representative amygdaloids become at times rather rare. Under my guidance members of the Institute often go there. Professor Richards, of the Massachusetts Institute of Technology with associates and students have twice examined it and collected specimens. Members of the British Association, after the Montreal meeting, also visited it. Last spring I also conducted thither the teachers of the Halifax Science School. This section shows also a massive quartzite boulder beautifully grooved and striated, being evidently a part of the machine that grooved and planed the Point Pleasant rocks. The other localities where the phenomenon has been particularly noticed are Osborne Head, Cow Bay (as above), and Thrum-Cap, Cornwallis or McNab's Island. *Vide* my Papers in Transactions of the Royal Society of Canada, Vol. III., and in the Royal Jubilee Number (1887) of the Journal of the Society of Science, Letters and Art, London. This seems to be a characteristic of the "Terminal Moraine," of which the Point Pleasant accumulations seems to be a part.

Glaciation.

In my constitutional walks in the south side of the city I have been giving special attention to the phenomena of glaciation. I have found in the streets, especially those newly and partially made, and on the north side of Pleasant Park, a sort of a series of glaciated surfaces extending from Tower Road to Pleasant Street. Two remarkably beautiful exposures extend completely across the street (Ivanhoe), and form a pavement for nearly half its length. My assistant and I have carefully taken the courses of lines, without number, on all the surfaces, and find a uniform direction—S. 30 E., N. 30 W. There is not the variation that we find at Prince of Wales Tower. *No body, but one moving in a uniform direction, could make such a track.*

Exhibition Grounds.

Walking in these grounds I observed one boulder, and afterwards several of the same kind, large and small. I recognized their *basaltic* character. I examined pieces of them according to my usual methods and found that they contained *magnetite* and also *olivine.* They were thus identified with the basalts of Blomidon and Partridge Island.

Camp Hill.

This is a well known locality on Halifax Common, adjoining "Camp Hill Cemetery." According to the measurements of the Royal Engineers, it measures 700 feet north and south, and 500 feet east and west. Its height above the mean tide of Halifax Harbor is 175 feet, its distance from the Harbor is 1350 yards, and from the North West Arm one mile. I have just discovered that this is a grand accumulation of the "Cow Bay type." Its constitution has been disclosed by military and other excavations. These occur throughout its length and width. Here I have collected all the usual Archæan and Triassic boulders, some of the latter are very beautiful. The collection numbers 28 specimens. My assistant, Henry Piers, also made a collection. Shortly after one of the lady teachers of the "Science Class" brought to the Museum a collection from this locality. One of the trap boulders had a bright amethyst vein. I consider this as one of the most important localities.

Block House Hill.

According to the Royal Engineers measurement this hill is two miles north of Camp Hill, and 225 feet above Bedford Basin.

It is so called as on it was erected a block house fort which commanded Bedford Basin and the road to Prince's Lodge (Duke of Kent's). It is now a cultivated field, but the site of the fort is still plain. From the heaps of stones on the field, Henry Piers brought to the Museum first a boulder of basalt and afterwards the usual Archæan and Triassic boulders. We may, therefore, regard this as another locality.

The Avon.

Last summer on an excursion to Wolfville I proceeded from Halifax by the Windsor and Annapolis Railway. This line approximately runs in the track of our glacier, so that on our way to the Avon we may be considered as following the *receding* glacier. The North Street Station from which we start, stands opposite H. M. Dockyard, where lately rose, Observatory Hill, which was a vast accumulation of the " Cow Bay Type." Of this we have a splendid memorial collection in our Museum, made during its removal. The hill disappeared finally, on November 4th, 1885, at 3.50 P.M., railway time; I watched its disappearance. Starting and proceeding we pass on the right of Fort Needham, another accumulation of the same kind, at Three-Mile House we come into the vicinity of Blockhouse Hill. We are in the track, on Bedford Basin. Navy Island is near the opposite shore. In the beginning of my investigations I was on this island and found the characteristic boulders of Cow Bay. When the Royal Engineers were surveying around Bedford Basin, Colonel Akers, R. E., late major general, examined the island and made a collection of boulders corresponding with his Thrum Cap collection. He intended to present both to the Museum of the Royal Engineers at Chatham. This island is 10 miles north of Thrum Cap. A full account of the glacial phenomena of this Basin is to be found in my paper, *Transactions of the Institute, 1885-6*. At Bedford we cross the bridge that crosses the Sackville River. On the opposite side of this, we have a drift cutting. I examined this when it was fresh and found our familiar boulders. It is now obscured. If we were to change our route and travel the Windsor Road, which runs nearly parallel with the Sackville

River, we could find our boulders, over another 15 miles. At this distance I picked up an amygdaloid last summer. They *seemed* to stop here. Proceeding, we reach Windsor Junction. Here we find the usual red drift with our boulders. If we were to go by the Intercolonial, we would find drift sections with amygdaloids, &c. The last of these we found a few years ago at Enfield Pottery and Brick Works in the red clay. This is 26 miles from Three Fathom Harbour, part of our "Terminal Moraine," where we found the last of the amygdaloid boulders on the Atlantic Coast. From the Windsor Junction we proceed onwards by the Railway to Windsor. We shortly pass through drift cuttings. In these we found the characteristic boulders in abundance. The ballast from them showed many and beautiful amygdaloids. The sections are of the only cultivatable land of the locality. How largely! the glacier has contributed to the sustenance of the inhabitants of the region which we have traversed. The underlying rocks only produce barrens. We come to Beaver Bank Station. To the right is a quarry of slates and paving stones. The rocks are glaciated ; the grooves running in Halifax courses. Proceeding, we observe drift sections, chiefly on the left hand side the wood. This has the usual appearance, and doubtless contains the usual boulders. Coming to the vicinity of the disappearance of amygdaloids, &c., on the Windsor Road referred to, the drift seems to disappear, and does not reappear until we reach Newport. For many years this interruption seemed unaccountable. We conjectured that the transportation had been effected away to the left of the railway. I had occasion, in 1855, to examine the region of Lakelands. On the side, a lake near the Windsor Road, and also near the house and building, I found the boulders of which I had been in quest. I was certainly gratified with the discovery. Locating this position on my "Geological Map of the Province," I find the name of the lake is L. Pigot, and that my Halifax and Blomidon general glacial line *almost* touches it. It seems to pass almost through the site of the buildings. This coincidence is certainly striking. The track thus crosses about Oland's farm, and passes to the right of the railway. Coming to Newport we have passed through our Lower Cambrian Formation, with its gold fields, near Windsor Junction and Mount Uniacke, and we have entered upon the Lower Carboniferous, with its sandstones, gypsums and limestones. All these are seen exposed in railway sections. The geological gap is enormous; all the formations between the Lower Cambrian and Lower Carboniferous are unrepresented. On the Lower Carboniferous is the post-pliocene drift. Here there is another gap. Our boulders, often large in size, are frequently seen. We come to the gypsum of Windsor, in quarries These also outcrop on the banks of the Avon, with fossiliferous limestones, of which we have abundance of boulders at Lawrencetown Head on the "Terminal Moraine." It was here that I first became acquainted, about twenty years ago, with those amygdaloids with which we are now so familiar. It was not clear to me how the Archæan boulders of the Cobequid Mountain rocks became associated with the amygdaloids as we have found them until I visited this locality with the members of the British Association. Dr. Blanford then turned my attention to boulders here, mixed with amygdaloids. I at once saw that they had crossed the Minas Basin with the amygdaloids, and that consequently some of the latter might have come from Partridge Island. I had not previously revisited this locality since I had commenced my investigations, and hence the perplexity. We now cross the Avon Bridge and proceed onward. Only drift is observed in all directions until we come to about 3 miles from Hantsport. An outcrop of gypsum is observed. Its continuation was afterward seen in considerable quantity on the side of the Avon. We now reach Hantsport. Here on the following morning we are to be met by the professors, lecturers and students of the Summer Science School, now in session at Acadia College, Wolfville.

As this locality was new to me I made a *reconnaissance*, rising at day-break, 5 o'clock. The ground is hilly, without any outcrops of rocks. Observing from the railway station a section of one of the hills, I approached it and found it to be a section of drift. Our familiar boulders, Archæan and Triassic, appear in great force and of all sizes. We are now in sight of Blomidon and only 15 miles distant. We make a collection corresponding with that of Cow Bay. Having arranged this on the platform, we await the arrival of our excursionists. On their arrival we define our standpoint, topographically and geologically. We are in sight of the county line of Hants and Kings. The underlying formation is Lower Carboniferous; the overlying, Post-pliocene. The collection corresponds precisely with one lately made at Cow Bay, on the Atlantic coast, the intervening distance being that traversed. We first examine the section and proceed to the shore. Taking advantage of the ebbing (Bay of Fundy) tide, we examine the fresh and clean section as we proceed onward. It is all of the same character as the Hantsport section. Now and then an amygdaloid boulder is met with, having amygdules of larger than usual size and minerals of less common occurrence. I would specify a piece of trap having a beautiful amethystine vein. The Archæan boulders are of the usual varieties and varying sizes. The sections continue a long distance. How long, we had no means of ascertaining. We at length reach a cove where on the opposite side we find strata exposed. These are the first of the series of Lower Carboniferous strata, which is known as "Horton Bluff." This extends to Avonport, which terminates our excursion. We are now 50 miles from Thrum Cap, 14 from Blomidon, 18 miles from Partridge Island, 29 from the middle of the Cobequids.

Blomidon and Partridge Island.

We had an excursion to these on the following day. Proceeding by steamer, we reached Blomidon and landed at Amethyst Cove. The chief objects of search were minerals, especially amethysts. Beautiful amethysts and agates were collected. Our attention was also directed to the rocks. We were now at the home of the Basalts and Amygdaloids. Large masses fallen from the cliffs are pointed out and compared with the travelled boulders. We afterwards proceeded to Partridge Island, landed on its basalts, examined them, the more particularly, as we regarded them as the near relations of the basaltic boulders at Halifax. After hard climbing, especially for the ladies of our party, we reached the other side of the Island, where the rocks are amygdaloidal, and, so to speak, amorphous, having zeolitic and jaspideous veins. As our time was short and uncertain, and depended upon the flow of the (Bay of Fundy) tide, our look at the rocks and their contents was very hurried. As for myself, this was not of much consequence, as I had already given them some considerable attention on my previous visit with the members of the British Association. After noticing the connection of those igneous rocks with the sandstones of the Triassic Formation we re-assembled and embarked on board the steamer. I could only then take a look of the Cobequid Mountains rising at no great distance—the home of our Archæan boulders, with which we have become familiar, but not more so than we are with the parent rocks, which we have repeatedly and carefully examined. *Vide* papers on the Cobequid Mountains. Trans. I. N. S., Vol. III, 1873-4.

The height of these Archæan Mountains only in one instance exceeds 1000 feet. We have thus followed our glacier in its retreat up to its possible source. We stop there.

In our first paper which we communicated to our Institute on this subject, and which we also read before the American Philosophical Society, Philadelphia, during the Centennial Exhibition, I incidentally referred to the work of two previous observers and their theories of the phenomena observable in our field. *Vide* Transactions, Vol. IV., page 122. The observers were Dr. Dawson (Sir J. W.), and the late Thomas Belt, F. G. S., "the Naturalist of Nicaragua," who is well known in connection with gold mining in Nova Scotia, and as an original and active member of our Institute and a personal friend. Both of these are regarded as authorities in Glacial Geology. We will quote the *ipsissima verba*, and only append one or two notes. This seems to me to be all that is necessary. In Dawson's Acadian Geology, second edition (1868), page 71, we thus read: "Nor would I exclude altogether the action of glaciers in eastern America, though I must dissent from any view which would assign to them the principal agency in our glacial phenomena. * * * The striation itself shows that there must have been extensive glaciers, as now, in the extreme Arctic regions. Yet I think that most of the alleged instances must be founded on error, and that old sea-beaches have been mistaken for moraines. I have failed to find in our higher mountains any distinct sign of glacier action, though the action of the ocean breakers is visible almost to their summits ; and though I have observed in Canada and Nova Scotia many old sea-beaches, gravel-ridges, and lake-margins, I have seen nothing that could fairly be regarded as the work of glaciers. The so-called moraines, in so far as my observation extends, are more probably shingle beaches and bars, old coast lines loaded with boulders, trains of boulders or 'ozars.' Most of them convey to my mind the impression of ice action along a slowly subsiding coast, forming successive deposits of stones in the shallow water, and burying them in clay and smaller stones as the depth increased. These deposits were again modified during emergence, when the old ridges were sometimes bared by denudation, and new ones heaped up."

Mr. Belt observes, Transactions of Institute, N. S., Vol. I., Part IV., 1866: "*Local character of drift.*—Having thus sketched out the probable action of the ice, during its advance, culmination and retreat, and explained the general distribution of the drift, it only remains to apply the theory to a few of its more striking features. The local character of most of the drift stones in Nova Scotia is one of these. Here and there a few blocks of granite are found that have been brought two, four, or even eight miles, but the great majority of fragments belong to the rock formation over which they lie. Boulders of slate occur where bands of slate cross the country, and boulders of quartzite where the bed rock is quartzite. Fragments of quartz, sometimes containing gold, are easily traced to the lodes (invariably to the north of them) from which they have been detached, and thus many auriferous lodes have been discovered. The local character of the stones in the drift is opposed to the supposition that to the north the land was so elevated that the ice moved over the country like a great glacier, and is in favor of the theory that it was formed by the retreating margin of a great accumulation of ice. If there had been during the glacial period high mountains to the north of Nova

Scotia, far-travelled blocks would have been of frequent occurrence. But without high ranges northwards, and with its own hills only of moderate elevation, we find as we might expect that the blocks are easily traced to their parent rock. Some boulders of granite have been carried farther because here and there granite hills rise above the general elevation of the country." Here we have two theories antagonistic to each other and both antagonistic to our glacial theory. I think that our grand array of facts summarily disposes of both. In opposition to 8 mile transportation we have proved 80 miles. As our glacier is only one of a system, see " Our Glacial Problem," Trans. 1884-5, high mountains to the north of Nova Scotia may or may not be found necessary.

We give the " sea agency " due credit for making such accumulations as the " Terrace " at Cow Bay, for destroying largely our " Terminal Moraine," and for scattering its material in the sea and along the sea shore. We will give it and other post glacial agencies (Champlain and recent) credit for aiding the advancing and retreating glacier itself in obstructing and destroying the glacial highway, such as in the forming of the Minas Basin and in scooping out and scattering the material, solid and superficial, so as to render any similar movement now impossible and to bewilder and mislead observers. We have thus also new accumulations formed and boulders scattered to the north, east and west of their original positions. *Vide* Geology of Kings and Annapolis Counties. Trans., Vol. V., page 29, and Geology of Aylesford (Annapolis County). Trans. 1886-7.

Art II.—List of Nova Scotian Butterflies.—By Arthur P. Silver.

Read December 12th, 1887.

I. Fam. PAPILIONIDÆ.

Gen. Papilio (Linn.)
Papilio turnus (Linn.)

II. Fam. PIERIDÆ.

(1.) Gen. Pieris (Schr.)
Pieris oleracea (Harr.)
rapæ (Linn.)
(2.) Gen. Colias (Schr.)
Colias philodice (Godt.)

III. Fam. DANAIDÆ.

Gen. Danais (Boisd.)
Danais archippus (Linn.)

IV. Fam. NYMPHALIDÆ.

(1.) Gen. Argynnis (Fab.)
Argynnis diana (Cram.)
aphrodite (Fab.)
myrina (Cram.)
(2.) Gen. Melitæa (Fab.)
Melitæa ismeria (Boisd.)
tharos (Cram.)
phæton (Fab.)
(3.) Gen. Grapta (Kirb.)
Grapta interrogationis (Fab.)
comma (Harr.)
C. album (Linn.)

(4.) Gen. Vanessa (Fab.)
Vanessa J. album (Boisd.)
milberti (Godt.)
progne (Cram.)
antiopa (Linn.)

(5.) Gen. Pyrameis (Doubleday.)
Pyrameis atalanta (Linn)
cardui (Linn.)
huntera (Linn.)

V Fam. LIBYTHEIDÆ.

Gen. Nymphalis (Latr.)
Nymphalis disippus (Godt.)
arthemis (Drury.)

VI. Fam. SATYRIDÆ.

(1.) Gen. Erebia (Dalman.)
Erebia nephele (Kirb.)

(2.) Gen. Satyrus (Fab.)
Satyrus alope (Fab.)

(3) Gen. Debis (Boisd.)
Debis portlandia (Fab.)

VII. Fam. LYCÆNIDÆ.

(1.) Gen. Argus (Linn.)
Argus pseudargiolus (Boisd.)

(2.) Gen. Polyommatus (Latr.)
Polyommatus lucia (Kirb.)
epixanthe (Kirb.)
americana (Harr.)
porsenna (Schr.)
cratægi (Boisd.)

(3.) Gen. Thecla (Fab.)
Thecla niphon (Hubn.)
augustus (Kirb.)
mopsus (Hubn.)

VIII. Fam. HESPERIDÆ.

(1.) Gen. HESPERIA (Linn.)

Hesperia hobomok (Harr.)

ahaton (Harr.)

peckius (Harr.)

cernes (Harr.)

meta-comet (Harr.)

leonardus (Harr.)

mystic (Ed.)

nemoris (Ed.)

(2.) Gen. NISONIADES (Hubn.)

Nisoniades brizo (Boisd.)

(3.) Gen. STEROPES.

Steropes paniscus.

(4.) Gen. PAMPHILA.

Pamphila zabulon (Boisd.)

ART. III.—ON THE ELEMENTARY TREATMENT OF THE PROPAGATION OF LONGITUDINAL WAVES.—BY PROF. J. G. MACGREGOR, D. SC.

Read January 9th, 1888.

The best elementary treatment of the propagation of longitudinal waves known to me is that contained in Maxwell's Theory of Heat, chapter XV. It is based on Rankine's more difficult treatment of the same subject in his paper "On the thermodynamic theory of waves of finite longitudinal disturbance," published in the Philosophical Transactions of 1870, and in Rankine's Miscellaneous Scientific Papers, page 530. "The kind of waves to which the investigation applies are those in which the motion of the parts of the substance is along straight lines parallel to the direction in which the wave is propagated, and the wave is defined to be one which is propagated with constant velocity, and the type of which does not alter during its propagation." Maxwell's investigation involves an error which vitiates his result, and it is the object of this paper to point out the error and to obtain the same result in a legitimate manner.

Maxwell imagines a plane of unit area, which he calls the plane A, perpendicular to the direction of propagation of the wave, to move with the velocity of the wave. Behind it another plane, B, of the same area, moves with the same velocity, thus maintaining its distance from A. As both these planes move with the velocity of the wave, the velocity, the specific volume (*i. e.*, volume of unit of mass), and the pressure, of the substance, at each of them, must remain the same. The same is true of any plane normal to the direction of propagation of the wave and moving with its velocity. During the passage of the wave portions of the substance are continually passing through the planes A and B.

Let V be the velocity of the wave, u_1, v_1, and p_1, the velocity, specific volume, and pressure, of the substance at P, u_2, v_2, and p_2, the velocity, specific volume and pressure of the substance at

B, and Q and Q_2 the masses of the substance passing through A and B respectively, in a direction opposite to that of the wave, in unit of time.

Maxwell first shows, in an unexceptionable manner, that

$$Q_1 = Q_2 = Q \text{ (say)} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

(we retain Maxwell's numbering of his equations), and that

$$u_1 = U - Qv_1 \text{ and } u_2 = U - Qv_2 \ldots\ldots (5)$$

He then points out (1) that the substance between the planes A and B is continually acted upon by a resultant force equal to $p_2 - p_1$ in the direction of the wave, and (2) that the momentum of the substance between these planes, in the direction of the wave, increases at a rate equal to $Q(u_1 - u_2)$ per unit of time. "The only way in which this momentum can be produced," he says, "is by the action of the external pressures p_1 and p_2," and hence in the earlier editions of the Theory of Heat, he puts

$$p_2 - p_1 = Q(u_1 - u_2) \ldots\ldots\ldots (6),$$

thus applying Newton's Second Law of Motion. He then substitutes in this equation the above values of u_1 and u_2, and by a slip finds that

$$p_2 - p_1 = Q^2 (v_1 - v_2) \ldots\ldots\ldots (7),$$

and consequently

$$p + Q^2 v_1 = p + Q^2 v_2 \ldots\ldots (8).$$

It follows that, as A and B are any planes whatever, normal to the direction of the wave, and moving with its velocity, if p and v are the pressure and specific volume of the substance at any such plane, we have

$$p + Q^2 v = \text{const.}$$

Hence, since for small changes of volume of actual substances the increase of pressure is proportional to the decrease of volume, the kind of wave under consideration is proved to be possible for actual substances, provided the changes of pressure and volume involved be small. Expressing, therefore, the elasticity (E) in terms of v and Q, by the aid of equation (7), he obtains

$$E = v\,Q^2,$$

and deduces at once the important result,

$$U^2 = Ev.$$

If we correct the slip in substitution referred to above, it will be obvious that Maxwell should have deduced from equation (6), not equation (7), but the equation

$$p_2 - p_1 = Q^2 (v_2 - v_1),$$

from which it would have followed that

$$p - Q^2 v = \text{const},$$

and consequently, that as an increase of pressure produces an increase of volume in no known substance, the form of wave under consideration was not possible in actual substances.

In later editions of the Theory of Heat there is substituted for equation (6) the equation

$$p_1 - p_2 = Q (u_1 - u_2),$$

and from this equation it follows that

$$p + Q^2 v = \text{const.};$$

but no reason is given for this modification of equation (6). Now, if the Second Law of Motion is applicable in the way in which Maxwell has applied it, equation (6) is correct in the earlier editions and incorrect as given in the later editions. For $p_2 - p_1$ is the value of the resultant force, in the direction of the propagation of the wave, acting on the portion of the substance between A and B, and $Q (u_1 - u_2)$ is the rate of increase of the momentum in the same direction of the substance between A and B. Hence, if the Second Law is applicable in this way the conclusion should be drawn that waves of this kind cannot be propagated by actual substances.

But the Second Law of Motion seems to be inapplicable in the present case. That law asserts that the resultant force acting on *a body* is equal to the rate of increase of the momentum of the body in the direction of the force, but not that the resultant force on the portion of a moving substance enclosed by certain bounding planes is equal to the rate of increase of the momentum of the substance thus enclosed. And hence the earlier form of equation (6) is not legitimately established.

Some other method must therefore be adopted of obtaining a relation between p, v and Q. The following method gives us the required relation: Let A and B be indefinitely near one another. Then the mass entering the space between A and B at A during any time may be supposed to be identical with the mass issuing at B; and during its motion it may be supposed to be acted upon by a resultant force equal to $p_2—p_1$ in the direction of the propagation of the wave. The mass Q, which enters in unit of time has initially, on entering, the momentum Qu_1 in the same direction, and finally, on issuing, the momentum Qu_2 also in the same direction. Hence the rate of increase of the momentum in the direction of the resultant force $p_2—p_1$ is Q $(u_2—u_1)$, and therefore, by the Second Law of Motion,

$$p_2-p_1 = Q\,(u_2-u_1).$$

When, now, we substitute in this equation the values of u_1 and u_2 given by equations (5), we obtain

$$p_2-p_1 = Q^2\,(v_1-v_2).$$

Consequently

$$p + Q^2\,v = \text{const.},$$

for planes indefinitely near, and therefore also for planes at a finite distance from one another. Waves of the kind under consideration are thus seen to be possible of transmission through actual substances, provided the changes of pressure and volume are small, and the result,

$$U^2 = E\,v,$$

may therefore be deduced.

ART. IV.—CARBONIFEROUS FLORA, WITH ATTACHED SPIRORBES. BY REV. D. HONEYMAN, D. C. L., &c.

Read Jan. 9th, 1888.

When making a special examination of the Fossil Flora in the Museum, and more particularly the beautiful series of Carboniferous Flora collected by the late Barnes, M. E., for the Paris Exhibition of 1867, as well as others collected by myself before and after this date, I had occasion to consult "The Fossil Plants of the Devonian and Upper Silurian Formations of Canada," by (Sir) J. W. Dawson, LL. D., F. R. S., F. G. S. (Geological Survey of Canada, 1841). In Plate XIV. I observed Fig. 161, a. b. of Cordaite with a number of Spirorbes attached, and enlargement of the latter. In page 43 "Like the Cordaites of the coal formation it sometimes has on its surface shells of Spirorbes (Fig. 161)." In a note we read "these shells are attached to some of the leaves of *Cordaites Robbii* in Prof. Hartt's collections, and I have noticed the same fact as occurring at Gaspe, though the specimens seem to have been mislaid. The shells from St. John are similar to the *S. Carbonarius* of the coal formation, but the tube widens more rapidly and is smooth. They may be named *S. Erianus*."

It seems hopeless to convince palaeobotanists that the *Spirorbes* are really shells. As long ago as 1845 I showed evidence of this, and described these shells as *Spirorbes*, and subsequently I have investigated and described the microscopic structure of the shell. Yet I see that Schimper reproduces, though with doubt, the old error, that these organisms are fungi (*Gyromyces ammonis* of Gœppert). I have represented the St. John specimens in fig. 161. They appear reversed or sinistral, but when placed on a thin leaf their appearance in this respect depends on the side of the leaf exposed. Fig. 161 b. shows the actual appearance as seen on the upper side of the leaf. *Vide* Acadian Geology, p. 205, and proceedings of the Geological Society, December, 1885.

Our first specimen is a cast of a *stipe* in clay slate. Its length is 73 mm., and width 6 mm. Attached to it are 23 Spirorbes; all are sinistral. I found this specimen at the McAulay Mine (Gowrie Mine), Cape Breton, in 1861.

Specimen second is a piece of clay slate, having six fronds of sphenopteris. Attached to five of these we have seven Spirorbes. All are on the outside of the fronds; all are sinistral. The specimen belongs to Mr. Barnes' Cape Breton collection.

The third specimen is a sigillaria, which I found at South Joggins. In the scars of this we find 12 distinct Spirorbes, and there is another plant on the back of the specimen. All appear sinistral. They are evidently casts of the basis of dextral forms.

As an illustration I show an alga, a common *melanosperm*, with a large number of attached Spirorbes, whose apex after the removal of the anneloid tube would make casts having a resemblance (with a specific difference) to that of the old Carboniferous forms. I am surprised to find that there ever was any difference of opinion entertained in reference to the character of these Carboniferous forms.

Art. V.—Studies in the Provincial Museum. 1. Fishes. 2. Fish Development. By Harry Piers.—Com. by the Secretary.

Read February 13th, 1888.

In the course of my studies in the Provincial Museum, the following new, rare, or interesting specimens have come under my notice, on which I would now make a few notes which may be of interest.

The Striped or Oceanic Bonito—*Euthynnus pelamys* (L), Lutken.

On August 22nd, 1887, a large individual of this uncommon species, which is well known for its activity and voracity, was captured in the North West Arm. It was subsequently examined by Dr. Honeyman, and furnished the following measurements:

Length, 36cm.
Girth, nearly 25cm.

There were three longitudinal black stripes under the lateral line on one side, while on the other a fourth might be observed, but less distinctly. This seems to correspond with the figure in the publication of the United States Fishery Commission (Fishery Industries). It is an excellent food-fish, and was unfortunately purchased by a hotel proprietor for the table before Dr. Honeyman could secure it.

Short-Finned Harvest Fish—*Stromateus triacanthus*, Peck.

Mr. Christian, of Prospect, obtained a very large specimen of this beautiful fish, which he forwarded to the Museum. Its total length is nearly 26cm., while that of two specimens in the Museum collection is 14cm., and 11cm. 5mm., respectively. In height it measures 9cm. 5mm., and in its greatest breadth over 3cm. The head constitutes one-fifth of the total length. According to Prof. G. Brown Goode, its northerly range is Maine.

This fish first appears with the mackerel. It associates with the jelly fish, which are sometimes observed "accompanied by ten or twelve, or more, young Butter-fishes, which seem to seek shelter under their disks, and which, perhaps, may obtain a supply of food from among the numerous soft-bodied invertebrates which are constantly becoming attached to the floating streamers of their protectors." Fifteen have thus been seen under a *Cyanea arctica* only three inches in diameter. Their entertainer, however, does not always prove a good host, "for they sometimes are destroyed by the tentacles of their protector, which are provided, as every one knows, with powerful lasso cells." Their flesh is excellent as an article of food, and resembles in flavor that of the mackerel. It is remarkable for its "brilliant, iridescent colors, which, in freshly caught individuals, are as beautiful as those of a dolphin." The fact of its appearing during harvest time gave it its common name. Our fishermen call it the Dollar-fish.

AMERICAN ASPIDOPHORE — *Aspidophoroides monopterygius*, STORER.

This rare and curious fish was collected on the shore of Cape Breton. It is more frequently observed on the coast of Greenland, and, although "not much thinner or softer than an iron spike," it is sometimes taken, by our fishermen, from the stomachs of codfish and halibut caught on the Banks.

DeKay gives but an imperfect figure of this species, and our specimen, now before me, appears to differ in the following particulars. The anal fin has *six* rays instead of five, and it commences slightly anterior to a point beneath the beginning of the dorsal and ends the same distance in front of the termination of the latter. The pectoral is nearly three times as long as that in the figure, the fourth ray being the longest. Our fish is also of much greater height just in advance of the pectorals and the breadth here is 11mm. But the chief difference appears to lie in the absence of the third spine on the snout, which latter is also more acute. The total length is a little over 16mm.

DeKay says he never had an opportunity of seeing this rare species, but copied from Storer his figure of one found on the coast of Massachusetts.

TETRODON. SP. ?

Description:—Body oblong, but being inflated it appears nearly globular. *The whole surface smooth.* No lateral line. Head nearly one-third total length. Lips thick. Jaws large. The branchial aperture small, just anterior to the base of the pectorals.

Dorsal fin anterior to the anal fin length to breadth as four to one. First ray longest. Pectorals of moderate size. The upper ray longest, then, after decreasing in length to the fifth, they remain equal until the twelfth when they suddenly decrease in size to the fifteenth, which is very short. Anal slender, rounded, second ray longest. Caudal equal.

Colour:—Back and upper part of head of a yellow ground-colour, minutely lined longitudinally with dark brown, thus giving it a yellowish brown hue which is darkest on the dorsal margin. These lines, when examined with a glass, are found to be made up of little dots of pigment arranged side by side and thus giving the appearance of lines. Under parts dull grey, slightly silvery in appearance. Throat yellowish. Margin of the mouth brown. Behind the poctorals there are several brown blotches which extend to the tail.

D. 8, P. 15, A. 8, C. 9.

Total length 10cm. Length from branchial aperture to jaws 4cm.

This seems to answer DeKay's description of *T. turgidus*, except in the total absence of the dermal spines, the presence of which he makes a characteristic of the genus, thus excluding our specimen. But Gunther (page 688) says that "in some of the species the dermal spines are extremely small, and may be absent altogether."

The Globe fishes inflate themselves with air, upon which they turn on their backs and are driven about by the wind and waves. Our fish was in a similar condition when taken on the coast of Nova Scotia.

A Young Siluroid.

A plate in the report of the Fishery Commission for 1885 (Part XIII.), illustrating a paper on the development of osseous fishes, by John A. Ryder, directed attention to a curious specimen in the Museum collection which had been exhibited at the London Fishery Exhibition of 1885. This was a young Catfish, with the yelk-sack still attached, but in a very advanced stage of development.

Description:—Skin smooth and shining. Lateral line distinct, convex under the dorsal and then straight. Body compressed. Head depressed, on the top of which is a curious five-lobed figure, lighter than the surrounding colour, which is probably the cartilaginous bones beneath showing through the semi-transparent skin. There are six discernible barbels, which are arranged as follows: One on the upper side of each angle of the mouth, and four arising at nearly equal intervals under the lower jaw. Anterior to each eye is a minute knob or flap, which may or may not be an undeveloped nasal barbel. The yelk-sack is sub-globular, slightly flattened on its under side, and having its greatest measurement longitudinally. On this the median ventral vessel appears as a raised line, which, as branched vitelline capillaries, arises from underneath, and thence, after passing over the anterior end, bends backwards on its way to the heart.

First dorsal fin sub-quadrate, third ray longest. The spine not serrated. This fin arises just posterior to the pectorals.

Second dorsal or adipose fin long, rounded on its upper margin, its height to its base as one to six.

Pectorals pointed with the posterior margin rounded. The spine being its greatest length.

Ventrals moderately broad and rounded.

Caudal forked with sixteen complete rays. Accessory rays present.

Colour:—The fish proper is flesh-coloured, but lighter on the head. A light ash-coloured spot on each side shows the position of the air-bladder. Pupil white; iris bluish-black.

The yelk-sack is flesh-coloured, but of a darker shade than the fish itself and more pink, the darker shade arising from its contents. A brown tortuous line goes round the sack near its attachment to the fish, and bends downward at the anterior end.

Total length from tip of snout to tip of tail about 4 cm.
Distance between the eyes (inter-orbital space), 7 mm.
Head nearly one-fourth the total length.
Breadth of head behind the eyes, 9 mm.
Length and breadth of yelk-sack, 23 mm.
Height of ditto, 18 mm.
Length of maxillary barbels, 8 mm.
" " chin " 4 mm.

FIN RAYS:—1 D. I. 7., 2 D 0., P. I. 6., V. 6., A. 19 (?), C. 16.

This fish I have not been able to identify, the chief difference being in the great length of the adipose fin compared with its height.

On referring to the eighteen fishes, whose development is treated of by Ryder, we find that the greatest length of time required for the absorption of the yelk is twenty days, which is the case in the *Ictalurus albidus* or White Cat-fish. At this time the caudal is not yet perfectly developed. Our fish appears, in the proportionate size and relation of the fish proper and yelk-sack, to correspond with the above when just hatched (sixth day). Yet on a closer examination the immense difference between their respective stages of development is at once observed. We find that while the *I. albidus* has no determinate fins whatever, but only a median fin-fold, our Cat-fish is perfect in every particular, and exhibits, in its accessory caudal rays and sharply defined adipose fin, evidences of its very advanced development. The latter fin, in regard to the White Cat-fish, is not perfect until about eighty days.

Now this early development is very curious when we compare it with other fishes at an apparent similar age, and is evidently worthy of careful attention.

ART. VI.—THE CARBONIFEROUS OF CAPE BRETON, WITH INTRODUCTORY REMARKS.—PART III.—BY E. GILPIN, JR., F. G. S., F. R. S. C., *Inspector of Mines.*

Read March 12, 1888.

As my paper to-night presents to the Institute little beyond columns of figures which are uninteresting to the general public, although eloquent to the chemist or mining engineer, I gladly avail myself of Mr. McKay's suggestion that it should be prefaced by a few remarks on Cape Breton Coal, of a character somewhat more popular.

I may remark that I have already in previous contributions outlined the various carboniferous districts of Cape Breton, and summarised their more valuable deposits of coal. In the accompanying paper, tabulated analyses of the seams worked at the different collieries, and of the typical seams of the western districts, serve as a ground of comparison with the coal products of other countries.

The popular idea is that a coal mine is a hole in the ground, and a coal field a section of country uninteresting from heaps of coal refuse, and the unpolished manners of its inhabitants. A closer survey, however, shows that the "holes in the ground" exercise the highest engineering and technical skill of those who conduct the operations connected with sinking them, and extracting the coal with the minimum of cost. The manners of the miners, if marked with a certain reserve toward strangers, are those of men whose occupations differ from the callings of ordinary humanity; and among themselves they are friendly and charitable, and ever ready to dare the dangers of the mine if a comrade calls for help. When the figures of the statistician show that the power and wealth of a nation is directly measured by the number of tons of coal it produces and consumes, the subject acquires a general and vivid interest. Coal fields seem to be a special gift of Providence to nations, and curiously enough the English-speaking races have the lion's share of coal fields, and have well availed themselves of their privileges.

The extraction and exportation only of coal however is not a permanent source of wealth. The treasures of the mine resemble more those of the forest, than the treasures of the field and of the sea. Every ton of coal when it leaves the country represents, in most cases it is presumed, a certain amount of profit, but its removal increases the cost of the extraction of the next ton, and like a tree of the forest it cannot be replaced. It must be used locally to smelt the ore, forge the metal, ply the loom, or to build the multifarious machinery demanded to-day, before its true value is seen. One man can dig a ton of coal, but two must toil before it has yielded up its many items of power, or heat, or light. Take the mother country, did she export all her coal, and close the myriad factories supported by it, her position would be vastly different.

The few introductory remarks I am permitted to make should however be directed rather to the geological than the economic side of my paper.

Could the student carry himself backward, beyond the time of Confederation, to the period of the formation of the Cape Breton coal beds, and take his stand on the granitic hills of Cape Dauphin, at the entrance of the Bras d'Or lake, his eyes would wander over a view widely different from that of the present day. Instead of the rolling hills covered with spruce undergrowth, and occasional ridges of hardwood which now stretch eastwardly from Sydney to the shores of the ever-encroaching Atlantic, he would see, mile upon mile, a dead monotonous level, with here and there dull sluggish reaches and swamps of dark peaty waters, while overhead the rays of a sun warmer than that now allotted to us, could scarce dissipate the clouds of vapor it kept drawing from the heated water and steaming soil.

On a nearer approach, this uninteresting country, which we would compare to some of the tidal marshes of the Bay of Fundy, is found to be covered with the densest of vegetation. No modern forest, tropical or temperate, reproduces the curious scene. A closer study, however, would detect some trees bearing a fanciful resemblance to plants now growing in the earth. There was one tree specially beautiful, its towering stem sometimes nearly one hundred feet in height, was fluted like a temple column, and crowned by magnificent fern-like fronds, a mysteriously-developed tree fern. Its roots descending into the marshy ground radiated, divided and sub-divided until they could suck nourishment rapidly for the great tree above with its quick growth and frequent branch-making.

There is also another tree with peculiarities now characteristic of the "club mosses," but its branches were flung wide in the air, and it appeared to the casual observer like a mighty pine.

Yet another curious plant recalls our "mare's tail," but its fluted bamboo-like stems were often forty feet high.

In those pre-historic forests of twenty millions of years ago, there was scarce a temptation for the little children to wander as Babes in the Woods, for nature, rioting in luxuriant growth, did not deign to captivate by the exhibition of the fleeting colors and fragrances which poets have sung and nations admired. In vain would search have been made for any plant now called national: the rose, the thistle, and even the humble emblem of our Province, all were wanting, and perchance only the mosses and fungi relieved the sombre colors of that "Dismal Swamp."

In vain would the hunter, so far as the records of the rocks inform us, have searched for his prey, in the air, or by land, or by sea. Locusts, beetles, scorpions, nondescript frogs or newts, all labored in their task of subduing, consuming and consolidating the great masses of vegetation. However, it must be said that these remarks are based on negative evidence only, the plants and insects from which our imagination has reconstructed so curious a page in the history of mother earth, are few in number, and owe their preservation as fossils to peculiar circumstances. There may have been many other organized helpers in the great scheme on the hills and highlands surrounding the marshes, and imagination may depicture the graces and beauties and the melodious sounds of an untrodden land.

Such were some of the curious forms that were crowded in the battle of life which left victors and vanquished preserved for our sole benefit. The plants grew and fell, and were buried, the water of the swamps allowing but a tardy decomposition, until a deep peaty mass accumulated. The sub-soil, a clay or loam, was filled with rootlets until perhaps no further mineral nourishment of silica or of potash, etc., was available. Long years this swamp, devoid of living vegetation, lay gradually undergoing changes consisting chiefly of elimination of water from the vegetable matter, until some oscillation of level, perchance a change in the current of some bygone river unnamed and unsung deposited on its partly hardened surface a layer of silt or mud. This went on until hundreds of feet of sandstone, shale, coal, fireclay, etc., are now presented. The accumulating mass in the slow course of time became firm. Pressure, the internal heat of the earth, chemical laws of change all combined to make the peaty mass a layer of carbon with a small percentage of ash, and of bituminous forming matter; the sand layers were cemented by silica into hard sandstone, the mud into bituminous or carbonaceous shale; and the ancient soil well robbed of its alkali; and silica became fireclay.

Almost without exception every bed of coal the miner explores has immediately below it a bed of fireclay often filled with carbonized roots. The coal bears in its structure the evidence of its vegetable origin, for under the microscope can be seen in it, fruits, flowers, and particles of wood fibre, etc. Above the coal comes the roof usually of shale or sandstone, often bearing in it at the junction with the coal bed, layers of ferns, pressed and preserved as in a herbarium; or a full length tree of that ancient forest showing in its flattened stem clearly and distinctly its species, etc., and recalling with its darkened color the logs found in our peat swamps.

We have now briefly traced the coal seam to its full growth, but had nature gone on adding the coral, the chalk, and all the varied and immense layers of subsequent formations this precious heritage would have been like an estate in chancery, pleasant to think about, but a thing unattainable, for we could not have sunk shafts some four or five thousand feet to provide our fuel.

The process of nature which has laid these stores of fossil fuel close to the surface in Cape Breton is one as yet little understood by geologists, but it is a subject fascinating from its grandeur, and to its operations do we owe all our mines. There have been elevations and depressions in the earth's surface ever since its creation, caused by internal forces, contraction of its crust, accumulation of sediments, or what not, we see the effect, and bless the hand that guided the cause. In the Sydney district it appears that the old, old rocks, the granites and gniesses of Coxheath, Boisdale and St. Ann's were forced slowly and gradually upwards. This motion enforced a tilting of the strata holding the coal so that they inclined to the eastward. This was continued until the "Atlantic" of that date came in upon the land, and had boundaries approximating those of the present day.

Had the uplifted edges of the older rocks been straight, like a ruler, the coal-bearing strata would have dipped uniformly away from them, and remained parallel throughout the district. But nature abhors a straight line, devoid of beauty save to the mathematician. Owing to underlying spurs of the older strata projecting beneath the coal measures the uplifting of the former produced transverse subordinate tilting in addition to the general or continental inclination to the east. The effect of this has been to throw the seams into a series of curves, having the ocean as a secant. Taking the coal seams of the Sydney district as they are met at Cape Dauphin they are seen ridged up against the Syenite of the Cape, then lessening in the steepness of their dip they range across the Big and Little Bras d'Or to Sydney Harbor, where their inclination is about four degrees. As they cross the harbor they turn more to the north-east, and dip steeply until they turn again with the regular dip and run into the sea at Lingan. Emerging again they stretch in a regular curve for miles across Glace Bay Brook and Basin, and turning again toward the north-east with increasing dips enter the sea at the north head of Cow Bay. Hitherto the transverse subordinate foldings have not been marked enough to interrupt the continuity of the strata enclosing the coal beds, but here the upward movement has brought lower rocks to the surface, and there is an interval of rocks which do not hold coal seams.

In Cow Bay the same forces have formed another basin, called a synclinal, the seams dipping down on the Long Beach side and up again on the Gowrie side. But the axis or general inclination of the trough is still to the eastward.

Finally, the seams of the Cow Bay district, after crossing the narrow strip of land forming the north side of Mira Bay, pass under the Atlantic and are lost beyond the three mile limit.

Speculation as to the original extent of this coal field is profitless, if interesting. But we do know that, reasoning from a fair basis of facts, we have now but a remnant of the great coal field of the Gulf of St. Lawrence. When we consider the fringes of coal fields, and of carboniferous strata which occur around Cape Breton, on the west side of Newfoundland, in the Magdalen Islands, and along the northern shores of Nova Scotia and New Brunswick, we can scarcely realize that over that great Gulf the forests of the Carboniferous once spread, amid the voiceless and sullen lagoons of the mysterious country.

Owing to sudden pressure or other causes, the movements of the coal-bearing strata are sometimes accompanied by breaks or faults. Often great blocks of strata, miles in extent, thousands of feet in depth, and weighing myriads of tons, have been raised out of the continuity of the coal field, so that the miner suddenly finds in front of him a wall of stone. His coal bed has vanished, cut off by the irresistible force of the great lever which is continually raising and depressing continents. Much trouble is often experienced in finding the lost bed of coal, which is sometimes moved many feet away. In the Cape Breton coal field the faults are few and of little moment,—a fact which not only reduces the risk and expense of mining, but encourages the capitalist and engineer in starting new pits. There are few coal fields of which it can be said, as in Cape Breton, that any seam can be located at any point inside the boundaries of the coal district with a margin of error not exceeding a few feet.

The question has often been asked me, " are the seams of the Cow Bay, Sydney, and Glace Bay districts distinct, or are they the same seams interrupted by the sea as the flexures of the strata approach and leave the shore. The answer is that they are the same seams although somewhat changed in character and size as they range over some twenty-five miles of country. The seams are identified by the thickness of the masses of intervening strata, some peculiarity of roof or floor, etc., etc. The Geological Survey have tabulated the seams of the different districts, and as their conclusions do not appear to coincide with the opinions of any of the critics, it may be assumed that they are pretty near the mark. The question, however, is one of geological rather than of economic interest, as the coal seams all vary slightly in their quality at intervals of a few miles.

Coal.

Having outlined the distribution of the Carboniferous of Cape Breton as laid down on the excellent maps of Mr. Fletcher's reports to the Geological Survey, the next task is the consideration of the minerals characterizing it. The principal minerals are coal, gypsum, limestone, and iron ore. As the first named is the most important, I venture to dedicate this paper to its consideration, and propose to describe the remaining minerals, together with those found in the other geological horizons, at a future time. This will prove more convenient for reference, as several of them, notably the iron ores, are common to several ages. In this island coal beds are found most abundantly in the productive measures, but there are important deposits in the millstone grit. There are also beds of coal in measures referable possibly to the upper coal measures, and in the Richmond district coal occurs apparently in conjunction with the marine limestone measures. Examples are not wanting in other countries of valuable deposits of coal in these divisions of the Carboniferous, but so far as our information goes we are not warranted in looking to them as important sources of this mineral in Cape Breton.

I have already alluded to the fact that it is difficult to draw with distinctness the line separating the productive from the millstone grit measures, and will therefore consider the coals without regard to their geological position, a factor little affecting their composition.

Speaking in general terms, the Cape Breton coals are bituminous and coking. Many of the seams yield large volumes of gas of good quality, provided that a reasonable care be exercised in screening and picking. For domestic purposes they have proved acceptable wherever offered, as they kindle readily and leave little ash. For house use public opinion has selected the Sydney mines' main seam as the typical coal of the Eastern district.

These coals have been largely used for marine and railway steam raising, and compare favorably with any foreign competitors. They may be ranked between the best Welsh and the best Newcastle steam coals, judging from analyses and the reports of practical tests on English and French men-of-war. The tests recorded appear to prove the contention that the evaporative power of a coal is in proportion to the total amount of carbon contained in it, and that the greater the gas value the less the amount of water it is capable of evaporating. It is to be regretted that a series of rigid tests of the coals now worked could not be made by an impartial authority, as they would undoubtedly show that with proper handling their evaporative powers are surpassed by few coals now used for marine boilers.

For coke-making these coals are well adapted, as they yield, from practical tests, a fuel excellently suited for iron and copper smelting. The adoption of any cheap form of washing would free the coal from the admixed stone and pyrites, and present a coke superior to that of Durham and Connelsville.

In presenting the following set of analyses of Coals of the eastern district I have followed the tabulation of the Geological Survey, altho' it differs from that of several writers, and have not attempted the correllation of the Gardner, Carrol, and other seams found underlying those at present being worked.

Pursuant to this arrangement the Hub and Crandal seams are grouped together. Next in descending order comes the seam known locally as the Block House, Harbor, Victoria and the Sydney Mines worked by the Block House, Glace Bay, Victoria, and Sydney Colleries. Below this comes the most extensively worked seam of the district known as the McAuley, Phelan, and Lingan and worked by the Gowrie, Ontario, Caledonia, Reserve, Bridgeport and Lingan mines. The next seam to be noticed is that known as the South Head, Ross and Collins. Below this comes the Gardner, Tracey, Carrol and other seams to be again referred to.

The Hub seam is not now worked. Altho' its land area is limited, it has an extensive sub-marine development. It was well adapted for gas making, and yielded 9,500 cubic feet of 15 candle gas per ton. The following analysis will serve to show its character.*

Volatile matter	33.21
Fixed Carbon	63.94
Ash	2.85
	100.00

The following table shows the composition of the second seam:

C.	Block House.	Harbor.	†International.	Victoria.	Sydney.
Moisture	.60	.80	.87	.75	1.26
Vol. Comb. matter, slow coking	29.48	27.85	35.41	26.85	33.84
" " " fast "	31.58	29.40		32.13	35.51
Fixed Carbon, slow coking	65.56	67.05	58.56	68.13	60.78
" " fast "	63.46	65.50		62.85	59.11
Ash	4.35	4.30	5.16	4.27	4.11
Sulphur	2.63	2.32	trace.	....	1,70
Specific gravity	1.29	1.29	....	....	1.31

The coals referred to above are generally laminated with a pitchy lustre, and carry a good deal of mineral charcoal on the deposition planes. The primary planes cut those of deposition at high angles, but the secondary planes are not so regular. The primary planes usually hold films of carbonate of lime and iron, which is less frequently present in the secondary planes.

The gas values vary from 8,200 feet of 8-candle power at the Sydney Mines to 10,000 feet of 16.5-candle power at the Block House workings. The gas values of the seam apparently increasing toward the south, while the northern openings produce, as at the Victoria and Sydney mines, an article better adapted for steam and domestic purposes.

* Analyst unknown.
Unless otherwise specified, the analyses in this paper are by the writer.
†Analyst Professor Chapman.

As few ultimate analyses have been made of Cape Breton coals, the following of the Block House seam made for the Admiralty (analyst unknown) is of interest:

Carbon	82.60
Hydrogen	4.79
Nitrogen	1.20
Oxygen	4.10
Sulphur	2.51
Ash	4.80
	100.00

The following is the result of a trial of the Sydney coal made by the American Government in 1844, and, so far as the writer is aware, it is the only practical test ever made of the evaporative power of any Cape Breton coal:

Moisture	3.13
Volatile combustible matter	23.81
Fixed carbon	67.57
Ash	5.49
Lbs. of steam to one of coal from 212°	7.90
Ash and clinker—per cent	6.00
*Theoretical evaporative power	9.25

The following table shows the composition of the ashes of the above coals:

	Block House.	Harbor.	Victoria.	Sydney. †
Iron peroxide	45.621	63.355	56.543	51.33
Alumina	3.250	8.280	6.456	4.84
Insoluble silicious residue	35.110	21.872	27.500	29.57
Manganese	....	.....	1.930	....
Magnesia	1.100	.....	.035	.23
Lime	5,425	4.640	2 598	3.05
Sulphate of lime	....	.....	.....	10.98
Sulphuric acid	6.750	2.126	3.790	....
Phosphoric acid	1.900	.514	.691	trace.
‡Alkalies	trace.	trace.	.150	trace.
Chlorine	....	trace.	.....	trace.
	99.156	100.787	99.693	100.00

*From Regnault's formula.
†Analyst, H. How.
‡In this and following analyses alkalies are estimated only when in quantity.

The coal of the third seam to be noticed as worked at the Gowrie Colliery is black with a grayish tinge. On fresh surfaces the lustre is bright and pitchy, with very fine laminœ of jet-like coal, and a good deal of mineral charcoal on the deposition planes. This coal sometimes exhibits four cleavage planes, sometimes holding films of calc spar. Coal tolerably compact, with nearly black powder and little visible pyrites. This description answers for it throughout the district, except that at the Reserve and Bridgeport mines it is more pitchy and lustrous.

The following analyses will serve to show the composition of this coal at the Collieries operated on it from Cow Bay to Sydney Harbor:

	Gowrie.	Caledonia.	Reserve.	Lingan.
Moisture	.50	.92	.52	.75
Vol. Comb. Matter, slow Coking.	28.13	28.62	34.21	34.61
" " " fast "	31.41	30.31	37.60	37.26
Fixed Carbon, slow Coking	66.01	64.02	59.73	61.39
" " fast "	62.73	62.33	56.34	58.74
Ash	5.36	6.43	5.54	3.25
Sulphur	2.71	1.10	1.25	1.35
Specific Gravity	1.31	1.33	1.28	1.29

The ashes of this coal vary in color from light to deep red.

The gas values of this seam vary from 8,900 to 9,500 cubic feet of gas, of from 13 to 15 candle power, and a good Coke is left.

The following ultimate analysis of the coal from the Reserve mine, made at the Royal School of mines, will prove of interest:

Carbon	77.41
Hydrogen	5.47
Nitrogen. } Oxygen. }	9.30
Sulphur	2.47
Water	1.00
Ash	4.35

The following analysis of the coke from this mine is from a report of Mr. E. D. Peters, on practical tests made by him in experimental smeltings of Coxheath copper ore, and it may be remarked that a better article would be produced if the manufacture were conducted on a large and systematic scale :

Moisture	1.03
Carbon	90.04
Sulphur	.70
Phosphoric Acid	trace
Ash	8.01

The ash of this seam presents the following composition :—

	Caledonia Mine.	Reserve Mine.	Lingan* Mine. Top.	Lingan* Mine. Middle.	Lingan* Mine. Bottom.	Lingan Average.
Iron Peroxide	11.853	21.810	35.66	1.57	27.75	21.66
Alumina	4.200	8.110	9.07	6.08	4.91	6.69
Silica	65.734	68.330	43.07	79.06	48.62	57.05
Lime	7.151	.915	6.13	8.84	11.83	8.93
Manganese	.950	....	....	....	....	....
Sulphuric Acid	4.283	.480	5.73	3.08	6.52	5.11
Alkalies	2.150	....	....	....	....	....
Magnesia	1.260	....	.34	.97	.37	.56
Phosphoric Acid	2.725	trace	....	....	....	....
Chlorine	trace	....	....	....	....	....
	100.306	99.645	100.00	100.00	100.00	100.00

The following is the composition of the lowest of the seams worked to any extent. The coal is usually compact and lustrous, with fine laminœ. Some specimens show mineral charcoal, while others are free from it.

S.	South Head.	Emery.	†Collins.
Moisture	1.767	65	
Vol. Comb. matter, slow coking	28.000	32.21	36.75
" " " fast "	28.833	34.80	
Fixed Carbon, slow coking	62.263	63.49	57.10
" " fast "	61.430	60.90	
Ash	7.970	3.65	6.06
Sulphur	2.641	2.41	....
Specific gravity	1.382	1.28	1.27

The ash of this seam, as worked at the Emery Colliery, has the following composition :—

* Analyst: H. How.
† Analyst Professor Chapman.

Iron peroxide	38.764
Alumina	1.336
Silicious residue........	50.673
Lime	4.200
Manganese	trace.
Magnesia..............	1.015
Sulphuric acid	4.030
Phosphoric acid	.012
Chlorine	decided trace.
Alkalies	do.
	100.030

During the examination of the ash of this coal numerous small rounded quartz pebbles the size of a pea were noticed.

The following analysis shows the ultimate composition of the seam as worked at the Schooner Pond Colliery (analyst unknown.)

Carbon..............................	78.10
Hydrogen	5.48
Oxygen and nitrogen..................	7.81
Sulphur.............................	2.49
Water	2.67
Ash.................................	3.45
	100.00

The coals from this seam are claimed to be good for steam raising, and to give off less smoke than the overlying coals.

The following analysis will serve to show the character of the best known seams opened below those referred to above:

Traccy seam, of Mira Bay, (analy. Geo. Survey.)

Moisture	22.35
Volatile combustible matter...............	30.09
Fixed carbon............................	66.61
Ash	.98
	99.915

Mullins' seam, south side Sydney Harbor:

	ft.	in.
Coal	2	0
Shale	0	4
Coal	4	0
	6	4

Volatile matter	31.4
Fixed carbon	62.4
Ash	6.2

This analysis was made some years ago by Dr. Dawson, and he remarks: "This coal has some of the properties of cannel. It has great heating power and yields much dense carbonaceous gas."

In the Glace Bay section, a few feet below the Hub seam, is a bed of cannel coal one foot two inches thick lying on nine inches of ordinary bituminous coal. The following analysis was made by Dr. How:

Moisture	.83
Volatile combustible matter	30.07
Fixed carbon	44.42
Ash	24.68
	100.00

BROAD COVE DISTRICT.

In the Geological Survey Report for the year 1874, there is a description of the Broad Cove coal field, and a set of analyses made by Mr. Hoffman of the survey, which are given here with his remarks, in a condensed form:

	7 ft. Seam.	5 ft. Seam.	4 ft. Seam.
Moisture	4.02	7.78	8.45
Vol. Comb. Matter, slow Coking	20.17	27.67	28.36
" " " fast "	25.39	34.51	36.52
Fixed Carbon, slow Coking	70.41	52.87	56.94
" " fast "	65.18	46.03	48.78
Ash	5.40	11.68	6.25

These coals do not soil the fingers. They are black, with pitchy lustre, banded, with uneven fracture. The powder of the five and of the four feet seams when boiled in caustic soda imparts a brown color to the liquid, this with the percentage of water would make them approach in character to brown coal, although they occur in strata of Carboniferous age. The coal from the largest seam does not color a solution of caustic soda and is more closely allied with the typical carboniferous coals. Zinc blende was observed as a film in this coal. These coals are said to produce little smoke when burned in marine boilers.

PORT HOOD DISTRICT.

As yet but little mining has been done here, and the qualities of the coals have not been settled by practical experience. The Geological Survey Report, 1876-77, page 469, gives a report on the coal of the lower or 7 feet seam. It appears to resemble in its general characteristics the Broad Cove coal, and yielded on analysis :—

	Fast Coking.	Slow Coking.
Moisture	4.02	4.02
Volatile combustible matter	38.81	34.86
Fixed carbon	49.65	53.60
Ash (purplish red)	7.52	7.52

The coal is said to contain rather above the percentage of sulphur usually found in Cape Breton coals.

I have no analysis of the Chimney Corner coals. They are not as bright as many of the eastern coals, but are good steam coals.

Reference has been already made to the area of millstone grit extending from Sydney up the valleys of the Mira and Salmon Rivers. These measures show several outcrops of coal beds apparently underlying large tracts of country. The beds are known only by natural outcrops, and no attempt has been made to ascertain if other beds are present. They do not exceed two feet in thickness, and, as the route of the Cape Breton railway will not follow these rivers as was expected at one time, they will probably not receive any attention for many years to come. The following analysis is from the Canadian Geological Survey :

Moisture	1.53
Volatile combustible matter	20.16
Fixed carbon	47.49
Ash	30.82
	100.00

At other points the coal is reported by Mr. Fletcher as yielding an inconsiderable amount of ash. Another outcrop of coal in this district is interesting, as it presents in the Lower Carboniferous conglomerate the evidences of an origin identical with that of the more important seams of the productive measures. It yielded:

Volatile combustible matter	17.80
Fixed carbon	29.04
Ash	53.16

About eight miles from Baddeck, at Hunter's Mountain, is an outcrop of coal similar in composition and mode of occurrence to that just mentioned. The coal is irregular, varying in thickness from a few inches to two feet. It is divided by numerous cleavage planes, sometimes coated with galena.

At East Bay, in the marine limestones and marls, pockets occur holding calc and fluor spar and patches of bright cubical coal yielding on analysis:

Volatile matter	36.72
Fixed carbon	46.64
Ash	16.64
	100.00

For comparison with the seams of coal of economic value the following analysis of coal from a fossil carbonized tree in millstone grit measures in the same district may prove interesting:

Volatile matter	34.9
Fixed carbon	59.9
Ash	5.2
	100.0

Coke firm and vesicular.

Some years ago a good deal of interest was aroused by a statement that active work was being performed on a seam of anthracite coal at McAdam's Lake, near the head of East Bay. The bed occurred in red and gray shales and conglomerates of the lowest division of the Carboniferous. It, however, proved to be little more than a coaly shale, lustrous and resembling the poorer anthracite coals of the United States. On analysis it yielded—

Volatile Matter	17.80
Fixed Carbon	29.04
Ash	53.16
	100.00

Notwithstanding the large amount of ash the coal yielded a firm and porous coke.

Irregular pockets and beds, or rather seams, of hard compact coal are frequently found in the carboniferous of this Province. The mineral frequently breaks irregularly, does not soil the fingers, and resembles anthracite. On a closer examination however these coals are found to be either highly carbonaceous shales, or compact semi-anthracite coal, its more volatile ingredients being lowered in amount by the hardening, etc., the containing strata have undergone. Considerable sums of money have been spent in testing and prospecting these deposits, but so far the results have not been at all satisfactory.

RIVER INHABITANTS COAL DISTRICT.

I am not aware of any recent analysis of the coals of this district. Little systematic mining has been carried on for a number of years, and the writer is obliged, like Mr. Fletcher, to refer to the report made a number of years ago by Dr. Dawson to the Government of Nova Scotia. He gives the following analysis of the Little River four feet seam:—

Volatile matter	30.25
Fixed carbon	56.40
Ash	13.35
	100.00

and remarks that it is more bituminous than the Sydney or

Pictou coals, and should prove practically a good domestic and gas coal.

He also gives the following analysis of the eleven-feet seam found at Sea Coal Bay :—

Volatile matter	25.2
Fixed carbon	44.7
Ash	30.1
	100.0

The amount of ash given in this analysis would make the coal of little use for ordinary purposes. I am informed, however, by parties interested, that it by no means yields this large percentage of ash, and that the other seams are apparently of excellent quality. These beds are very well situated, as the harbor remains open all winter, and they will no doubt be re-opened whenever the conditions of the coal trade hold out more promising inducements to the miner. I have no analysis of the coal found at the head waters of the Inhabitants river.

From the analysis I have given it will be seen that the island of Cape Breton furnishes Coals adapted for every purpose. They are largely used for steam raising in locomotive and marine boilers, and as their qualities become better known they will be a favorite railway fuel. For gas making and domestic purposes they have established a good reputation. In connection with the various schemes mooted for iron and copper smelting in Cape Breton it is encouraging to note that practical tests have shown that an excellent coke can be made from them. At present the low price obtainable for coal, and the presence of large mines in the eastern district, will operate against developments in other parts of the Island. But it is to be hoped that the discovery of metallic deposits in the districts surrounding the western and southern coal beds may lead to the erection of works drawing their fuel from local sources, and the projected railway from the line of the Sydney and Hawkesbury Railway to Broad Cove will give this part of the island an outlet to good shipping ports.

Art. VII.—Remarks on the Japanese Magic Mirror in the Provincial Museum.—By Harry Piers.

Read May 14th. 1888.

Our mirror is circular, measuring 23 cm. (9.05 ins.) in diameter. The face is slightly convex, the centre being 2.5 mm. (0.1 in.) higher than the rim, which latter is nearly 4 mm. deep. When struck the metal gives out a clear note, corresponding to middle C sharp. Distant images appear decreased in size and slightly distorted, although this distortion is least observable when the mirror is held close to the eye. The back is ornamented in relief by characteristic Japanese inscriptions, and designs representing foaming waves and birds conventionally treated.

Having made a full-sized drawing of the figures on the back of the mirror, and having marked the face with two non-reflecting spots to correspond with two other spots on the drawing, I proceeded to reflect the sun's rays from the polished surface on to the drawing, which served for the purpose of a screen. The spots being made to coincide, I at once observed that one of the largest and most prominent designs on the paper was illumined more highly than the surrounding portion, and this difference was so decided and it corresponded so exactly with the drawing, that it left no doubt but that our mirror possessed the curious properties said to belong to it, and which have been referred to by Mr. F. E. Ives in a late number of the Journal of the Franklin Institute.

Although this part appeared so decided and sharp, yet there were other portions which should have been clearly reflected on the drawing which were either entirely wanting or so obscured and confused as to be, to all purposes, absent. On pressure being applied to the face the images dissolved, the illumined disc became smaller and finally appeared to correspond with the reflection of a common plane mirror.

The same results were obtained by lamp-light but in this case the screen had to be placed much nearer the mirror in order to obtain a distinct image.

I have heard an explanation given for this phenomena which appears to be very rational. It is said that the face of the mirror, previous to being polished, is scraped by an instrument which quickly reduces the rigid portions caused by the raised designs on the back, while the thinner and more elastic portions give under the tool and thus retain their convexity.

ART. VIII.—OUR MUSEUM METEORITES, *et caetera.*—BY REV. D. HONEYMAN, D. C. L., F. R. S. C., F. S. SC., *Hon. Mem. Geologists' Association London, &c.*

Read May 14, 1888.

Of these mysterious and interesting bodies, we have examples: I. Victorian. II. Bolivian.

At the Great London Exhibition 1862, in front of the Department of Victoria, Australia, a great mass of meteoric iron lay. I passed it almost daily during seven months. It became very familiar. It was found at Ballarat. The authorities of the British Museum purchased it.

On a counter in the same department lay another small one with a pair of horse shoes made from a part of it. This was exhibited by Sir Henry Barklay, the Governor. We have two pieces of its crust.

These meteorites come into Daubrée's 1st division, 2nd subdivision of 1866.

Towards the close of the Exhibition, Prof. Sheppard, of New Haven, Conn., U. S. A., came to London with a collection of meteorites. I examined these at Prof. Tennant's, Strand, W. C. The latter purchased one; giving for it an equal weight of silver coin.

At L' Exposition Universelle de Paris, 1867, I became acquainted with M. Daubrée, and his work on meteorites. I also found an account of his experiments and results in "Bulletin de La Société Geologique de France 1866." On my way home I visited the British Museum, where Prof. Maskeleyne showed me a very large meteorite which was falling in pieces, although every effort was made to arrest decomposition. This seems to be an American meteorite.

At the Centennial Exhibition, Philadelphia, 1876, I had another opportunity of seeing other meteorites. In the Canadian Mineral department, in front of my office, was placed the Madoc meteorite. It is thus described in "Geology of Canada 1863." "It was found in 1854 upon the surface of a field and weighed 370 lbs. Its shape is rudely rectangular and flattened on one side. The surface is irregularly pitted, as is generally the case with meteoric masses, and coated with a film of oxide of iron. This iron is malleable and highly crystalline in texture, and when etched by an acid exhibits beautifully the peculiar markings which are known as the Widmanstættian figures. Its analysis shows it to be an alloy of iron with 6.35 per cent of nickel. Small portions of the phosphuret of nickel and iron are disseminated through the iron and in making a section of it rounded masses of magnetic iron pyrites are met with."

In the United States Government building were the Smithsonian collections. Here was a fine display of meteorites. A ring-shaped one was the most remarkable, and not readily to be forgotten. This is called the Tucson meteorite. The greatest diameter is 49 inches. Its weight is 14 cwt.

Our second Museum specimen differs from all these, as far as I can remember. It is from Atacama, Bolivia, South America. The late H. B. Bland, Esq., Hill-fields, Berks, kindly presented it. It is a fine specimen; its size is 3 x 2½ x 1½ inches; its weight 1 lb. 580 grs. It belongs to the 2nd sub-division of Daubreé, 1st division of which the Pallas meteorite is the type.

Mr. Kuntz, of New York, has kindly given me a series of beautifully illustrated and instructive memoirs on meteorites.

In *one*, "On two new meteorites from Carroll County, Kentucky, and Catorze, Mexico," we read: "The mass is largely made up of fine yellow transparent olivine, resembling closely that of the famous Pallas iron. This meteorite belongs to the Siderolites or Syssidiéres of Daubreé."

This is compared with the meteorites of Atacama, such as our Museum specimen.

"Their specific gravity is 4.33.

"Taking the specific gravity of iron as 7.6, and that of olivine as 3.3, these meteorities consist of about three parts of olivine and one part of iron."

Olivine and iron are the obvious constituents of our own specimen.

Analysis of these meteorites:

Olivine sp. gr. 3.3

Si O	36.92
Fe O	17.21
$Mn_2 O_3$	1.89
Mg O	43 90

Schmid-Pogg Ann 87.501

IRON.

Fe	88.01
Ni	10.25
P	0.33
Na	0.21
K	0.15

Buchner Die Meteoriten Giessen, 1859.

Mr. Kuntz, in another memoir, "On the meteorites of Glorietta Mountain, Santa Fe Co., New Mexico," observes: "This iron is of the 'Holosiderites' of Daubreé, and comes under the general group of 'Caillite' of Stanislaus Meunier (type meteorite of Caille, Var). It is related to the iron of Augusta County, Virginia; Whitfield, Georgia, and Washington County, Wisconsin. It is of characteristic octohedral structure, and the Widmanstættian figures are made of *kamacite*, i. e., iron with a little nickel enveloped in *taenite*, i. e, iron rich in nickel and plessite. Olivine was observed at the upper end of fragment No. 1. The meteorite had been broken into seven fragments." A plate of this from an electrotype of the etched surface shows the characteristic Widmanstættian figures in great beauty.

In *another*: "On the Waldron Ridge, Tennessee, Meteorite," he observes: "This iron is of the Caillite group of Meunier. *Schreibersite* is a constituent, also *Troilite*, as well as *graphite*, clearly suggesting that the iron is identical with that of the Greenbrier County mass in the British Museum." This has already been referred to.

In *another:* "On Chatooga County, Georgia, Meteorite," he observes: "This, too, is of the 'Caillite group' of Meunier. Part of it was worked into a horse shoe, nails and other forms, by the local blacksmith."

Yet *another:* "On Taney County Meteorite, Mo:" "This is one of the 'Syssidieres' of Daubreé. Two large crystals of olivine are present."

Before proceeding farther, I would observe that the announcement of Professor Macgregor's lecture, delivered before our Institute at the March meeting, "On Lockyer's Spectroscopic investigation of Meteorites," directed special attention to "Our Museum Meteorites." I had intended to show them as illustrations, but was prevented by indisposition. Subsequently, Mr. Kuntz's Memoirs, in their allusion to the Atacama Meteorites, led me to examine my specimens with new interest. Their frequent allusion to Daubreé reminded me of the Bulletin de la Société Geologique de France and Daubreé's 'Communications.' Referring to this Journal I found, in that of 1866, page 391, one of which this is the title (translated), "Synthetic experiments relative to Meteorites. High-probabilities *(rapprochements)*, to which these experiments lead, as well for the formation of these planetary bodies as for that of the terrestrial globe: By Daubreé." As far as I can learn from the report of Prof. Macgregor's lecture, Daubreé's investigations seem to be *very much akin* to those of Mr. Lockyer. I consider, therefore, that I am doing some service in submitting to the Institute a translation of the salient points of Daubreé's paper, with an occasional illustration from our local investigations.

Daubreé observes: "Already, for a long time, we could not doubt that among the matters that fall from the atmosphere on the surface of our globe, they (the Meteorites) are in origin incontestably foreign to the planet which we inhabit. Their fall is recognized by the considerable production of light and of noise which accompanies it, by the trajectory almost horizontal which they describe, and by the excessive speed with which they are animated,—a velocity which has not its analogue on earth, and which we can only compare with that of the planets gravitating.

in their orbits. Whatever may be the region whence these masses proceed, they constitute the only tangible products which reach us of celestial bodies. Anyone can comprehend the interest that their study presents, not only for Astronomy, but also for Geology, who thus sees the horizons of these to be enlarged, and who draws a comparison between these bodies from a distance with our globe of 'useful information' *(d'utiles renseignements)* on the mode of the formation of the latter and of our planetary system, as I shall try to demonstrate.

It seems to me that the time has arrived for confirming by synthetic experiments the numerous notions, that analysis has furnished, on the constitution of meteorites.

Permit me to hope that experimental synthesis will not render less service in this study than in that of the earth's rocks and minerals.

Before entering on this subject I would state very briefly—

That the various Meteorites known arrange themselves into two grand divisions: the irons *(fers)* and the stones *(pierres)* The Irons:

I. Of the *first* we have established *three* divisions.

1. Iron with a mixture of stony matter (Meteorite of Caille, Var.)

2. Iron containing globules of *peridote* (Fer de Pallas.)

3. Iron associated with the Silicates *peridote* (olivine) and *pyroxene* (augite), (Sierra de Chaco.)

The last establishes a connection between the *two grand divisions* established, between the extremes—in appearance so different.

II. The *stones*, for the most part, do not contain native iron except in small grains, and disseminated in the Silicates principally with a base of magnesia and of protoxide of iron, of which the peridote forms in general a great part. It is this group that we designate here, by reason of its extreme frequence, under the name of the "common type."

The other stony Meteorites which do not contain native iron can be referred to three principal groups:—

1st. In the one, the magnesian silicates predominate. On the one hand, peridot may constitute almost the whole mass (Chassigny); on the other, a silicate less basic may predominate (Bischopville.)

2nd. Another group without peridot, poor in magnesia, containing alumina in notable quantity, is characterized by a granular anorthite and pyroxene, and by its analogy with certain lavas (Jovinas, Jonzac, Stannern.)

3. The last type is characterized in a very remarkable manner by the presence of carbonaceous matter (Alais, Orgueil).

I. Synthetic experiments relative to meteorites.

The Widmanstættian Figures.

"The most characteristic physical feature of the meteoric iron is the crystaline structure which appears on a surface that has been polished and then treated with an acid," e. g., the Madoc meteorite of Canada and the Glorietta mountain meteorite.

"The regular design which then appears has been named after the *Savant* who first recognized them. Since then the structure has been the subject of profound observation by Haidinger, Reichenbach and Gustave Rose.

The figures are produced not only by crystallization but also by the homogeneity of the mass and by the separation mode of a substance not so easily acted on by acids as iron. The substance so disseminated in the middle of the iron is considered to be the phosphuret of iron and nickel, with the first predominating.

Up to the present we have not been able to imitate this remarkable structure.

In trying to reproduce it I have melted the meteoric iron of Caille, Var., &c.

The chemical analyses have been made by M. Stanislaus Meunier attaché to the Geological Laboratory of the museum of the Ecole des Mines, to whom I have the pleasurse of rendering justice for the care which he has brought to their execution.

Peridot or Olivine.

"Stromeyer has marked a singular contrast that the composition of this mineral presents. The terrestrial almost all contain a little nickel but the peridots of the meteoric iron like that of Siberia and Atacama do not contain it, although they are enveloped in one mass of iron, where the nickel enters in the proportion of 6 to 10 per cent.

Note.—I have frequently directed the attention of the Institute to the terrestrial olivines. 1st. In my Polariscopic investigations (Trans., vol. vi., pp. 122–3) I noticed—for the first time—olivine, in a section of our Blomidon basalt (dolerite). I also showed it abounding in pieces of a large basaltic boulder. This was examined macroscopically, and also microscopically in a section similar to that of Blomidon, prepared for me by A. Julien, N. Y. 2nd. Subsequently it has been referred to frequently in my Papers " On Glacial Geology " (Trans.) as occurring in similar boulders on the Bedford Basin and in the Halifax Peninsula, such as on the Citadel Hill and other strategic glacial accumulations, noticed in my Paper " On the Glacial Period on the East Coast of Canada," read before the Victoria Institute, London, April 8th. In some of these boulders the green of the olivine appears very abundant and distinct on the weathered outside, which is generally red in consequence of the decomposition of the abounding *magnetite,* associated with the *augite* (pyroxene) and *labradorite.*

TEMPERATURE.

" The operations of which I am going to render an account have been made with a temperature near the melting point of platina." *Vide Comm.*

II. Conclusions relative to the mode of formation of the planetary bodies, whence the meteorites proceed.

It is necessary, first of all, to remark that we do not here seek the cause which brings the meteorites to our globe. It is our object to illustrate their mode of formation as far as the difficulty of the subject permits.

The meteorites reach us on the surface of the earth with a form, in general, that of polyhedrons with the angles blunted. They appear only to be pieces detached from masses of greater or less size, which after entering our atmosphere retreated, when a sort of *ricochet* was possible. *Note.*—The fall of May 14th, 1864, of Argeuil. Tarn et Garonne appears to furnish an example of this sort of trajectory as I have shown. *Compt. rend.* Sceance du May, 1864, vol. lviii., p. 177.

"These wandering masses could themselves be only fragments of planetary bodies, shattered at epochs undetermined and perhaps extremely remote.

Be it as it may with the preceding suppositions, it appears certain that these masses, when circulating in space, do not at all possess an elevated temperature. By their entering into our atmosphere they acquire a sudden incandescence, which, without doubt, makes them break in pieces, but which, in wholly vitrifying their surface, does not at all modify the interior of the pieces. This, then, represents the state of the mass such as it was in space and up to a certain point, and consequently the state of the planetary bodies, of which these fragments are specimens.

To study these specimens in a profound manner, is, then, to prepare certain landmarks *(jalons)*, so full of interest, of the history of these planetary bodies.

III. Conclusions relative to the mode of formation of the terrestrial globe. The terrestrial rocks which are analogous to the meteorites, are eruptive masses of a basic nature, e. g., basalts, which have come from depths *inferior* to the granites.

Importance of the magnesian rocks of the "peridot type" as well, in the terrestrial globe as in our planetary system.

Among the basic silicates, there is one which presents itself with a remarkable constancy in almost all the variety of meteorites from *lefers* to *lepierres* properly so called, i. e., peridot. It is seldom alone (Chassigny); ordinarily it is mixed with silicates, more acid often in parts undiscernible." *Note.*—In more than 150 falls represented in the collections examined we have only four which belong to the "aluminous type" as Jovinas, Jonzac, Stannern and Petersburg, U. S., the others are magnesian meteorites, which almost all include peridot."

On the other hand, the peridot necessarily exists in the depths of our globe. Indeed, the basalts of countries the most distant carry fragments (?) of it, often angular, and, as one would say, derived from a mass profound and pre-existent: *e. g.*, Nova Scotian Basalts already referred to.

"There are other pyroxenic rocks where peridot abounds, *e. g.*, in the dolerites of Montarville and Montreal, Canada. M. Hochstetter has recently recognized it in considerable mass and called it "*Dunite*." NOTE.—We would add the Peridotic rocks in the diamond mines of South Africa.

"Transformation of Serpentine or Lherzolyte, or, in Peridot, theoretic consequences. *Vide Comm.*"

Note.—Subsequent to this, in 1869, I examined what I now call the Archæan series of rocks at Arisaig, N. S. These had *previously* been regarded as igneous rocks of uncertain (Devonian) age. While engaged in the geological survey under the direction of Sir W. E. Logan, I found they were altogether different from what we had supposed them to be. I recognized in them rocks corresponding with the Laurentian rocks as represented in the beautiful series of specimens exhibited by the geological survey in the Canadian Department of the late Paris Exhibition (1867). At Arisaig I found crystalline limestones, Ophites, Ophicalcites, Hornblendic rocks, Diorites, Syenites, &c. Sir W. E. Logan considered that my specimens corresponded with his Quebec series. Dr. T. S. Hunt agreed with me in regarding them as Laurentian. Dana, in his Manual, 2nd edition, applied the term Archæan to this series

In 1878 I adopted this term, and have invariably applied it since then to this typical series and corresponding rocks. Trans. Ins.

Application of what proceeds to the mode of formation of our globe. Origin of peridot as a "scorie universelle," like a *metallurgic*, not volcanic scoria.

Absence in the meteorites of stratified rocks and granite.

The meteorites so analagous to certain rocks of ours differ considerably from the greater part of those which form the earth's crust.

The most important difference consists, in that we do not find in the meteorites anything that resembles the constituent material of stratified rocks—*e. g.*, neither arenaceous rocks nor fossiliferous rocks; that is to say, nothing which recalls the action of an ocean on these bodies, no more than the presence of life.

A grand difference reveals itself even when we compare the meteorites with the terrestrial rocks *not* stratified. We never find in the meteorites either granites or gneiss, or any of the rocks of the same family (the Archæan), which form with these the general bed upon which the stratified rocks repose. We do not even see any of the constituent minerals of the granitic rocks—orthoclose, mica or quartz—no more than the tourmaline and the other silicates which are accidental to those rocks.

So the silicate rocks which form the envelope of our globe are wanting among the meteorites. It is only to the profound regions that we must go to find the analogues of the latter—that is to say, in the basic silicate rocks which do not reach us except by eruptions, which make them come forth from their initial abode.

This contrast shows how just and profound is the division of the Silicate rocks into *acid* and *basic*, which M. Elie de Beaumont has established in his memorable work "On the emanations, volcanic and metalliferous."

At all events the absence in the meteorites of all the series of rocks which form a thickness so important of the terrestrial globe, whatever may be the cause, is a thing altogether remarkable.

This absence can be explained in different ways. It may be that the meteoric fragments which reach us only come from the interior part of the planetary bodies, which may be constituted like our globe. It may be that these planetary bodies themselves fail in Silicate rocks, quartziferous or acid, as well as in the stratified rocks.

In this latter case, which is the more probable, they would have followed evolutions less complete than the planet which we inhabit, and it would be to the co-operation of the ocean that the earth would be indebted for the origin of her *granitic* rocks (Archæan) as she is indebted later for the *stratified* rocks.

One can conclude from the preceding that the oxygen so essential to organic nature would also play an important role in the formation of the planetary bodies.

We add, that without it we cannot at all conceive of an ocean or of those grand functions, superficial and profound, of which water is the cause.

We arrive, so as to touch the foundation of the History of our Globe, and to draw closer the bonds of relationship (already revealed by the similitude of composition) between the parts of our planetary system, of which it is given us to know the nature.

We present this as a very interesting article by a recognized authority on meteorites. It is to be borne in mind, that it is over 20 years since it was written. It is therefore possible that in some respects it may be subject to modification. From Mr. Kuntz's memoirs we observe changes in nomenclature, e. g. In that on the Glorietta mountain meteorites, we have the meteorites of Division 1 and 1st sub-division characterized as the Holosiderites of Daubreé and the "Caillites of Meunier." Our first museum specimen is of this kind. The Atacama meteorites are also characterized as the "Syssidieres of Daubreé." Our second museum specimen is of this class.

Our latest information regarding his operations is derived from Bulletin de la Société Géologique de France, July 1871.

M. de Chancourtois communicates a letter which he had addressed to M. Elie de Beaumont concerning the bombardment. In this he says: "The second *obus* fell on the night of the 12th, at 9 p. m. It penetrated into the room of M. Daubreé, Professor of Mineralogy, traversing the thick stone wall at the side of the window and settling itself, without bursting, on end, like a bottle, right under the table of the Professor, about 2½ metres from the opening of the wall. We have long known that the aërolites are chiefly formed of iron, other metals have been recognized, also sulphur and carbon, &c. Their composition has therefore much analogy with that of the *obus* (small bomb shell). Is it not then striking to see one of these artificial missiles (bolides) coming right to the seat of the eminent mineralogist, who in these times has made a specialty of the study of natural *bolides*."

ART. IX.—NOVA SCOTIAN SUPERFICIAL GEOLOGY, WITH MAP, SYSTEMATIZED AND ILLUSTRATED.—BY THE REV. D. HONEYMAN, D. C. L., F. R. S. C., F. S. SC., &c. *Curator of the Provincial Museum.*

Read May 14, 1888.

When mapping the geology of the Province I was led to make a separate map, to indicate its superficial geology. In doing this I had to classify the phenomena under the divisions (1) glacial, (2) champlain, (3) recent, and (4) pre-glacial, probable. It was found impossible, however, to define these in the same manner as the underlying geological formations, as there is an obvious blending of the several periods, so as to render it impossible to ascertain where the one concluded and the other commenced. Sometimes even the existence of one or other is only a legitimate inference arising from the "nature of things."

1.—*Glacial.*

This I have sub-divided into topographic—central, eastern, western. As the first has its chief development in the city of Halifax and its harbor it may, with the greatest propriety, be designated the Halifax division. *Vide* map. Its glacial character is here chiefly illustrated by striking and extensive glaciation.

It is now requisite to take into account certain great features of the *older geology*. We accordingly define on our map—1st, the archæan formation of the Cobequid Mountains; 2nd, the triassic igneous rocks of the Minas Basin, Blomidon, North Mountain, and onward to Briar Island, &c. We also define the granites of east and west divisions of Halifax County, and also of the South Mountain of Kings and Annapolis Counties. These will be found to give character to the glacial geology, and also to, still further, sub-divide the formation. They will also tend to divide the glacial from the succeeding champlain, if not the recent.

In our illustrative process I would use the initial capitals. A for the Cobequid archæan, T for the Blomidon, &c., igneous rocks, and G for the granites of Halifax, Kings and Annapolis Counties. Also, the small letters a, t, g, respectively, for boulders derived from these rocks.

The notable peculiarity of the central division is the prevalence of "Amygdaloid Boulders" with amygdules of zeolite minerals. It was the discovery of these in 1874, their identification with the triassic rocks of Blomidon and the establishing of a connection between these and this their parental source, by means of the Halifax glaciation course, that led to the investigations in superficial geology, of which we now give the leading results. Associated with these amygdaloids and still more prevalent are found gneisses and cognate boulders from the archæan rocks of the Cobequid Mountain. We are thus led to indicate this formation in our map by a colour (red) corresponding with the characteristic colour of the deposit and the letters, t, a, (triassic, archæan). A line having a course S. 20 E., N. 20 W., magnetic or hypothetic extension of one of the prevailing glaciation lines, pervades the colour, connecting the deposits of the formation.

We would now define the Central Division on the map.

Regarding the Cobequid Mountains on the North and the Atlantic Coast on the South as two lines, we draw another (meridian line) through Blomidon connecting the other two. From Three Fathom Harbor, the S. E. extremity of the central formation, we draw another meridian extending to the Cobequids. We have thus an area of which the glacial course is a sort of diagonal, comprehending the Central Division.

On the East of this, we draw a meridian-line from Clam Bay, on the Atlantic, long. 63° to the Cobequids. This area comprehends the Eastern Division.

On the west of the Central Division we also draw a meridian line from the Atlantic, near long. 63° 65° to North Mountain. This area comprehends the Western Division.

The Central Division is farther sub-divided. One grand granitic area occupies the south west side, and another intrudes into the eastern side. While we regard these rocks as Archæan, we characterize them by the capital letter G. These two have been subjected to glacial transportation, and hence we have to use the small letter (g) in our Central Division Transportation.

The t. a., accumulations form a grand striking and important part of our superficial geology. On the Halifax coast they extend along the Terminal moraine. from Osborne Head to Thrum Cap. In the Harbour they constitute a large if not the greater part of Cornwallis or McNab's Island and George's Island. On the Dartmouth side of the Harbour, they enter largely into the constitution of the elevated grounds on which are the Mount Hope Asylum. The great deposits of the city, whose names are strategic, Fort Massey, Citadel Hill, Camp Hill, Fort Needham, &c., and aspect picturesque, have all been proved to be *t. a.* in character. These include the Cemeteries, Fort Massey and Camp Hill. Thence onward to the vicinity of Blomidon similar deposits are found overlying the hard rocks and soft, as at the Cow Bay farm, at the Terminal moraine.

From Cow Bay to "Three Fathom Harbour," we have granites of frequent occurrence, characterizing the part of the Terminal moraine (t. a. g.)

On the Western side of the Harbour the transported granites, (g.) are often *roches perches*, perched rocks. The most remarkable of these is the great "Rocking Stone" of Spryfield. The "Eastern Division" is sub-divided into two parts by the granitic band which we have found intruding into the Central and contributing its quota (g.) to the "Terminal moraine." This extends eastward to the eastern side of the Division and beyond. Its width is about 6 miles. North of this and onward to the Cobiquids we find boulders from the latter (a) scattered broadcast. The vermilion wash of this area is consequently dotted with (a.). Amygdaloid boulders are also to be met with, associated with the archæan. These are different from the Triassic amygdaloids being from older igneous rocks that are found in the Cobequids associated with the metamorphic Archæan, and are not therefore regarded as characteristic. Of these the amygdules are calcite or quartz, and are thus easily distinguished from those of Blomidon.

This Archæan (a) transportation seems to have been intercepted by the granitic band and superseded. The granites (g) are now transported toward the Atlantic. The (a) boulders have, however, evidently passed along the course of the Musquodoboit River and reached the shore, where I found them mixed with the granite (g) boulders. Glaciation was also observed at no great distance on an exposed surface of Lower Cambrian Argillites.

In like manner at Clam Bay and Ship Harbour Lake where there is also extensive glaciation, (a) are associated with (g). On the Bay we have a part of the Terminal moraine (a g) exposed to the storms of the Atlantic, where as at Cow Bay a "Recent Formation" is in progress. We shall again meet with these in the sequel.

The "Western Division" is in like manner sub-divided by a great range of granites (g.) extending from N. W. side of the "Central Division" along the South Mountain of Kings and Annapolis Counties. The Northern part of this Division consists of the south side of the valley that runs between the North and South Mountains, and the north side of South Mountain. The characteristic transportation is (t) from the triassic (T) rocks of Blomidon and North Mountain. I would here observe that the (a) of the Central (t a) and the Eastern Division does not put in an appearance in the West Division, although it crossed the Minas Basin it did not cross the Bay of Fundy from the Cobequid Mountains.

We have examined this part at Wolfville, Kentville, Aylesford, and Nictaux.

At the two last localities, *glaciation* was observed on the north side of South Mountain, over which the (t) of North Mountain must have passed in its southerly course. I have not yet examined the southern sub-division. Mr. Murphy, the Government Engineer, has traced the Nictaux glacial course along the Nictaux and Atlantic Railway. *Vide* paper in Trans., Vol. VI., page 130.

In our Museum Boulder Collections, we have a boulder of gray Amygdaloid, which the late Peter Jack picked up at the Lunenburg ovens. I have no doubt that the great granite masses which I observed in the fields on the road between Chester and Lunenburg are to be regarded as (g) of the granites (G) of the South Mountain, and that amygdaloids (t) will also be found in the southern sub-division south of Aylesford and Kentville.*

GOLD.

Mr. Belt refers to the transportation of boulders of auriferous quartz in the glacial period, and his success in discovering the original lodes or leads by following the glacial striation course. Mr. Campbell of Dartmouth, maintains that he has washed gold out of the glacial drift.

METEOROLOGICAL.

Causes seemed to have changed "pre-glacial" temperate into extraordinary "glacial" frigid, and afterward the latter into extraordinary "champlain" torrid, which was succeeded by the existing conditions of temperature.

In this terrestrial magnetism seems to have acted a very important part, the character of which is still problematical. *Vide* "Our Glacial Problem," APPENDIX of Trans. of Institute, 1886.

2.—*Champlain* (Ch.)

While we regard our transportation and glaciation as the work of glacial agency, we consider the deposition of the glacial freight and its inland distribution as the work of champlain agency.

The extreme (?) torrid heat of the *latter* period succeeding the arctic cold of the *former*, the glaciers were forced to retreat and so to discharge their accumulated freight.

Their dissolution and consequent liberation of the captive floods must have been fearfully catastrophal, sweeping away barriers, transgressing boundaries and effecting endless confusion.

Of this we have ample evidence in the phenomena from time to time observed, and the perplexity and contradictions of even experienced and competent observers when interpreting phenomena from different standpoints.

We regard certain valley, excavation, striking northern transportation, sometimes, too, crossing southern transportation and

* These have been found by Mr. J. McLeod, on Meisner's Island, Chester.

other numerous irregularities as effects of the champlain period.

The formation of the valley of Kings and Annapolis which lies within the bounds of our western glacial division is a notable example. During the process a glacial highway was swept away. Granite masses from the South Mountain were displaced, carried northward, landed in the middle of the valley, and boulders were even carried into the North Mountain, and aqueous accumulations were formed in the valley, having North Mountain amygdaloids and South Mountain granites, and other rocks imbedded in sand hills, having bedding which is absent from the glacial accumulations of the central division.

Co-temporaneous with the excavation of this valley and the destruction of the glacial highway was a like operation in the central division, between Parrsboro', Blomidon and the south side of the Avon Estuary, where the waters of the Minas Basin now flow.

The celebrated "Boar's Back" of River Hebert, in Cumberland County, the filling of the break in the Cobequid, between Springhill and Parrsboro', through which the railway passes and the archæan (A) transported boulders at Springhill, &c, to the north of the Cobequids, are all referred to the champlain period and indicated by the (yellow) colouring of our map and the small letters (ch.)

In like manner we refer and indicate certain phenomena in Pictou County.

In following up the Archæan (A) transportation (a) of the eastern division I found boulders lying on the sides of the Pictou Railway, east of Mount Thom and the eastern extremity of the Cobequids and still continuing in a North East direction as far as the Albion Mines. Among the syenitic boulders, one which was very beautiful reminded me of a large boulder which I found at Merigomish in 1869, when I was in the service of the Geological survey. Of this I had a specimen in my rock collection. Sir W. E. Logan admired it very much and was disappointed when I told him that it was part of a boulder.

In Antigonish County, we have associated with an important glacial transportation, a champlain series of elevations which commence near the shore, Malignant Cove, and extend in a southerly direction to a distance of 4 miles. On the top of the last hill is a R. C. Chapel, which is visible from a great distance. In the rising ground, in the town and around it are stratified clays one of the beds produced a number of specimens of a fossil plant. Some of these had a beautiful blue pigment, which Prof. How describes in his Mineralogy of Nova Scotia. *Vide* " Revision of the Geology of Antigonish County." Trans., 1885-6.

We have defined the formation on our map. From the eastern extremity of the province we pass to the western counties, Digby and Yarmouth. At Weymouth, the Railway shows a section of a formation which we regard as Champlain. *Vide* map. At the station was a large boulder (t) of triassic Basalt from the triassic (I) igneous range. *Vide* Polariscopic Notes Trans. Vol, VI., p. 121.

3.—*Recent* (r).

We go to Clam Bay, on the Atlantic coast and the eastern side of the eastern division. Here we find on the shore a section of (a g) formation very much covered by sands thrown up by the waves and winds. If we are to regard (a g) as a part of the " terminal moraine," then we have a glacial period formation overlaid by Recent with Champlain overlapped. We cannot for a moment suppose that the latter is missing, as the Atlantic must have been unintermittingly active since the glacial period.

There is however another alternative.

The Atlantic may have encroached so far on the Terminal moraine as to have reached the accumulations formed during the Champlain period. We may thus have the Recent in course of formation on the Champlain, and the succession may, in a manner, be considered as regular. The same reasoning may apply to Cow Bay and other parts of the coast.

Antigonish is built largely on " intervale " and hence the town itself was wont to be called by the old inhabitants " the Intervale."

This is formed at the confluence of a number of rivers and brooks and succeeds the Champlain referred to above. The Indian Gardens which lie at the head of the Harbour is a continuation of this intervale. All this is remarkable for its fertility.

With its picturesque environs, Antigonish is decidedly beautiful.

In Cumberland, Colchester, Hants and Kings Counties there are extensive formations which have their beginning in the champlain, extend through the early Recent and are now in progress. Of these are the Grand Pre, the marshes and dyke land of Amherst, the intervals of the Shubenacadie and the Stewiacke Rivers, and all the creeks of the various counties where the muddy tides of the Bay of Fundy force admission.

The deposits in the rivers and creeks, is the well known "marsh mud," which is fully appreciated by the agriculturists. The mode of deposition, the stratification, well shewn in cuttings, the rain prints, sun cracks, worm trails, foot prints, embedded leaves and shells are beautifully illustrative of phenomena observed in older formations, e. g., our Carboniferons.

Lacustrine.

In the bottom of Grand Lake, Halifax County, we discovered a formation which must have been a long time in progress. It largely consists of singular concretions, having an artificial appearance, so as to have been mistaken for "ancient pottery." I found, however, from an examination of the deposit and from chemical analysis that it was natural, and consisting of "ferruginous concretions." The whole is regarded as a formation of iron-sesquoxide with water. *Vide* Transactions of the Royal Society of Canada, Vol. I.

In some lakes are diatomaceous deposits, pure or clayey, e. g., in Fauleigh Lake, Colchester, and Long Lake, Halifax.

Bogs, &c.

Bogs and other surface formations have bog iron and bog manganese. Clays with limnæidæ, &c., localities are numerous in Nova Scotia and Cape Breton.

Clays and Sands.

Clays, sands and shingle, separate or intermingled, are the regular constituents of our sea beaches, and have been in past ages and are easily accounted for. Clays and sands which largely cover the interior are the results of the operations of agencies which cannot be readily specified.

Of course they are largely derived from the constituents of the geological formations with which they are associated.

The carboniferous regions—lower, middle and upper—and the triassic are chiefly to be distinguished, the latter for its red sands, and the former for its clays and sands.

Our map indicates that a champlain period left its mark on these regions, so as to cap largely and obscure the underlying formations, but not so as to obliterate the traces of their existence even where they are most obscure.

Recent agencies re-arrange and re-distribute so as to modify the material provided, and adapt it for economic purposes.

I would remark that after a rainy and stormy period the peculiar features of this surface geology are clearly displayed.

These were the conditions under which I collected in Nova Scotia and Cape Breton the beautifully illustrative collection which was exhibited in London, 1862. This consisted of clays of great variety, useful and beautiful. Ochre and ores (?) Bog iron and Manganese, &c.

Gold.

In Lunenburg County we have the Ovens Gold washings. These are recent, and are still in the course of formation by the action of the Atlantic streams.

This has been regarded as illustrative of the mode of formation of the auriferous conglomerates of Lower Carboniferous age at Gay's River, Colchester County. *Vide* Transactions 1886-7.

Stone Age.—Implements.

Our Glacial Deposits, after the search of years, have failed to furnish any stone forms that can be regarded as the work of man.

In my examination of the superficial geology on the Bay Chaleur, New Brunswick, *Vide* "A Month Among the Geological Formations of New Brunswick," Trans., 1875, I was crossing a field to get at the section of the Intercolonial Railway from which was taken the skeleton of the Beluga which is in our Provincial Museum, I saw a stone axe in my way. Of course I picked it up. It is in our Museum, duly labelled with the date, 1874. I found the bed of the Beluga a section of Champlain clays, having the characteristic shells of the formation. *Vide* Museum Collection. The axe could not have come out of this underlying marine bed. This by the way.

Our collections contain many axes now associated with it. These are Nova Scotian. One of them I found in the town of Dartmouth. Another with a groove was picked up by a boy and presented to the Museum. Our Glacial accumulations are not far from where the first was found. The last was found in a pile of stones above one of these accumulations—not in it.

A magnificent and beautifully-formed spear head has on it an inscription which informs us that it was found in an Indian grave more than twenty years ago. Sheriff Hill, of Antigonish, and I collected stone arrow-heads both well and indifferently shaped, at Ogden's Pond, on George's Bay, near our Eastern Glacial terminus.

In Lunenburg County, at Bachman's Beach on the Atlantic, and six miles North of the "Ovens" Gold Diggings, an arrow-head maker's factory was discovered about 1874. Of the first collection the late Mr. Lewis Anderson, merchant, Lunenburg, presented to our Museum 202 specimens Jasper arrow-heads of elegant form and beautiful chips of agates. There are also arrow-heads of quartz and porphyrite. Many of them were broken in the making. Of these the pieces have been fitted together. Associated are needles and other rude implements with nuggets of native copper, such as is found in the Triassic (T) igneous rocks of Cape d'Or, or Margaretville. Since the discovery many have gone to the locality and collected specimens, and the supply seems yet to be unexhausted.

We have another collection of Jasper arrow-heads and chips from another locality, in Cornwallis, King's County. The workmanship is much inferior to that of the preceding.

All the implements are of the same character. They correspond with those of Abbeville. Ours, however, cannot be older than early recent.

4.—*Pre-glacial?*

This division seems to be represented in the Cobequid Mountains, as I observed in my examination of the sections of the Intercolonial Railway in 1873. Transactions Vol. III., page 349. We read, "the gravel banks which obscure or partially cover the rocks of this band seem to merit more than a passing notice. The sections on both sides of the railway indicate the thickness and the extent of the accumulations of gravel. An examination of the material (e g) boulders, gravel and sand, shows that it is chiefly, if not wholly derived from the surrounding rocks."

The extent of the accumulations, their breadth and depth show that the waste of rocks must have been very great. The roundness of the material shows the amount of rolling to which it had been subjected, while its stratification indicates that water was the agency engaged in arranging the banks.

The formation of the material may largely belong to a period, or periods anterior to the post pliocene, while its diminution and partial transportation southwards was the work of the agencies of the latter period, &c.

We regard the gravel beds as the representatives in formation and time of those formations that occur between the triassic and post pliocene, as well as the post pliocene itself. We thus give work and attributable results to those mountain agencies which we find now in operation, and which we have no right to regard as quiescent from the triassic to the post pliocene periods.

This is represented by a gap in the deep colouring of the Cobequids and light *vermilion*.

The small proportion of colouring in our map, serves to show the extent of the investigations to be made, before the colouring can be completed.

Art. X.—A Catalogue of the Birds of Nova Scotia.—By A. Downs, *Cor. Mem. Zool. Soc. of London.*

Read May 14, 1888.

The following catalogue presents all the birds we have personally observed as occuring in Nova Scotia, with the addition of one or two additional ones which are inserted on the authority of those whose names follow them.

The nomenclature and classification adopted is that of the *Code of nomenclature and check-list of North American birds*, as issued by the American Ornithologist's Union. The numbers in parenthesis refer to that work.

Order PYGOPODES. Diving Birds.

Suborder Podicipedes. Grebes.

Family PODICIPIDÆ. Grebes.

Genus Colymbus Linnæus.

Subgenus Colymbus.

1. **Colymbus holboellii** (*Reinh.*). (2.) Holboell's Grebe; "Red-necked Grebe."

Rare, migrant in spring and fall. It breeds near St. Stephens, N. B., but, so far as is known, the eggs have not been obtained from this Province. *When opened it is found full of whitish feathers.*

Subgenus Dytes Kaup.

2. **Colymbus auritus** *(Linn.)* (3.) Horned Grebe.

I only know of one instance of this bird having been taken in Nova Scotia.

Genus Podilymbus Lesson.

3. **Podilymbus podiceps** *(Linn.)*, (6) Pied-billed Grebe; "Dab Chick."

Occasionally got in the fall.

Suborder CEPPHI. Loons and Auks.

FAMILY URINATORIDÆ. LOONS.

Genus URINATOR Cuvier.

4. **Urinator imber** (*Gunn.*) (7.) LOON.

Common. Arrives as soon as the lakes are open and remains until they are frozen.

5. **Urinator lumme** (*Gunn.*) (11.) RED-THROATED LOON.

Not very plentiful. A purely salt-water diver.

FAMILY ALCIDÆ. AUKS, MURRES, AND PUFFINS.

Subfamily Fraterculinæ. Puffins.

Genus FRATERCULA Brisson.

6. **Fratercula arctica** (*Linn.*) (13.) COMMON PUFFIN.

Rather common in winter and breeds on the coast.

Subfamily PHALERINÆ.

Genus CEPPHUS Pallas.

7. **Cepphus grylle** (*Linn.*) (27.) BLACK GUILLEMOT.

Very common in winter. Breeds on the Isle Haut, Bay of Fundy.

Subfamily ALCINÆ.

Genus URIA Brisson.

8. **Uria troile** (30.) MURRE.

Common in winter.

9. **Uria lomvia** (*Linn.*) (31.) BRUNNICK'S MURRE.

Inserted on Boardman's authority. Said to be common in the Bay of Fundy during winter.

Genus ALCA.

10. **Alca torda** (*Linn.*)

Not very common. Breeds on Sable Island. Winter.

Genus PLAUTUS.

11. **Plautus impennis** GREAT AUK.

Now extinct, but, no doubt, formerly common on our shores. Three of these birds were found entombed in the ice of the Funk Islands, Newfoundland, and one of them was forwarded to Mr. J. Matthew Jones, of Halifax, and thence to the British Museum.

Subfamily ALLINÆ.

Genus ALLE.

12. **Alle alle** DOVEKIE; "LITTLE AUK."

Formerly common, but now rare. At one time it was not uncommon to see them shot from the wharves.

ORDER LONGIPENNES. LONG-WINGED SWIMMERS.

FAMILY STERCORARUÆ. SKUAS & JAEGERS.

Genus MEGALESTRIS.

13. **Megalestris skua.** SKUA.

Not very common. Winter and Spring.

Genus STERCORARIUS.

14. **Stercorarius pomarinus** (*Temm*). (36.) POMARINE JAEGER.

Very rare.

15. **Stercorarius parasiticus** (*Temm*). (37.) PARASITIC JAEGER.

16. **Stercorarius logicaudus** (38.) LONG-TAILED JAEGER.

Probably occurs here.

FAMILY LARIDÆ. GULLS & FERNS.

Subfamily LARINÆ. Gulls.

Genus GAVIA.

17. **Gavia alba** (*Gunn*). (39.) IVORY GULL.

Rare.

Genus RISSA Leach.

18. **Rissa tridactyla** (*Linn.*). (40.) KITTIWAKE.

Common in winter.

Genus LARUS Linnaeus.

19. **Larus glaucus** (*Brunn*). (42). GLAUCOUS GULL: "BURGOMASTER."

Not common. Winter.

20. **Larus leucopterus** (*Faber*). ICELAND GULL: "WHITE WINGED GULL."

Rare. Winter.

21. **Larus marinus** (*Linn.*) (47). GREAT BLACK-BACKED GULL; "SADDLE-BACK."

Very common. Seems to be two varieties, alargerand a medium sized. I have seen the large ones breeding on the lakes and the smaller ones on the Isle Haut, breeding with the Herring Gull.

22. **Larus argentatus smithsonianus** *Coues.* (51.) AMERICAN HERRING GULL.

This is the most common gull we have. Breeds on the Isle Haut in great numbers.

23. **Larus philadelphia** (*Ord.*) (60.) BONAPARTE'S GULL.

Rather common. It is rarely that one is got in full breeding plumage with the black hood.

Genus XEMA.

24. **Xema sabinii.** SABINE'S GULL.

Subfamily STERNINÆ. Terns.

Genus STERNA Linnæus.

Subgenus THALASSEUS Boil.

25. **Sterna tschegrava** (*Lepech.*) (64.) CASPIAN TERN.

Very rare. A very fine specimen shot at Cole Harbor.

Subgenus STERNA.

26. **Sterna hirundo** (*Linn.*) (70) COMMON TERN; "MACKEREL GULL."

Very common. Breeds all along the coast. Favourable localities are Meagher's Beach and Sable Island. At the latter place numbers of the eggs are consumed for food.

27. **Sterna paradisæa** (*Brunn.*) (71) ARCTIC TERN.

The same remarks may be applied to this one.

28. **Sterna dougalli** (*Montag.*) (72) ROSEATE TERN.

Rare.

Subgenus STERNULA Boie.

29. **Sterna antillarum** (*Less.*) LEAST TERN.

Very rare. One specimen was obtained at Polly Bog, N. S.

ORDER TUBINARES.

FAMILY PROCELLARIIDÆ.

Subfamily PROCELLARUNÆ.

Genus FULMARUS.

Subgenus Fulmarus.

30. **Fulmarus glacialis** (*Stephens.*) FULMAR.

Rare. Mr. T. Egan has a young one.

Genus PUFFINUS.

31. **Puffinus stricklandi.** SOOTY SHEARWATER.
Rare.

Genus PROCELLARIA.

32. **Procellaria pelagica** (*Linn.*) STORMY PETREL.
Common all the year. Breeds on St. Paul's Island and other favourable localities. Nest in a bank. Eggs pure white.

Genus OCEANODROMA.

33. **Oceanodroma leucorhoa.** LEACH'S PETREL.
Rare.

Subfamily OCEANITINÆ.

Genus OCEANITES.

34. **Oceanites oceanicus.** WILSON'S PETREL.

ORDER STEGANOPODES. TOTIPALMATE SWIMMERS.

FAMILY PHAETHONTIDÆ.

Genus PHAETHON.

35. **Phaethon flavirostris** (*Brandt.*) YELLOW-BILLED TROPIC BIRD.

Accidental. One of this species was taken, after a storm, at Shubenacadie, and is now in the Provincial Museum collection.

FAMILY SULIDÆ. GANNETS.

Genus SULA.

Subgenus DYSPORUS. Illiger.

36. **Sula bassana** (*Linn.*) (117.) GANNET.
Common all the year. Breeds on the coast.

FAMILY PHALACROCORACIDÆ CORMORANTS.

Genus PHALACROCORAX. Brisson.

Subgenus PHALACROCORAX.

37. **Phalacrocorax carbo** (*Linn.*) (119) CORMORANT.
Not common. Breeds here.

38. **Phalacrocorax dilophus** (*Sw. & Rich.*) (120) DOUBLE-CRESTED CORMORANT.

Not common. The crest is only present in the breeding season.

FAMILY FREGATIDÆ.

Genus FREGATA.

39. **Fregata aquila** (*Vieill.*) MAN O'-WAR BIRD.
One shot at Cole Harbour after a southerly gale.

ORDER ANSERES. LAMELLIROSTRAL SWIMMERS.

FAMILY ANATIDÆ. DUCKS, GEESE, AND SWANS.

Subfamily MERGINÆ. Mergansers.

Genus MERGANSER Brisson.

40. **Merganser americanus** (*Cass.*) (129.) AMERICAN MERGANSER; "GOOSANDER."

Very common, chiefly in spring. Breeds on the Nepisiquit River, N. B.

41. **Merganser serrator** (*Linn.*) (130.) RED-BREASTED MERGANSER; "SHELL-DRAKE."

Common in Grand Lake. Winter.

Genus LOPHODYTES Reichenbach.

42. **Lophodytes cucullatus** (*Linn.*) (131). HOODED MERGANSER.
Not very common. Migrant.

Subfamily ANATINÆ. River ducks.

Genus ANAS Linnæus.

43. **Anas boschas** (*Linn.*) (132.) MALLARD.
Rare.

44. **Anas obscura** (*Gmel.*) (133). BLACK DUCK.
This may be called our commonest fresh-water duck and is also, perhaps, the best eating. Breeds in all our lakes. The cross obtained by breeding with the common domestic duck, has puzzled many naturalists (Audubon included) who have come upon it in a wild state.

Subgenus MARECA Stephens.

45. **Anas penelope** (*Linn.*) (136): WIDGEON.
Rare.

46. **Anas americana** (*Gmel.*) (137). BALDPATE.
Rare.

Subgenus NETTION Kaup.

47. **Anas crecca** (*Linn.*) (138). EUROPEAN TEAL.

Very rare. Only know of one example of this species having been taken here. It is now in the collection of Sir Arthur Guinness, who purchased it at the Dublin Exhibition.

48. **Anas carolinensis** *Gmel.* (139). GREEN-WINGED TEAL.
Abundant. Breeds to the northward.

Subgenus QUERQUEDULA Stephens.

49. **Anas discors** *Linn.* (140). BLUE-WINGED TEAL.
Uncommon. A good many young birds are shot during their fall migration.

Genus SPATULA Boie.

50. **Spatula clypeata** *(Linn.)* (142). SHOVELLER.
Rather rare migrant.

Genus DAFILA Stephens.

51. **Dafila acuta** *(Linn.)* (143). PINTAIL.
Not very rare. Migrant. Excellent eating. Sometimes called "Wood Duck" in this province.

Genus AIX Boie.

52. **Aix sponsa** *(Linn.)* (144). WOOD DUCK; "SUMMER DUCK."
Rare. A few breed in the province.

Genus AYTHYA Boie.

53. **Aythya americana** *(Eyt)* (146). REDHEAD.
Rare migrant. This is one of the most abundant species which visits the Upper Provinces.

54. **Aythya vallisneria** *(Wils.)* (147.) CANVAS-BACK.
Rare. Mr. T. Egan, obtained a specimen.

Subgenus FULIGULA Stephens.

55. **Aythya marila nearctica** *Stejn.* (148.) AMERICAN SCAUP DUCK.
Rare migrant.

56. **Aythya affinis** *(Eyt.)* (149.) LESSER SCAUP DUCK; "LITTLE BLACK-HEAD."
Rare migrant. Once had a brood of young ones which were captured at Grand Lake.

57. **Aythya collaris** *(Donov.)* (150). RING-NECKED DUCK.
Rare. Winters in Guatemala and the West Indies.

Genus GLAUCIONETTA Stejneger.

58. **Glaucionetta clangula americana** *(Bonap.)* (151). AMERICAN GOLDEN-EYE; "WHISTLER."

Abundant. All winter. Breeds north.

59. **Glaucionetta islandica** *(Gmel.)* (152). BARROW'S GOLDEN-EYE.

Rare. Of late years it has been occasionally taken in the spring.

Genus CHARITONETTA Stejneger.

60. **Charitonetta albeola** *(Linn.)* (153). BUFFLE-HEAD.

Common migrant in winter.

Genus CLANGULA Leach.

61. **Clangula hyemalis** *(Linn.)* (154.) OLD-SQUAW; "LONG-TAILED DUCK;" "COCKAWEE."

Very common. They pair in the province, but breed farther north.

Genus HISTRIONICUS Lesson.

62. **Histrionicus histrionicus** *(Linn.)* (155.) HARLEQUIN DUCK; "LORD;" "IMP."

Rather common in winter. It is called "Lord" by our fishermen on account of the gaudy plumage of the male, while the name "Imp" has been applied to it by reason of its being a very hard shot.

Genus CAMPTOLAIMUS Gray.

63. **Camptolaimus labradorius** *(Gmel.)* LABRADOR DUCK; "PIED DUCK."

Now extinct. Boardman reports it to have been common in the Bay of Fundy in 1845. William Winton, of Halifax, and Capt. Waderburn, of the 42nd Highland Regiment, each obtained a male in the market. *Vide*, Notes on the Pied, or Labrador Duck. Trans., 1885-6.

Genus SOMATERIA Leach.

Subgenus SOMATERIA.

64. **Somateria mollissima borealis.** GREENLAND EIDER; "SEA DUCK."

Common. Breeds on the Isle Haut, Bay of Fundy.

Subgenus ERIONETTA.

65. Somateria spectabilis (*Linn.*) (162). KING EIDER; "BOTTLE-NOSE DRAKE."

Rare. Winter.

Genus OIDEMIA Fleming.

Subgenus OIDEMIA.

66. Oidemia americana (*Sw. & Rich.*) (163). AMERICAN SCOTER; "BLACK COOT."

Very common migrant.

Subgenus MELANITTA Boie.

67. Oidemia deglandi *Bonap.* (165). WHITE-WINGED SCOTER; "VELVET DUCK."

Uncommon. Winter.

Subgenus PELIONETTA Kaup.

68. Oidemia perspicillata (*Linn.*) (166). SURF SCOTER; "BOTTLE-NOSE COOT."

Common migrant. Winter.

Genus ERISMATURA Bonaparte.

69. Erismatura rubida (*Wils.*) (167). RUDDY DUCK.

A good many are shot during the fall migration, but they are never obtained in breeding plumage.

Subfamily ANSERINÆ. Geese.

Genus CHEN Boie.

70. Chen hyperborea (*Pall.*) (169). LESSER SNOW GOOSE.

Rare. Capt. Waderburn, of the 42nd Highlanders, had a specimen. Some were also killed on the "Common" in 1874; others, again, occurred at the Eastern Passage, and were driven in with the domestic geese and shot. Those killed on the "Common" are now in the possession of Mr. James Walker, of Halifax. These Dr. Gilpin erroneously described as the Barnacle Goose (*B. leucopsis*). *Vide* Trans., I. N. S., 1879-80.

Genus BRANTA Scopoli.

71. Branta canadensis (*Linn.*) (172). CANADA GOOSE; "WILD GOOSE."

Common migrant.

72. **Branta bernicla** (*Linn.*) (173). Brant.

A few are obtained every winter. In Prince Edward Island it is very common. Its favourite food is the eel grass which grows in great abundance along the shores. Its flesh is highly esteemed by epicures, and Sir Gaspard LeMarchant, formerly Governor of the Province, used to consider it, of all geese, the best for the table.

Subfamily Cygninæ. Swans.

Genus Olor Wagler.

73. **Olor columbianus** (*Ord.*) (180). Whistling Swan.

There are only one or two instances of this species being taken in Nova Scotia. Liverpool was the locality for one of these captures.

Order HERODIONES. Herons, Storks, Ibises, etc.

Suborder Ibides. Spoonbills and Ibises.

Family IBIDIDÆ. Ibises.

Genus Plegadis Kaup.

74. **Plegadis autumnalis** (*Hasselq.*) (186). Glossy Ibis.

A flock ran the gauntlet along the shore from New England to Country Harbor, N. S. Their number had been considerably diminished by the time they arrived within our limits.

Suborder Herodii. Herons, Egrets, Bitterns, etc.

Family ARDEIDÆ. Herons, Bitterns, etc.

Subfamily Botaurinæ. Bitterns.

Genus Botaurus Hermann.

Subgenus Botaurus.

75. **Botaurus lentiginosus** (*Montag.*) (190). American Bittern.

Very common, during summer, in our marshes. It breeds in the Province, making its nest on dry hilly ground at some distance from the water.

Subfamily Ardeinæ. Herons and Egrets.

Genus Ardea Linn.

Subgenus Ardea.

76. **Ardea herodias** *Linn.* (194). Great Blue Heron.

Common. Breeds in great quantities at Mount Uniacke, on the tops of high birch trees. Lays a beautiful greenish egg of rather small size. It is locally called "Crane."

Subgenus HERODIAS Boie.

77. Ardea egretta *(Gmel.)* (196). AMERICAN EGRET.
Casual. Summer.

Subgenus GARZETTA Kaup.

78. Ardea candidissima (*Gmel.*) (197). SNOWY HERON.
Casual visitor. A fine specimen was shot by Mr. G. Drillio, of Halifax, in a marsh up the country, and another was obtained at Musquodoboit. Mr. T. Egan informs us of the capture of one near the St. Margaret's Bay Road (1887).

Subgenus FLORIDA.

79. Ardea cœrulea (*Linn.*) LITTLE BLUE HERON.
Very rare. Inserted on the authority of Mr. T. Egan, who reports the capture of one specimen in immature plumage.

Subgenus BUTORIDES Blyth.

80. Ardea virescens *(Linn.)* (201). GREEN HERON.
Mr. Egan has had several of these herons from Prospect and other localities.

Genus NYCTICORAX Stephens.

Subgenus NYCTICORAX.

81. Nycticorax nycticorax nævius (*Bodd.*) (202). BLACK-CROWNED NIGHT HERON.
Rare. One year a number of them visited our Province and Mr. Egan obtained some specimens.

ORDER PALUDICOLÆ. CRANES, RAILS, ETC.

Suborder RALLI. Rails, Gallinules, Coots, Etc.

FAMILY RALLIDÆ. RAILS, GALLINULES, COOTS, ETC.

Subfamily RALLINÆ. RAILS.

Genus RALLUS Linnæus.

82. Rallus virginianus *(Linn.)* (212). VIRGINIA RAIL.
Rare. Autumn.

Genus PORZANA Vieillot.

Subgenus PORZANA.

83. Porzana carolina (*Linn.*) (214). SORA; "CAROLINA RAIL."
Rare. Autumn.

Subgenus Coturnicops Bonaparte.

84. **Porzana noveboracensis** *(Gmel.)* (215). Yellow Rail.
Rare. Autumn.

I have obtained the young of one of the Rails at Cole Harbour. They were inky black in colour.

Subfamily Gallinulinæ.

Genus Ionornis Reichenbach.

85. **Ionornis martinica** *(Linn.)* (218). Purple Gallinule.
Very rare. Only accidental.

Subfamily Fulicinæ.

Genus Fulica Linnæus.

86. **Fulica americana** *(Gmel.)* (221). American Coot.
Not very common. Autumn.

Order LIMICOLÆ. Shore Birds.

Family PHALAROPODIDÆ. Phalaropes.

Genus Crymophilus Vieillot.

87. **Crymophilus fulicarius** *(Linn.)* (222). Red Phalarope.
Uncommon. Summer. One shot this year (Austen). Specimens from Sable Island, where it is plentiful (Downs).

Genus Phalaropus Brisson.

Subgenus Phalaropus.

88. **Phalaropus lobatus** *(Linn.)* (223). Northern Phalarope.
Occasional. Spring and fall.

Family SCOLOPACIDÆ. Snipes, Sandpipers, etc.

Genus Philohela Gray.

89. **Philohela minor** *(Gmel.)* (228). American Woodcock.
Common. This well-known bird is nearly the first to breed in the spring; its nest being sometimes made before the snow is off the ground. When discovered with its young it attempts to draw attention from them by feigning injuries.

Genus Gallinago Leach.

90. **Gallinago delicata** *(Ord.)* (230). Wilson's Snipe.
Common. A few breed in the Province.

Genus TRINGA Linnæus.
Subgenus ARQUATELLA Baird.

91. Tringa maritima (*Brunn.*) (235). PURPLE SANDPIPER.
Uncommon. Winter resident.

Subgenus ACTODROMAS Kaup.

92. Tringa maculata (*Vieill.*) (239). PECTORAL SANDPIPER; "JACK SNIPE."

Common in the fall and spring.

93. Tringa fuscicollis (*Vieill.*) (240.) WHITE-RUMPED SANDPIPER.

Common in fall.

94. Tringa minutilla (*Vieill.*) (242). LEAST SANDPIPER.
Common. Autumn.

Subgenus ANCYLOCHEILUS.

95. Tringa ferruginea (*Brunn.*) (244). CURLEW SANDPIPER.
Very rare. One purchased in the Halifax market (Downs).

Genus EREUNETES Illiger.

96. Ereunetes pusillus (*Linn.*) (246). SEMIPALMATED SANDPIPER.

Uncommon.

Genus CALIDRIS Cuvier.

97. Calidris arenaria (*Linn.*) (248). SANDERLING.
Common during autumnal migration.

Genus LIMOSA Brisson.

98. Limosa hæmastica (*Linn.*) (251). HUDSONIAN GODWIT.
Common during autumnal migration.

Genus TOTANUS Bechstein.
Subgenus GLOTTIS Koch.

99. Totanus melanoleucus (*Gmel.*) (254). GREATER YELLOW-LEGS.

Common during the vernal and autumnal migrations. Winters as far south as Chili.

100. Totanus flavipes (*Gmel.*) (255). YELLOW-LEGS.
Rather common in spring and fall.

Subgenus HELODROMAS.

101. Totanus solitarius (*Wils.*) (256). SOLITARY SANDPIPER.

Rather common in August.

Genus SYMPHEMIA Rafinesque.

102. Symphemia semipalmata (*Gmel.*) (258). WILLET.

Common. Summer and fall. Breeds at Port Petpiswick.

Genus TRYNGITES Cabanis.

103. Tryngites subruficollis (*Vieill.*) (262). BUFF-BREASTED SANDPIPER.

Uncommon migrant. Fall. Locally called "Robin Snipe."

Genus ACTITIS Illiger.

104. Actitis macularia (*Linn.*) (263). SPOTTED SANDPIPER.

This is the most common sandpiper we have. It is early in spring when its "*peet weet*" is first heard near our brooks and shores and it remains with us until the fall, when the approaching cold forces it to retreat farther south. Breeds near the side of streams and on salt-water beaches.

Genus NUMENIUS Brisson.

105. Numenius hudsonicus (*Lath.*) (265). HUDSONIAN CURLEW.

Common fall migrant. Arrives about the 23rd August, with the plover and a north-east gale.

106. Numenius borealis (*Forst.*) (266). ESQUIMAUX CURLEW.

Rather less abundant than the last. Arrives about the same time and under the same circumstances.

FAMILY CHARADRIIDÆ. PLOVERS.

Genus CHARADRIUS Linnæus.

Subgenus SQUATAROLA Cuvier.

107. Charadrius squatarola (*Linn.*) (270). BLACK-BELLIED PLOVER; "BULL-HEAD."

This bird is rarely taken in its nuptual dress (face and entire under parts black) but is very common in the less striking winter plumage. September to October.

Subgenus CHARADRIUS Linnæus.

108. Charadrius dominicus (*Mull.*) (272). AMERICAN GOLDEN PLOVER.

A few stragglers visit us. These birds used to be very abundant on the "Common." After a heavy rain the gunners have been out in such force as to present the appearance of a sham-fight. Fall.

Genus ÆGIALITIS Boie.

Subgenus OXYECHUS Reichenbach.

109. Ægialitis vocifera (*Linn.*) (273). KILLDEER.

Very rare. One was killed at Meagher's Beech, on New Year's Day, by W. G. Winton.

Subgenus ÆGIALITIS Boie.

110. Ægialitis semipalmata *Bonap.* (274). SEMIPALMATED PLOVER; "RING NECK."

Abundant.

111. Ægialitis meloda (*Ord.*) (277.) PIPING PLOVER.

Common. Breeds at Port Petpiswick. Summer and fall.

FAMILY APHRIZIDÆ. SURF BIRDS AND TURNSTONES.

Subfamily ARENARUNÆ. Turnstones.

Genus ARENARIA Brisson.

112. Arenaria interpres (*Linn.*) (283). TURNSTONE.

Not very abundant. Some young birds obtained by Mr. R. Allen may probably be referred to this species.

ORDER GALLINÆ. GALLINACEOUS BIRDS.

Suborder PHASIANI. Pheasants, Grouse, Partridges, Quails, etc.

FAMILY TETRAONIDÆ. GROUSE, PARTRIDGES, ETC.

Subfamily TETRAONINÆ. Grouse, Partridges, etc.

Genus DENDRAGAPUS Elliot.

Subgenus CANACHITES Stejneger.

113. Dendragapus canadensis (*Linn.*) (298). CANADA GROUSE; "SPRUCE PARTRIDGE."

Common. On account of its tameness it will probably in time be exterminated; that is, at the present rate of destruction. I have never known of any one—even an Indian—who had found a nest. The only way in which I managed to obtain the eggs was by keeping the birds in confinement. Mr. Bishop, of Kentville, adopted the same method with success. Collectors occasionally give as much as a dollar each for the eggs. This species frequents the soft-wooded districts, and feeds principally on the hacmatac or larch *(L. americana)* in summer, and on the balsam fir *(A. balsamea)* in winter.

Genus BONASA Stephens.

114. Bonasa umbellus togata (*Linn.*) (300). CANADIAN RUFFED GROUSE; "BIRCH PARTRIDGE."

More abundant than the above species. It is this bird, not the last, which occasions "partridge poisoning." The poisonous properties probably arise from its eating the leaves and berries of the sheep-laurel or "lamb-kill" *(Kalmia angustifolia)*. An emetic of mustard and water is the best remedy.

114 a. A cross between *D. canadensis* and *B. umbellus togata*, was purchased at a butcher's shop in Halifax. I never saw another.

ORDER COLUMBÆ. PIGEONS.

Family COLUMBIDÆ. Pigeons.

Genus ECTOPISTES Swainson.

115. Ectopistes migratorius (*Linn.*) (315). PASSENGER PIGEON; "WILD PIGEON."

At one time bred in Nova Scotia and were very abundant. It is now rare to the eastward of Manitoba, and, in all probability, is becoming extinct.

Genus ZENAIDURA Bonaparte.

116. Zenaidura macroura (*Linn.*) (316.) MOURNING DOVE; "CAROLINA DOVE."

Appears to be becoming rather common. A few are killed every fall. It was once rare.

ORDER RAPTORES. BIRDS OF PREY.

Suborder FALCONES. Vultures, Falcons, Hawks, Buzzards, Eagles, Kites, Harriers, etc.

FAMILY FALCONIDÆ. Vultures, Falcons, Hawks, Eagles, etc.

Subfamily ACCIPITRINÆ. Kites, Buzzards, Hawks, Goshawks, Eagles, etc.

Genus CIRCUS Lacepede.

117. Circus hudsonius (*Linn.*) (331). MARSH HAWK; "HEN, OR MARSH HARRIER."

Common. Summer. Flies very low and "comes up" sharp. Mr. John Bayers says that there is a great difference in the size of the eggs, females being hatched from much larger ones than the males. Breed on the ground in pasture land near Blockhouse (Standford's) Pond. Food being scarce when they first arrive, they eat the Green Snake *(C. vernalus)*.

Genus ACCIPITER Brisson.

Subgenus ACCIPITER.

118. Accipiter velox (*Wils.*) (332). SHARP-SHINNED HAWK.

This daring little hawk is a common summer resident. Breeds in the Province. One flew through a pane of glass to attack a cage of doves. Audubon mentions its hardihood in plunging headlong into a patch of briars to secure a bird.

Subgenus ASTUR Lacepede.

119. Accipiter atricapillus (*Wils.*) (334). AMERICAN GOSHAWK.

This handsome bird is the commonest hawk we have, and also, unfortunately, the most destructive. Found with us during the entire year.

Genus BUTEO Cuvier.

120. Buteo borealis *(Gmel.)* (337). RED-TAILED HAWK.

Not very common. I think it breeds here. One of these birds was taken by a soldier at the Ordnance Yard, while it was in the act of seizing a pet crow belonging to Mr. Pringle, Ordnance Store keeper. He came into my possession, and one day Mr. Livesey was looking at him and I told him that I had tried and condemned my specimen for attempted murder. Mr. Livesey remarked that he had evidently made a bad use of his talents (talons).

121. Buteo latissimus (*Wils.*) (343). BROAD-WINGED HAWK.

Very rare. One specimen was obtained in the market, September, 1888, and I think Mr. W. Winton had another which he shot some years ago in Stewiacke. My bird, when opened, was found to contain a green snake and a grasshopper.

Genus ARCHIBUTEO Brehm.

122. **Archibuteo lagopus sancti-johannis** (*Gmel.*) (347 a). AMERICAN ROUGH-LEGGED HAWK.

Not common and becoming more rare. This bird is feathered to the toes and by this circumstance it may be readily recognized.

Genus AQUILA Brisson.

123. **Aquila chrysaetos** (*Linn.*) (349). GOLDEN EAGLE.

Not a common bird. Mr. Winton caught a pair in a trap at Stewiacke. They are not so common as the Bald Eagle from which it may be distinguished by the feathers on the legs, those of the Golden Eagle extending far down to the toes.

Genus HALIÆETUS Savigny.

124. **Haliæetus leucocephalus** (*Linn.*) (352). BALD EAGLE; "WHITE-HEADED EAGLE."

Common. Breeds along our coast. He is the sworn enemy of the diligent Fish Hawk which is deprived of many a hard-earned prize by this lazy, theiving bully. Audubon grieved with Franklin that it should have been selected as the emblem of the United States; "he is a bird of bad moral character—does not get his living honestly—and besides, is a rank coward."

Subfamily FALCONINÆ. Falcons.

Genus FALCO Linnæus.

Subgenus HIEROFALCO.

125. **Falco islandus** *Gmel.* (353). WHITE GYRFALCON.

Casual visitor. An Arctic bird.

Subgenus RHYNCHODON Nitzsch.

126. **Falco peregrinus anatum** (*Bonap.*) (356). DUCK HAWK; "PEREGRINE HAWK."

Very rare. Obtained a specimen from the market.

Subgenus ÆSALON Kaup.

127. **Falco columbarius** *Linn* (357). PIGEON HAWK.

Common in fall, breeding in the wooded parts of the Province.

Subgenus TINNUNCULUS Vieillot.

128. **Falco sparverius** *Linn.* (360). AMERICAN SPARROW HAWK.

Common in fall. Breeds here. Feeds on grasshoppers in the autumn.

Subfamily PANDIONINÆ. Ospreys.

Genus PANDION Savigny.

129. Pandion haliaetus carolinensis (*Gmel.*) (364). AMERICAN OSPREY; "FISH HAWK."

This noble fisherman is a common summer resident, breeding in the vicinity of the coast. He has great powers of flight, the wings extending some distance beyond the tail. The breast-bone (sternum) is very deep in proportion to the size of the bird.

Suborder STRIGES. Owls.

FAMILY BUBONIDÆ. HORNED OWLS, ETC.

Genus ASIO Brisson.

130. Asio wilsonianus (*Less.*) (366). AMERICAN LONG-EARED OWL.

Not common. Occurs in the fall.

131. Asio accipitrinus (*Pall.*) (367). SHORT-EARED OWL.

Not common. Fall.

Genus SYRNIUM Savigny.

132. Syrnium nebulosum (*Forst.*) (368). BARRED OWL.

Common resident.

Genus NYCTALA Brehm.

133. Nyctala tengmalmi richardsoni (*Bonap.*) (371). RICHARDSON'S OWL; "TENGMALMI'S OWL."

Becoming very rare. Winter. Breeds in Newfoundland.

134. Nyctala acadica (*Gmel.*) (372). SAW-WHET OWL; "ACADIAN OWL."

Becoming rare. Resident.

Genus BUBO Cuvier.

135. Bubo virginianus (*Gmel.*) (375). GREAT HORNED OWL.

Common resident. I once had a pair of these birds in confinement. The female was very fierce, and eventually killed and ate her mate. "The Lord Chancellor" she was called, on account of her dignified deportment. Mr. McKay, of the *Illustrated*

London News, was so struck with the appearance of this owl that I had her photographed in order to present him with a copy.

Genus NYCTEA Stephens.

136. Nyctea nyctea *(Linn.)* (376). SNOWY OWL.

Some years plentiful, but generally scarce. Winter visitor. This bird hunts by day and is extremely fond of sea ducks. Mr. Bayers found their flesh of a fishy flavour and very distasteful. One of these birds in confinement would swallow a one-month-old kitten whole, head foremost. Sable Island, since 1827, has been regularly visited by this owl, which is drawn thither by the tempting food presented in the rabbits which were introduced about that time.

Genus SURNIA Dumeril.

137. Surnia ulula caparoch *(Mull.)* (377 a). AMERICAN HAWK OWL.

Now become very rare. Winter.

ORDER COCCYGES. CUCKOOS, ETC.

Suborder CUCULI. Cuckoos, Etc.

FAMILY CUCULIDÆ. CUCKOOS, ANIS, ETC.

Subfamily COCCYGINÆ. American Cuckoos.

Genus COCCYZUS Vieillot.

138. Coccyzus americanus *(Linn.)* (387). YELLOW-BILLED CUCKOO.

Very rare. One of these birds I recently mounted for Lord Russel, and Mr. Egan obtained the nest in Cunard's grounds. This is the only record of its having been taken in Nova Scotia.

139. Coccyzus erythrophthalmus *(Wils.)* (388). BLACK-BILLED CUCKOO.

Not very common. Summer. The Cuckoo builds its nest in a careless and slovenly manner. Its note is said to be usually heard before rain, which circumstance has given rise to the name by which it is known to many of the country people—"the Rain-crow."

Suborder ALCYONES. Kingfishers.

FAMILY ALCEDINIDÆ. KINGFISHERS.

Genus CERYLE Boie.

Subgenus STREPTOCERYLE.

140. Ceryle alcyon (*Linn.*) (390). BELTED KINGFISHER.

This is a common bird, breeding all over the Province, and there are few favorable localities where its ratting notes are not heard. Summer resident, migrating south to Panama and the West Indies.

ORDER PICI. WOODPECKERS, WRYNECKS, ETC.

FAMILY PICIDÆ. WOODPECKERS.

Genus DRYOBATES Boie.

141. Dryobates villosus leucomelas (*Linn.*) (393 b). NORTHERN HAIRY WOODPECKER.

Common resident.

142. Dryobates pubescens (*Linn.*) (394). DOWNY WOODPECKER. Rather common. Resident.

Genus PICOIDES Lacepede.

143. Picoides arcticus (*Swains.*) (400). ARCTIC THREE-TOED WOODPECKER; "BLACK-BACKED THREE-TOED WOODPECKER."

Not common. Resident. Prefers burnt barrens.

Genus SPHYRAPICUS Baird.

144. Sphyrapicus varius (*Linn.*) (402). YELLOW-BELLIED SAPSUCKER.

Abundant summer resident. Breeds in the vicinity of Grand Lake.

Genus CEOPHLŒUS Cabanis.

145. Ceophlœus pileatus (*Linn.*) (405). PILEATED WOODPECKER.

Uncommon resident in heavily timbered districts. This handsome bird is also called the "Great Northern Chief," while the name of "Great Southern Chief" is given to the Ivory-billed Wood-pecker of the United States.

Genus MELANERPES Swainson.

Subgenus MELANERPES.

146. **Melanerpes erythrocephalus** (*Linn.*) (406). RED-HEADED WOODPECKER.

Very rare. Only a mere straggler.

Genus COLAPTES Swainson.

147. **Colaptes auratus** (*Linn.*) (412). FLICKER; "GOLDEN-WINGED WOODPECKER;" "YELLOW-HAMMER;" HIGH-HOLDER."

This is the commonest woodpecker we have. Arrives as soon as the season opens and stops until late in the fall. Will breed in any favorable place, and brings up a very large family. *All the young have the black moustache.* This the females subsequently lose, and these birds present, in this particular, a curious exception to the general rule, by which the young males usually resemble the females in plumage, and their distinctive dress is a later acquisition.

ORDER MACROCHIRES. GOATSUCKERS, SWIFTS, ETC.

Suborder CAPRIMULGI. Goatsuckers, etc.

FAMILY CAPRIMULGIDÆ. GOATSUCKERS, ETC.

Genus ANTROSTOMUS Gould.

148. **Antrostomus vociferus** (*Wils.*) (417). WHIP-POOR-WILL.

Formerly common, but now become rare. Summer resident. It used to breed regularly near Hosterman's mill, at the head of the Arm.

Genus CHORDEILES Swainson.

149. **Chordeiles virginianus** (*Gmel.*) (420). NIGHTHAWK.

Very common. Arrives about the 1st of June and departs for the south before the first frosts of autumn arrive. It is said to breed occasionally on the gravel of flat-roofed houses in the city.

Suborder CYPSELI. Swifts.

FAMILY MICROPODIDÆ. SWIFTS.

Subfamily CHÆTURINÆ. Spine-tailed Swifts.

Genus CHÆTURA Stephens.

150. **Chætura pelagica** (*Linn.*) (423). CHIMNEY SWIFT; "CHIMNEY SWALLOW.

Abundant summer resident. Makes a nest of a very log-house style of architecture.

Suborder TROCHILI. Humming Birds.
FAMILY TROCHILIDÆ. HUMMING BIRDS.
Genus FROCHILUS Linnæus.
Subgenus TROCHILUS.

151. Trochilus colubris *Linn.* (428). RUBY-THROATED HUMMING BIRD.

Abundant summer visitor. Arrives as soon as the Red Maple *(A. rubrum)* is in blossom.

ORDER PASSERES. PERCHING BIRDS.
Suborder CLAMATORES. Songless Perching Birds.
FAMILY TYRANNIDÆ. TYRANT FLYEATCHERS.
Genus TYRANNUS Cuvier.

152. Tyrannus tyrannus *(Linn.)* (444). KING-BIRD.

Common inland but rare about Halifax. Summer. Several of these birds regularly visit the residence of Mr. H. Piers at Willow Park, Halifax.

Genus CONTOPUS Cabanis.
Subgenus NUTTALLORNIS.

153. Contopus borealis *(Swains.)* (459). OLIVE-SIDED FLYCATCHER.

Common summer resident.

Subgenus CONTOPUS.

154. Contopus virens *(Linn.)* (461). WOOD PEWEE.

Common summer resident.

Genus EMPIDONAX Cabanis.

155. Empidonax flavinentris *Baird.* (463). YELLOW-BELLIED FLYCATCHER.

Common summer resident.

156. Empidonax pusillus traillii *(Aud.)* (466 a). TRAILL'S FLYCATCHER.

Rather common. Summer resident.

157. **Empidonax minimus** *Baird.* (467). LEAST FLYCATCHER.
Common summer resident.

Suborder OSCINES. Song Birds.

FAMILY ALAUDIDÆ. LARKS.

Genus OTOCORIS Bonaparte.

158. **Otocoris alpestris** *(Linn.)* (474). HORNED LARK; "SHORE LARK."

Common during the vernal and autumnal migrations.

FAMILY CORVIDÆ. CROWS, JAYS, MAGPIES, ETC.

Subfamily GARRULINÆ. Magpies and Jays.

Genus CYANOCITTA Strickland.

159. **Cyanocitta cristata** *(Linn.)* (477.) BLUE JAY.
Common resident.

Genus PERISOREUS Bonaparte.

160. **Perisoreus canadensis** *(Linn.)* (484.) CANADA JAY; "MOOSE BIRD;" "WHISKEY JACK."

Abundant resident. Breeds in March. The young are almost black in colour.

Subfamily CORVINÆ. Crows.

Genus CORVUS Linnæus.

161. **Corvus corax principalis** *(Ridg).* (486). NORTHERN RAVEN.

Common resident. Builds its nest in February and incubation goes on during March. We follow Mr. Chamberlain in adopting the above name for this sub-species in place of *C. Corax sinuatus*. Vide Canadian Birds, and Ridgway's Manual of N. A. Birds.

162. **Corvus americanus*** *Aud.* (488). AMERICAN CROW.
Common resident.

FAMILY ICTERIDÆ. BLACKBIRDS, ORIOLES, ETC.

Genus DOLICHONYX Swainson.

163. **Dolichonyx oryzivorus** *(Linn.)* (494). BOBOLINK.
Common. Summer. Breeds on all our marshes.

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* Crows have been shot on the coast, which, from their small size, I consider were Fish Crows; but, in the absence of specimens, and in view of the differences of opinion held by naturalists as to its occurrence here, I have omitted this bird from our list until further proof is adduced.

Genius AGELAIUS Vieillot.

164. **Agelaius phœniceus** (*Linn.*) (498). RED-WINGED BLACKBIRD.

Very rare. Summer resident. A few occur in the western part of the Province.

Genus STURNELLA Vieillot.

165. **Sturnella magna** (*Linn.*) (501). MEADOWLARK.

Very rare. Only a mere straggler. One was shot at Stewiacke.

Genus SCOLECOPHAGUS Swainson.

166. **Scolecophagus carolinus** (*Mull.*) (509). RUSTY BLACKBIRD; "RUSTY GRACKLE."

Common summer resident.

Genus QUISCALUS Vieillot.

Subgenus QUISCALUS.

167. **Quiscalus quiscala æneus** (*Ridgw.*) (511 b). BRONZED GRACKLE.

Rare. Three of these birds are all that come under my notice. One was shot near my pond at Dutch Village, another at Block House (Standford's) Pond, and a third at Cornwallis.

FAMILY FRINGILLIDÆ. FINCHES, SPARROWS, ETC.

Genus PINICOLA Vieillot.

168. **Pinicola enucleator canadesis** (515). AMERICAN PINE GROSBEAK.

Common in winter. Breeds in Newfoundland.

Genus CARPODACUS Kaup.

169. **Carpodacus purpureus** (*Gmel.*) (517). PURPLE FINCH.

Common. A few stop with us all winter. It is known to the country people under the name of "Red," or Grey Linnet."

Genus LOXIA Linnæus.

170. **Loxia curvirostra minor** (*Brehm.*) (521). AMERICAN CROSSBILL.

Common. Arrives after the breeding season.

171. **Loxia leucoptera** *Gmel.* (522). WHITE-WINGED CROSSBILL.

Irregularly abundant after the breeding season. This year

(1888) they are very common indeed. Judge Ritchie informs me that this bird was breeding at St. John, N. B., in February.

Genus ACANTHIS Bechstein.

172. Acanthis linaria (*Linn.*) (528). REDPOLL.
Rather common in winter. Breeds north.

Genus SPINUS Koch.

173. Spinus tristis (*Linn.*) (529). AMERICAN GOLDFINCH.
Common. Breeds in the Province. A few remain all winter.

174. Spinus pinus (*Wils.*) (533). PINE SISKIN; "PINE FINCH."
At one time common, then, from some unknown cause, they became rare, and now are again appearing in their former abundance. Mr. W. Winton obtained a nest of this species with eggs in it in the month of March. Summer resident.

Genus PASSER Brisson.

175. Passer domesticus (*Linn.*) EUROPEAN HOUSE SPARROW.
Recently introduced. Common resident.

Genus PLECTROPHENAX Stejneger.

176. Plectrophenax nivalis (*Linn.*) (534). SNOWFLAKE; "SNOW BUNTING."
Becoming rather scarce. Formerly abundant in winter. Arrives with the first snow-storm, and departs about the beginning of March. Breeds in the Arctic regions.

Genus CALCARIUS Bechstein.

177. Calcarius lapponicus (*Linn.*) (536). LAPLAND LONGSPUR.
Mr. Jones shot some of these birds at Cole Harbor. This is the only instance of its occurring in Nova Scotia that has come under our notice.

Genus POOCÆTES Baird.

178. Poocætes gramineus (*Gmel.*) (540). VESPER SPARROW; "GRASS FINCH;" "BAY-WINGED SPARROW."
Common summer resident. In fields.

Genus AMMODRAMUS Swainson.

Subgenus PASSERCULUS Bonaparte.

179. Ammodramus sandwichensis savanna (*Wils.*) (542 a.) SAVANNA SPARROW.

Uncommon. Passes through the Province in the spring. When running it suggests the appearance of a rat.

Subgenus AMMODRAMUS.

180. Ammodramus candacutus subvirgatus. ACADIAN SHARP-TAILED SPARROW.

I think this bird occurs in the Province.

Genus ZONOTRICHIA Swainson.

181. Zonotrichia albicollis (*Gmel.*) (558). WHITE-THROATED SPARROW; "KENNEDY BIRD;" "PEABODY BIRD."

Abundant summer resident. Its welcome song—"*Oh come pity-me, pity-me, pity-me*"—is first heard about the end of April. When walking through the woods late at night, this bird is sometimes heard to break forth into his sweet and plaintive lay, as though unconscious of the darkness which hangs in the trees around.

Genus SPIZELLA Bonaparte.

182. Spizella monticola (*Gmel.*) (559). TREE SPARROW.

Common winter visitor. Breeds in the north.

183. Spizella socialis (*Wils.*) (560). CHIPPING SPARROW.

Lately became rather common. Summer. Builds in Mr. Nisbit's grounds and other favourable localities.

184. Spizella pusilla (*Wils.*) (563). FIELD SPARROW.

Not very common. A few observed about Mr. W. Winton's place. Breeds here. Summer resident.

Genus JUNCO Wagler.

185. Junco hyemalis (*Linn.*) (567). SLATE-COLOURED JUNCO; "BLACK SNOWBIRD."

This is one of the commonest birds we have. It breeds everywhere. Resident. Locally called the "Blue-bird."

Genus MELOSPIZA Baird.

186. Melospiza faciata (*Gmel.*) (581). SONG SPARROW.

Very common. A few remain all winter. Sometimes called "Spring Bird" by the country people.

187. Melospiza lincolni (*Aud.*) (583). LINCOLN'S SPARROW.
Not uncommon inland. Summer resident.

188. Melospiza georgiana (*Lath.*) (584). SWAMP SPARROW.
Common summer resident.

Genus PASSERELLA Swainson.

189. Passerella iliaca (*Merr.*) (585). FOX SPARROW; "FOX-BIRD."

Common during the vernal and autumnal migrations. Breeds about the fish-flakes of Newfoundland. Sometimes called "Tom Fox" by the country people.

Genus HABIA Reichenbach.

190. Habia ludoviciana (*Linn.*) (595). ROSE-BREASTED GROSBEAK.

Not common about Halifax, but of more frequent occurrence in the vicinity of Truro and Pictou. Summer resident. Frequents hardwood hills. It is rather common in Prince Edward Island.

Genus GUIRACA Swainson.

191. Guiraca cærulea (*Linn.*) (597). BLUE GROSBEAK.

Accidental. I have one specimen of this bird which was shot at the Four-mile House, Bedford Basin, in the spring.

FAMILY TANAGRIDÆ. TANAGERS.

Genus PIRANGA Vielillot.

192. Piranga erythromelas *Vieill.* (608). SCARLET TANAGER.
A few occur in the spring but generally die.

193. Piranga rubra (*Linn.*) (610). SUMMER TANAGER.

One or two instances of their having been taken in the spring has come to my notice.

FAMILY HIRUNDINIDÆ. SWALLOWS.

Genus PROGNE Boie.

194. Progne subis (*Linn.*) (611). PURPLE MARTIN.

Rare. A few are seen in spring but never stop. It is more common about Windsor.

Genus PETROCHELIDON Cabanis.

195. Petrochelidon lunifrons (*Say.*) (612). CLIFF SWALLOW; "EAVE SWALLOW."

Common summer resident. Builds its nest under the eaves of buildings.

Genus CHELIDON Forster.

196. Chelidon erythrogaster (*Bodd.*) (613). BARN SWALLOW.

Common summer resident, breeding in most of the barns of the country.

Genus TACHYCINETA Cabanis.

197. Tachycineta bicolor (*Vieill.*) (614). TREE SWALLOW; "WHITE-BELLIED SWALLOW."

Common summer resident. Breeding in boxes and holes in trees It is the earliest swallow we have, arriving here about the 23rd of April and leaving us for the south about August 10th.

Genus CLIVICOLA Forster.

198. Clivicola riparia (*Linn.*) (616). BANK SWALLOW.

Not found about Halifax, but is plentiful about the shores of the Bay of Fundy. Summer.

FAMILY AMPELIDÆ. WAXWINGS, ETC.

Subfamily AMPELINÆ. Waxwings.

Genus AMPELIS Linnæus.

199. Ampelis garrulus *Linn.* (618). BOHEMIAN WAXWING.

This bird occurred here in the winter of 1864-5. A flock of about twelve were seen near the Three Mile House, and some specimens were shot by Mr. Bellis. This is the only instance of its appearance in the Province, so far as I know. Audubon was under the impression that it was a common bird here and I had some correspondence with him on the subject.

200. Ampelis cedrorum (*Vieill.*) (619). CEDAR WAXWING.

Common summer resident. Arrives about June 1st. Feeds on apple blossoms, spiders, and berries. Locally called "Spider-bird" and "Blossom-bird."

Family LANIIDÆ. Shrikes.

Genus Lanius Linnæus.

201. **Lanius borealis** *Vieill.* (621). Northern Shrike.

Rare. I don't think it has ever been found breeding here. Occurs in winter time; always single. Have known it to carry away a snow-bunting *(P. nivalis)*, and even attack a canary which it had seen through a window.

Family VIREONIDÆ. Vireos.

Genus Vireo Vieillot.

Subgenus Vireosylvia Bonaparte.

202. **Vireo olivaceus** (*Linn.*) (624). Red-eyed Vireo.

Common summer resident. Prefers hardwood groves. Its note sounds like "*Whip Tom Kelly.*"

203. **Vireo gilvus** (*Vieill.*) (627). Warbling Vireo.

Common summer resident.

204. **Vireo solitarius** (*Wils.*) (629). Blue-headed Vireo; Solitary Vireo.

Probably occurs.

Family MNIOTILTIDÆ. Wood-Warblers.

Genus Mniotilta Vieillot.

205. **Mniotilta varia** (*Linn.*) (636). Black and White Warbler; "Black and White Creeper."

Common summer resident.

Genus Helminthophila Ridgway.

206. **Helminthophila ruficapilla** (*Wils.*) (645). Nashville Warbler.

Not very common. Summer resident.

207. **Helminthophila peregrina** (*Wils.*) (647). Tennessee Warbler.

Rather common inland (about Stewiacke, &c). Never noted as occuring near Halifax. Summer resident.

Genus Compsothlypis Cabanis.

208. **Compsothlypis americana** (*Linn.*) (648). Parula Warbler; "Blue Yellow-backed Warbler."

Rare summer resident, occurring inland in hardwood districts. I have shot several specimens; always perched on the tops of the highest maples and other hardwood trees, over brooks of running water. Mr. Egan has also obtained specimens from Grand Lake.

Genus DENDROICA Gray.

Subgenus PERISSOGLOSSA Baird.

209. Dendroica tigrina *(Gmel.)* (650). CAPE MAY WARBLER.

Very rare. The only specimen I have obtained was taken with young at Middle Stewiacke in midsummer.

Subgenus DENDROICA Gray.

210. Dendroica æstiva *(Gmel.)* (652). YELLOW WARBLER; "SUMMER YELLOW-BIRD."

Very common in gardens, etc. Summer resident. It builds a beautiful nest frequently ornamented with the red fluff of the cinnamon fern *(O. cinnamomea).*

211. Dendroica cærulescens *(Gmel.)* (654). BLACK-THROATED BLUE WARBLER.

Not common. Summer resident.

212. Dendroica coronata *(Linn.)* (655). MYRTLE WARBLER; "YELLOW RUMP WARBLER."

This is the commonest warbler we have, arriving about the 1st of May. Summer resident. It is easily kept in confinement, and may be fed on bread-and-milk and raw meat.

213. Dendroica maculosa *(Gmel.)* (657). MAGNOLIA WARBLER; "BLACK AND YELLOW WARBLER."

Abundant summer resident, arriving about the 10th of May.

214. Dendroica pennsylvanica *(Linn.)* (659). CHESTNUT-SIDED WARBLER.

Abundant summer resident. It is usually observed in hardwood groves in such localities as Herring Cove Falls or the western side of the Arm.

215. Dendroica castanea *(Wils.)* (660). BAY-BREASTED WARBLER.

Not common. Summer resident. Usually observed inland, although I have shot it at the "Rocking Stone" (Kidston's). Frequents spruce and hemlock woods.

216. Dendroica striata (*Forst.*) (661). BLACK-POLL WARBLER.
Not common. Summer resident.

217. Dendroica blackburniæ (*Gmel.*) (662) BLACKBURNIAN WARBLER.

Very rare. Summer resident. Inland.

218. Dendroica virens (*Gmel*) (667). BLACK-THROATED GREEN WARBLER.

Common in pine and spruce woods. Its note sounds like "*a little bit of bread and no cheese.*" Summer resident.

219. Dendroica palmarum hypochrysea (*Ridgw.*) (672 a) YELLOW PALM WARBLER; "YELLOW REDPOLL."

Not very common. Summer resident. This hardy bird arrives early in the season (about St. George's Day.) I have found its nest in a swamp. It jerks its tail up and down in the manner of a Wagtail.

Genus SEIURUS Swainson.

220. Seiurus aurocapillus (*Linn.*) (674). OVEN-BIRD; "GOLDEN-CROWNED THRUSH."

Common summer resident. This bird, which is a fine, loud singer, is met with in thick, sombre forests. It may be kept in confinement.

221. Seiurus noveboracensis (*Gmel.*) (675). WATER-THRUSH.
Rather common summer resident. Occurs in the vicinity of Kentville and Grand Lake. It is found about the margins of solitary lakes in the woods, and is rarely seen by common observers.

Genus GEOTHLYPIS Cabanis.

222. Geothlypis philadelphia (*Wils.*) (679). MOURNING WARBLER.

Rare about Halifax, but more common in the interior. Summer resident.

223. Geothlypis trichas (*Linn.*) (681). MARYLAND YELLOW-THROAT.

Abundant summer resident, breeding in wet places. In habits it resembles the wren.

Genus SYLVANIA Nuttall.

224. Sylvania pusilla (*Wils.*) (685). WILSON'S WARBLER; "WILSON'S BLACK CAP;" "BLACK-CAPPED YELLOW WARBLER."

Rare summer resident.

Genus SETOPHAGA Swainson.

225. Setophaga ruticilla (*Linn.*) (687). AMERICAN REDSTART.

Abundant summer resident, arriving about the 10th of May. Locally called "Gold-finch." My old friend, Charles Waterton, author of Wanderings in South America, writes, "I wonder where this little bird breeds?" He found it during the winter season in the forests of Demerara. It breeds in great numbers in Nova Scotia.

FAMILY MOTACILLIDÆ. WAGTAILS.

Genus ANTHUS Bechstein.

Subgenus ANTHUS.

226. Anthus pensilvanicus (*Lath.*) (697). AMERICAN PIPIT; "TITLARK."

Common migrant in fall only. It arrives on its way south about the 20th September, and only remains a week or ten days. I never have seen it alight on a bush. It runs about the bare pastures and perches on stone walls.

FAMILY TROGLODYTIDÆ. WRENS, THRASHERS, ETC.

Subfamily MIMINÆ. Thrashes.

Genus GALEOSCOPTES Cabanis.

227. Galeoscoptes carolinensis (*Linn.*) (704). CATBIRD.

Rather common. Summer resident. It does not arrive until the summer is well advanced. Breeds in alder swamps. Locally called "Mocking-bird."

Subfamily TROGLODYTINÆ. Wrens.
Genus TROGLODYTES Vieillot.
Subgenus ANORTHURA Rennie.

228. **Troglodytes hiemalis** *(Vieill.)* (722). WINTER WREN.

Not very common. Occuring here usually in the fall. A few breed in the Province.

FAMILY CERTHIIDÆ. CREEPERS.
Genus CERTHIA Linnæus.

229. **Certhia familiaris americana** *(Bonap.)* (726). BROWN CREEPER.

Rather uncommon. Resident.

FAMILY PARIDÆ. NUTHATCHES AND TITS.
Subfamily SITTINÆ. Nuthatches.
Genus SITTA Linnæus.

230. **Sitta carolinensis** *Lath.* (727). WHITE-BREASTED NUTHATCH.

Rather common summer resident.

231. **Sitta canadensis** *Linn.* (728). RED-BREASTED NUTHATCH.

Fairly common. Resident. Associates with the chickadees.

Subfamily PARINÆ. Titmice.
Genus PARUS Linnæus.
Subgenus PARUS Linnæus.

232. **Parus atricapillus** *Linn.* (735). CHICKADEE; "BLACK CAP-TIT."

Abundant resident.

233. **Parus hudsonicus** *(Forst.)* (740). HUDSONIAN CHICKADEE; "HUDSON'S BAY TIT."

Rather common resident. Often found in company with the last species.

FAMILY SYLVIIDÆ. WARBLERS, KINGLETS, GNATCATCHERS.
Subfamily REGULINÆ. Kinglets.
Genus REGULUS Cuvier.

234. **Regulus satrapa** *Licht.* (748). GOLDEN-CROWNED KINGLET.

Common resident. Generally found in pine woods, feeding on the larva of insects.

235. Regulus calendula *(Linn.)* (749). RUBY-CROWNED KINGLET.

Uncommon. Occurs chiefly in spring.

FAMILY TURDIDÆ. THRUSHES, SOLITAIRES, STONECHATS, BLUEBIRDS, ETC.

Subfamily TURDINÆ. Thrushes.

Genus TURDUS Linnæus.

Subgenus HYLOCICHLA Baird.

236. Turdus fuscescens *Steph.* (756). WILSON'S THRUSH; "TAWNY THRUSH;" "VEERY."

Not very common, (only inland). Breeds at Stewiacke.

237. Turdus ustulatus swainsonii *(Cab.)* (758 a). OLIVE-BACKED THRUSH.

Not as common as the Hermit Thrush. Summer. Builds its nest in a bush and lays four or five freckled eggs.

238. Turdus aonalaschkæ pallasii *(Cab.)* (759 b). HERMIT THRUSH.

Abundant summer resident. Its sweet yet melancholy song has caused it to be locally termed the "Nightingale." It lays four unspotted eggs of a bluish colour. Nest on ground. I have kept this bird in confinement.

Genus MERULA Leach.

239. Merula migratoria *(Linn.)* (761). AMERICAN ROBIN.

Abundant summer resident, arriving about the 17th of March. Many of them pass through the Province and breed in Newfoundland. A few stragglers remain all winter. It is one of the commonest birds we have.

Genus SIALIA Swainson.

240. Sialia sialis *(Linn.)* (766). BLUEBIRD.

Uncommon. I have seen it breeding in an apple tree at Kentville. It appears to be getting a footing in Nova Scotia.

NOTE I.

Special List, giving the Species known to breed in Nova Scotia.

(The numbers refer to the previous Catalogue.)

4, 7, 10, 21, 22, 26, 27, 32, 36, 37, 38 (?), 40, 41, 44, 52, 56, 64, 75, 76, 87 (?), 89, 90, 102, 104, 111, 113, 114, 115, 117, 118, 119, 120, 124, 127, 128, 129, 132, 134, 135, 138, 139, 140, 141, 142, 143, 144, 145, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 159, 160, 161, 162, 163, 166, 169, 173, 174, 175, 178, 181, 183, 184, 185, 186, 187, 188, 190, 194 (?), 195, 196, 197, 198, 200, 202, 203, 205, 206, 207, 209, 210, 211, 212, 213, 214, 215, 216, 218, 219, 220, 221, 222, 223, 225, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240.

Other species probably breed occasionally, but are not known to do so.

NOTE 2.

Chen hyperborea (70). Lesser Snow Goose. Through the kindness of the present possessor of these birds, we are enabled to give the following description, which will enable others to decide for themselves as to its specific identity :—

Description :—Bill much higher than broad at base and rising high on the forehead and towards the eye; tip consisting of a large convex decurved nail; sides with deep longitudinal furrows, in one of which is situated the nasal aperture. Lower edge of upper mandible much arched; the teeth showing prominently *without* the edge of the lower mandible. Tarsus much longer than bill; tip of hind toe reaching to the ground. Wings long; reaching to about the end of the tail. Tail rounded, of sixteen (?) feathers.

Colour:—Bill, dark blackish brown; nail lighter. Iris dark. Legs brown. Head and upper part of neck white, with a dusky reddish stripe passing from the bill through the eye and meeting on the nape a like-coloured, but broader, stripe, which proceeds from the crown, and, becoming more narrow, passes down the back of the neck to the shoulders. Lower part of neck and sides of body ashy. Back and greater part of wing coverts dark ash (darker in male) each feather with a lighter margin. Primaries black at the ends; shafts whitish to within a short distance of the tip. Secondaries blackish, broadly margined with white. The rest of the wing, from the carpal angle to the beginning of the black portion of the primaries, pure white. Tail pure white, with a rusty tinge near the vane of each feather. Upper and lower tail coverts and body beneath white.

Total length of male, 27; wing, 15; tarsus, 2.8; bill along ridge, 2.1; ditto along gape, 2.1; height of bill at base, 1.2.

Total length of female, 26; wing 14.6; tarsus, 2.7; bill above, 2.1; ditto along gape, 1.9; height of bill, 1.1.

I am not a book-naturalist, and the above catalogue is simply given as the result of sixty-six years of *practical field work*, during which time few of our birds could have escaped coming to my knowledge.

ARRANGED AND EDITED BY HARRY PIERS.

ERRATA.

Page 142, before the title insert *Appendix*.
" " omit *Art. IV.* and *Read May 14, 1888*.
" " line 14, for *Holboellii* read *Holbœllii*, and for *Holboell's Grebe* read *Holbœll's Grebe*.
" 143, line 9 from bottom, for (*Linn.*) read *Linn*, and insert (*32.*) *Razor-billed Auk*.
" " line 6 from bottom, insert (*33.*)
" 144, line 3, insert (*34.*)
" " line 7, for *Stercorarucæ* read *Stercorariidæ*.
" " line 9, insert (*35.*)
" " line 17, for *Ferns* read *Terns*.
" " line 10 from bottom, for *Linnaeus* read *Linnæus*.
" " line 9 from bottom, for (*Brmnn.*) read (*Brunn.*)
" " line 6 from bottom, for (*Faber.*) read *Faber*.
" 145, line 15, for *Boil* read *Boie*.
" " line 16, for (*Lepech.*) read *Lepech*.
" " line 19, for (*Linn.*) read *Linn*.
" " line 23, for (*Brunn.*) read *Brunn*.

PROCEEDINGS

OF THE

Nova Scotian Institute of Natural Science.

VOL. VII. PART III.

Provincial Engineer's Office,
Halifax, 10th Oct., 1888.

ANNIVERSARY MEETING.

MARTIN MURPHY, Esq., *in the Chair.*

The Minutes of the last Anniversary Meeting were read and approved.

Dr. HONEYMAN moved that a committee be appointed to convey to the family of the late J. M. JONES, F. L. S., the sympathy of the I. N. S. in their recent bereavement. He referred at length and in fitting terms to the valuable scientific labors of the deceased, who was one of the founders of the Institute, and always one of its ablest supporters. The motion passed. Drs. HONEYMAN and MACGREGOR were appointed on the committee.

Dr. HONEYMAN laid on the table the Transactions for the year 1887–'88.

The Treasurer's accounts were audited and found correct.

Mr. HARRY PIERS was proposed for membership.

The following members were elected as Officers and Councillors for the ensuing year:

PROF. J. G. MACGREGOR—*President.*
MARTIN MURPHY, Esq., C. E.—*1st Vice-President.*
A. H. MCKAY, A. B., B. SC.—*2nd Vice-President.*
DR. HONEYMAN—*Corresponding Secretary.*
ALEXANDER MCKAY—*Recording Secretary.*
W. C. SILVER, Esq.—*Treasurer.*
E. GILPIN, F. G. S., M. BOWMAN, Esq., J. J. FOX, Esq., WM. GOSSIP, Esq., H. W. W. DOANE, Esq., and J. SOMERS, M. D., *Councillors.*

On motion the appointment of Librarian was left to the Council.

PROVINCIAL ENGINEER'S OFFICE,
November 12, 1888.

PROF. MACGREGOR, *President, in the Chair.*

Inter alia.

The President read an opening address, which, on motion, was referred to a committee for early publication.

Dr. HONEYMAN read a paper entitled—"A Geological Recreation in Massachusetts Centre, U. S. A."

ART SCHOOL, *Dec.* 10, 1888.

PROF. MACGREGOR, *President, in the Chair.*

Inter alia.

Mr. HARRY PIERS read a paper—"Larva of May Beetle with Parasitical Fungus."

The PRESIDENT read a paper—"Carnot's Cycle in Thermodynamics."

ART SCHOOL, *Jan.* 14, 1889.

PROF. MACGREGOR, *President, in the Chair.*

Inter alia.

Dr. HONEYMAN read a paper—"Glacial Boulders of our Fisheries, and Invertebrates attached and detached."

DALHOUSIE COLLEGE, *Feb.* 11, 1889.

PROF. MACGREGOR, *President, in the Chair.*

Inter alia.

Dr. PATTERSON read a paper—"The Stone Age in Nova Scotia, as illustrated by a collection of relics presented to Dalhousie College." He submitted a large and varied collection of stone implements, copper knives, ancient crockery, &c.

ART SCHOOL, *March* 11, 1889.

PROF. MACGREGOR, *President, in the Chair.*

Inter alia.

H. S. POOLE, F. G. S., read a paper—"Ice in the Carboniferous Period."

A paper written by MR. E. GILPIN, was read by the PRESIDENT. The paper was entitled—"The Geology of Cape Breton. The Minerals of the Carboniferous.—Part IV."

ART SCHOOL, *April* 8, 1889.

M. MURPHY, ESQ., *Vice-President, in the Chair.*

Inter alia.

A motion was passed referring in appropriate terms to the death of the late WM. GOSSIP, for several years Secretary and President of the Institute.

Mr. MARTIN MURPHY read a paper—"Terrestrial Magnetism."

Dr. HONEYMAN submitted a paper—"Nova Scotian Echinodermata."

ART SCHOOL, *May* 13, 1889.

PROF. MACGREGOR, *President, in the Chair.*

Inter alia.

Dr. HONEYMAN read a paper—"Two Cable Hauls of Marine Invertebrates by the Cable Steamer Minia, Capt. Trott, Commander."

Mr. HARRY PIERS read a paper—"Aboriginal Remains of Nova Scotia, illustrated by the Provincial Museum Collections."

LIST OF MEMBERS.

DATE OF ADMISSION:

1873. Jan. 11. Akins, T. B., D. C. L., Halifax.
69. Feb. 15. Allison, Augustus, *Meteorologist*, Halifax.
86. Nov. 3. Bennett, Joseph.
64. Dec. 20. Brown, C. E., Halifax.
84. Mch. 13. Bowman, Maynard, Public Analyst, Halifax.
84. Nov. 10. Campbell, G. M., Truro.
87. April 1. Colonel Coates.
84. April 13. Denton, A. J., Academy, Halifax.
65. Oct. 26. DeWolfe, J. R., M. D., L. R. C. S. E., Dartmouth.
86. Nov. 3. Doane, Harvey W. W., Halifax.
63. Feb. 5. Downs, Andrew, M. Z. S. London, Taxidermist, Halifax.
83. Mch. 14. Forbes, John, Halifax.
83. Mch. 12. Foster, James G., Barrister, Dartmouth.
82. May 8. Fox, John J., Halifax.
88. Jan. 9. Fyshe, Thos., Halifax.
73. April 11. Gilpin, Edwin, F. G. S., F. R. S. C., Deputy Commissioner of Mines.
63. Jan. 5. Gilpin, J. Bernard, M. D., M. R. C. S. Lond., F. R. S. C.
81. Dec. 12. Hare, A. A., Bedford.
67. Dec. 3. Honeyman, Rev. D., D. C. L., F. R. S. C., F. S. Sc. Lond., &c., *Secretary*, Curator of the Provincial Museum, Halifax.
82. April 12. Keating, E. H., City Engineer, Halifax.
85. Jan. 11. Laing, Rev. Robert, Halifax.
64. Mar. 7. Lawson, George, Ph.D., LL.D., F. I. C., F. R. S. C., Prof. of Chemistry and Mineralogy, Dalhousie College, Halifax.
81. Mch. 14. Macdonald, Simon D., F. G. S., Halifax.
77. Jan. 11. MacGregor, J. G., D. Sc., F. R. SS. C. and E., *President*, Prof. of Physics, Dalhousie College, Halifax.
72. Feb. 5. McKay, Alex., *Secretary*, Supervisor of Halifax Public Schools, Dartmouth.
85. Oct. 11. McKay, A. H., B. A., B. Sc., &c., *Vice-President*, Principal of Halifax Academy, Halifax.
78. Nov. 1. McLeod, John, F. S. Sc. London, Demerara.

DATE OF ADMISSION:

1870. Jan. 15. Murphy, Martin, C. E., Provincial Engineer, *Vice-President*, Halifax.
88. Nov. 2. Piers, Harry, Halifax.
79. Nov. 11. Poole, H. S., Associate of the Royal School of Mines, F. G. S., Gen. Sup. of Pictou Coal Mines, Stellarton, Pictou Co.
65. Jan. 8. Rutherford, John, M. E., Stellarton, Pictou Co.
64. May 7. Silver, W. C., *Treasurer*, Halifax.
87. Dec. 12. Silver, A. P., Halifax.
75. Jan. 11. Somers, John, M. D., Halifax.
85. Jan. 12. Stewart, John, M. D., Pictou.
85. Mar. 9. Uniacke, Robert J., C. E., Halifax.
89. May 3. Wilson, R. J., Secretary School Board, Halifax.

ASSOCIATE MEMBERS.

88. Mch. 6. Faribault, E. R., C. E., Ottawa.
81. Nov. 13. Harris, C., Prof. of Civil Engineering, Royal Military College, Kingston, Ontario.
82. Nov. 9. Kennedy, Professor, King's College, Windsor.
82. Mch. 31. McKenzie, W. B., Engineer, Moncton, N. B.
78. Mar. 12. Patterson, Rev. G., D. D., New Glasgow.
84. April 4. Pineo, A. J., Kentville.

CORRESPONDING MEMBERS.

77. Nov. 19. King, Major, R. A., Halifax.
71. Nov. 29. Ball, Rev. E., Tangier.
87. Dec. 30. Duns, J., Professor, New College, Edinburgh.
71. Oct. 12. Marcou, Jules, Cambridge, Mass.
80. June 10. McClintock, Sir Leopold, Knt., F. R. S., Vice-Admiral.
77. May 12. Weston, Thomas C., Geological Survey of Canada.

LIFE MEMBER.

Parker, Hon. Dr., M. L. C., Halifax, N. S.

OPENING ADDRESS.

By Professor J. G. MACGREGOR, President.

Members of the Institute of Natural Science:

I take this, the earliest opportunity which has presented itself, of thanking you for the honour you have shown me, in electing me to the Presidency of the Institute. To be asked to preside over the work of a number of earnest men, however few, must always be a source of gratification. The invitation to preside over your work at the present time is especially so, because of the critical point which the activity of the Institute seems to have reached. We have recently had the misfortune to lose some of our most active members, and so far as we can see there are few young men who are ready to take their places. For this reason the Presidency of the Institute at present should involve much more onerous duties than ever before, and I undertake to discharge them, only because I know that, though there are few active scientific workers left among us, those few are willing and ready to exert themselves to the utmost.

I have looked recently somewhat fully into our history, and find that, since its first meeting in 1863, this Institute has published about 304 papers, dealing for the most part with the Natural History and Geology of the Province of Nova Scotia, and averaging about 9 pages each. It is interesting to know how these papers have been distributed in time, and I have therefore plotted two curves, shewing, one, how the number of papers, and the other, how the number of pages, in our Transactions, has varied with the years. These you see before you; and they shew that our Institute has had its ups and downs. Judging by numbers of papers, you see that the time of our greatest activity was the first few years of our existence, that since 1867 we have kept oscillating about an average of about 11 papers a year, never getting far above that number and never falling far below it, that the year of greatest intellectual dearth was 1875, and that, during the last few years we have been below the average. If we remember that in the first few years we published regularly papers on our local meteorology, and that now all such returns are made to the Meteorological Bureau and published by the Legislature, it would appear that for the last 20 years we have kept at a pretty uniform level, and that at present we are but little below it. The other curve, the curve of pages, has an interest of its own. It shews much greater variations than the curve of papers, the Transactions having been much bulkier in some years than in others. In 1866, 1869, 1873, 1876, and 1878, our members scattered the silver of speech with lavish hand, but since 1878 we seem to have realized that though speech may be silver silence is gold; and it is a somewhat remarkable fact that, though since 1868 the number of papers has not in any year varied very much from the average, the average length of papers between 1868 and 1879 was nearly twice as great as between 1879 and the present time. Of course the falling off is by no means an indication of lethargy. It is possibly due to a growing power of perceiving rubbish, and a consequent growing determination to eliminate it.

On the whole the record which these curves show is not satisfactory. The activity of the Society ought to have been gradually increasing; instead of that, it has been gradually diminishing, until now we find ourselves not only making no progress, but even falling somewhat below the records of former years. And this just means as I said at the outset, that the older workers in our Institute are passing away, and that few young men are coming forward to take their places.

If we ask why this is, it must be noted that in the early history of a country, it is a comparatively easy matter to make additions to the knowledge of its local Natural History and Geology, the two departments in which the work of the Institute for the most part lies. The knowledge of the geographical distribution of its plants and animals, for example, makes at first very rapid strides, but progresses more slowly as time goes on. The discovery of new species becomes more and more rare and the recognition of new species as new involves ever increasing research. So, also, the main features of the geological character of a new country are apparent even to an observer who is provided with no large stock of geological lore, whereas when the surface problems are solved and more intricate questions come to be investigated, their solution is found to require thorough knowledge and deep research. We cast no slur upon the early workers in the Natural Science of this Province when we say that much of their work was of a character that required no very thorough scientific training. Nor do we glorify ourselves when we assert that in these latter days the problems that confront us are, in general, of a higher and more difficult order than those which naturally first presented themselves for solution.

Unfortunately, scientific education in Nova Scotia has not kept pace with scientific investigation; and now, when progress in our local scientific knowledge demands more thorough training than in former years, we find ourselves with no body of young men whom our Schools and Colleges have provided with the necessary training, and with but few who have had the energy to train themselves. We lack even the constituency which most scientific societies find in the Colleges themselves. If we look through the records of such societies, we find that usually a large proportion of their memoirs are contributed by College Professors, men who are appointed not only to teach but to extend the bounds of the departments of science which they profess, and who for that purpose are enabled to devote their whole attention to comparatively small departments. Our Colleges are so small and so poorly equipped that in general their Professors require to teach, and therefore to spend their time in studying, several subjects instead of one. And it is consequently almost impossible for them, however able they may be, to lend a hand in work such as our Institute was founded to foster. When our Colleges, either by acquiring large endowments or by combining their small endowments, become able to allow their scientific Professors to devote themselves to special departments of Science, we may expect the golden age of the Institute of Natural Science to begin. Meantime we must look elsewhere for the most of our recruits.

There is one source from which we may hope that before long a considerable number of recruits may be drawn, and that is from the teachers of the schools and academies of the Province. From our point of view it is most hopeful that the necessity of introducing Science-teaching into the schools is being more and more clearly perceived by our teachers, and that they are making great efforts to acquire the knowledge that is necessary for its introduction. The Summer School of Science, which leading men among them have established, will not only assist them in preparation for their educational duties, but must in some cases produce an interest in scientific work which will lead to still greater results. The many will of course fit themselves merely to teach, but the few will fit themselves to investigate. And the public-spirited men who devote their vacations to assisting their colleagues to prepare for the more thorough discharge of their academic duties, may have the satisfaction before long of finding that some of the seed they have sown is springing up and bearing fruit worthy of being preserved in the Transactions of our Institute.

There seems, therefore, to be ground for hope that, by the aid of Teachers in our Colleges and Schools, and of laymen with leisure and taste for scientific work,—some of whom have been our main supporters in the past,—we may be able at present to maintain, and in future to increase, the activity of our Institute. Where there is interesting work to be done, we may have confidence that workers will not fail.

And that leads me to attempt to make a synopsis of the work which the Institute has to do, to ask how far we have been doing it, and to make some suggestions as to the best mode of doing those portions of it which seem hitherto to have been left undone.

Our work may be said roughly to be three-fold—(1) Investigating; (2) Stimulating the love of investigation; and (3) Providing the means of investigating.

The first and purely scientific part of our work is the extension of our knowledge of Natural Science, more particularly of the Natural Science of our own Province, by original investigation. To a great extent this must be the outcome of the knowledge and tastes and resources of individual members of the Institute, each member following the bent of his own inclination and doing the work which falls to his hand, while the Society aids by providing sympathetic criticism. This is the work which the Institute has hitherto for the most part done, with what result our Transactions bear witness. It is not permitted unto us to glory, but we may nevertheless say that a large amount of this individual work has been done. And while our publications contain much that on looking back we would wish had never seen the light, they contain still more in which the most rigorous critic can take delight, and feel a justifiable pride.

There are a great many important scientific problems, however, which cannot be solved by the isolated work of individuals, but require the concerted action of a great many observers, not necessarily highly skilled observers, but intelligent men, working under the guidance of one who is able to direct them as to what they should observe, and to record and systematise their observations. This collective form of work has been attempted only to a very limited extent by the Institute, owing probably to the difficulty of securing the necessary observers. But if this difficulty could be overcome,—and now that our teachers are obtaining a knowledge of the elements of science, it would seem to be more easily overcome than heretofore,—we might very largely increase the "output" of our Society. I may mention as a subject requiring for its proper elucidation the combined observations of many observers, the occurrence of luminous meteors. Any person with such knowledge of the constellations as may be obtained from a fairly good star-atlas could describe the apparent path of a meteor in the heavens, and the comparison of the apparent paths as seen by different observers would shew what the actual path had been. Now, had we, scattered over the Province, a large body of correspondents who would send us descriptions of the appearance, positions, directions, &c., of such meteors as they might see, we might add greatly to our knowledge of this interesting subject. In the department of meteorology good work might be done by correspondents who would send us extracts from the log-books of ships, descriptive of unusual meteorological phenomena. Had we funds to supply such correspondents with simple instruments we might get valuable data with regard to magnetic and tidal phenomena. But as the funds are wanting the collective investigation of phenomena requiring them is beyond our powers.

In the departments of Natural Science there would seem to be many subjects in which collective investigation is both necessary and possible. I would suggest merely observations of the times of the flowering of plants, the migration of birds, the movements of fish, the first appearance of insects, a systematic record of which would seem to be comparatively easy to obtain and would certainly throw much light both on the life history of the plants and animals themselves and on the variation of our climate.

It would seem to be eminently desirable, not only that our Institute should itself undertake the superintendence of some forms of collective work of this kind, but also that it should induce other Canadian Societies to co-operate with it, and perhaps prevail upon the Royal Society of Canada to collect and systematise the results which the local Societies might be able to supply year after year.

Besides purely scientific work, a Society such as ours, which exists in a community as yet but slightly developed in the direction of scientific education, ought to do something towards stimulating outsiders to an interest in scientific work; and not only ought to do so, in fact must do so, if it is to have a successful career. The stimulating in the non-scientific a desire to become scientific can be done only by making some or all of our meetings more popular and more attractive than the ordinary meeting of a Scientific Society usually is. Outsiders are accustomed to think of us as a lot of old fossils engaged in riding hobby horses in the form of insects and plants, and birds and rocks, and bringing occasionally to light facts of more or less utility. Because of the utility of our work we receive a little monetary assistance; but countenance and encouragement and the opportunity of making proselytes, such as attendance at our meetings would provide, are but rarely given us. And that is as much our misfortune as our fault. For the discussion of a scientific paper in general is conducted, and must in many cases be conducted, in a language whose technical terms render it unintelligible to all but the initiated. It would appear therefore, that our ordinary meetings, which must be devoted to the hearing and discussing of new and somewhat recondite things, cannot readily be rendered wholly popular. And accordingly it has been proposed that we should devote some evenings to popular lectures or to conversaziones, or that we should organize excursions of a scientific kind. Doubtless, popular lectures and excursions have their merits and should not be neglected; but we would probably get at the few outsiders who have observational tastes more readily, if we could render the ordinary meeting of the Institute sufficiently attractive to make them regular attendants. And it is in this direction that the Institute has lately been moving. It may not be generally known that we are endeavouring now to make our ordinary monthly meetings more popular than they have hitherto been by the introduction of what may be called popular prefaces to the various scientific papers that may be read and discussed. We invite the readers of papers in fact to prepare introductions which will enable even their non-scientific hearers to understand the work of which the papers are to give an account, and to describe the contents of the papers in as untechnical language as possible. Men differ very much of course in their power of complying with this invitation. But in many cases the result has been quite successful, and audiences which contained but few persons who possessed any previous knowledge of the subject under consideration, have appeared to follow and enjoy the whole discussion. I think that the most of us feel that our efforts in this direction have been sufficiently successful to warrant our continuing them, and persons who have scientific inclinations but no extensive knowledge, may therefore henceforth attend our meetings with the assurance that the time devoted to them will not be thrown away.

The third department of our work consists in providing for investigators to as great an extent as possible the means of investigation. And this we are doing with greater or less success in a variety of ways.

First, it is above all things necessary that investigators should know all that has been already discovered in connection with the Natural Science of the Province; and this involves the publication, from time to time, of such papers read before the Institute, as may be considered to contain new and well established results. Hence for the last quarter of a century our "Proceedings and Transactions" have been published year by year. It is often difficult to determine whether or not the results contained in any paper are really new and really well established, and doubtless occasionally papers are published whose contents do not possess these characteristics. But on the whole our Transactions will be found to be a record of continuous advances made in the knowledge of the Natural Science of Nova Scotia; and it is a source of legitimate gratification to us to find that scientific men and scientific societies all over the world welcome our publications gladly, and are ready to send us in exchange for them, publications, I will not say of much greater value, but certainly of much greater magnitude and of much greater cost.

Secondly, it is necessary that investigators should have access to collections of specimens of the various species of plants, animals, minerals, etc., which have so far been discovered in Nova Scotia, together with similar specimens found in other countries, for purposes of comparison. And it is therefore the duty of the Institute to see that the Province possesses a well filled and well arranged museum. Fortunately, however, this part of our work has been to a large extent taken out of our hands by an intelligent Legislature which itself has provided the public with a museum, and has put an experienced scientific man at its head; and our work in this department, therefore, consists in giving him such assistance as we can in adding to his collecti ns. If the fact that we do make efforts in this direction gives us the right to make suggestions, we might suggest that since the Legislature has provided the collections and a curator to look after them, it should complete its work by providing a local habitation in which they might be advantageously exhibited. The room at present set apart for this purpose is so small that a study of the specimens which it contains is attended by great difficulty, while the arrangement of typical collections for the use of students of the elements of Natural Science is well nigh impossible; and thus the very object with which the collections have been made is to a large extent rendered unattainable by the lack of suitable accommodation. Apart from this defect, however, it is a matter of great consequence to our Society that the Legislature has taken off its hands the work of forming a Museum. For it is, I believe, the experience of local scientific societies in Great Britain, that the expenses connected with the maintenance of Museums are in general too heavy for them, and that too often they are crushed by the weight of the material which they collect.

Thirdly, it is necessary that investigators should have means of informing themselves of the progress which Natural Science is making in other countries, and it thus becomes the duty of the Institute to collect a Library of scientific publications giving accounts of what is being done in Natural Science all over the world. Could such publications be obtained only by purchase, it would be quite impossible for the Institute with its limited income to form any adequate collection of the kind referred to. But fortunately a large portion of them can be obtained at slight expense so long as we exhibit a reasonable activity ourselves and continue to publish Transactions of scientific value. For, as stated above, foreign Societies will in that case be ready and willing to send us their publications in exchange for ours. The value of such publications, not only to the scientific investigator but also to the practical man engaged in pursuits whose methods improve with the increase of our knowledge of Natural Science, such as mining, agriculture, fishing, manufactures, etc., cannot be over-estimated ; and from this point of view alone it is important that our Transactions should be kept at least up to their present volume and value.

For many reasons the publications which have accumulated during the last seventy-five years have neither been so numerous as they might have been, nor so well preserved as they should have been; and, for want of proper cases and rooms, they have been lying in a state in which it was impossible to use them. Lately, however, the Institute has been engaged in reducing them to order, and has bound up all the volumes which were found to be complete. It is our intention now to get as many as possible of the incomplete works rendered complete, and to add largely to our list of exchanges; so that if we are able to maintain the publication of our own Transactions, we shall very soon acquire a valuable Library of the Transactions of other Societies.

There are many works, however, in which records of progress in Natural Science are contained, which cannot be obtained in this way, but must be purchased; and in cases in which such works are too expensive to be purchased by individual investigators, and are required for purposes of investigation, it would seem to be the duty of the Institute to obtain them. Here our poverty makes judicious selection necessary. But it may be hoped that as our Library increases and is found to be of practical utility, funds available for this purpose may be found also.

And lastly, it is desirable, if not necessary, that in many cases the Institute should provide for investigators instruments which are too costly to be purchased by individuals themselves. Our funds have always been too small to enable us to make any extensive provision of this kind. We have recently, however, purchased an excellent microscope for the use of our members,—such an instrument as individual members could not be expected to purchase for themselves,—and good work has already been done by means of it. There are many instruments of this kind that the Institute ought to possess, and that doubtless will be acquired as time goes on and funds increase.

Such, then, is a rough sketch of the work which, as I conceive it, the Institute has to do; and it will be seen that while in some departments we have been active and successful, in others we have not done so much. Even now, it may not be possible for us to put much energy into all. But, it is well, nevertheless, that we should compare what we are doing with what a Society such as ours ought to be doing. For such comparison must result in a desire to do more and better work.

While referring to the many things which we have left undone in the past, I must urge in our behalf that, few though we have been, we would have done much more, and few though we still are, we could look forward with greater expectations, were it not for the smallness of our income. But we are hampered on all sides for want of funds. We ought to have a commodious meeting place with our books on the walls and our working materials easy of access. As it is we have no room we can call our own, but are indebted to one Government official for the use of his office once a month and to another for allowing us standing room for our book cases in a corridor. We ought to have a paid librarian and secretary to take charge of books and instruments and conduct our correspondence, whereas these onerous duties are discharged by volunteers. We ought to be able to stock our Library with books of reference and costly publications of all kinds, whereas the purchase of a new book is a great event in our history. We ought to be able to furnish our members with expensive instruments, whereas, so far, we have been able to purchase but one. Had we the funds at command there are many ways, to which I have not even referred, in which they might be advantageously expended. I may mention the making of grants to assist in defraying the expenses of experimental investigations of great public utility, as for example, the introduction into our Nova Scotian climate of foreign plants useful for manufacturing purposes, and the offering of prizes for memoirs of practical value, as for example, on the raw materials for manufactures which our Province supplies. Such modes of stimulating research have been tried with much success in other countries, and could we adopt them, would doubtless be found equally successful here. Perhaps our Institute has been too backward in the past in making its wants and wishes known. And it may therefore be well that we should let it be known that no man who is looking about him for a public-spirited mode of investing capital can do better than establish for us a Library Fund or a Prize Fund.

I fear I have already kept you too long from the main work of this evening. Let me therefore in conclusion simply express the hope that the Session which we are now beginning may be one of great productivity and of unusual progress.

TRANSACTIONS.

ART. I.—A GEOLOGICAL RECREATION IN MASSACHUSETTS CENTRE, U. S. A. BY REV. D. HONEYMAN, D. C. L., F. R. S. C., F. S. SC., F. G S. A., &c. *Curator of the Provincial Museum.*

(Read Nov. 12, 1888.*)*

We left Halifax *en route* to Boston on the 1st of September. We reached Boston on the 3rd. On the same day we proceeded by the Central Massachusetts R. R. and arrived at our destination, Barrie Plains, 62 miles from Boston, or rather on the high ground above the station, Belledune.

The house is of red brick made from a clay deposit, just beyond the border of the farm. The steps are of granitic gneiss from a quarry on Rocky Hill which is on the east of the "old brick yard". The dykes which intersect the farm are largely constructed of gneisses and schists which once cumbered the fields. The solid rocks are not visible. All are covered and clothed with vegetation.

There can be little doubt however that these stones represent the underlying rocks.

Ascending to Rocky Hill I found in the rear beautiful sections of granitic gneisses, and in the front the same were seen exposed so as to reveal their granitic character and constitution. This is the so-called quarry whence the slabs were taken which we have already noticed. Out of the bands we collected fine specimens of oligoclase with attached quartz. The best specimen was picked up in a potatoe field.

These rocks were at once recognised as Laurentian—Archæan Gneisses.

In the cairns of rocks gathered from the fields I found abundance of boulders of Micaceous Schists thickly set with garnets. Finer specimens were collected from the dykes or fences.

Going from Barre Plains to New Braintree we found the garnetiferous schists, in fine outcrops on the roadside. A rock specimen collected has several garnets having an amethystine-like colour.

On the heights of Barre and around, and on the rocks which we traversed for miles we found every where rocks of allied character and considered to be of similar age.

From Rocky Hill and Barre Heights we beheld Wachussett Mountain.

This is said to be the highest mountain in Massachusetts. Its height being only conjectured by our informant, we leave it. A summer hotel on the top of it is also visible. We infer that this is the highest house in Massachusetts. As the distance from Barre is said to be only 14 miles, we propose an excursion. In anticipation we indulge in a sort of forecast. On a railway map "Pathfinder" which Mr. Matthews the Barre Plains station master kindly gave us, we note the White Mountains in New Hampshire and other lofty mountains and connect them with a hypothetical line. This extended southwards, connects Wachussett Mountain and penetrates our field. We thus infer Mount Alban or Archaean age. This is so far satisfactory.

We set out on our excursion from Barre Plains with Wachussetts in view. We descend into the valleys, lose sight of it, and lose our way. We come to station after station of the Mass. Central R. R. and consequently are on the way to Boston. Geologically our way is not lost, as we find a long succession of drift elevation sections; these are composed of boulders, sands, etc., debris of the Archæan rocks; we collect specimens of this material. Reaching the station we make enquiries after the way to Wachussett, and proceed according to directions. We come to West Rutland. In this town we observe frequent rock exposures. These appear different from any that we have heretofore observed. They are found however to be mica schists crystalline rocks—of the same Archæan series. We collect specimens. We come to Princeton height. Here we have a good exposure of granites. We examine them. They are much quarried for building. Being on the side of the public road or street, we desiderate quiet for a satisfactory examination, the more so, as a great Agricultural and Industrial Exhibition is being held and our road seems also to be a race course. Our excursion terminates. Our party after partaking of the feast in the Town Hall proceeds to examine and admire the beautiful, extensive and interesting display of the productions of Princeton and the regions around.

In admiring the extensive prospect from this commanding height, we observe Wachussett Mountain to be enveloped in mist, and our further progress terminates, to be resumed at some subsequent time. We proceed homewards, and again wander from the straight road, getting a further observation of the Archæan rocks. It is dark before we reach Barre Plains. We examine also the drift sections opposite the Barre Plains station. These are a westward continuation of those observed along the line on our way to Wachussett. We would now take a trip westward on the Central R. R. as far as Ware. Our course is nearly coincident with that of Ware river, which flows through Barre Plains. Away on the left are the heights of New Braintree, with their garnetiferous rocks already examined. On the line of railway are recurring drift accumulations exposed in sections. Reaching the Ware station we are at our destination. We look at the heights on the left. These still extend beyond Ware and then seem to terminate. The day is very hot. We only look at them and assume that these rocks are of the same character as those of Barre Plains and New Braintree. We proceed to an examination of the geology of Ware. The only rocks that are seen are in a ledge that crosses the Ware at the Cotton Mills. It is inaccessible. We go round about the town without finding any outcrop of rocks. On the south-west we climb the elevations and find that they are of drift. A sheet of water is on the opposite side. At our feet lie two portable and characteristic boulders—gneissic—distinctly banded. One is syenitic; the other granitic. They remind of boulders in the Museum, Labrador collection, and shew that the Archæan rocks of the region include both Granitic and Syenitic gneisses. In rounding the sheet of water we pass through the beautiful Cemetery, which is a continuation of the drift elevation. While the drift of Ware and the railway may be regarded as the product of glacial action, its present appearance reminds of the accumulations of the Annapolis Valley and the Boar's Back of Cumberland, which we regard as glacial drift redistributed by the action of melting ice and disastrous floods. I searched in vain for glaciation on the exposed-rock outcrops.

Still further comparison will be interesting. The rocks of Princeton and Rocky Hill, with the boulders of the Ware drift, while exhibiting differences, show at the same time sufficient points of resemblance as to establish a relationship between the Massachusetts Archæan and our own, as occurring at Arisaig and the Cobequid Mountain. In the latter especially where we have syenitic gneisses associated with granitic rocks. Vide my Papers on the Geology of the I. C. R. and the Cobequids. Trans. Vol. III, pp. 345–393.

The garnetiferous schists of Barre Plains and New Braintree have their undoubted equivalents in the Labrador rocks, as we know from the frequent occurrence of garnets and garnetiferous schists brought to our Museum by fishermen and others who have occasion to visit Labrador.

The only rocks with which I can compare them in Nova Scotia are associated with rocks of a later age in the County of Yarmouth. I have pointed out interesting micaceous schists at George's Lake and Chegoggin Point. Vide Geology of Digby and Yarmouth Counties. Trans., Vol. V., pp. 236-243. From their association with the Lower Cambrian rocks of our gold fields. I was led to refer them to a corresp nding age. It is, however, possible that their proper associates are the granites rather than the quartzites and argillites. With Dana and others I am disposed to refer these also to the Archæan Period. This would bring the garnetiferous schists of Massachusetts Centre and the like schists of Yarmouth into close relationship. In paper "Geological Notes," Trans., Vol. V., 335. These garnetiferous and auriferous schists as compared with the Medicine Bow Range, are regarded by Arnold Hague as having a "strong resemblance" to "characteristic beds of the Huronian (Archæan) formation, Canada." Descrip. Geology.* I would also observe that in going and returning from Barre Plains I noticed the frequent occurrence of rocks on the railroad sections which seemed to correspond with the Lower Cambrian formation of Nova Scotia. I have since found that others regard them in this light, and that fossils have been found at Braintree which might establish such a relationship and at the same time confirm the views which I have established in reference to the relations of the St. John, New Brunswick, and the Halifax, Nova Scotia, series of rocks. *Vide* Hitchcock's Map in the Bulletin of the Blake Expedition and Shaler's memoir on the fossils of Braintree. Museum of Comparative Zoology, Cambridge, Mass.

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*Page 109, Clarence King, Geologist in charge.

ART. II.—ICE IN THE CARBONIFEROUS PERIOD.—BY HENRY S. POOLE, F. G. S., ASSOC. R. S. M., &c.

Read March 11th, 1889.

Along our Atlantic shore the beaches are strewn with travel-worn rocks from distant hills and equally well rounded fragments that have dropped from neighboring cliffs. On the Cape Breton coast, where seams of coal crop out and suffer erosion, they contribute to the supply of pebbles and boulders found in the coves and under the headlands. Every winter, clampers of ice, stranded at high water, freeze to the rocks and loose stones that lie on the shore line, and are thence lifted with the ice when the tide returns; then, if the wind be favorable, they are borne away to be dropped in deep water.

When the dredge brings up from among the déposits of mud or sand that compose the contiguous sea bottom, any isolated rock or water-worn stone, no one questions how they were transported from among their fellows on the shore; everyone sees at work every year an agent that answers all the requirements of their surroundings.

Before us on the table are three pebbles of coal that came from a bed of fireclay 450 feet below the surface, and overlying by some ten feet the Acadia coal seam at Westville. They were found when taking stone from the goaf to make stoppings for the pit air-courses. How came these pebbles into this position? The beds above and below are uniform in quality and in thickness, and their geological horizon is some 2500 feet below the highest strata in the series.

Other pebbles were said to have been also seen in the same bed, but they were not secured, and when sought for could not be found; that they were seen however, is highly probable.

A cursory examination of the pebbles shews that at the time of their deposition, the coal of which they are composed was as mature as that of those to-day lying at the foot of the Cape Breton cliffs. In short, it suggests the formation of coal seams from which they subsequently parted, the deposition over them of strata weighty enough to consolidate them, a long lapse of time, their elevation, exposure to eroding influences, the breaking off of fragments subsequently rounded by attrition in moving water, and then their transportation from the shore of their birth to the quiet waters of their resting place, and that too at a time when the coals we now mine were but newly deposited and not yet consolidated.

What was the agent that transported these carboniferous voyagers? May it not be assumed that the same agent that now does its work so well and easily in conveying the pebbles of to-day to their bed in the growing deposits of the Atlantic played the same part in ancient times? Certainly, with one so capable as ice, what need is there to seek the possible ability of other agents to effect similar results.

Sir Charles Lyell, in his Principles of Geology (Page 232), writes in his concluding remarks on climate:—

"If we carry back our retrospect to the primary or Palæozoic ages we find an assemblage of plants which imply that a warm, humid and equable climate extended in the Carboniferous period uninterruptedly from the 30th parallel of latitude to within a few degrees of the pole;" and he goes on to say, "while some indications seem also to have been discovered of intercalated glacial periods of older date (he is here speaking of *the* glacial period, as we know it) especially in the Miocene, Eocene and Permian eras."

In these passages and their context Sir Charles seems to have in mind only the action of ice where the average temperature was below 32° Fah., and not to be considering the action of winter ice as we know it, *pari passu*, with a luxuriant summer vegetation.

But whence came these pebbles? Of lower Carboniferous and Devonian coals we have now none known nearer than the head-waters of the West River, to the South of the present coal field, where the seams are small and of inferior quality. It is to ~

hoped that the general Geological Survey now in progress by that careful observer, Mr. Hugh Fletcher, may throw some light on this interesting point, and possibly indicate the extent of the seams that have been swept away.

ART. III.—GLACIAL BOULDERS OF OUR FISHERIES AND INVERTEBRATES, ATTACHED AND DETACHED.—BY THE REV. D. HONEYMAN, D.C.L., F.R.S.C., F.S.Sc., F.G.S.A., &c., *Curator of the Provincial Museum.*

Read January 14th, 1889.

The presentation to our Provincial Museum by Henry Lawson, Esq., of three interesting boulders from our fishing banks, specially directed attention to the subject of our paper.

Each of these is adorned by a prominent and singular organism, which attracted the attention of the fisherman who found them. To the striking and puzzling character of these we are indebted for the preservation of the boulders and their attachés.

The boulders are of Lower Cambrian quartzites. They were brought up from a depth of 65 fathoms. Our Museum has a number of other boulders from the same banks. Some of these we have had for many years. Other interesting ones have been received from Mr. Lawson and others, since we began our investigations. During my glacial researches I have directed the Devil's Island fishermen to bring boulders from the shore of that Island and the fishing banks, with or without attachés. I am thereby enabled to ascertain that our glacial transportation had extended a considerable distance into the Atlantic. I have already noted Thrum Cap and its shoal as the *ultima thule* of this glacial transportation. We are not disposed, on the evidence of our boulders, to extend it to 60 or 80 fathoms, or 26 miles beyond Thrum Cap or Devil's Island. This *may* have been effected by bergs or floes from our glaciers, ice sheets, or other causes. It is possible that icebergs from Arctic regions, which are often seen on our coast, borne along by the Arctic current, may have contributed their quota to the boulders of our fishing banks. This, however, is only a peradventure.

Our Boulders are—

1. Archæan Granite, of Halifax.

2, 3, 4, 5, 6. Lower Cambrian Quartzites.

7. Calcareo-Quartzite, corresponding with rocks of Eastern Passage. (*Vide* Geology of Halifax, &c., Trans. I. N. S.)

8. 9. &c., Argillites.

10. Diorite, like that of Sunday Point, Yarmouth. (*Vide* Geology of Digby and Yarmouth, Trans. I. N. S.)

11 to 22. Lower Carboniferous Limestones, like those of Hants County. Boulders of these abound in the glacial moraine deposits at Laurencetown Head and entrance to Eastern Passage. (*Vide* Papers on Surface Geology, Trans. I. N. S.)

Our 11 boulders are all perforated marvellously by *Saxicava artica (rugosa)*, a characteristic mollusc of the Champlain Period, which still abounds in our harbour and on the fishing banks.

In a paper read before the Institute—" Additional Notes on Glacial Action at Bedford Basin, Halifax Harbour, &c.,"—Trans. Vol. VI., pp. 251-260,—is a list of Mollusca from Jones' catalogue of 1887. In the list of 42, we have 12 Arctic and 30 Boreal. We will find many of these mollusca attached to our boulders. The other associated invertebrata have also a Boreal facies, *e. g.*, the " Spongidæ." Hence the illustrated memoirs of the Norwegian North Atlantic Expedition in our Institute Library has been largely available in our recent investigations.

Classification of our Invertebrata.

I. Protozoa—*Foramenifera* and Radiolaria, Metazoa or Parazoa *Sponges.*

II. Cœlenterata—*Hydroida.*

III. Annuloida—*Starfishes*, &c., Ophiura.

IV. Annulosa—*Crustaceans.*

V. Mollusca—*Saxicava* and *Buccinum*, &c.

In Lawson's 1st Boulder (A) the most prominent attaché is an Oothèca. Its first appearance suggested an ear of indian corn. A closer examination shows the egg capsules of a mollusc, but different from the familiar clusters of *Purpura lapillus*. We find the two associated in one of the museum collections from Sable Island.

In a plate of the Buccinidae of the Norwegian North Atlantic Expedition, we find the figures of two similar of reduced size. We assign ours to *Buccinum undatum*, our allied boreal mollusc. In one of my walks on the shore of Point Pleasant, last summer, I observed an unusually large number of the clusters of empty egg capsules of *Purpura lapillus*, cast ashore during a storm. I searched in vain, among them for our Ootheca. I opened the specimen of boulder (B). It was empty, all the fry had escaped. The next in prominence on our bolder (A) is a dark brown sponge, *Myxilla lawsoni*. We leave this and other sponges for another paper. Other attachés are polyzoa. Entangled in these we have a beautiful shell of the tiny *Margarita undulata*, another boreal mollusc.

Mr. Willis reported this shell to Gould as found on our banks.

A lower valve of *Anomia* was also found on the Sponge.

Five small *Gammari* lay in the thick pendant plume of a sertularia.

A Caprella, species? Was attached to the sponge.

A small *Balanus* adheres to the stone.

Serpulæ are abundant on the stone, and a *campanularia* on the sponge.

One species of *serpulæ* has a crypt-spire. A *spirorbis* is also attached to the *Margarita*. *Sertularida* of more than one species are prominent. One has a number of branches forming the plume in which the *gammari* were esconced. The Campanularia with attached *spirorbes* trails over the sponge forming a net in which the *Margarita* was entangled. *Bryozoa* with a small encrusting sponge. *Suberites incrustans* ? complete the very interesting group of attachés of this Boulder (A). We number the boulders as they are described with large capitals for reference in this and the following Papers of our series. Lawson boulder (B) in addition to its Ootheca, has several *bryozoa* and two sessile *foramenifera*.

Lawson boulder (C) has another Ootheca and an interesting sponge—*Myxilla*. Also, a multitude of sessile foramenifera.

As already stated, these three boulders are of Lower Cambrian Quartzites. (D. E. F.) are also quartzite boulders. These are adorned with branching sponges, *Reniera*. (D.) has only a sponge. (E.) has bryozoa, a small *Balanus* and *Spirobes*. (F.) has two species of *Spirorbes*, a small *Anomia* and small *Balani*. (G.) boulder is an argillite with a side of quartz ; this has a very singular sponge—a *Suberites* and a small variety of the *Suberites incrustans* ? the small sponge on boulder (A), also, serpulæ, spirorbes, bryozoa (coralline) and foramenifera. (H.) has another interesting sponge—*Suberites villosum*. Other *four* argillites have as follows :

No. 1 has a serpula, spirorbes, *Terebratulina septentrionalis* with its sponge, and another sponge, *Reniera*.

No. 2 has a sponge *Suberites* and Terebratulina, with its sponge a *Myxilla*.

No. 3 has *Terebratulina septentrionalis* and its sponge, and a remarkable sponge—*Stelletta hanseni*.

No. 4 has *Terebratulina* with its sponge. *Serpula* and a remarkable sponge—*Stelletta etoile-pistolet*.

We have given *provisional* names to the two *Stellar* sponges.

(I.) a diorite boulder from the Halibut Fishery, called by the fisherman Little Banquereau, has a branching coral, *Primnoa reseda* ? and the remains of a sponge—*Suberites*. Other corals of the same kind and locality, but detached are also to be found in our museum collections.

(K.) is a large and heavy boulder. It is of calcareo-quartzite It is singularly and deeply excavated—*water-worn*. This character of the original rock at Cow Bay and Eastern Passage, attracted my attention when I was surveying the region, and led to the recognition of their *calcareous* character, in the proportion 30 per cent., Vide Paper, Geology of Halifax and Colchester Counties, Tran. Vol. VI., Page 62. One of the cavities of the boulder is coated with a white sponge—*Myxilla eximia*, a small cavity contains a small sponge, a *Reniera*. Other attachés are *foramenifera, hydrozoa, serpulæ, spirorbes, ophiura, bryozoa, coralline*.

(L.) boulder is of granite—it is ponderous. Two fishermen brought it to the Museum many years ago. It was regarded as curious, on account of a large sponge which was firmly attached to it. This is a remarkable and unique specimen of *Geodea.* Between its base and the granite, *Saxicava* had inserted themselves, and were there embedded.

Numerous patches of *bryozoa* still remain on the boulder. The sponge had to be detached for its safe keeping and proper examination.

Having thus briefly described the boulders of Lower Cambrian rocks and associated Archæan Granites with their varied and interesting attached and detached invertebrates, we now proceed with like brevity to notice the remaining group of our introductory catalogue and attachés.

(M.) another ponderous boulder is of deceptive appearance. It was long assumed to be a quartzite. Its perforation was regarded as remarkable. This also was brought from our fishing banks. When I directed particular attention to it, I found that it was a limestone. The application of the hammer showed that the perforations were deeper and larger than they appeared, and were occupied by *Saxicava* and *Ophiura.* The limestone is also recognized as of Lower Carboniferous age.

(N.) is another limestone boulder. It is regularly stratified. Saxicava have penetrated the strata horizontally; the upper strata present the aspect of a coral. This is caused by a coating of nullipores and bryozoa, which appears chalky from exposure to the rain and sun. It thus assumes quite a cretaceous aspect. The hammer shows the true character of the limestone. An *Ophiura* and a small *Echinus* occupied cavities.

(O.) is of the same character with chalky patches.

(P.) is another limestone boulder. This has been perforated by *Saxicava* entering on the edges of the laminæ. The perforations are empty.

(Q.) Is a thoroughly perforated boulder of Lower Carboniferous Limestone. Its cavities contain one or two saxicava and serpulæ. A flat side is thickly studded with Spirorbes of, at least, two species. Numerous Serpulini lie among these.

(R.) Is another limestone boulder, much perforated by *Saxicava.* A small one lies in a cavity.

(S.) Is another. It is limestone veined with Calcite. It is also perforated by Saxicava. Two of these occupy cavities. There are no other attachés in this and the preceding.

(T.) Is also a limestone boulder of considerable size. It is thoroughly perforated by Saxicava. The top and circumference are covered with Nullipores. Two algæ, one of which is *Corallina officinalis*, a lime former, occupy a large part of the nullipore covered top. Several ophiuræ occupy holes. The hammer shows the boulder to be Lower Carboniferous limestone.

Boulder (U.) Has attachés, *Terebratulina septentrionalis* in abundance—young and old. The latter are coated with the usual sponge, a *Myxilla*, sessile foramenifera, hydroida, a large *Serpula* tube, an *ophiura*, specimens of *Chiton ruber*. It is of Lower Carboniferous limestone.

(V.) Another L. C. limestone boulder. This is well perforated by Saxicava. The greater part of the cavities is occupied by Ophiurans, old and young. This is by far the greatest number found in any boulder. I have not yet attempted to specialize them. All our Ophiurans, or brittle stars, have the usual number of 5 rays. *An exception* will be noted in a future paper. This has 6 rays. I simply refer to it in this connection as a notice. Other attachés of our boulder are *Serpulini, Spirorbes, Bryozoa, Corallines, Foramenifera, Incertæ Sedis.*

(W.) the last boulder to which I would refer. It is the last addition to the Museum collection. The fisherman from whom it was purchased informed me that it came from the banks, and from a depth of 65 fathoms. It is of Lower Carboniferous Limestone, and is thoroughly bored with Saxicava. Some of these occupy under cavities. Ophiurans have taken possession of others. The upper side of the boulder is covered with nullipores.

Two interesting sponges are seated on the nullipores. Of these, the smaller is of dark brown colour, it is a *Myxilla*. The larger is different in appearance from all the other sponges in our collection—it is a *Reniera*.

I received from Mr. Wilson, Fish Merchant, a splendid specimen of *Boltenia rubra* from our fishing banks. It was detached from the stone to which it had been attached. Its stalk is 12 inches in length. This is completely covered with attachés; campanularia coats it. From this projects a pendant sponge—a *Reniera*—a Bryozoa, coralline, of beautiful form and of the same character as others frequently noticed on boulders, is also prominent.

We have also two large, detached, bushy sponges with thick and short stalks. These are *Renieras*.

I would only refer to another sponge from our fishing banks. It was brought up from a depth of 80 fathoms, at a distance of 40 miles south of Sambro. It is shaped like the "Cap of Liberty." It is a Hexactinallid—a sponge of the highest order. It was highly appreciated at the I. F. E., and regarded as unique. It seems to have been unattached.

This completes our series of sponges. Their aspect also is decidedly Boreal, as well as that of the other invertebrata of our Fishing Banks.

I have yet to note the presence of *Radiolaria* and *marine diatoms*, which may be regarded as a sort of attachés. They are found in almost every one of the sponges attached to the several boulders. The smallness of pieces of sponges examined, and the number found in these pieces, indicate abundance in the sponges, and consequently teeming waters. From the Bulletins of the Blake Expedition we were led to infer the absence of Radiolarians in our Northern Atlantic waters. The Radiolarians are *Protozoa*, and the Diatoms *Protophyta*. When we report the examinations of our sponges these Protos will be duly noticed.

In this Bulletin reference is made, as elsewhere, to Mr. Verrill's finding Boulders on the Fishing Banks, St. George's, etc., which led him to the striking conclusion, "That a Tetriary Formation probably might be regarded as underlying our Coastal Fishing Banks." We, on the contrary, might now be led to consider that our own banks are underlaid by a Carboniferous Formation, and that the more readily, as Lower Carboniferous Limestones, do exist at Chester, to the west of Halifax. Our knowledge of the Geology of Nova Scotia and glacial investigations lead us to the alternat ve set forth in our introduction, and to regard the

Geological Formation underlying our Fishing Banks as rather allied to the First division of its Glacial Boulders—as Lower Cambrian.

(Appendix).

We would add a few notes to the Paper read which will bring under notice other invertebrates not attached wholly to boulders. We are indebted to others for those already noticed. The succeeding have been collected in our walks around the shores of Point Pleasant. It is many years since we first noticed sponges with other attachés on the "so-called roots," of the great quantities of Laminaria and other large algæ cast ashore by the sea after storms which had torn them from the rocks to which they had been attached. Heretofore, we regarded these as of no peculiar interest. Choice specimens of the sponges were, however then collected, put in proper jars with alcohol, and placed in the lowest position in our Alcoholic Collection. These sponges are associated with, and sometimes almost enveloping, large specimens of *Modiolus modiola*, *Mytilus edulis*. The calcareous alga *Corallina officinalis* very often accompanies these Saxicava old and young. The hydrozoa, campanularia and sertularida, bryozoa and spirorbes also abound. Gammari swarm. Clusters of the egg capsules of *Purpura lapillus* and the univalve itself are found often enough in connection, and the *Littorina littorea* of all sizes. Since we became interested in the sponges, by the discovery of their siliceous character and the beauty of their skeletal and somal spicules and incorporated diatoms and radiolarians, we have often explored the piles of kelp after storms and made a large collection of the objects described, especially the sponges.

In this kelp I found, many years ago, when searching for marine objects of interest, a densely reticulated alga with the spawn of small fish newly developed. Putting it into a small bottle having alcohol, I observed a number of small, oval sponges. One of these I have just examined, and found it to be a *Myxilla*. I have given it the specific name *pisciniae*.

I would, in conclusion, notice the valve of a modiola. This has attached to it, a bunch of a beautiful alga, and an interesting sponge—*Reniera.* This was for some time, singular by the incorporation of the diatom, *Grammatophora serpentina,* in abundance. From this I gave it the specific name *anguillellidæ.*

Mr. McLeod, of Demerara, gave me a piece of *Pecten tenuistricatus* from Chester, N. S., with an incrusting sponge, a *Reniera.* My collection in the Canadian Department of I. F. E., Lond, 1883, contained a short, branching sponge, which was found attached to a valve, of *Ostrea virgineana* from Prince Edward Island. This is *Suberites edouardii.*

NOTE.—Two other boulders have been added to our collection. X is of Lower Carboniferous Limestone. Its weight is 31 lbs. On it are two *Suberites,* one *Myxilla,* and two *Stellittas etoile-pistolet.*

Boulder Y has a *Suberites.*

Art. IV.—The Geology of Cape Breton. The Minerals of the Carboniferous.—By E. Gilpin, Jr., F.G.S., Inspector of Mines, &c.—Part IV.

Read January 14th, 1889.

In my last contribution I gave an account of the Coal Beds of Cape Breton, and purpose in this paper to attempt a brief description of the more prominent of the remaining minerals known to occur in the sub-divisions of the Carboniferous in this Island.

The gypsum is certainly the most conspicuous of these. It recalls the white cliffs of Old England, and may some day inspire a local muse. It is a first cousin of the chalk too, for here the coy oxide of lime has allied herself with the more stable and powerful sulphuric acid, instead of the etherial, volatile, and social carbonic acid. The former in the furnace parts readily from her consort, while the latter boils, drops a tear of water of composition, but does not dissolve partnership.

There is one notable geological fact connected with the gypsum of the Maritime Provinces, its occurrence in measures of palæozoic age, the marine limestone formation of the Carboniferous. In nearly all other countries it is of much later age. This led to much confusion in the earlier attempts to outline Nova Scotian geology, and it was, I believe, first placed in its true position, below the coal measures, through the researches of Mr. R. Brown, and Sir Wm. Dawson.

I have already described the marine limestone formation of the Island, and followed it, now skirting the Bras d'Or Lake, or mantling round the older hills, or filling the valleys of the numerous rivers of the Margaree, River Dennys, and Middle River districts. In it the gypsum is met rising like a ruined marble palace of Eastern climes from the waters of the Bras d'Or, or frowning in a cliff, hollowed into a thousand little caves and recesses by the waves and ice. In the woods, from a distance, it recalls the tented homes of an army, or broods like a dismantled castle over some quiet valley.

Soft and friable the untiring finger of time plays many a rude prank with it, and the malice of the destroyer of all things even follows it below ground. Subterranean streams wear it away, and with equal power remove the adjoining marls and shales, until the cover of a hidden pool falls in a crash. The inborne earth is soon coated with grass and shrubbery, and these funnel-shaped depressions mark the passage of the gypsum beds when no outcrop is visible.

Thanks to the help of the microscope, and to our knowledge of the labors of marine insects the course of the formation of the limestones frequently associated with the gypsums can be readily followed. We are, however, at a loss to account in an equally satisfactory manner for the growth of the gypsum masses. No branching coral, or mild bicarbonate formed this mineral, one half of which is the strongest and most deadly of acids. We can now perhaps imagine that some faulting of the rocks poured out springs carrying free sulphuric acid, this meeting limestone would lead to the formation of gypsum. Other scientists account for its formation by the slow process of concentration and evaporation of inland seas. Certainly it is frequently accompanied by salts of magnesia, and of sodium, etc., more or less pronounced ingredients of the ocean. Interesting as this question is, I could not attempt to do justice to Cape Breton if I were to discuss it now.

The gypsum occurs in every variety of color. The prevailing color is white, which is shaded into blue, but it is noticed red, black and blue, and occasionally green. The anbrydrite variety is white, pale blue and gray. Both varieties occur massive, crystalline, and granular. The tabular translucent crystals, known as selenite, are frequently taken for mica. The beds of gypsum vary in thickness up to one hundred and fifty feet, and proximately continuous, extend often for miles. The minerals is frequently found in crystals and veins in marls, shales, and limestone. I have frequently observed it in films coating the joints of the coal seams.

The precise effect of gypsum on soils is, I believe, still a matter of doubt, but unquestionably it and the limestone occur in the best farming districts in the Island. So far as I am aware no attempts have been made to practically test its effects on the poorer and colder soils of the Millstone grit or Devonian measures.

The principal market for gypsum is found in the United States, where it is ground for agricultural purposes, and boiled and ground for the house builders' use. The export of this mineral from Nova Scotia for a number of years past has varied between 80,000 and 150,000 tons a year. Little, if any, ground gypsum is exported to the United States, as there is a heavy duty imposed on it. Windsor and the surrounding villages form the principal point of export. The short transport via the Bay of Fundy, and the excellent position of the Nova Scotia quarries, close to shipping, have excluded the Cape Breton gypsum from the United States market.

Lennox Passage, Baddeck, and St. Ann's Harbor are the points in Cape Breton whence shipments have been made. The total amounts have, so far as my information goes, not exceeded 10,000 tons in any one year. All this, I believe, goes up the St. Lawrence, and it is to be regretted that the markets of the Gulf are not extensive enough to permit an output in some degree proportionate to the extent of the deposits.

The following analysis of a gypsum from a quarry opened some years ago, about four miles East of Baddeck, will serve to show the composition of an article of good quality :—

Gypsum (hydrated lime sulphate)	98.85
Lime Carbonate	1.07
Silica	.11
	100.03

The gypsum varies a little in hardness, the soft rock being generally preferred. The anhydrite is, as its name shows, the same mineral without water, it is seldom quarried, and forms great part of the spoil. It has been experimentally polished, and yields a material adapted for in-door decoration. In the vicinity of the quarries I have seen it used for foundations for houses.

In the United States, Ohio and Michigan are the principal producers, the output being annually about 50,000 tons of land, and about 25,000 tons of calcined plaster. The imported stone is divided about equally between the land and the calcining mills. About three-fourths of the Nova Scotia gypsum goes to New York, where the prices vary from $2.50 to $3.50 a ton. The remainder is absorbed in the States nearer the Bay of Fundy. The Grand River, Ontario, plaster quarries send annually about 5,000 tons of medium grade rock into the Western States for agricultural purposes.

In England the annual production is about 80,000 tons, valued at from $3.00 to $4.00 per ton. The French deposits are very large, and its extensive use for fictile purposes by the ingenious artists of the capital of that country has gained for it the distinctive appellation of Plaster of Paris.

In many places salt and gypsum are closely associated, and usually include magnesian limestones in the surrounding strata. This conjunction is the basis of the theory that gypsum is a product of concentration. Taking the converse, in this Province the associated limestones are, so far as I have been able to investigate the subject, decidedly non-magnesian, and the presence of workable deposits of salt does not clearly follow.

Crystals of salt (chloride of sodium) are not uncommon in gypsum quarries, and at various points saliferous brines come to the surface. In our climate it would not itself be exposed as an outcropping stratum, but if present in our gypsum districts would exist as subterranean deposits, at a level below the surface drainage of the country.

It could be found only by boring, and if the calculations of the cost of mining it, etc., would permit of its competing with the Canadian and foreign article, the Government could present to the people of this Province no more acceptable gift than the discovery of workable deposits of a mineral so necessary in the economic and domestic arts of the present day.

Among the better known mineral springs of Cape Breton may be mentioned the following :—

Springs half-way between Baddeck and Whyhogomah, on the shore road. These extend over several acres of ground, the largest discharging from 100 to 200 gallons per minute. An analysis by the chemist of the Geological Survey gave—in 1000 parts :—

Chloride of Sodium	50.6881
" Potassium	.1942
" Magnesium	.1593
Sulphate of Calcium	5.6810
Alumina	traces.
Silica	traces.
	56.7226

Salt has been made from this brine for local use, and at one time its systematic extraction was comtemplated.

At Deadman's Point, near Washaback, is a chalybeate spring. Mention may be made here of a mineral spring near Ben Eoin, East Bay, which is strongly saline, although said to issue from Laurentian rocks. Over twenty years ago, when it was first brought into notice, many resorted to it, but lately it has not been much visited. An analysis by the late Professor How gave, in grains to the imperial gallon :—

Iron and Phosphoric acid	traces.
Carbonate of Lime and Magnesia	.60
Sulphate of Lime	.94
Chloride of Sodium	343.11
Chloride of Potassium	4.55
Chloride of Calcium	308.90
Chloride of Magnesium	4.47
	662.57

No iodine was detected.

He compared the water to that of St. Catherines, Ancaster and Whitby, Ontario.

Mr. Fletcher, in his report on Richmond County, states that salt and sulphur springs are found on Rabbit Island, at Landry Lake, McMaster's Mill, Greenville, River Dennys, and River Tilliard. A sample of the McMaster's Mill Spring gave Mr. Hoffman, Chemist of the Survey, in 1000 parts :—

BASES.

Potassia	Trace.
Soda	Very large quantity.
Lime	Small quantity.
Magnesia	Very small quantity.
Ferrous Oxide	Small quantity.

ACIDS.

Sulphuric Acid	Rather large quantity.
Phosphoric Acid	Trace.
Carbonic Acid	Rather small quantity.
Chlorine	Very large quantity.

Neither bromine or iodine were detected.

Iron Ore. Clay Iron Stone. This ore is frequently met in the coal measures, in thin beds and layers of nodules, seldom, however, in deposits exceeding a thickness of a few inches This ore of iron forms the basis of the cheap pig iron of Great Britain, for it is frequently found so closely associated with the coal beds, that it is extracted at the one operation, and hoisted through the same shaft. When the coal is of good coking quality it is evident that cheap pig iron can be easily made.

So far the sections of the coal measures exposed in Cape Breton have not shown this ore in beds thick enough to be of economic value. But as a demand for it has not yet risen its presence may frequently have been overlooked. Such was the case with the celebrated "black band," a variety of this ore, which, neglected for many years, long formed the basis of the great iron industry of Scotland.

Some years ago I noticed the occurrence of the black band ore in the Pictou coal field, where it had also been overlooked as valueless. Similar varieties of this ore may be found in the Cape Breton carboniferous when the analyst and iron smelter begin their search for furnace supplies. I am not aware of any complete analysis of this ore, from the Island, but samples I have seen would yield from 25 to 35 per cent. of iron.

The purest variety of this ore, known as siderite, does not occur in the coal measures, but in this Province is usually associated with the limestones. It occurs at Sutherland's Brook, Pictou Co,, in a large bed, and is found in a bed said to be three feet thick on Boulardarie Island. At this locality, according to Dr. B. Harrington, it yields 32.58 per cent. of metallic iron. It is also frequently met in veinlets, in various rocks.

At a point near Sydney Town, the limestone beds near the summit of the millstone grit, pass, in places, into beds of red hematite, carrying about 30 per cent. of iron. But the quality of the ore is such as hardly to warrant further exploration.

At numerous points where the lower carboniferous conglomerates rest on the Precambrian felsites, etc., deposits of red hematite are found. The ore occurs in pockets and veinlets, and encrusting films along the line of junction. The ore is usually of excellent quality, but irregular in amount. The following analysis of a sample from Loran, near Louisburg, will serve to show its quality:—

Peroxide of Iron	90.14
Lime and Magnesia	4.20
Sulphur	.10
Phosphoric Acid	.11
Silica	5.45
	100.00

As the ore frequently coats the heavy stones of the conglomerates, it often deceives the inexperienced miner, who finds, on breaking his ore, that he has lavished his affection and built his hopes on a very commonplace and valueless pebble.

Some attention has been paid to deposits of this nature at

East Bay, and considerable amounts of ore have been found. It is quite possible that deposits capable of yielding large amounts of ore do exist, and the working of these deposits may disclose the rules governing their location. I would suggest that the lines of junction of the marine limestones with the older rocks furnish better hunting grounds for the prospector, as the greater solubility of the limestones affords more opportunity for the seggregation of workable ore bodies. An instance of this is furnished by the occurrence near Loch Lomond of rich, red hematite ore, apparently in the limestone horizon; and a more widely known parallel is furnished by the limestones of Barrow and Furness, in England, which have supplied immense amounts of the purest red hematites, in many respects resembling those in Cape Breton, now under consideration.

Cape Breton is not without examples of the earliest step in the aggregation of this useful metal. Beds of bog iron ore are frequently met, and the large amounts of iron-bearing rocks and the presence of varying minerals aiding their formation make them perhaps more numerous in the Carboniferous than elsewhere. Frequently they occur in the sites of old swamps or bogs, as beds from a few inches to a couple of feet in thickness. This ore is good enough for local use in blast furnace practice for foundry iron, but is neither rich enough in metallic iron, or free enough from phosphorus to be sought after for steel making.

It not unfrequently happens that considerable amounts of manganese, a metal in many points resembling iron, become incorporated with these bog ores. They therefore graduate from bog iron ore, a hydrous peroxide of iron into a similar manganese ore. In this latter form it is not known in Cape Breton pure enough for exportation.

As I have insensibly passed from iron to manganese, I may remark here that throughout the Lower Provinces the limestones of the Carboniferous and their associated silicious shales form the habitat of a very valuable and pure variety of manganese ore. In a paper read a few years ago before the Royal Society of Canada I gave a full account of the manganese ores of Nova Scotia. In Cape Breton this crystalline pyrolusite is known mineralogically at many points, but has been found in workable amounts only at Salmon River, in the East part of Cape Breton County.

Here the old coves of the precambrian shores were filled with carboniferous shales, conglomerates, and limestones. At the McCuish mine the ores are found in irregular bedded layers, in a soft arenaceous shale, up to 18 inches in thickness. At the Eastern mine, the ore occurs as a bed underlying a soft manganiferous limestone, the ore varying in thickness up to 8 inches.

The following analyses by Mr. Hoffman of the Geological Survey will show the character of the ores:—

Sample No. 1, Pyrolusite, with a little Manganite, gave—

Binoxide	81.52 per cent.

Sample No. 2, Pyrolusite, gave—

Binoxide	88.98 per cent.
Ferric oxide.....................	21 "

Ores represented by the above analyses would be adapted for all the uses to which the mineral is usually put, and especially for glass-making.

These deposits are worked by Mr. E. T. Mosely of Sydney, and it is to be hoped will form a permanent addition to the mineral resources of the island.

Of the more impure and at present valueless varieties of manganese ores, that occurring in surface layers, like the bog iron ore referred to, is the most common. This is usually presented as a loose friable earthy mineral, of a brown or black color. It is known at several points in Cape Breton, the largest deposit is perhaps that found near Big Harbor, Boularderie, which contained:—

Manganese	25.42 p. c.
Water.............................	32.52 "

Other samples from this locality yielded me on analysis somewhat larger percentages of manganese. Another sample from Lewis Bay, Grand Mira, yielded Mr. Hoffman:

Manganese oroxide (available)........	44.96 p. c.
Insoluble matter....................	12.25 "

Limestones.—Everywhere through the Island of Cape Breton, this mineral is exposed, and here as elsewhere its abundance has given the farmers division of the carboniferous its characteristic title. As distinguished from the same mineral in the older rocks, it is presented as oolitic, shelly, flaggy, grannular, etc., but never crystallized as marble. Its color, texture and purity vary continually, and the lime burner has little trouble in securing an article fit for any of his operations. In the coal measures there are numerous thin beds of limestone bituminous, and fossiliferous. I have seen no analysis of these beds, but it is quite probable that some of them may hold several per cent. of phosphoric acid, and be suitable for cheap local fertilisers. A limestone near St. Peters is said to be suitable for making hydraulic cement, but so far it is questionable if any bed of limestone has yet been found in Nova Scotia maintaining a composition, indicating hydraulicity, ever a distance large enough to secure uniformity in the cement.

At Lennox Passage a limestone has been quarried for a number of years, and it is said to be of excellent quality.

Silver and Lead.—The carboniferous limestones not unfrequently contain grains and veinlets of Galena. At a few points these indications have been decided enough to lead to exploratory work. As yet, however, the Galena has not been found either in quantity enough to form an economic ore of lead, or associated with silver in amount sufficient to warrant much attention being paid to it. Among the localities noticed as in this connection may be mentioned: South-west Margaree, and Middle River. At Pleasant Bay, near the mouth of McKenzie River, Galena containing gold and silver, and associated with copper pyrites, occurs in calcspar veins, up to three feet in thickness, in grits, sandstone, and bituminous limestone. Near the Head of Lochlomond, and on Salmon River, in Cape Breton Co., Galena occurs in a massive limestone, and in a dark manganiferous limestone, in small grains; and in veinlets in a dark breccia apparently of carboniferous age. Here the cementing matter of the stone is calcareous. A few tons have been taken out, and on assay were found to yield a small per centage of lead, a trace of gold, and 2°879 ounces of silver to the ton.

In the Port Hood coal measures a small vein of galena was noticed in a sandstone bed between two coal seams. A similar case was noticed some years ago at the Joggins coal mines, in Nova Scotia, where, if I remember correctly, the lead ore was noticed in the coal bed where cut by a fault.

Copper.—In Cape Breton this ore occurs principally as pyrites. The conglomerates frequently show it in small quantities near their junction with older rocks. In the vicinity of Whycogomah it occurs in diorite dykes, cutting the lower carboniferous measures, and its occurrence at Port Bevis, under similar conditions, has been noticed.

At Cheticamp, a number of years ago, a good deal of money was spent in prospecting for Copper. The ores were green and blue carbonate of copper, gray and yellow sulphides, and chrysocolla. The deposits are in the vicinity of lower carboniferous traps and sandstones, but probably resemble in economic value ores frequently met in rocks of the same age in Pictou, Colchester and Cumberland Counties. Copper ore occurs under similar conditions at Jerome's Point, where native copper is found in trap. Copper pyrites is frequently met from this point as far as Cape North, and so wide spread are the traces of the ores of this metal in this part of Inverness County, that it may safely be predicted that workable deposits will be found either in the Pre-Cambrian rocks, or as derivative ore bodies in the adjoining carboniferous strata.

Celestite.—This mineral, the Sulphate of Strontium, is reported by Mr. Fletcher as occurring on the right bank of the Sydney River, about a mile and a half above the Coxheath Bridge, as a bed about a foot thick, of a bluish grey color, associated with limestone. This mineral is used largely for the crimson color of fireworks, and lately has been introduced in certain processes of sugar refining. The principal source of supply is, I believe, Italy, whence about 5000 tons are annually exported to England and

Germany. The mineral may be much more common here than is supposed, as it might readily be mistaken for a limestone.

Barytes. This mineral is largely used in paint making, and is found in Nova Scotia in at least two localities as a workable deposit, River John, Pictou County, and at Stewiacke. The River John mine is not being worked, but the Messrs. Henderson & Potts, of this city, took last year a large amount of the ore from the Stewiacke mine. Mr. Fletcher reports the mineral as occurring in Pine Brook, Loch Lomond, but does not consider the deposit of much importance. I have noticed it in small veinlets, with fluor spar in a clayey limestone near the Sydney River Bridge.

Building stones. As a rule Carboniferous measures of Cape Breton do not yield building stone of extra quality. Sandstones are quarried for local use at Margaree, Broad Cove, Cheticamp, Whyhogomah and Mabou. The limestone grit of Boularderie Island and Sydney Harbor yield a stone which is of fair quality. Generally speaking, however, the beds are too coarse, irregular in bedding, and frequently so impregnated with iron as to make them adapted principally for foundations and rough work. However, some of the upper beds of the limestone formation yield sandstones of firm and even texture, and good color which may be extensive enough to admit of regular quarry work.

In the construction of bridges and culverts on the railway now being built across the Island, a considerable amount of limestone has been used from contractors' quarries opened near the line. This rock when found in beds with suitable division planes forms an excellent and durable building material. Several thousand cubic yards were used for this purpose last year.

Oil.—A good deal of interest was shown in the so-called Lake Anslie oil fields a few years ago. This large lake occupies a portion of an extensive basin of lower carboniferous measures, flanked on all sides by older strata. At numerous points in the vicinity of the lake, petroleum is found in cavities in the sandstones, and oosing from the shales, etc. A large amount of money was spent in putting down bore holes in this district, and on the Middle River of Baddeck, where similar indications were observed. All the exploratory work proved unsuccessful.

The source of these widespread signs of oil must be sought in the carboniferous measures, as they are probably immediately underlaid by the Laurentian. None of the bore holes were put down deep enough to settle whether or no there does exist an oil-bearing stratum before the older rocks are reached. No attempts were made to identify any bed or set of beds as probable oil-bearers, or to test any section systematically. From the nonsense talked about the identification in this district of certain beds with the first, second, etc. rocks of the United States oil fields, it was apparent that no system was recognised, and the money spent has done nothing to settle the question practically.

ART. V.—ON CARNOT'S CYCLE IN THERMODYNAMICS.—BY PROF. J. G. MACGREGOR.

(Received Jan. 16th, 1889.)

The object of this paper, which is pedagogic rather than scientific, is to point out and remove a defect in the proofs usually given of the universality of the results obtained in Thermodynamics by the consideration of Carnot's Cycle of Operations.

From the Second Law of Thermodynamics it is proven that a Heat Engine has the greatest efficiency possible, provided, (1) it is reversible, and (2) when worked directly *(i. e.,* so as to do external work), its "working substance" absorbs heat when at a high temperature, and emits heat when at a low temperature. The second of these two conditions is not generally specified in so many words by writers on Thermodynamics; but the argument by which the efficiency of the reversible heat engine is shewn to be the greatest possible always assumes that the heat engine referred to is one of the kind specified above.

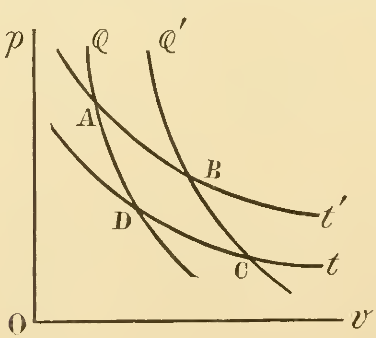
It is next pointed out that a substance subjected by the aid of Carnot's Ideal Heat Engine to what is known as Carnot's Cycle of Operations, in such a way that the cycle is reversible, constitutes a heat engine fulfilling both the above conditions. It follows that its efficiency is the greatest possible, and is independent of the nature of the working substance; and a result is thus reached which is of extreme importance, because of its perfect generality.

The defect referred to above is in the proof that any substance whatever subjected to Carnot's Cycle, in such a manner that it does external work, absorbs heat when at a high temperature and emits heat when at a low temperature. All writers* on Thermodynamics known to me, prove, not that this is true of any substance whatever, but only that it is true of one or two

* I do not refer here to writers on air and steam engines, who rightly enough restrict themselves to a study of Carnot's Cycle as applied to gases and saturated vapours.

classes of substances, usually gases and substances partly in the liquid state and partly in the state of saturated vapour. And they either assume it to be true of all other classes of substances without any farther statement or state that it may be shewn to be so. These other substances, however, including simple substances which contract as their temperature rises and mixtures of substances in the solid and liquid state, some of which contract while others expand on liquefaction, differ in their thermal properties in so marked a manner from both gases and saturated vapours, that it would seem to be necessary before applying to them the results of the study of Carnot's Cycle, to prove that they too when subjected to that cycle, so as to do external work, absorb heat when at a high temperature and emit heat when at a low temperature.

To shew how different the proofs are for substances of different kinds, I give them for all kinds, including those ordinarily given in works on Thermodynamics. In all cases I assume the operations of the cycle to be applied directly, i. e., so that the working substance does external work. As the conditions of reversibility may be fulfilled equally well by all substances, it will follow that when so subjected to the operations of the cycle that work is done on the working substance by the external forces, heat is absorbed by the working substance when at a low temperature and emitted by it when at a high temperature.



Let the variation of the physical state of a body when subjected to Carnot's cycle be represented in the usual way on the Indicator diagram, by the line ABCDA, ϕ and ϕ' being the two adiabatics or isentropics, and t and t' the two isothermals, of which portions are described by the indicating point during the cycle. Let ϕ, ϕ', stand also for the entropy of the isentropics, and t t' for the temperatures of the isothermals.

In the case of an ordinary substance which expands with rise of temperature at constant pressure, t' is obviously a higher isothermal than t, and ϕ' a higher isentropic than ϕ. Hence, during the operation A B heat is absorbed, the substance being at a high temperature, and during the operation C D heat is emitted, the substance being at a low temperature.

In the case of a substance which contracts with rise of temperature at constant pressure, t is a higher temperature than t'. For as a greater volume corresponds to a lower temperature, a straight line drawn in the direction of O v (the axis of volumes) must meet successively isothermals of lower and lower temperature. Also in this case, ϕ is a higher isentropic than ϕ'. For, in order that such a substance may be made to expand at constant pressure, heat must be taken from it; and therefore a straight line drawn in the direction O v must meet successively adiabatics of lower and lower entropy. It follows that in the case of substances which contract with rise of temperature, heat is emitted during the operation AB, and absorbed during the operation CD; but in this case the temperature during the operation AB is low, and that during CD is high.

In the case of a substance consisting of a mixture of a liquid and its vapour, AB and DC are straight lines, parallel to the axis of volumes. Since the saturation pressures of all vapours increase with the temperature, t' is a higher temperature than t. And since evaporation at constant pressure invariably increases the volume of a substance and involves absorption of heat, ϕ' is a higher isentropic than ϕ. Hence, in this case, heat is absorbed during AB when the working substance is at a high temperature, and emitted during CD when it is at a low temperature.

In the case of a working substance which is partly in the solid and partly in the liquid state, and which contracts on liquefaction, AB and DC are straight lines, parallel to the line of volumes. For the absorption of heat at constant pressure diminishes the volume. It follows from this consideration also that ϕ is a higher isentropic than ϕ', for it cuts a line parallel to Ov at a point nearer Op than ϕ' does. As the working substance in this case is always at the melting point, t' and t are the melting points at higher and lower pressures respectively. Now it may be proved by the aid of the First Law of Thermodynamics alone that the melting point of a substance which contracts on liquefying must lower as the pressure rises. It was so proved originally by Professor James Thomson.* Hence, in this case, t is a higher temperature than t'. It follows that in this case heat is emitted during the operation AB when the temperature of the working substance is low, and absorbed during CD when its temperature is high.

In the case of a working substance which is partly in the solid and partly in the liquid state and which expands on liquefaction, A B and D C will again be straight lines parallel to O v. In this case, however, since absorption of heat at constant pressure means increase of volume ϕ' is a higher isentropic than ϕ. Also, it may be proved by the aid of the First Law of Thermodynamics alone by an argument similar to that of Prof. James Thomson, referred to above, that in this case the melting point rises as the pressure increases, and therefore that t' is a higher temperature than t. Hence, in this case, heat is absorbed during A B when the temperature is high and emitted during C D when the temperature is low.

Hence, in the case of all kinds of working substances, Carnot's Cycle when carried out so that work is done against external forces, involves absorption of heat when the substance is at a high temperature and emission of heat when at a low temperature.

And the differences in the above arguments by which this result is reached in the case of different kinds of substances seem to shew that it is not sufficient to prove it for one and then assume it for all, but that it should be proved for all before being regarded as universally applicable.

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* Trans. Roy. Soc., Edin., Jan. 2, 1849; Sir Wm. Thomson's Mathematical and Physical Papers, Vol. I, p. 156.

ART. VI.—THE STONE AGE IN NOVA SCOTIA, AS ILLUSTRATED BY A COLLECTION OF RELICS PRESENTED TO DALHOUSIE COLLEGE.—BY THE REV. GEORGE PATTERSON, D.D., NEW GLASGOW.

During the last few years I have embraced any opportunities afforded me of collecting relics of the Stone Age in Nova Scotia, and have now concluded that the purposes of such a collection will be best served by presenting it to Dalhousie College, to form part of the museum of that institution. In handing it over, I desire, through the N. S. Institute of Natural Science, to place on record any points of interest noted in my explorations, or suggested by the articles discovered.

In older countries, these relics have been obtained principally from four sources :—

1. Burial mounds and old cemeteries.
2. Kitchen Middens, or the shell heaps and refuse heaps which mark the site of old encampments.
3. Cave dwellings.
4. Lake dwellings, as in Switzerland.

Nothing of the nature of the last two has ever been found in Nova Scotia, and there is no probability that there ever will. It is therefore to the first two of these that we are indebted for any remains of this primitive state of society found among us. As to the first, I have only in one instance come across a genuine prehistoric cemetery. It was situated on the Big Island of Merigomish, on the farms of Donald McGregor and James McGlashan, near the shore and close by the line between their farms. Attention was first directed to the place by Mr. McGregor, while ploughing up a portion of his field in which the vegetation was ranker than usual, turning up a human skull, pierced in front by a stone arrow-head, which still remained in its place. This interesting relic unfortunately was not taken care of, and has been lost. I did not hear of this discovery till some time after. In the meantime the place had been examined by other parties, and a number of stone axes and arrow-heads had been taken away. My first visit to it in 1874 was the commencement of my Archæological investigations. I did not examine the place with the same intelligence that I would have done since, but the circumstances just mentioned excited my curiosity, and on this and subsequent visits I examined the ground with some care, and with results of some interest.

At the spot where the transfixed skull had been turned up, though the ground had been a good deal disturbed before my visit, I found over a circular space of over six feet in diameter and to a depth varying from fifteen inches to two feet, a loose brown mould, mixed with fragments of bone, so decayed that not a complete bone could be found, and what remained could be crushed between the fingers. Below this I found fragments of birch bark in which the Indians were accustomed to enclose their dead, and below that was a hard subsoil, which plainly had never been disturbed. The soil around was also entirely different in color and composition.

There could be no doubt that this dark mould was from the decay of animal matter, and that the place formed a sort of pit into which a number of bodies had been thrown. From the ground having been thoroughly dug over before my visit, and the fragmentary condition of the bones, it was impossible to ascertain anything of the order in which the bodies had been arranged, but the transfixed skull with the other circumstances, seemed to indicate that these were the remains of those who had fallen in some battle, which had been here heaped together, "in one red burial blent." The shallowness of the pit shows that it must have been used previous to the arrival of Europeans, when sharpened sticks were perhaps the only instruments of digging. The same appears from the fact that no articles giving evidence of intercourse with civilization were found among the remains. Whether there had been any mound formed over them could not be ascertained. If there ever had it could have only been a very small one, and whatever there was had been levelled by the repeated ploughings the ground had undergone.

A number of stone implements had been found before my arrival, and taken away. But on close examination I found more,—a small axe, evidently a war axe, which seemed freshly ground to a sharp edge, probably immediately before the encounter in which the owner had lost his life, some stone arrow and spear-heads, some fragments of rude pottery, some small copper knives, an imperfect bone fish spear-head, and a stone pipe.

On exploring around, I discovered that the ground toward the shore, within a circuit with a radius of from forty to fifty feet, and sloping gently towards the south-west, had been an old cemetery. In spots at irregular distances, but from two to four feet apart, on digging down I would find, at a depth of from six to ten inches, a layer, perhaps about two inches thick, of a rich, dark, velvety mould, intermixed with fragments of bones. In some cases this extended a length of less than three feet, with a breadth of, perhaps, half as much, indicating, as I judged, the grave of a single body; but in at least one instance the layer was of much greater extent, as if the remains of several bodies were joined together. The bones were so decayed that, though this might have been owing to my ignorance of anatomy, only in a few instances could I recognize what they were. There was only one case in which I could trace the position in which the body lay. That was on its side, in a crouching position. In this case the skull remained in fragments, and had I known the modes now adopted by Archæologists for joining the fractured portions of skeletons, I might have gathered them and restored it, so as to show its original shape. As it was, I was struck with the great thickness of the pieces, and brought some of them away; but I have since learned that this is not uncommon among barbarous tribes.

In all these cases, with a single exception, I found prehistoric implements, stone axes, knives, arrow and spear-heads, portions of bone spear-heads, small copper knives, with fragments of pottery. It thus appeared that the people to whom these remains belonged had the practice, common among so many primitive races both in the old and new world, of burying with the dead the implements which they were accustomed to use when in life.

But I found one exception to this, which otherwise was curious. In this case instead of the mould referred to there was a layer almost entirely of ashes, with fragments of bone seemingly burnt, and none of them an inch long. This covered a smaller space than in the other cases, being of an elleptical shape, and speaking from recollection, scarcely two feet in the longest diameter, and a little over half as much in the shorter. In this there was nothing in the shape of a prehistoric implement except a fragment of a broken stone spear-head. In explanation of these circumstances I could only suppose that we had here the remains of some poor captive who had been burned.

In connection with this I observed in my digging indications of fire for some unexplained purpose, ashes, small pieces of charcoal and burnt earth. Possibly this might have been caused by white men burning the wood in clearing the land, but I observed also stones, which seemed to have been subjected to fire for some time, as the stones in a chimney or a hearth. I regret that I did not carefully examine into this point. I may observe, however, that I picked upon the ground a number of stone flakes such as are formed in the making of arrow-heads, and such as I have always found on the sites of old encampments. This would indicate that the place had been occupied after the interments, and perhaps by another race. This would account for some of the stones having the appearance of being acted on by fire, perhaps from their having been used as hearth stones.

The stone implements found in this cemetery present no particular difference from those found elsewhere. The arrow and spear-heads are generally well made. Some of them are of jasper or other fine grained mineral, such as are found in the trap rocks of the Bay of Fundy, and they exhibit a variety of forms exactly resembling those found in other collections both in the old and in the new world. There are also what I regard as knives intended to be grasped in the hand and drawn to the person as is done by the Mic-macs to the present day. There is one curious implement of which I have seen nothing similar. It is four-sided and rectangular, each side at the broadest being a little over one-fourth of an inch, from which it tapers to a blunt point. Part of the larger end is broken off, but what remains is $3\frac{1}{4}$ inches long. The use of this I cannot determine. It may have been intended as a perforator, but this does not seem probable, as it is carefully polished into a quadrilateral, which would rather tend to render it unsuitable for such a purpose.

The copper knives found here deserve notice. It is known to all Archæologists that the Indian tribes bordering on the Great Lakes had learned to use the native copper, which is found abundantly in the neighbourhood of Lake Superior for knives and a variety of other implements. It is also known to our geologists that native copper existed in small quantities in Nova Scotia, particularly in the trap rocks of the Bay of Fundy. But this was the first case in which it was found that the Aborigines of this Province had learned to turn it to practical use. The implements consist of small knives formed by hammering, which also served to harden the metal. There are three specimens in the collection beside pieces of copper hammered out as if intended for the formation of similar ones. A few others I have given to other collections. About the same time, articles of copper of prehistoric origin were found in Lunenburg County, principally however what has been supposed to be small needles or piercers, and beads. I believe, however, that more copper knives have been found in this cemetery than in all the rest of Nova Scotia.

The bone fish spear-heads are of interest. One nearly perfect was taken from the pit which I have described. Both ends have been broken off, but a length of $3\frac{6}{16}$ inches remain. It is flat, about one-eighth of an inch thick, and in width from half an inch tapering to a point. It shows very delicate workmanship. On one side are cut three notches in a descending direction, so narrow and even, that it is difficult to understand how the old workmen could have done it with any tools they possessed. The points at the lower edge of these would form barbs, taking the firmest hold. Between these notches the edge is very finely serrated, which would serve to give the implement additional holding power. The others show care and skill in the formation of the barbs. But a point of special interest is that near the base they have each a small hole. To this was attached a string, which doubtless had a float attached to the other end. When the fish was struck the head became detached from the shaft, and he went off with the line. But the float would retard his progress, and exhaust him, or perhaps bring him to the surface, while the fisherman could by it easily follow him up. This mode of capturing the denizens of the deep is still practised by the Eskimo and other barbarous tribes. There are some other specimens of bone, horn or ivory, the use of which I am unable to determine from their being so much decayed or being in fragments.

The pieces of pottery found here did not exhibit any features of special interest. Some of them are blackened as if they had been suspended over a fire.

We must, however, particularly notice the stone pipe mentioned. It is of a micaceous clay state, very hard, and yet besides the drilling of the bowl, a hole is drilled in the stone not more than the three-sixteenths of an inch in diameter for a length of nearly two inches. Along the upper surface at each side a fine groove has been cut. I fancy that any of our modern mechanics with all their improved implements would be puzzled to do the same work. But the most curious circumstance remains to be mentioned. The form of it is not like that of any hitherto found in Nova Scotia, nor do I find any figured like it in the account of the collection of the Smithsonian Institution, but Sir William Dawson directed my attention to a collection of relics made up the Ottawa, purchased for McGill College, in which were several pipes if not exactly the same in shape, yet plainly of the same type. It may be worth noting that in no case did I find any thing like wampum, so frequently found in Indian graves.

Some of these circumstances raise the question whether these might not be the relics of a race who occupied the ground before the Micmacs. But this is more strongly suggested by another fact. Almost the only bones found here that could be recognized are the two jaw-bones, one of them plainly that of an old person, as indicated by the manner in which the teeth are worn down. Both are imperfect, but each in its small size and the slight diverging angle of the sides stands in contrast with the true Indian jaw. This would suggest a people of small size like the Eskimos. It is now believed that this race formerly extended much further south in America than they now do, occupying indeed much of the New England coast. It is also a received opinion that the Algonquin race of which the Micmacs are the tribe farthest to the North and East, came from the South West, and the tradition of the latter is to the same effect. In such a migration they must have come into collision with the Eskimos, and driven them before them. Charlevoix in the map accompanying his work sets down the land to the North of the St. Lawrence as "Pays des Esquimaux," he mentions also that they were to be found in summer on the coast of Newfoundland, and describes the Micmacs in his day as maintaining a constant warfare with them, and these remains may be memorials of some such conflict. It is worthy of note that though I made several trials I found no evidence of any burial further from the shore than the pit, where was formed the transfixed skull. It really appeared as if the race who used this cemetery had here deposited their warriors dead, and returned to the spot no more.

The evidence of these remains being of a previous race I admit to be scanty. But the point is worthy to be kept in view in future explorations.

The chief source, however, from which in this country we obtain relics of the stone age, is the kitchen middens (Kjokken moddings, as they are called in the North of Europe) or those collections of shells and other refuse, which mark the site of old encampments. These are to be found in every part of the Province. Indeed, judging from those places I have had the opportunity of examining, I believe that every harbor and the embouchure of every considerable river will be found to exhibit to a greater or less extent such evidence of having been occupied by the people of the stone age. Thus, on the north shore, I have found them in Pictou Harbor, on both sides of the mouth of the East River, and at Middle River Point. In Merigomish Harbor there is scarcely an island or a point on which such remains are not to be seen. I have found them on Big Island, Point Betty Island, the smaller islands known as the Pig Islands, and on the shore, particularly on the farm of the Rev. A. P. Millar. Farther East I have found them at Antigonish Harbor and at Tracadie, and to the West at Tatamagouche, and I have heard of such at Wallace. On the South Shore there is or was a place on what was known as Bauchman's Beach, in Lunenburg County, which had all the appearance of being the site of an ancient arrow-head manufactory. But kitchen middens I have found on the LaHave, near Bridgewater, and at Port Medway, in the same County. I am informed that they are to be found at Port Joly and on Mr. Nutt's Island, in Shelburne Harbor, and I have myself observed them at more than one point at Barrington. On rivers near their embouchure I have particularly observed two, one a little above Sherbrooke, on the St. Mary's River, on the farm of Mr. George McIntosh, and the other on the Lequille River, Annapolis County, on the farm of Mr. George Hoyt. The situation of these two spots is very similar, and the reasons of their selection are easily detected. Both are just below falls or rapids in rivers abounding with fish, and thus in the best position for capturing them, particularly in their ascent or descent. Both are on low level flats on the edge of the river and backed by high banks which afforded shelter from the winds.

Where the coast is not indented by harbors the inhabitants naturally resorted to places in the interior, but mostly on the borders of rivers, navigable at least by canoes. Thus, on the Bay of Fundy, where there is the great wall of trap from Blomidon to Digby Gut, we find their places of resort on the Gaspereaux River, and I have heard of implements being found elsewhere. So in Cape Breton we find evidence of the occupancy by the people of the stone age at Lake Ainslie, and at various points on the Bras d'Or Lake. And probably a careful examination would show similar results throughout the other parts of the Province.

Lescarbot mentions that the Micmacs were in the habit of retiring to the interior in winter, and encamping on the borders of lakes. Such places will now be found so overgrown with trees and bushes that no traces of their occupancy will be discernable. But along the rivers when the land is cleared stone implements are picked up at various points. Thus I have obtained them on the St. Mary's River, near the Forks, and on both the East and West Branches. On the Roseway River, about fourteen miles from Shelburne, the stream divides forming an island, on which have been found a number of implements, principally goudges. I have seen a number, some of them rather singular, which were gathered on the Musquodoboit; and I have heard of a place on the Shubenacadie, not far below the railway station, which has yielded a number of such articles. But except at such chosen spots as those I have mentioned near the embouchures of the Lequille and St. Mary's Rivers, so far as I have observed, the relics found in the interior have not been in such quantities as to indicate continued occupancy.

The kitchen middens on the sea coast are in most cases easily distinguishable by the quantity of shells which they contain. Up the rivers they are usually known only by finding implements on the stone chips left in the formation of arrow heads. Even of that which I have mentioned on the Lequille River, though Mr. Hoyt has picked up on about three-quarters of an acre of ground between fifty and a hundred implements, yet the soil does not differ in appearance from that around, though its present occupiers notice a greater fertility in it which is retained through successive croppings. But on such places on the coast we will generally find on the surface a distinct layer, varying from two or three inches to fifteen or twenty inches in depth, composed sometimes almost entirely of shells of edible mollusks but genally mixed with soil formed by the decay of the other refuse from their camps. In no place that I have seen does there appear any thing like the quantities, shown in other countries, where accumulations almost entirely of shells to the depth of two, three or even more feet, will be found extending over acres of ground. What I have seen might more properly be called refuse heaps, of which shells formed an important part, and they covered but very limited areas, the largest not exceeding three-quarters of an acre, and I have seen instances where such a layer of not more than two or three inches deep was found covering a circuit of not more than twenty or twenty-five feet in diameter, as if it had been occupied by a single camp.

The first question which arises is as to the geological age of such deposits. Some Archæologists of the United States have claimed to find relics of man in situations, which would indicate his existence previous to the glacial age, and many European Archæologists have drawn similar conclusions regarding the antiquity of man in the old world. Whether these inferences be correct as to these countries or not, in Nova Scotia, as Dr. Honeyman has pointed out, the remains have always been found in such situations as clearly showed that they were not of glacial age. They may be in the vicinity of deposits of this kind, but they are not of them.

Another question may be noted here. In the old world Archæologists from the nature of the implements found, and their position when discovered, have divided the stone age into two periods, distinguished by the use of chipped and polished stone implements, and known as the Palæolithic and the Neolithic. Some American students, carried away by the authority of their names, have sought to find the same in America. But I believe that American Archæologists are now generally coming to the conclusion that in the new world there is no ground for such a distinction. We have always thought the idea irrational in itself. Instead of the making an implement by chipping being a simple act, which could be performed by beings in a low state of development, and polished implements, being the product of skill requiring a more advanced intelligence, it is rather the reverse. The grinding of a stone to an edge by rubbing it on another is the simplest act, requiring the least amount of thought (see No. 12) while the formation of an arrow-head is a work of considerable skill, so much so that scientific men only learned how it was done from savage tribes, who still practised the act. At all events, in Nova Scotia the rudely blocked out implements and the perfectly formed ones, both chipped and polished, are found together in a way that precludes the idea of their being the product of different eras.

Coming more particularly to our Nova Scotia kitchen middens, it must be noticed that in no case, so far as I am aware, have they been examined with the care with which scientific men have treated those in other countries. Besides, the ground has in most cases been ploughed over, in some instances frequently, thus changing its condition from what it was when abandoned by the Indians. But they will still amply repay investigation. The majority of the implements in my collection have been obtained from one to which I wish more particularly to refer.

It is situated on the farm of the Rev. A. P. Millar, Merigomish, in the rear of a point projecting from the south side of the harbor. One has only to look round to see that the spot has been selected with a skilful reference to the circumstances and wants of the people of that time. It was close upon the waters of the harbor then teeming with fish, and not far from the open Gulf. The creeks and small islands around swarmed with wild fowl, while behind them was the forest abounding in game. The point has an elevation of perhaps 40 or 50 feet. It has been wearing away, and was probably higher in former times. Being also then covered with wood it would still better serve as a shelter from northerly winds. From the point the ground slopes gently to the south till it is little above high water mark. On the face of this slope over a space of perhaps three quarters of an acre are found the shells and other refuse of a Kitchen midden. At the foot there is a little stream, which would have afforded fresh water. Where it reaches the shore a little cove makes in, which would have suited admirably for drawing up their canoes, and it may be observed that in digging at the point there was found pieces of partially decayed birch bark, which had been covered by earth washed down from the higher ground.

The layer of shells and refuse referred to is on the level only from six to eight inches deep, where the ground had been cut out by a small run of water from twelve to fifteen, and it thins out to nothing at the outer edge. The shells were mostly if not entirely the common oyster (Ostrea Virginiana) the quahog (Venus purpurea), the clam (Mya Arenaria) and the mussel

(Mytilus edulis). I confess I did not look for others. My attention was recently directed to the subject of smaller shells, by a letter from Mr. W. F. Ganong, enquiring if I had ever found the English periwinkle in such places. In the few observations I have been able to make since, I have not found any other than those mentioned.

From this place have been obtained about half the objects in the present collection, besides a number given by me to other collections and a number taken away by other parties.

Referring more particularly to the collection as a whole, it will be seen to contain nearly 300 objects of Archæological interest. Of these over 250 are connected with Nova Scotia, representing the stone age of its aboriginal inhabitants. These are so varied as to form an almost complete representation of the articles found among the remains of the native races of North America, thus exhibiting their life at the period referred to, so far as that can be done by their implements and other relics. Besides these there are a number of articles of a similar character, not only from the United States, but from Scotland, the West Indies and particularly the New Hebrides Islands, where the stone age continued till very recently, and on some of which it has scarcely yet passed away.

They have been arranged according to the classification adopted in the account of the Archæological Collection of the Smithsonian Institution, prepared at the time of the Centennial Exhibition. In noticing the articles more particularly I shall follow the order there observed, as we will thus be enabled to see how far the various kinds of implements found elsewhere are represented in Nova Scotia, and thus illustrate by comparison, the condition of its inhabitants at that period.

I.—STONE.

A.—FLAKED AND CHIPPED STONE.

1. *Raw Material.*—The collection shows, particularly from Bauchman's Beach, Lunenburg County, some of the rocks brought from the trap rocks of the Bay of Fundy, in nodules rounded by

the action of the waves rolling them against one another, just as they are found at the foot of the cliffs there, or partially operated on, besides a great variety of stone chips and flakes from different places, (Nos. 124, 170, 225.)

2, 3. *Irregular flakes of obsidian*, etc., produced by a single blow, and two edged narrow flakes of obsidian produced by pressure, etc. We have nothing to represent these from Nova Scotia but there is in the collection a piece of a small obsidian knife from Mexico, (No. 173.)

4. *Unfinished Arrow and Spear-heads.*—Of these the collection affords an abundant representation, (Nos. 99, 114, 115, 150, 246.)

5. *Arrowheads.*—The collection contains over sixty specimens from Nova Scotia. The majority of these are from Merigomish Pictou County, but there are also some from St. Mary's, Antigonish, Annapolis, and particularly Lunenburg County. In the material of which they are composed, there is a difference between those obtained on the North shore of the Province, and those from the South and West. The former are generally composed of hard flinty slate, felsite, quartzite, or other of the rocks found in the metamorphic rocks in the mountain range in the interior, and occasionally white quartz. The latter are generally formed of the agates, jaspers and other fine grained minerals found in the crevices of the Trap Rocks on the Bay of Fundy. The action of the weather brings these down to the foot of the cliffs, where being rolled together by the action of the waves, they form nodules of from two to four inches in diameter. These seem to have been a favorite material for the formation of arrow heads. In some respects they are very suitable for the purpose. They are hard, fine grained, and in cleavage form sharp edges, but not being stratified they are apt in splitting to break into short pieces, so that the implements formed of them are generally small, though sometimes very pretty.

These are found of all shapes that are represented in other countries, some being leaf shaped, with base rounded or pointed, some triangular, some straight-sided with base more or less concave, some notched near the base, some are stemmed in considerable variety of forms, and some are barbed as well as stemmed. There is a piece of one from Yarmouth County (No. 174) which is interesting as giving evidence of having been wrought into a spiral form. There is what is set down as a spear-head from Michigan (No. 105) which shows the same peculiarity. Such implements have been regarded as showing that the aborigines had discovered the principle of the rifle gun.

Besides the specimens from Nova Scotia are several from Massachusetts and New Jersey, (Nos. 158–164), one from Collingwood, Ont., (No. 165), and one from Aberdeenshire, Scotland, (No. 166), which will show the similarity of the workmanship of the people of the stone age in widely separted countries.

6. *Spear-heads.*—These are of the same forms as the arrowheads but larger. Some fine specimens are in the collection, some leaf-shaped with rounded base and some stemmed (Nos. 100–104.) Some instruments passing under this name may have been used as cutting or scraping tools.

7. *Perforators.*—Two implements in this collection, both from Annapolis, are set down under this name, but both have the points broken off. One (No. 282) has a broad base, but shows evidence of having been worked to form a point. The other (No. 278) though having something the appearance of an arrowhead, appears really to have been intended as a perforator.

8. *Scrapers.*—Thick flakes of flint, &c., worked at one extremity, sometimes at both, into a convex or semi-lunar edge. Such are still used by the Eskimo in cleaning skins, and in scraping and smoothing horn, bone, wood, &c. Two specimens, both from Annapolis, (Nos. 283, 286.) But a number of others probably also served the same purpose.

9. *Cutting and sawing implements.* — There are several implements of this kind from Nova Scotia (Nos. 91, 249.) But a crescent shaped one from New Jersey is worthy of special notice (No. 106.)

10. *Dagger-shaped implements.*—Not represented.

11. *Leaf-shaped implements.*—"Perhaps mostly used for scraping and cutting. Some may be unfinished tools." A number of such in the collection (Nos. 94, 97.)

12. *Large flat instruments usually ovoid in shape,* supposed to have been used as spades or hoes. One fine specimen from Merigomish, 7½ inches in the longest and 3¼ in the shortest diameter (No. 85.)

B.—PECKED, GROUND OR POLISHED STONE.

1. *Wedges or celts.*—There is a great variety of these, though in the catalogue they are generally named axes. They are from different parts of the Province, though the majority are from the kitchen midden at Merigomish, previously described. Our weather, with its frequent freezing and thawing in winter, seems to act severely upon them, when on or near the surface of the ground, so that they become rough or fretted, and portions spall off. So that we do not generally find them with the fine polish, that we see in many from other countries. They are formed of various hard rocks, which may be found among the older Geological formations in Nova Scotia, or fragments found in the drift. Their shape seems in many cases to have depended on the original form of the stone, (see No. 36.) In one from Merigomish (No. 12) we see the simplest workmanship, where there has been only a little rubbing or grinding at one edge, and the stone otherwise left in its original condition. But others have been carefully and laboriously brought into a regular shape, (No 50, from East River of Pictou.) They are of all sizes, from an inch and a half to seven inches. A number are two edged, showing that in use they were to be hafted as axes, (No. 22, Merigomish ; 55, Bauchman's Beach ; 268, South Pictou.)

Some are flat on one side, and are known as fleshers or bark peelers, (No. 65, Merigomish.)

There are also one from Scotland (No 60), two small but finely polished ones from Trinidad (Nos. 61, 62), several from the New Hebrides (Nos. 57, 58, 59). They show the similiarity of form of these implements in widely separated countries, that from Scotland being scarcely distinguishable from one from Erromanga. There is one hafted according to the mode customary till recently on that island, (No. 179.)

2. *Chisels.* In the collection some are set down as axes

that others would set down as celts or wedges. No 269 answers the description given, though it is thought more likely to have been used as a striker or pogomakunn. Under this title perhaps also may be classed a peculiar implement from Lake Ainslie, C. B., (No. 79). It is about 8 inches in length over all. In the front it is brought to an edge, but the rest is about $\frac{5}{8}$ of an inch thick throughout. At the base, it is $3\frac{3}{16}$ inches wide, but gradually decreases almost to nothing.

3. *Goudges.*—These are of three kinds: 1. Those slightly hollowed out at the cutting part, as No. 73, $10\frac{1}{2}$ inches long from Aneiteum, and Nos. 74 and 75 from St. Mary's, $13\frac{1}{2}$ and 14 inches long. 2. Those which have a concavity, of which there is a beautiful specimen from Lake Ainslie, C. B., (No.). These were probably hafted and used as adzes and employed in hollowing out wooden vessels, fire having been first applied. This one is partially grooved transversely seemingly for this purpose. And 3. Those hollowed out through their whole length. Of these there are one from Shelburne, one from St. Mary's, and one from Cape Breton, besides one from Massachusetts. These seem to have been used for tapping and gathering the sap of the maple trees. Some of the axes have the cutting edge ground in a slightly goudged form (No. 263 from Antigonish County).

4. *Adzes.*—None of the implements are marked as such, but probably some were hafted and used in this manner.

5. *Grooved Axes.*—I have obtained but one specimen of these (No. 52 from St. Mary's.) It is $7\frac{1}{4}$ inches long.

6. *Hammers,* including hammer stones and hammer heads. The collection contains a number of stones of hard composition, which on their edges show that they have been used as such, (Nos. 50, 167). Others show that they were manufactured and perhaps were intended to be hafted as the axes, (Nos. 67, 70.)

7. *Drilled Ceremonial Weapons.*—No specimens.

8. *Cutting Tools.*—Some are marked as knives that in other collections might be marked as celts, because from their shape they are fitted and seem intended to be held in the hand in the manner the Mic-macs hold their knives to the present day, drawing them towards them, (No. 8, Merigomish Cemetery, No.

80, Sherbrooke). But besides these there are quite a number of implements undoubtedly intended for cutting (Nos. 10, 81, 84, 107, etc). One crescent shaped one from St. Mary's (No. 276), deserves particular notice.

9. *Scraper and spade-like instruments.*—There are no implements in the collection like those represented under this title.

10. *Pendants and sinkers.*—Besides those pendants supposed to be intended as ornaments there are two of the class supposed to have been used as sinkers for nets, one from Shelburne County (No. 88), and one from Annapolis (283.)

11. *Discoidal stones and implements of kindred shape.*—There are no stones here exactly of the form figured in the Smithsonian report, but stones in their natural state have been picked up on the site of old encampments in the shape of flattened spheres, which seem to have been sought after for some purpose (No. 168, Lunenburg, and 169, Merigomish). But besides there is a large stone from Cape Breton (No. 264), ground to a perfect oblate spheroid, 5 inches in the longest diameter, and $3\frac{5}{8}$ in the shortest, seemingly a chung-ky stone. Another from the same quarter, more flattened, partly ground, but not brought to such perfect shape, may have been used for the same purpose. But both may have been used for grinding meal.

12. *Pierced Tablets.*—Of this class the object of which is not quite certain, there is one specimen from Green Hill, Pictou County (No. 86).

13. *Stones used in grinding and polishing.*—There are no stones with grooves such as figured, but we have in No. 66, from Merigomish, a good specimen of an instrument with a smooth even surface, like a flat iron, probably used for polishing or as a muller for grinding pigments, and probably some of the other implements were used for the same purpose.

14. *Stone vessels.*—None.

15. *Mortars*—Have found none yet, but it is evident that they must have been used.

16. *Pestles.*—There is here one specimen from Barney's River, Pictou County, (No. 72) weighing $8\frac{3}{4}$ pounds. This stone is almost in its natural state, but has a distinct groove cut round

the upper end for suspension, probably to be used with a spring pole.

17. *Tubes.*—None in this collection, but it may be mentioned that there is one in the Provincial Museum, showing that in whatever way they were used by other tribes, the Mic-macs had the same practice.

18. *Pipes.*—I have not found many pipes in Nova Scotia and none with sculptured figures upon them, as is common farther west, but I have heard of some being found by other collectors, and there is one in the collection from Collingwood, Ont., in which the bowl forms the representation of the head of an animal (No. 178). Besides the one already described from the cemetery on the Big Island of Merigomish, there are two from Nova Scotia and one from Metapedia, N. B. One from Big Island of Merigomish is simply a bowl roughly formed of sandstone, and is probably modern. The other two, one from Tatamagouche (No. 176), and the one from Metapedia, N. B. (No. 287), exhibit what I regard as the typical Mic-mac pipe. It is known that each tribe of Indians has its form of canœ, snow shoe, etc., and I believe also of pipes. It consists of a round bowl upon a ridge like a keel from one and a half to two and a half inches long, from one end of which a hole is bored to the bottom of the bowl. This ridge is on the lower side again cut out so as to form a narrower keel, which is pierced with holes, probably for the receiving of a string by which it might be suspended from the neck. Of the pipes which I have seen both in Nova Scotia and New Brunswick, so large a majority were of this form that I believe it to be representative. On the ridge of the one from Metapedia there is delicately incised ornamental work, in waving lines and other shapes.

But there is an interesting stone found at Annapolis (No. 281), out of which the manufacturer had begun to make a pipe. He had drilled through what he intended as the stem, and also from the top, till the two perforations met, and had partially drilled the bowl. But the stone had split from some cause and was rejected. It also shows marks of attempts to cut it by sawing. The holes drilled are about three-sixteenths of an inch in diameter, and are striated longitudinally. Altogether it shows that it was the practice first to drill the bowl and stem, and afterward cut down the stone to the shape intended.

19. *Ornaments.*—Of these may be noticed two pendants (No. 87, 88), each with a hole near the end, for suspension, and probably intended as breast ornaments, the first from Barrington, the last a flattened oval with rounded edge, very exactly formed and beautifully polished, from Lake Ainslie, C. B.

20. *Sculptures.*—None.

In addition to these there are a number of articles which cannot be classed under any of these heads. I notice the following: 1.—" A fire stone" from Merigomish (No. 277), a lump of iron pyrites, used in striking fire. 2.—A small flat stone from Annapolis (No. 280), one and three-quarter inches long by one and a half wide, with a series of small notches along one edge of each end. The only use I can imagine of this would be for making a series of lines on their pottery. 3.—A figure from Upper Miramichi (No. 265), somewhat resembling a woman with a shawl over her head. The stone is in its natural state, but exhibits one of those curious forms sometimes found and which ignorant tribes are often disposed to invest with sacredness. From the representation of an aged Indian, it is believed that this was a sacred stone used by their old Shamans. 4.—Two coffin-shaped stones, one broken from Merigomish cemetery (No. 90), the other whole from West Cornwallis (No. 89), which have been ground to their present shape. As we can discover no practical use which these serve, we must suppose them connected with some fancy or superstition.

II.—COPPER.

Native copper is found in small quantities in Nova Scotia, and the people of the stone age had learned that by hammering it could be formed into small knives or other implements, and in the process become hardened. Besides the specimens from the Big Island cemetery already described (No. 227–230), there are from Bauchman's Beach, Lunenburg County, what appears to have been intended as a piercer, with some smaller pieces perhaps intended for beads or ornaments (No. 231). Thus that period was in a measure a copper age.

III.—BONE AND HORN.

To these we must add ivory. The walrus frequented the Northern coast of Nova Scotia till a recent period, and its tusks afforded excellent ivory, which the people of the stone age formed into various implements. Few implements of this kind have been collected in Nova Scotia, partly from their perishable nature, and partly from their not having engaged the attention of collectors. But this collection contains several that are quite interesting.

1. *Bone piercers* (Nos. 199–201, 274), from Merigomish. Unfortunately all these have the butt ends broken off, so that we cannot say whether they had holes in them like an eye for fastening the string.

2. *Bone fish spear heads.* I have already referred to those from the Big Island cemetery (No. 211–214), but these are portions of several others from Merigomish (No. 204–207).

3. *Two ivory harpoon points* from Merigomish (No. 197, 198), similar to those used by the Eskimo at the present day for taking seals, walruses and even whales. One end has a slit transversely to receive the stone point (for which the Eskimo have now substituted iron). At the other end is a hollow for the reception of the ends of the shaft, and a projecting point on each side to serve as a barb. In the centre is a hole. By a cord from this it is attached to the shaft in such a manner, that it can be disengaged the moment it strikes the animal. When it started off, the pressure upon the centre of the implement caused it to turn at right angles to the direction of its entrance, like a toggle, and Capt. Parry tells us that no barb could hold as firmly. The Eskimo attach an inflated seal skin to the other end of the line, which serves to bring the animal quickly to the surface of the water, and doubtless our stone age men used a similar device. Indeed these implements show either that the Eskimo then inhabited the Northern shore of Nova Scotia, or that the Micmacs had the same mode of hunting the larger sea animals.

4. *Several implements of which the use is uncertain*, one from a mussel bed (so called) in Merigomish Harbor (No. 203), and two from the cemetery referred to (No. 209, 210), besides pieces of ivory (No. 216.)

5. *An unknown instrument of horn or ivory* from Merigomish, (No. 188.) It is eight inches long, flat in the centre, where it is seven-eighths of an inch thick, with rounded edges, and one and five-eighths of an inch wide at its greatest breadth, and tapering at the one end to a blunt point, and at the other forming a rounded edge. It may have been used as an ice chisel.

6. There are three *instruments of walrus ivory*, formed by sawing the tusk longitudinally from both sides, (Nos. 185—187.) They seem to have been used as pressers in forming arrow-heads, but it is possible that they may have been used as diggers by being attached to a handle, or even as strikers. With them is a tusk unmanufactured (No. 195), which I take to be the tooth of a spermaceti whale. This animal was formerly found at least as an occasional visitant in temperate climates, and its capture by the Micmacs is of interest.

IV.—SHELLS.

I have found no shell implements in Nova Scotia, but there are in the collection some very noticable shell adzes from the New Hebrides, (Nos. 180, 183.)

V.—CLAY.

For some time it was believed that the Micmacs made no pottery in pre-historic times. But though no perfect vessel has been found, yet considerable quantities of fragments have been discovered, sufficient to show the state of the art among them. They are fully represented in this collection. The first found were in the pre-historic cemetery on Merigomish Island (No. 222), but afterward fragments were found in kitchen middens (No.. 223), later still larger quantities were found at a spot on the Lahave River above Bridgewater, in Lunenburg County, where there seems to have been a regular manufactory (Nos. 251, 255). These are of red or brownish grey color. The clay is seen to have been tempered by pounded granite being mixed with it. They vary in thickness from three sixteenths to one half of an inch. Some show that they belonged to vessels of large size. They show that the vessels were generally of the gourd shape, though one piece especially shows that the bottom had been prolonged to a blunt point. Portions of the mouth show sometimes a lip vertically straight, but in most instances it is curved outwards. Some have ears showing that they were to be suspended over the fire. There is considerable ornamentation on the outside on the upper part, but I have not been able to trace any design in the marks. They consist sometimes of rows of dots made by some sharp pointed instrument, and again of such impressions as might have been made by the nail of the forefinger. Sometimes they were made by an instrument about two inches long with small teeth, with the points of which an impression was made in one row, then the one end was swung around, and a second made at an angle with it, then the other end was moved in the same way, and thus a zigzag formed. Sometimes two lines were drawn up and down meeting at a sharp angle at the top suggesting the shape of the wigwam. Some show scratches on the inside, the cause of which does not appear.

Of course these are all coarse and do not in any respect compare with the specimens found in many parts of the West and South.

With these from Nova Scotia are exhibited specimens from Hochelaga, the site of the present Montreal (No. 224), a broad shallow vessel from the New Hebrides (No. 256), with portions of one of gourd shape from the same quarter, though Sir John Lubbock informs us that the people of these islands did not make any pottery.

VI.—WOOD.

No prehistoric objects of this material have been found in Nova Scotia, so far as known to me. Our climate would in most instances be fatal to the preservation of them.

Art. VII.—Nova Scotian Echinodermata.—By the Rev. D. Honeyman, D. C. L., F. R. S. C., F. S. Sc., &c., *Curator of the Provincial Museum, Halifax.*

In our recent Studies of Marine Invertebrates, we have been led to give some attention to the admirable collection of Nova Scotian Echinodermata in our Provincial Museum. We propose to give the results in this paper.

Of the Sub-kingdom Anneloida, Class I, Echinodermata, we have the following *Orders* represented:

1st.—Crinoidea.
2nd.—Ophiuroidea.
3rd.—Asteroidea.
4th.—Echinoidea.
5th.—Holothuroidea.

The first of these is represented by

Comatula or Antedon Specimens.

Of this we have two specimens which were presented to the Museum by Sir C. Wyville Thomson, of H. M. S. "Challenger." They were dredged on the LaHave Banks from a depth of 75 fathoms. This is a modern representative of the ancient Crinoids, which flourished in Nova Scotia, largely at Arisaig, in the Lower and Upper Silurian Periods, and to a less extent in the Lower Carboniferous, e. g., East River, Pictou. For examples see our Museum Collections.

Our *Antedon* specimens are in the mature state. When young they were on stalks and fixed. Then their resemblance to our Silurian Crinoids was sufficiently obvious. Now their resemblance is not so striking. It is only when examined critically that this is manifest. Their present aspect is feather-like. Hence a "common name"—"Feather Star." Their body is cup-shaped and pentagonal. From each side proceeds a double ray—arm. The mouth lies between. The rays are each fringed with a double row of *pinnulae*—20 rows in all. This is the inferior or ventral side. On the other dorsal side is a multitude of *Cirri*, by which the Crinoid anchors itself and clings to other bodies. These cirri are characteristic and distinguish species. The joints of ours are plain, the terminations are *single claws*. The joints of arms and cirri have central perforations like those of other Crinoids, "St. Cuthbert's Beads." Three *foramenifera* adhere to one of the cirri which we have examined.

The next ORDER is represented by two families. 1. *Asterophytidæ*. 2. *Ophiuridæ*. Of the Asterophyton the body is large. From this proceed five arms which divide and subdivide until the number can only be conjectured. The back has 5 rays (ridges) which differ in character and constitute different species. The common form, with us, has been named *Asterophyton Agassizii*. Of this we have *three* specimens. *Two* others and a small *one* from Cape Breton make at least *two* other species. They are all now curled up and have a "basket-like" appearance. They have received a common name—"basket fish."

The second family, *Ophiuroidea*.

The body of these is discoidal. It is covered with granules, spines, or scales. Pedicellariæ are wanting. This contains all the viscera. From it proceed five—*exceptional six*—slender arms. They are simple and without prolongations from the stomach. Unlike the *Asteridæ*, these are unexcavated and without ambulacral grooves. The mouth is in the centre of the lower part of the body. It has a masticating apparatus, and is surrounded by tentacles. The mouth is also the anal aperture. The arms are each composed of four rows of calcareous plates. The lateral ones have well developed spines. These are very numerous. The arms are very brittle, hence they have received the common name "brittle stars." They are serpentine, and hence the family name, *Ophiura*. In our harbor we recognize two genera: 1st. *Ophioglypha, species, robusta*. This is the form with which we are best acquainted. It abounds in the centres of our boulders. Vide preceding Paper. 2nd. *Ophiopholes; species, aculeata;* received from the U. S. Fish Commission, 1877. These are very beautiful.

The third order is *Asteroidea.*

Like the Crinoidea, this is a very ancient order in Nova Scotia. One of our first Arisaig fossils was *Palæaster-parviusculus.* Billings. This *tiny* aster is in a boulder found near Arisaig Pier. We cannot locate it *exactly.* It is doubtless as old as the Clinton ledge, from which we have the best *Crinoidea* in our Museum—"Arisaig Collection." Its size equals that of the youngest of the "Common Starfish" in our suite of specimens. This is half inch. It is figured and described in Dawson's Acadian Geology, pp. 597–8. It has five rays, and shows the under side; two of the rays are defective. We quote from Nicholson's Geology a description of the Starfish, page 164:—

The body is star-shaped or pentagonal and consists of a central body or "disc," surrounded by five or more lobes or "arms," which radiate from the body, are hollow and contain prolongations of the viscera. The mouth is inferior and central in position, the arms either central or dorsal. The skeleton is composed of a vast number of calcareous plates or ossicula, united together by the coriaceous perisome, so as to form a species of chain armour. Besides these the integument is abundantly supplied with spines, tubercules and "pedicellariæ." Lastly, the radiating ambulacral vessels run underneath a species of internal skeleton, occupying the axis of each arm and composed of a great number of bilateral "vertebral," or calcareous plates, which are movably articulated to one another and are provided with special muscles by which they are brought together or drawn apart." Our common species is *Asterias vulgaris.* This attains to a large size. One of our Museum specimens measures 17 inches. This has five rays. Of another species—*Asterias polaris*—we have two specimens having six rays. The size of these is 12 inches. When devouring a mussel or oyster they bring the disc and mouth to the juncture of the valves, clasp the valves with their rays, and then deliberately raise the body, opening the valves and extracting the inmate by suction. We have witnessed the operation in our aquarium, where we had young star fish, and small mussels placed together. In the United States department of the Fisheries Exhibition a large number of star fishes caught in the act of swallowing oysters were exhibited.

We have also *Crenaster-papposus;* the "Sun Star" of the Family *Solasteriadae* and *Hippasteria phrygiana,* the "Cushion Star" of the Family *Astropectenidae.*

The fourth order is *Echinoidea.*

Of this order we have a representative of the Family *Echinidae; Echinus drobrachienses,* our common sea urchin. This differs from the preceding in having the animal enclosed in a test of spherical form which bristles all over with spines of different sizes. When alive and in the aquarium, the spines, which have a "ball and socket" movement, are seen moving in all directions. Beyond these stretch the tentacles, which protrude from ten perforated zones. These, too, are in motion ready to catch any creature of convenient size and proper for food that may come within reach. This is thereby conveyed to the mouth, which occupies a central position below. This differs from that of the other echinoderms which we have already described, in having teeth. There are *five* of these arranged as a pentagon. They are set in jaws of equal number, which may be seen on opening the test. This masticatory apparatus is known as "Aristotle's Lantern." The anus is on the summit. When the spines are removed the structure of the test is then observable. The spines are beautifully formed. Their structure can only be properly seen by the microscope. They have sockets which fit the tubercules with which the test is ornamented. The perforations from which the tentacles protruded are now distinctly seen. The test is composed of calcareous plates, which are nicely fitted together and firmly cemented. These plates have names according to their position and functions. Certain ones surround the mouth, the oral, and also the anus, the anal. The latter are surrounded by the genital plates, which are five in number and of pentagonal form. Each of these has a perforation. One of them is larger than the others. This has a spongy, minutely perforated tubercule, like the rose of a watering pot — the "madre poriform tubercule." Wedged in between the plates and occupying the summits of the ambulacral areas are five smaller plates—the "ocular plates." Each of these is perforated, to accommodate the "ocellus" or eye. The mechanism and design of the whole is admirable—perfect.

The next family is *Clypeastridæ.*

Of this we have one representative—*Echinarachnius parma* —(sand dollars.) Our specimens of these were collected from the sand flats of Cow Bay and Clam Bay. Their form is discoidal. The accommodation for the creature seems scanty. They are covered with minute spines. Their mouth is under, central, on the flat side. The anus is central, on the upper convex side. Like the Echinus they have five teeth. Unlike they do not project. You have to look into the mouth to see them. In the Echinus the ambulacral apertures extend from pole to pole. In our Clypeaster they are only on the convex side, where they are arranged in stellar form—five rays—having the anus for a centre. They burrow in the sand. Only tests can be seen on the surface. When the sea is ebbing, circular depressions in the wet sand, mark their existence. Our specimens vary in size from ½ inch to 2½ inches.

The fifth order is *Holothuroidea.*

These are known as "Sea Cucumbers," Trepangs and "Beches-de-mer." They are the most highly organized of the Echinoderms. These are well represented in our Harbor and Bedford Basin Collections. We have notable examples of the Family Dendrocherotæ.

1. *Psolus phantapus.*

Our specimen is an unusually large one. It measures from the oral to the anal opening along the middle of the disc 8 inches; its girth is 6 inches. The length of the disc is 3½ inches. There are two rows of feet along either side and another along the middle; along the back from the oval to the anal opening it measures 4½ inches. The tail and neck and mouth rise above the back, giving it a saddle shape. Its color is *brownish.* A Chinaman who loves a trepang as much as a bird's nest would gloat over it. We have had many specimens of the common size—none approaching to this one.

2nd. *Cuvieria Fabricii* is represented by ore large and three smaller ones. This is clad with a coat of mail, calcareous plates, thickly tuberculed—imbricated. One of these was caught in Bedford Basin. It was living, with tentacles fully spread; its colour was a brilliant red. It was very beautiful; we were sorry when it died. The plates overlap, having rounded free edges toward the medium line of the back. The ventral disc has two rows of feet extending along the sides. There is no median line. The largest specimen is 4 inches in length and 2½ inches in breadth. A common name is "Sea Orange."

3rd. *Pentacta frondosa*—"Sea Cucumber." Of this we have four specimens. They are very much contracted and do not afford any satisfactory measurement. Their colour is faded purple. The tentacles of three of them appear. The tube feet are distributed over the quarter part of the body. The skin is very tough. Portions of this were dissolved in caustic potassa. Irregular forms only survived. The tentacles of one were treated in the same manner with a like result, excepting, certain foreign bodies which are very beautiful. Of these we recognize the familiar *diatoma vulgare* in various forms of fission. Some of these are very striking and instructive. There is another form which we also encounter very frequently. In the present case some are perfect. These resemble a wheel with 6 and 7 spokes without the felloes. The centre is polygonal. We consider this also to be a marine diatom.

4th. *Trochostoma (Molpadia) oolitica.* This is a rare "Holothurian." Our specimen is the only one we have seen except in figures. It was caught in our harbor in 1873 by Captain C. D. Grant, of the brigantine Strickland, and presented to the Museum. I regarded it as a great curiosity and preserved it carefully in alcohol. When fresh it was of a lovely purple colour. This changed considerably in the alcohol. It has a circular mouth, a long neck, and an oval body with a short tail. Its lengtn from the oval to the anal opening is 6½ inches; the greatest girth is 6 inches.

When the naturalists of the U. S. Fish Commission were in

Halifax in 1877, Mr. Verrill identified it and labelled it *Molpadia oolitica.*

Danielssen and Koren, in *Holothurioidea* of the Norwegian North Atlantic Expedition, 1876–1878, include this Holothurian in their genus *Trochostoma*—Gr. *Trochos,* a wheel, and *Stoma,* a mouth, of which *Trochostoma Thomsoni* is the type.

ART. VIII.—TWO CABLE HAULS OF MARINE INVERTEBRATES,— *By Cable Steamer Minia, Capt. Trott, Commander.*
—REV. D. HONEYMAN, D. C. L., F. R. S. C., F. S. SC., &c., *Curator of the Provincial Museum, Halifax.*

The *first* Haul is of the Anglo-American or "Brest Cable"—of 1869.

The *second* of the Anglo-American or Duxbury Cable—of 1869.

The *first* Cable extends from St. Pierre to Brest, France.

The *second* from St. Pierre to Duxbury, Mass., U. S. A.

The portion of the *first* to which our invertebrates were attached lay in lat. 44°, 38'; long. 54°, 6', and depth 570 fathoms. Of the *second*, in lat. 43°, 4', 38"; long. 66°, 14', 30", and depth 48 fathoms. We are under great obligations to Capt. Trott for the gift of the interesting and important material, which we have submitted to a thorough examination, the results of which we now propose to communicate. It is interesting to know that the part of the first cable in question was brought up on the 19th anniversary of the laying of it, July 11, 1888. That of the second cable, Oct. 26, 1888. The position of the first was on the side of the Grand Bank, near the Gulf Stream. Of the second, in the Bay of Fundy, west of Seal Island. The creatures of the first are far below the extension of solar light and heat, while these of the second enjoy both. We may, therefore, expect differences in character and constitution of the attaches of the respective cables.

I would here observe that the attaches of the "glacial boulders" of the Nova Scotia Fishing Banks, described in our January paper, from the depth of sixty fathoms, may be expected to correspond in character and constitution with those of the second cable and to differ from those of the first.

It is possible that the fauna of the second cable may be less complete than that of the first, and that we may have to supplement it with our boulder fauna for the purpose of comparison and illustration.

As in the paper "On Boulders" we classify thus:

Sub-Kingdoms.

I.—(1.)—PROTOZOA.
(2.)—PARAZOA.
II.— CŒLENTERATA.
III.— ANNULOIDA.
IV.— ANNULOSA.
V.— MOLLUSCA.

I.—PROTOZOA—*Foramenifera.*

As might be expected, on account of depth, we have on the *first* cable *Orbulina universa, Globigerina bulloides, Nodosaria,* &c. These are found separately and in agglutinated tubes of *Annelida* found in the hempen debris of the cable.

On the *second* cable foramenifera were also found, firmly attached to other objects. On the Nova Scotia "Fishing Banks" similar ones are found—e. g., on the *Cirri* of the LaHave Antedon; *vide* paper on the N. S. *Echinodermata, Trans.;* on Boulders, Nullipores and Algæ. *Vide* paper "On Glacial Boulders of the Fishing Banks," *Trans.*, and other papers read before the Institute.

PARAZOA—*Spongidæ.*

On Cable I, we have three sponges. These were found in the "hempen debris." They are MONAXONIDA. The first that we found was attached to a *Bryozon.* It is a thin undiscribable sponge of brown colour. We have found several detached. Its spicules are *ac*², oxeas of various form and size. We give names to this and others which may be provisional. Our sponges are so *numerous* that we require this for *our own use.* This is *Reniera escharæ.* A *second* sponge, of which we have a number of specimens, or parts of specimens, is distinguishable from the other, but also indiscribable. Of this the spicules are *ac*² and *trac*, styles, the latter are of small size, and straight or bent

The former are of various forms—straight, bent, stout, slender. We name this *Reniera Miniæ*. A *third* is a small oval-shaped sponge, distinguishable from the two preceding, but not describable, so as to be recognised by others. The spicules of this are *trac*, styles and *anc*², bianchorate or bihamate, large, middle and small. It is a *Myxilla*. We give it a specific name—*Greeri*. Dr. Greer is the doctor of the "Minia."

The sponges of Cable II do not require hunting up with the magnifying glass. We have four pieces of this cable, each 2½ feet in length, densely coated with them, so as to astonish with the growth, and a large "tubful" besides.

The sponges of Cable II, in the Bay of Fundy, are *Reniera duxburyensis*, *Reniera fundyensis*, *Reniera collinculi*, *Myxilla Miniæ*.

The two first are the prominent ones. *R. fundyensis* is firmly rooted to the coating of the cable. *R. duxburyensis* covers the coating and encloses the other. The latter then branches above it, the two forming a dense thicket. Here and there *R. collinculi* forms a series of hillocks, with oscula on the tops. *Myxilla Miniæ* is found attached to the Hydroid, Campanalaria. The oscula of this are not much unlike the pores. This is a characteristic of our Myxilla in general. The oscula of *R. fundyensis* are distinct, small, and numerous, the figures being *pitted* with them. Of *duxburyensis* the oscula are large and wide apart. The *spiculation* of *Reniera fundyensis* is *complex*. It has this character in common with *Reniera Miniæ* of Cable I. I would also observe that the sponges of both cables have *diatomacea* of considerable variety and beauty. These of Cable II have also *radiolaria*. We defer further remarks on these to our paper on *Spongiadæ*.

Hydroida have a luxuriant growth on both cables. We do not attempt the description of these. They have done good service in securing many specimens which would otherwise have been wanting.

There are *Alcyonida* on both cables. These are of a kind that attach themselves to other objects, and hence we have them

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NOTE.—We hope to give plates with Camera lucida figures of the spicules, &c., of *R. fundyensis*.

attached to our cables. We consider both to be Cornularinæ. Danielssen thus describes one: "The Zoanthedem has no stem; the basal part is thin and semi-transparent, and it extends itself in bands over the objects to which it is attached. Isolated polyps, with their cells, stand up from the basal part, having larger or smaller intervals between them." Two specimens are described as *new species* and illustrated by plates.

We had not consulted the work to which we refer—Alcyonidiæ, of the Norwegian North Atlantic Expedition—until we had examined and re-examined histologically, our "First Cable" specimen. We had its beautiful spicules under the microscope when we received a new Report of the same Expedition. On opening it at random we were surprised to see *plates* representing the spicules before us, as we at first sight supposed.

In the memoir and plates by Greig we found two new species of Cornularinæ very much like our own. On closer examination we found the basal part of *Sympodium margaretaceum* to be like our own, but the polyps different, and also our spicules much different and apparently new. We therefore give it the *provisional* name—*Sympodium Griegii.* On the second cable we find another of a form decidedly different seated in the sponge *Reniera duxburyensis* and attached by its base to the coating of the cable. We also suppose this to be a new species. The spicules are very much different. The polyps of both are shrunk and only external character and spicules are available for examination. We would name this *Sympodium* (?) *Danielsseni.*

Our introduction to the First Cable Collection was thus: Mr. Hamilton, the Electrician of the Minia, meeting me on the street, informed me that he had something like a bamboo from the bottom of the ocean. Curiosity quickly led me to his room on board of the ship. When I was shewn the specimen I recognized an old acquaintance of the I. F. E., Canadian Department, which came from British Columbia with the name *Verrillia Blakei.* It was an attaché of the cable. Being told that Capt. Trott had other specimens, I went to his cabin to see them, and became the fortunate possesser of them all. Among the illustrations of the "Blake Expedition Bulletin," I further recognised the British Columbia specimens in the *Balticina finmarchica* of Koren and Danielssen, and its axis.

Our *Balticina* is certainly identical. The general aspect is the same, and so is the axis. The latter is exposed at the club-shaped end, and at the upper extremity it is bare, a length of *one* and *six-tenths* of an inch. The arrangement of polyp cells is the same—a farther length of *five inches*. They are confused and irregular, being injured—a length of *six inches*. They are then regular, but small—a farther length of *five* and *six-tenths* of an inch. This reaches to about *six inches* from the lower extremity. The spicules of one of the largest cells are long and short, fusiform, with longitudinal corrugations and colourless, The whole length is 24.2 inches. It must have been very prominent on the cable.

It is to be regretted that so small a portion of the organic material of the cable has been preserved. It was in great quantity. The rest was thrown overboard.

ANNULOIDA.

Of the Sub-kingdom IV we have also interesting representations. First—*Crinoidea*. *Comatula*, or *Antedon*. This is on Cable I. We have not found any on Cable II. We have one, however, which might be regarded as an equivalent. Sir C. Wyville Thomson presented to the Museum the specimens of a *Comatula* which he dredged on LaHave Banks; not far from the cable, and at a depth of 75 fathoms. We do not know the name given to it by the "Challenger Reporter." It is possibly *Antedon Eschrichtii*. We have three specimens of our Cable *Antedon*. They were found entangled among the *Campanularia* and are very much broken. We seem to have all the fragments, so as to be able to form a pretty correct idea of its character and appearance. We compare it with the larger species. The girth of the folded arms of the larger near the body is 30 m. m. Of the smaller 8 m. m. The dorsal *cirri* of both are perfect, generally, and are evidently characteristic. Those of our tiny Cable *Antedon* can only be properly examined by the *one* and *a half* inch objective of our microscope. They are pearly, translucent, The terminal claws are double. The number of joints is 20. These are fringed on the lower ends with minute spines, larger and smaller. The claws of the LaHave *Antedon cirri* are single. The number of joints is 37 and upward. They have no spines. They are yellow and opaque. We have another *Antedon* from another part of the same cable. The size of this is evidently intermediate. Its cirri have also double claws. They are also *spinous*—more strongly than our other. The number of joints is greater than of the other two. We have counted 55. Regarding our little *Antedon* as a new species we have named it *Antedon moræ.*

Of Order OPHIUROIDEA—Fam. *Ophiuridea*—we have specimens on both Cables. On Cable II we have *Ophioglypha sp.* These also abound on the "Glacial Boulders" of the Halifax Fishing Banks. *Vide* paper in Transactions preceding. They are strong in constitution and have the *normal* number of rays—*five.*

On Cable I the *Ophiura* is beautiful, delicate, white, with glassy spines, almost like spicules of sponges. This has *six* rays, an *abnormal* number. After a diligent search among authorities we have been able to find only one six-rayed ophiuran—in the Report of the Challenger, where it is described and figured and named as *unique.* In Vol. OPHIURIDA, plate 47, fig. 1, is *Ophyoglupha hexactis,* of Kerguelen Island, 20 to 75 fathoms, and Marion Island, 50 to 75 fathoms. It would be rather too much to expect our ophiuran, with so much difference of distance and depth, to be the same species. Except in the number of rays they are altogether unlike. Without interfering with the name of the other we would in the meantime assume the *Family* name, and distinguish ours as *Ophiura annæ.* Our specimen is much injured. The body is perfect; all the rays are well represented; one is almost complete and there is no difficulty in finding a terminal part to complete it. The joints and spines of the other rays are plentiful in the hempen *debris.*

In this *debris* we have also found two specimens belonging to *Order* Echinoidea.

1st.—A tiny test of an Echinus, without the spines. The oral apparatus and plates, and anal and genital plates are wanting. It is 7 m. m. in diameter; the height is a little more than 3 m. m.

2nd.—Detached plates of another. The spines are mixed with those of our *Ophiura*. We have separated a few of them as microscopic objects. In a cavity of one of our boulders we found a perfect *Echinus* of about the same dimensions as the preceding.

SUB-KINGDOM IV. *Annulosa* is well represented on our Cables.

Annelida—ORD. Tubicolæ.

On Cable I we have 1st—*spirorbes* attached to Hydroids. 2nd—Two long coiled leathery tubes; one of these is about a foot in length. 3rd.—Agglutenated tubes composed largely of grains of sand and tests of *foramenifera*. They were all without tenants. We can only conjecture their character. *Diopatra glutinatrix* may have occupied the last, as our portion of the Cable lies in the zone of their greatest abundance. *Vide* Bulletin of the Blake Expedition. We have not yet found *Tubicolæ* on the second Cable. *Spirorbes* and serpulæ are sufficiently abundant on our "Boulders." *Vide* a preceding paper.

The next Order is well represented on Cable I. They also occur, but less numerous on Cable II. These are "sea centipeds." That of Cable II resembles the *low water* species of our Harbour. That of Cable I is much different. Our low water species are tough and easily handled. It is scarcely possible to turn or otherwise handle the worms of the first Cable without breaking them. So that all our specimens are fragments, with one or two exceptions, and even these are not perfect. I may here make the remark that with the exceptions, Hydroida and Balticina, all are tender and fragile, and have to be handled with the greatest care.

The length of the first Cable annelid is 48 m. m.

The head is small; on the top are two pairs of ocelli (black spots.) The mouth is in front and is circular; above it are tentacles which seldom appear. The *spatulate* termination is 6 m. m. and 4 m. m. length in two specimens. The *anus* is at the end of this. Under the microscope the spatula has fine cross lines. The parapodia are bunches of bristles. They have a brilliancy in sunshine like those of *Aphrodite.* These bristles under the microscope are very beautiful. Some are doubly serrated and ensiform, others are long narrow cones without serratures and sharply pointed. On our microscopic slides are detached ones. We have one of our best specimens, which we allowed to dry in sunshine, on a glass slide. Observing it with the 1½ in. objective the sight was interesting. Bristles made their appearance in front—two conical and sharp pointed ones—so as to have the appearance of two horns. The whole body became translucent, showing the imbedded parts of the bristles, on either side almost meeting in the middle of the body. The bristles of the parapodia are in this specimen directed forward. We have it enclosed in dried Canada Balsam. Another specimen, head and part of the body, was prepared in the same way. In this one of the pointed conical, bristles at the front, is *fractured.*

Yet another specimen was laid on its back and dried in a similar manner. This shewed a formidable front with 6 projecting bristle points. The *parapodia* terminate at the top of the "spatula." We have not been able to recognize our annelid in any other, actual or figured. We give it the *provisional name Eunicea? Trottii.* We will now look at its work. There are four pieces of the Cable before us. 1st, is intact. 2nd, shews the iron wire, with the hemp between. There are numerous holes in the hemp—burrows of *E. Trottii.* 3rd and 4th, shows the gutta percha insulator pitted all over, but not deeply. These are the evident ends of the burrows. The frontal bristles of the annelid may have made the pits and one of them suffered in consequence. Our specimens of the annelid were taken from the hemp. One is still partially enclosed in it.

Arthropoda.

Our next are *Arthropoda,* Class 1st, *Crustacea,* Sub-Class *Cirripedia, Balanoid.* Among the debris of Cable I, we found parts of the shell of a *balanus.*

On Cable II they are abundant—small and large. The base or head of some is 1 inch in diameter.

MALACOSTRACA—Order *Lemadipodia.*

CAPRELLA, sp. We have already noticed this fantastic little Crustacean on Lawson Boulder. (A.) *Vide* Paper "Glacial Boulders," &c., Trans. I. N. S. On Cable II they abound. We have found them among the *Hydroida,* where they had been evidently feasting. They are of various sizes, some very small We regard all as one species. All that we now note regarding them is: Under the microscope they are plain, without spines, and have small *red eyes.* They are male and female. We would name it *Caprella Sarsii.* On Cable I, we found among the *Hydroida* three complete specimens of another species. These have a long spine on the back of the head curved backward, and two on the back, opposite the *Chelæ*, curved forward; also granulation. *These are blind.* They are, one male and two females. We would give this the provisional name—*Caprella trispinis.*

On this Cable we found 9 specimens of a *Podocerus.* The feelers are in length equal to the body—5 m. m. each. The telson is 1 m. m.; total length 11 m. m. Some of them have *eye spots.*

MOLLUSCOIDA. Among the hempen debris of Cable I, we found Bryozoa. One had a sponge, *Reniera escharae,* attached to it; others were free. On Cable II Bryozoa abound. Some of them are very beautiful; they are calcareous. Elsewhere we have designated them "Corallines." They also occur abundantly with the *corneous bryozoa* on our Boulders, and *Boltenia clavata,* large and small, in abundance.

Among the debris of Cable I we have found MOLLUSCA—*three* small saxicava.

On Cable II, old and young species occur frequently.

In the debris of Cable I, we found a small *anomia,* and three specimens of a tiny *arca* of different sizes. Measurement of the largest—width 8 m. m.

Height 6 m. m.

Hinge line, straight length 6 m. m.

Teeth very small and numerous, umbones *prominent.*

Epidermis *hairy.*

Considering it to be new, we name it *Arca ninæ.*

There is also a very minute pearly circular bivalve, *inc. gen.*

There was a large number of specimens of a beautiful *Pecten.* These are transparent and pearly. The molluscs are seen through the shell. The outer edge and the growth lines have round tubercules occurring at frequent intervals. The small shells resemble fish scales, and can only be searched up with a magnifying glass: Measurement of largest — width, 25 m. m.; height, 20 m. m.; hinge, 14 m. m. Supposing it to be new we name it *Pecten Hicksii.* On Cable II there is also a *Pecten* and valve of small anomia.

GASTEROPODA.

We have two perfect specimens of Trichotropis.

Measurement of largest—mouth, 12 m. m. x 10 m. m.

Height, 10 m. m.

No opercle.

Tongue exposed.

Epidermis hairy; mouth and lines of growth fringed with hair.

It is unlike *Trichotropis borealis,* as figured by Gould. We give it a provisional name—*Trichotropis Hamiltonensis.*

Attached to the cable and having its impression, was a beautiful round group of mollusc egg capsules. There is little doubt that they are connected with this gasteropod. Among the hempen debris we found a large number of similar egg capsules empty, and also a number of shells of trichotropis of various sizes; some very small.

PISCES.

In the debris of Cable I we also found a *fish scale* of peculiar structure. Is it of a *deep sea* fish?

SUMMARY OF FAUNAS.

Cable I.	Cable II.
I.	
SUB-KINGDOM.	
Protozoa.	
1 Foramenifera.	
Orbulina universa.	Sessile, 2 sp.
Globigerina bulloides.	
Nodosaria.	
2 Radiolaria.	
2 species.	2 species.
Parazoa.	
Sponges.	
*Reniera Miniæ.	*Reniera Fundyensis.
R. escharæ.	R. Duxburyensis.
Myxilla Greerii.	R. collinculi.
	Myxilla Miniæ.
II.	
Cœlenterata.	
Hydroida.	
Campanularia.	Campanularia.
	Sertularida.
Alcyonida.	
Sympodium Griegii.	Sympodium ? Danielsseni.
Balticina Finmarchica.	
III.	
Annuloida.	
Crinoidea.	
Antedon moræ.	

NOTE.—The two Cable Sponges, Reniera Miniæ and Reniera Fundyensis, are illustrated by two plates, with figures, drawn by the Camera Lucida.

Cable I.	Cable II.
Ophiuroidea.	
Ophiura annæ. (6 rays.)	Ophioglypha, sp ? (5 rays.)
Echinoidea.	
Echinus, sp. (Small.)	

IV.

Annulosa.

Cable I.	Cable II.
Tubicola.	
Spirorbes, sp.	
Leathery tubes.	
Diopatra glutinatrix ? tubes.	
Errantia.	
Eunicea ? Trottii.	
Crustacea.	
Balanus.	Balani.
Caprella trispinis. *Male* and *female.*	Caprella Sarsii. *Male* and *female.*
Podocerus ? Newtoni.	

V.

Mollusca.

1 Molluscoida.

Cable I.	Cable II.
Polyzoa.	
Bryozoa.	Bryozoa.
Coralline.	Coralline.
Tunicata.	
	Boltenea clavata.

Cable I.	Cable II.
Mollusca.	
Conchifera.	
Saxicava Rugosa.	Saxicava Rugosa.
Corbula?	
Tellina?	
Arca Ninæ.	
Pecten Hicksii.	Mytilus edulis.
Anomia sp.	Pecten sp.
	Anomia sp.
Gasteropoda.	
Trichotropis Hamiltonenses.	
Nidamental capsules.	
Pisces.	
Fish scale.	
Protophyta.	
Diatoma vulgare.	Diatoma vulgare.
Coscinodiscus.	Coscinodiscus.
	Bacteriastrum furcatum.
	Pinnularia, &c.

Art. IX.—Larva of May Beetle with Parasitical Fungus. —By Harry Piers.

Read December 10, 1888.

Mr. D. R. Boyle, of West Arichat, Cape Breton, forwarded to the Museum a number of "potato grubs" whose peculiar aspect had greatly puzzled him. They were accompanied by a letter in which the writer asked for information regarding what he had sent.

Upon examination I found the grubs to be the larvæ of the May Beetle (*Lachnosterna quercina*, Knoch) a common and well-known insect in Nova Scotia. What had excited Mr. Boyle's curiosity, and about which he desired to be enlightened, was a long fungus arising from the head and bending backwards like an enormous horn. The Museum already possessed a case of a similar growth, in a specimen of the New Zealand Swift Caterpillar to which we will subsequently refer.

The grubs which had the growth upon the head were found in the ground close to the potatoes on the 18th of October, 1888. They were all dead. They were great numbers without the growth and these were mostly within the potatoes.

Mr. Boyle informs me that he had never before seen the grubs affected in this manner, and that the same had been said by several others whom he had questioned.

The growth—or more properly speaking, growths, arise from a spot immediately behind the head on either side. That on one side is long and tapering and that on the other short and conical —at least this is the case with all the specimens which I have examined.

The shorter growth, in a perfect specimen, measures about .08 of an inch in length and the longer about 1.50. The latter, as it now appears in alcohol, has numerous longitudinal raised lines or wrinkles, and, when examined with the microscope, the whole surface to within a short distance of the end is tomentose. A longitudinal section, examined in the same manner, showed it to be of a fibrous nature. Near the base, the centre can be separated from the other portions as a core.

When first taken from the ground the growths were of a dark purplish colour, changing to white at the extremity. They have been gradually becoming darker until now they are almost black. The interior parts are white. There is no appearance of fruit.

Wood, in his Natural History, gives a figure of the larva of *Hepialus virescens*, which has a similar growth upon the head. He thus describes it (p. 530):

"The New Zealand Swift is a truly curious insect, not so much for its form or colours, but for the strange mischance which often befalls the larva, a vegetable taking the place of the ichneumon fly, and nourishing itself on the substance of the being which gives it support. A kind of fungus affixed itself to the larva, and becomes developed on its strange bed, taking up gradually the fatty parts and tissues of the caterpillar, until at last the creature dies under the parasitic growth, and is converted almost wholly into vegetable matter."

In the Museum Collection there is a specimen of this larva with the fungus growth as described above. It is from New Zealand, and was presented by Mr. A. Crichton. The fungus proceeds from the summit of the head in the same manner as shown in Wood's plate.

With the exception of about an inch of the extremity, the whole surface, under the microscope, appears tomentose. The basal portion is of an ochre colour and the extremity for about an inch is brown-red. Length of caterpillar 2.50 inches. Length of fungus 4.60 inches. (Dry specimen.) This is doubtless *Torrubia robertsii.*

A writer makes the following remarks upon the sight of one of these doomed insects in the grasp of its merciless murderer.

"It is a curious spectacle to behold the heavily-burdened larva bearing erect upon its body a vegetable growth often three or four times its own length—colour-bearers, as they look to be, bearing not the ensign of victory, but the signal of individual distress, telling plainly of the sure but inevitable approach of death."

Here we have the larva of a moth and the larva of a beetle affected by two nearly related fungi, the one in New Zealand and the other in Nova Scotia. Both larvæ are subterranean and both are ultimately destroyed by this death-dealing parasite whose unbidden presence, unwelcome and not to be got rid of, marks their sure and certain dissolution. It seems to be one of Nature's quiet ways of keeping these troublesome insects within proper bounds.

Note.—Since writing the above, Mr. A. H. MacKay has kindly furnished me with notes from which it seems probable that the fungus, mentioned in the above paper as occuring on the Potato Grub, is *Torrubia melolonthæ* (Tulasne). The absence of fruit makes any detailed comparison with descriptions impossible.

ART. X.—ABORIGINAL REMAINS OF NOVA SCOTIA.—ILLUSTRATED BY THE PROVINCIAL MUSEUM COLLECTIONS.—BY HARRY PIERS.

Read May 13, 1889.

In the following paper I shall confine myself to remarks upon such specimens of aboriginal work as are preserved in the Provincial Museum.

The archæology of our Province has already received the attention of a few of our members. In the Transactions of the Institute, Vol. III, pp. 220–231, Dr. J. Bernard Gilpin has given us an account of Nova Scotia in the stone age. Since then, more material for study has been obtained, and more light has been thrown upon the subject. Recently, a paper has been read before the Society in which a general view of Nova Scotian archæology is presented. All I wish to do is to bring into notice the excellent, and hitherto almost undescribed, collection of Nova Scotian specimens displayed in the cases of our Museum; and, when possible, to make use of similar implements, &c., from other parts of the world, by way of illustration and comparison. For this purpose the Museum Collections will also be resorted to.

According to the arrangements of the Museum, the articles are separated into two divisions, namely, the "General," and the "Webster," Collections. The former is composed of objects collected by various persons from many localities. The latter was presented by the gentleman whose name it bears—Dr. Webster, of Kentville, N. S.

Unfortunately, most of the specimens are unlabelled, consequently their particular localities cannot be ascertained. In classifying and arranging the collections, I have in general used the nomenclature of the Smithsonian Institute, as given in "Contributions to Knowledge," No. 287.* In some respects, however,

* Rau: Archæological collections of the U. S. National Museum, 1876.

I have deviated slightly from the plan of that work in order to meet the requirements of the case. Many specimens, set down as arrow-heads, may have been hafted and used as cutting tools, while others may have been small spear-heads. Considering, however, the fact that it is impossible to draw a distinction between a large arrow-head and a small spear-head, or, in many cases, to distinguish a cutting implement from either of the above, I have decided to classify them all as either arrow, or spear-heads. Those above 3.85 inches in length I designate by the latter name; those below 3 inches by the former.

I. STONE.

A. FLAKED AND CHIPPED STONE.

Raw Material.—In a small collection of various articles from Starr's Point, Kings Co., are three or four large fragments of agate and jasper, which were evidently intended to be worked into implements.

Flakes.—The collection contains a beautiful series of chips from Bachmann's Beach, Lunenburg County. They were presented by Mr. Lewis Anderson. The materials are agates, jaspers, porphyrites, &c. They were produced during the manufacture of the succeeding implements. Some of these flakes could be, and possibly were, used as primitive cutting tools, and scrapers for rounding and finishing articles of wood and bone.

Unfinished Arrow and Spear-heads.—Thin, neatly chipped, and regularly shaped specimens are doubtless unfinished spear or arrow-heads. They are convex-sided with a truncated base. Before me is a series showing the transition from the incomplete, to the finished weapon. Here is the truncated convex-sided implement. Next, we have another of the same form, but with one side notched. And lastly, the complete arrow-head notched on both sides. Omitting the notches, the form in each is precisely the same.

Arrow-heads.—These are the most abundant aboriginal relics represented in the collection. Most of them are from the seat of the arrow-maker's operations at Bachmann's Beach, Lunenburg Co. There are fifty complete heads together with about thirty-five incomplete ones. These latter have been either fractured whilst still in the hands of the arrow-maker, or damaged by striking some hard object, during their flight. Among the arrow-heads obtained at Bachmann's Beach, are some which were broken while in process of being made. The parts have been recovered and fitted together. These attest to the difficulty of working such fragile materials as were employed by our men of the stone age. After toiling at the delicate point before him, the swarthy craftsman, by an unlucky slip of his flaking instrument, spoiled his work. It was thrown to one side, where, centuries afterwards, the pieces were found and fitted together, and the complete arrow-head is now lying before us.

The forms of these implements are various:—Leaf-shaped; convex-sided with truncated base; straight-sided with slight concave base; notched at the sides near the base, which is straight, concave or convex; stemmed, expanding, straight, or tapering; barbed and stemmed.

In the Webster collection there is one arrow-head of decidedly foreign appearance. It is most beautifully wrought, being bevelled along both edges on opposite sides. This corresponds with an arrow-head from Texas, now in the Museum. From its appearance, I doubt very much if Dr. Webster obtained his specimen in Nova Scotia. As that gentleman has left no record of the place where it was found the question must remain undecided.* The material of which it is made agrees exactly with that of a well finished (notched) spear-head in the same collection. Some of the undoubted Nova Scotian specimens are beautiful pieces of workmanship.

Spear-heads.—There are, in the collection, six specimens which I have designated spear-heads. The first is a fine example of masterly workmanship. Its length is 7.90 inches, its greatest thickness .50, and its greatest breadth 2.75 inches. In form, it is

* Dr. Patterson tells me that he has obtained a portion of a similar head, but of inferior finish, from Yarmouth County, N. S.

nearly symmetrical. It has a straight stem, the base of which is also nearly straight. The sides are moderately convex. It is formed of a jaspideous rock of a yellowish colour. With it might be compared an implement of inferior workmanship in Dr. Patterson's collection (No. 85.) This is designated a "(supposed) Spade." If the maker of this last implement had continued his operations somewhat further, by notching it on either side so as to form a stem, it would constitute an efficient, if perhaps somewhat clumsy and broad, spear-head. Our specimen, as on inscription upon it informs us, was found in an Indian grave.

Another spear-head in the Museum is imperfect and somewhat rudely formed, but it was originally almost equal in size to the above. Yet another specimen is short and thick, and may have been used as a cutting implement of some description. A broken spear-head is interesting from the fact that it is fashioned from slate and polished. If this is aboriginal work it must have been used only as a ceremonial weapon. Such a weapon would be almost useless in actual warfare. Dr. Gilpin, in a paper already referred to, speaks of an arrow-head in his possession which was polished like a celt and of hardened slate.

It is curious to find that in Les Carbot's narrative no mention is made of spears or javelins as being in use among the Micmacs.

Perforators.—There is one example of a perforator, or drill, in the collection. It is somewhat lozenge-shaped. The point bears no indications of use.

Cutting Implements.—In this group I place two implements which probably were used as knives. They agree with the arrow-heads in all particulars, except that one edge is nearly straight, whilst the other is convex. As has been already said, many so-called "arrow-heads" were probably put to the same use.

Leaf-shaped Implements.—There are about a dozen of these in the collection (three or four broken) varying in length from 1½ inches to nearly 4 inches They are formed of jasper and agate. The thicker and larger ones I consider were inserted in a club of wood. The rough, projecting portion would then form a terrible addition to an already formidable weapon. Catlin mentions the use of steel and bone for the same purpose and figures several specimens.

B. PECKED, GROUND AND POLISHED STONE.

Wedges or Celts.—These are numerously and well represented in our collection. There are about fifteen examples. With few exceptions I consider that these have been hafted, and used as adzes. Specimens from the Rocky Mountain collection of Col. W. Chearnley, from the West Indies, British New Guinea, and elsewhere, show similar forms which are hafted by being bound, in various ways, to a handle of wood. In this manner they could be used for working wood and preparing skins, and also, in some cases, for hoeing the ground when there was need. For the latter use some of the larger ones are admirably adapted. A celt from Summerside, P. E. I. may have been hafted and used as a hatchet. It is beautifully polished, and is made of a felsite rock which Dr. Honeyman recognizes as the same as that occurring at Arisaig, N. S. It is 2.45 inches in length, while a similar one from the same locality is nearly 2 inches. The largest celt in the collection is about 10 inches long.

The material of which one of the celts is formed, precludes it from being put to any rough use. It is made of soft red sandstone, and is 2.45 inches in length. The edge shows but few marks of wear. The edge of one or two adze-like implements is round, so that the cutting effect may be likened to that of a gouge. On many of the celts, the scratches made by grinding show that their makers were right handed men like ourselves.

Before going on to the next group of implements, I should like to mention a peculiarity in many of our celts, and also, to a certain extent, in our gouges, which occurs so frequently as to have attracted my notice. The cutting edges of these implements are convex to a greater or less extent. The *general* line of the edge, however, is not at right angles to the axis of the implement, but rather cuts such an imaginary line in a more or less oblique direction. This makes one end of the edge higher than the other. When examining different specimens, I have found that, as a rule, this higher end is upon the same side of the celt or gouge. This may be consequent upon a peculiar method of using the implement or it may be intentional. I only mention it as I see it occurring in our specimens.

Chisels.—There is only one specimen which I have classified as a chisel, and even this may have been hafted and used in the same manner as a small jade adze in the Museum.

Gouges.—There are eight unmistakable gouges before me, varying in length from 6.75 inches (smallest complete specimen) to 11.25 inches, and in form from those in which the concavity is confined to the lower part of the implement only to those in which it extends throughout their whole length. In one the concavity is remarkably deep, while another might almost be classed as a chisel, so slight is the groove. Another specimen has been broken. Enough is left however to show that it was slender. The groove is very evenly made and probably ran from end to end. What is chiefly remarkable about this gouge, however, is that it is made of the same material as the two tubes which I shall mention further on. The style of workmanship is also much the same in both. Another gouge exhibits to a remarkable degree, the obliquity of edge which has been already mentioned.*

Adzes.—These I have treated of in connection with the celts.

Grooved Axes.—These implements, although common in the United States, are quite rare in Nova Scotia. They could never be used to cut down a tree. For the process of "girdling" they were better adapted. After a tree was killed by this means, fire was resorted to, and the stone axe was used to clear away the charred wood. The same implement upon occasion, could also be used as a weapon, while the rounded, or blunt end, was well suited to breaking open bones in order to extract the marrow. This last use probably accounts for the battered apperance of that portion of these articles. Dr. Gilpin suggests that they may also have been used for detaching the bark from the birch tree.

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* There is some doubt as to where this specimen was obtained. It may be from Newfoundland and consequently the work of Bethuks.

Our specimens vary in size from 4.60 to 7.60 inches in length. The smallest is of syenite. It is interesting as showing the transition from the celt, to the axe, form. One side is straight, the other convex. There is a short groove across each lateral edge. This implement may have been hafted in a different manner from other axes which are completely encircled by a groove. Another specimen shows how a sea-worn boulder was utilised in forming an implement, thus lessening the labour required in fashioning it. Here we see the original and naturally rounded surface of the stone. Around the upper part has been pecked a well-formed groove, whilst the lower part has been, rather irregularly, pecked to an edge. Such stones as this axe was formed from, may be found abundantly upon our sea-shores. These the Micmacs, with comparatively little labour, adapted to their wants. A third specimen is an example of the double grooved axes. They are exceedingly rare in our Province. It is more square in outline than the single grooved ones. The length is 6.80 inches; the breadth 4 inches. There are two well-marked grooves lying close together. The upper one—or one nearest to butt of the axe—is broader than the other. The latter is polished on either face of the axe.

Discoidal Stones and Implements of Kindred Shape.—The two implements which I shall now describe seem to be unique. Nowhere can I find anything which resembles them.

They are formed of marble. In shape they both resemble a coiled snake. A section of the body would represent an oval.

The most regularly formed one (Figs. 3 & 4) was presented by Mr. Gilbert Seaman, of Minudie, in the County of Cumberland. The thicker end of the coil, which may be considered as representing the head of the reptile, is turned to the left and lies upon the thinner end, or tail. It thus presents the appearance of a ring. No attempt has been made to represent the head in detail. It is simply a rounded termination to the tapering body. The whole surface seems to have been once highly polished. The circumference of this stone is 8.25 inches and the diameter 2.55 inches. The perforation, or space left between the coil, is .75 of an inch in diameter. The greatest diameter at the "head" is 1 inch.

Thence it tapers regularly and gradually to within a short distance of the tail, where the diameter is .80 of an inch.

The other specimen* (Figs. 5 & 6) was presented by Miss Frame, of Shubenacadie, Hants County. In form it is somewhat elongated, thus differing from the one found at Minudie, which latter is circular. This elongation is caused by the "head," which, instead of lying upon the "tail" is placed outside that portion of the object. The circumference measures 10 inches. The greatest diameter is 3.60.

The greatest diameter at the head is about 1.10 inch. From this it gradually decreases until a couple of inches from the head when it again increases in size and then decreases to the end of the tail, near which the diameter is .65 of an inch. The original surface of this specimen has unfortunately been defaced by the use of acid in determining its composition.

Such is a description of these two curious relics of the old stone age of Nova. As to their use, little can be said. Any designation which we can give them only serves to cover our own ignorance of the subject. They can neither be weights for digging sticks, club-heads, hammer-stones, tchunkee-stones, net-sinkers, nor spindle-whorls. They were exhibited and discussed at the Archæological Convention held during the Centennial Exhibition, 1876. They seemed to puzzle all. In both specimens it is evident that a rude representation of a serpent was attempted. These stones, says Dr. Gilpin, are so peculiar, and bear so strongly on the universal snake worship papers lately put forward, as, in the absence of all tradition or history of such worship in this Province, to demand a paper to themselves.

Pierced Tablets.—There are before me two specimens of these implements. Regarding their use nothing seemed to be definitely known. The first specimen (Fig. 1) is made of slate, very regularly formed, and carefully finished. Its shape is that of a rectangle with moderately concave sides. The thickest part—which measures .42 of an inch—is midway between the perforations. From this place it slopes to the edges on either side and also to the extremities. Beneath it is flat. The perforations are two, biconical, and 2.18 inches apart (measuring from the centre of

* It was presented to the Museum some years previous to the one from Minudie.

each.) They show no traces of abrasion. Length of tablet 6.50 inches nearly ; breadth at extremities 1.50 in. ; at middle 1.20 in. This implement was found in a Kitchen-midden at Smith's Cove, near Digby, by Mr. Robert Austin, and was presented by him to the Museum, 1887. Accompanying it was the following note :—

" An instrument used by the Micmacs in the stone age, for scraping scraps of fat and other integuments from the skins of Moose and Cariboo, when making them wearable. The two holes in this instrument were for the purpose of preparing the sinews of the animals for serving as bowstrings. The sinew was inserted at the larger end of the hole and pulled through the smaller end.—J. AMBROSE,* Digby, N. S."

The second specimen (Fig. 2) is in the Webster collection. The workmanship is very much inferior to that of the one from Smith's Cove. It is formed of a banded slate of a greenish color. The sides are nearly parallel, and the extremities bevelled so as to form an edge, which is blunted, apparently from use. The perforations are like those in the specimen just described, except that they are closer together and not so truly placed. One side shows a conical pit close to one of the perforations. Here, evidently, the maker of the implement first set his drill, then, for some reason, he abandoned the place and drilled a perforation close alongside. Greatest length, 5.50 in. ; breadth, about 1.60 in. ; thickness, varying from .45 to .24 in. Distance between the perforations, measuring from the centre of each, nearly one inch.

Stones used in Grinding and Polishing.—A piece of slate in the collection seems to have been employed in rubbing down or polishing some piece of work. One edge in particular is rounded throughout its length, as though it had been used for sharpening a gouge or some other implement of like form. One face of our specimen has fourteen parallel oblique lines scratched upon it.

Tubes.—These objects have always puzzled greatly those archæologists who have striven to assign a use for such singular implements, the fashioning of which must have cost their makers much hard labor. Schoolcraft considered the larger ones to be

* Rev. John Ambrose, D. C. L.

telescopic instruments, which were used by the aborigines for observing the heavenly bodies; others thought them to be a kind of speaking trumpet. Many articles of tubular form are now considered to be pipes, while others are classed as instruments of the Shamans or Medicine Men.

Two specimens from Nova Scotia are now in the cases of the Museum. Both are formed of a light grey material, which is highly polished on the outside. The first and finest one was found at Dartmouth, N. S., and was presented by Adam Esson, Esq. At first it was erroneously supposed to be a moose "call." It is perfectly cylindrical, and, when first discovered, was complete. A small piece, an inch or so in length, has since been broken off, and is now unfortunately lost. At present it measures a trifle over 12 inches in length, and in outside diameter 1.25 inch. One end is closed, with the exception of a perforation .32 of an inch in diameter, which penetrates, in a slightly oblique direction, to the inner cavity. This cavity has been formed with great care. I examined the interior by the aid of sunlight, which was reflected into the tube. As far as I could discern the surface exhibited longitudinal striæ only. No circular markings were visible. The pipe from Musquodoboit, which will be described further on, has similar longitudinal scratches in the bowl; so, also, has the fragment of another tube which I shall now describe.

This specimen is smaller and thinner than the preceding one. It is a fragment, 5.70 inches long and 1.06 inch in outside diameter. The thickness varies from .28 to .10 of an inch or less. This variation in the thickness is caused by the position of the hole, which is not central. One end of the tube is thinned to an edge.*

The material is the same as that of the first specimen. From my examination of these tubes it has occurred to me that they may possibly have been formed of some material which was worked while in a plastic state. If this was the case the making of these objects was comparatively easy.

In Schoolcraft's Indian Tribes, Vol. I., pl. 32, are figured two

*The missing portion of the larger specimen is said to have been similarly finished off.

tubes formed of steatite. These tubes were found on opening some of the minor mounds of the Ohio Valley. Figures 9 to 12, when drawn to the correct size of the originals, agree almost exactly with our larger specimen. The outside and inside diameter (and consequently the thickness), and the diameter of the small perforation are practically the same in each. The only difference is that our specimen was, when complete, slightly longer than Schoolcraft's and not quite so regular in section. Now this agreement in form and measurement can hardly be accidental. And yet, it may be asked, what need was there for such a correspondence? We cannot answer.

As to their use, it is now generally believed that they were employed by the medicine men when performing their conjurations upon a diseased person. Many early travellers describe similar tubes which were used for this purpose.*

Pipes.—There are four pipes in the collection. The first (Figs. 7 & 8,) was found at Musquodoboit, in Halifax County, and was presented by Mr. Alexander Riach. It is remarkable for being of the same type as the mound-builder's pipes. The bowl, which is round, rises from the centre of an oblong, slightly cured base, which has a central line of elevation above and below, and through which passes the perforation, .30 of an inch in diameter, leading to the inner cavity which is designed to hold the narcotics. The top of the bowl has a wide flange, which is ornamented above by several short grooves, disposed in radiating positions. Length of base, 5.10 inch; greatest width of ditto, 1.45 in.; height of bowl above base, about 1.75; diameter of cavity of bowl, .90 inch.

The second pipe (Fig. 9.) is of the type which Dr. Patterson considers to be the Micmac form of pipe. The bowl rises from the edge of a flattened handle or base, which is pierced with a hole for receiving the stem. The lower edge of the base—or keel, as it might be called—is cut into three small lobes, each of which has a small perforation through it, probably for the purpose of attaching some ornament. This pipe was found near the River Dennis, Cape Breton. It was presented by Mr. W. McPherson.

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* See RAU—Archæological Collection of the National Museum, pp. 43-45. And ABBOTT—Surveys West of the 100th Meridian, Vol. VII., pp. 190-2.

The third specimen is beautifully made and ornamented. It was found at Dartmouth, Jan., 1870, and was presented by Dr. A. C. Cogswell. It is of the same general form as the preceding one, only more finely finished. The "keel" is straight, and has only one hole. The ornamentation is very elaborate, consisting of groups of incised lines, wheel-like forms, and rows of triangular pits. This pipe is probably of late date. It is formed of argellite.

The fourth pipe was found near the old Dutch Church, corner of Gerrish and Brunswick Streets, Halifax, in September, 1873. It is made of red clay. I consider it to be of European manufacture. Many clay pipes resembling those of Indian production are known to have been made in Europe for the purpose of trade with the Indians. In our specimen, one side of the base has scratched upon it the date 1560 and the other side bears a figure which is probably intended for a bow-and-arrow. The form is similar to the two preceding specimens. No importance, however, can be attached to this one.

In order to show that the making of stone pipes is not altogether a lost art among our Indian tribes, I may mention a beautiful pipe in the possession of my father, Mr. Henry Piers. It was made some years ago, by an Indian of the Malicite tribe of New Brunswick. It is a beautiful piece of work, the fore part representing a seated Indian, while the bowl itself is decorated with designs which are executed with great care. It bears the date March 5th, 1859.

Ornaments.—There are two specimens which may be classed as ornaments. The first is a stone measuring three inches in greatest length. Both faces have been ground into facets. The second specimen is a little over two inches in length. It is leaf-shaped. The surface is smooth, apparently from the constant wear of being carried about the person. Extending in a diagonal direction across the stone, are three raised lines, the material being harder in those places. Two of the lines have been notched throughout their length. One line has about twelve notches; every third one longer than the others. The other has about nine small notches. No provision has been made for suspending the object. The notches may have served as a record or they may have been only added for ornament.

II.—COPPER.

A collection of eighteen specimens is from Bachmann's Beach, Lunenburg. Presented by L. Anderson & Co., 1874. There are eight nuggets, four of which are in their natural state, the rest have been slightly hammered on two sides. Two other pieces have been hammered out very thin—too thin even for knives. The other objects comprise two "knives" and about six piercers. The latter are hammered square and brought to a point. One specimen is pointed at both ends.

III.—BONE AND HORN.

An imperfect specimen in the collection would probably be classed by many as a piercer. It bears a great resemblance, however, to a portion of a large fish-hook from Fraser's River (Chearnley Collection.) Similar hooks may be seen figured by Swan and Schoolcraft.

IV.—SHELLS.

The only objects of shell are two very fine strings of wampum beads. They may not be pre-historic. Slight irregularities in the beads, however, seem to point to the Indians as their fabricators. They were presented by Mrs. John Liddell some thirty years ago. The first one is a little more than 11.50 inches in length. It consists of eighty-one black and eighty-two white beads strung alternately; one hundred and sixty-three in all. These beads are in the form of small perforated discs about .24 of an inch in diameter. Diameter of perforation .07 of an inch. The average thickness of the beads is .07 of an inch. A twisted, two-strand cord made of fibre is used for the purpose of holding these beads together.

The other string of wampum is composed of smaller discs. The length of the string is 61.7 inches. The diameter of the beads vary from .19 to .10 of an inch. The beads of this specimen are strung with little regularity; one part consisting wholly of black beads.

V.—CLAY.

Schoolcraft (Vol. I, p. 81) informs us that the Micmacs and other northern tribes, boiled "by casting heated stones into bark vessels filled with water." However this may be, it is well known that our Indians were acquainted with the art of making pottery. Several fragments are in our collection. I shall designate them by letters.

A, *B*, *C*, *D*, *E*, and *F* are examples of unornamented work. Thickness from .22 to .38 inches.

G is ornamented with impressions which probably were produced by a twisted cord, which was applied to the clay while still in a plastic state. It is also ornamented with short oblique dashes. Thickness .20 of an inch. *H* is somewhat similar in ornamentation.

I exhibits crescent shaped impressions; possibly made by the finger nail.

J Here two distinct styles of ornamentation have been applied; zigzag rows of square dots and incised, crossed lines. The *inside* of this specimen has also a few rows of dots. Thickness half an inch.

In *K* and *L* (probably portions of the same utensil) the zigzag rows of square dots again appear. These dots often diminish regularly in size towards one end of the row. Holmes considered that these markings on pottery were made by rolling back and forth a circular tool, a *roulette*, the edge of which was notched. Dr. Patterson is of the opinion that they were made by a straight implement with small teeth.

M exhibits rows of crescent-shaped depressions which are graded in size. They have not been made by the finger nail. Near the upper edge there are two parallel rows of round holes .15 of an inch in diameter, and about the same in depth. Thickness, .3 of an inch.

N is a portion of the projecting rim and body of a pot about

12 inches in diameter. Thickness one-half inch. The lower portion of this fragment is ornamented with *very* fine and delicate wave-like undulations, which are made with great regularity. This pattern must have been stamped on the clay while in a soft state. The sides of the projecting rim are decorated by a row of deeply incised lines, while that portion is further decorated on its summit by short diagonal lines. The specimen is from Bridgewater, and was presented by Judge Desbrisay.

O shows a peculiar style of ornamentation formed by incised lines, about an inch in length, which overlap each other for a short distance at each end.

ART. XI.—TERRESTRIAL MAGNETISM.—BY MARTIN MURPHY, *C. E.*

I merely wish to make a few remarks on certain points which have occurred to me in reading what Arago, Hansteen, Humboldt, Sabine, Faraday, Thomson and others, have said on the subject of terrestrial magnetism. The magnetic power of our globe is manifested on the terrestrial surface in three cases of phenomena, one of which exhibits itself in the varying intensity of the force, and the two others in the varying direction of the inclination and in the horizontal deviation from the terrestrial meridian of the spot. Their combined action may therefore be graphically represented by three systems of lines or those of equal force, equal inclination and equal declination. The distances apart and relative positions of these moving, oscilating and advancing curves, do not always remain the same.

If we take a steel bar which has been magnetized, its centres of power are located near each extremity, while near the middle is a neutral ground, over which the influence of neither end predominates. If fine iron filings be sprinkled around the magnet, they will form into curved lines emenating from each other, and tending towards an union.

These centres are called poles. The magnetism in one is opposite in kind and nearly equal in degree to that in the other; there is a mutual attraction between these opposite magnetisms and this tendency to rush across neutral ground, and by combining yield up every distinctive feature of the magnet is successsully opposed by the hardness of the steel bar.

These lines are called the lines of magnetic force, and the area over which their influence is felt is known as the magnetic field. If a compass needle suspended by a silk thread, and free to move in any plane, be brought into the field, it will assume a direction parallel to the lines of force, as at e e' e'' e'''

The strength of the field and hence the force that tends to give the needle steadiness and direction, varies greatly at different points; at e it is powerful, at e''' it is feeble.

If two magnets similar to that at the figure be brought into proximity so that the poles of the same touch, they will repel each other; if, on the other hand, the north pole of one be approached to the south pole of the other, both bars, as if instinct with life, will fly in contact and cling one unto the other, and this intense affinity of opposite magnetisms is a general characteristic.

The Magnetic Property is Molecular.—Apart altogether from the question as how we are to represent the action of a magnet upon other magnets, there arises another distinct question as to where the course of the action resides. A very old experiment at once throws considerable light on this point. If we break a bar magnet into two pieces, it will be found that each of these is itself a magnet, its axis being in much the same direction as that of the original magnet, and its poles in corresponding positions. The same holds if we break the bar into any number of pieces, and, quite generally, if we remove any piece however small from a magnet, this piece will be found to be magnetic, the direction of its axis usually bearing a distinct and easily recognizable relation to the direction of the axis of the whole magnet. We are driven to the conclusion, therefore, that the magnetic quality of a body is related to its ultimate structure, and not simply to its mass as a whole, or to its surface alone, and this conclusion is not to be invalidated by the fact that we can in general, as will afterwards appear, represent the action of the magnet at external points by means of a proper distribution of centres of attractive and repulsive forces upon its surface merely. *We shall again refer to this property of the magnet.*

Temporary magnetism of soft iron and steel in the magnetic field.—Bodies which possess permanent magnetic properties not depending on the circumstances in which they are placed we shall call "permanent magnets." The law of the action of one permanent magnet on another, as we have seen, is that like poles repel and unlike poles attract each other. The action of a permanent magnet on pieces of soft iron is, at first sight, different, for either pole attracts them alike.

THE EARTH A MAGNET.—The earth has magnetic features entirely analagous to those of the bar marget. If we examine the figure which I place before you we find the parallels of latitude and meridians of longitude appear at regular cuives. But from a focus at N. radiate a series of curves, which take sinuous forms and finally converge towards another focus at the antipodes. These foci are the magnetic poles of the earth toward which the compass needle ever points, not directly but parallel to the lines of force. It will be seen that these magnetic poles are far removed from the geographical poles.

These three features of the earth's magnetic action which are chiefly attended to by observers are then—the inclination, the declination and the intensity.

The inclination is the angle at which the dipping needle is inclined to the horizon. The declination is the angle at which the horizontal needle is inclined to the north and south line. The intensity is the magnitude of the force with which the needle seeks the position of rest.

Now if we travelled over the whole surface of our earth and carefully determined the declination, the inclination and the intensity of the magnetic action at every point, we should be able to map down on a chart of the earth the relations thus presented to our notice, we should—speaking generally—have the following peculiarities to deal with :

First, as to the declination, we should find that in certain regions the magnet's northern end was to the west of north, whilst in certain other regions the reverse was the case. If we marked in the boundary line between these regions, it is obvious that we should have traced a line along which the needle would lie due north and south. This is what is termed the line of no declination. On charts of the earth's magnetic relations the position of this line for the middle of the present century is usually indicated. In some maps a set of lines used to be added along each of which the magnetic needle had a definite declination. These lines are now omitted on account of their complexity.

Secondly, as to the inclination, we should find as we travelled over the earth's surface that the dipping needle tends to vertical at two nearly opposite points—one close to the Arctic, and he other to the Antarctic circle. These are called the northern and southern inclination poles, and must not be confounded with the intensity poles presently to be mentioned. As we leave either inclination pole, the dipping needle leaves its vertical position and gradually approaches the horizontal direction, until, along a curve lying midway between the two poles, the needle becomes exactly horizontal. This curve is called the magnetic inclination equator.

Lastly, as to the intensity. If we noticed in every part of the earth's surface the number of times the needle vibrated through its position of rest in a given interval, we should find that along a curve lying near to, but not absolutely coincident with the inclination equator, the intensity has a minimum value. This curve is called the intensity equator. Leaving it towards the north or south, we should find the intensity gradually increasing. We should not, however, find this increase guiding us to an intensity pole either north or south, but we should recognize two magnetic intensity poles in each hemisphere.

Now, in considering the various relations here presented, it is important that we should decide which property of the magnetic needle should be adopted as our guide or receive our chief attention.

General Sabine considers that intensity is the primary quality of the magnet in all such inquiries as we are at present concerned with. Professor Proctor considers that if we were to select one or the other of these elements as our special guide it must clearly be the inclination, because he says the declination has comparatively narrow limits of range, which the inclination varies from 0 to 90.

If a properly balanced magnet could be suspended or supported so as to be free to take up any position, it would be found at London at the present time, that it would finally rest in a position making an angle of about 67 degrees, with the horizontal; also that the vertical plane passing through the magnet would make an angle of about 18 degrees with that of the meridian, the magnetic deviation being to the west of the true astronomical or geographical north and to the east of south. Such is the dip and declination given at the Royal Observatory for the first of the present year. I am not aware of any record being kept at Halifax, N. S. I cannot speak with any degree of reliability respecting the dipping needle here. The declination was about 20.50 degrees west of north, and I am informed by the officers of the Crown Land Department that there is an annual variation of about three minutes per year.

If a magnetic needle be pivoted so as to confine its motion to the horizontal plane as an ordinary compass needle, the north end of such a needle when at rest will deviate in the azimuth to the west of true north by the amount of this magnetic declination or variation of the compass, which varies with locality. For any place situate on one of the magnetic lines on the map or chart the value of the magnetic declination will be exactly that of the line, and for places situate between the two lines proportion will be made between the values of the adjacent lines. Such values are generally made to apply to the year for which the map or chart has been issued. The values shewn by the lines on the English chart or map are for the year 1889, but to obtain values for any other epoch it must be understood that the magnetic declination over the area included in that map diminishes yearly by about seven minutes of an arc. Thus mean values for any place and for any time within a few years may be found.

Values of magnetic declination obtained in the way described will, it is presumed, serve for all purposes of mine surveying. It may, however, be further mentioned that the needle is subject also to diurnal variation, its north end being drawn most to the west at about two hours p. m., and most to the east during the night or early morning, occupying its mean position about 10 hours a. m., and 6 hours p. m. The diurnal variation is greater in summer than in winter, but the needle seldom deviates from its mean position more than from five to ten minutes of an arc, excepting during what are called "magnetic storms." During the year 1888 there were very few occasations of much change recorded at London, so we seem to be passing through a quiet period.

The English map produced has been tested by comparing results obtained at Greenwich, Kew, Stoneyhurst and Falmouth, as well as other recent determinations for Newcastle, Scarborough, Whitehaven, Cardiff and Falmouth. This comparison gave the compilers the means of correcting as necessary the maps brought up from Sabine and Evans in the way mentioned. There are of course practically local peculiarities or irregularities which cannot be considered in such a map.

The whole of Europe, excepting a small part of Russia, has now a western declination, while at the close of the seventeenth century the needle first pointed due north in London, in 1657, and in Paris in 1669,—there being thus a difference of twelve years, notwithstanding the small distance between these places. Hunsteen and Erman shew the remarkable double curvature of the lines of declination in the region of Northern Asia. On the 13th of September, 1492, Columbus found a line of no variation 3° west of the meridian of the island of Flores, one of the Azores. Gilbert says that in 1600 the declination was still null in the region of the Azores, just as it had been found by the discoverer of the New World. Columbus attached great importance to the zone in which the compass showed no variation. In the beginning of the present century, at an elevation of 11,936 feet above the level of the sea, Humboldt made an astronomical determination of the point (7° 1′ south lat. 48° 40′ west longitude from Paris), where, in the interior of the new continent, the chain of the Andes is intersected by the magnetic equator between Quito and Lima. The more recent observations of Sabine have shewn that the node near the island of St. Thomas moved 4° from east to west between 1825 and 1837. In London the needle pointed to the east of north before the year 1657, when it pointed due north. From that time the westerly declination gradually increased until the beginning of the present century, when the westerly motion was observed to flag. In 1819 the greatest westerly declination was reached. At this time the needle pointed $24\frac{2}{3}$ degrees to the west of north. Since then the needle has been slowly travelling eastwards, and the westerly declination is now only some 17° west of north.

In Paris the needle pointed due North in 1663, it ceased to move westwards in 1817, and the greatest westerly declination attained was only $22\frac{1}{2}$ degrees.

On the western side of the Atlantic a line of no variation, as it is called, is marked on the Admiralty chart, which I place before you. It leaves Dutch Guiana, crosses the meridian of 60 west from Greenwich, crosses the islands of St. Lucia and Porto Rico of the Antilles, runs East of San Domingo and San Salvador, of the Bahama Islands, touches the coast of South Carolina at Long Bay, crosses the western shores of Lake Erie and the narrows between Lake Huron and Lake Michigan, follows the eastern shores of Lake Superior and touches Hudson Bay at West Pens, and after running through western waters of Hudson Bay passes through Pistol Bay and Farther Hope Island in Chesterfield Inlet.

From these facts of observation, Professor Proctor seemed to favor the theory that at some time near the year 1657 the northern magnetic pole must have been on the meridian of Greenwich, or that the magnetic pole must have been directly between England and the real pole of the earth, or somewhere beyond the real pole; and as before 1657 the declination was easterly, whereas afterwards it was westerly, hence the magnetic pole must have travelled from east to west round the north pole of the earth, and he further says that from these observations we can learn something about the rate at which the magnetic pole is travelling. For he says:—

"Supposing the magnetic needle in the meridian of London in 1657, and Ross's estimate of the place of the magnetic pole to be approximately correct, giving (in round figures) 95° west of Greenwich for the longitude of the magnetic pole in 1883, we get a period of revolution of

$$\frac{360}{15} \times (1883\text{–}1657) \text{ years.}$$
$$= \frac{72}{19} \times 176 \text{ years} = 667 \text{ years about.}$$

"And combining Ross's estimate with Paris epoch we get a period of

$$\frac{72}{19} \times (1833\text{–}1663) \text{ years.}$$
$$= \frac{72}{19} (\times 170) \text{ years} = 644 \text{ years about.}$$

"The mean of these values is about 655 years; and I think that there is good reason in believing that the northern magnetic pole revolves around the north pole of the earth from east to west in about this time."

The latter reasoning is rather vague in taking means of such extremes, and these extremes between points so close as London and Paris. The permanency of the compass in Jamaica since 1660, says Sir John Herschel, is remarkable. He says:—During the last century all surveys of property there have been conducted solely by the compass. There is very little magnetic variation. Humboldt says:—If we compare Ermen's observations in the southern part of the Atlantic Ocean where a faint zone (0.706) extends from Angola over the Island of St. Helena to the Brazilian coast, with the most recent investigations of the celebrated navigator, James Clark Ross, we shall find that on the surface of our planet the force increases almost in the relation of 1:3 towards the magnetic south pole where Victoria Land extends from Cape Crozier towards the volcano Erebus, which has been raised to an elevation of 12,600 feet above the ice. The intensity near the magnetic south pole is expressed by 2.052 (the unit still employed being the intensity which he discovered on the magnetic equator in Northern Peru) Sabine found it was only 1.264 at the magnetic north pole near Melville Island (74° 27′ north lat.) while it is 1.803 at New York.

All these different systems of magnetic lines—variation, dip, and intensity—have not on the earth that symmetry and regularity which they would present around a steel bar; on the contrary, they are often bent, looped, and turned into devious paths, wherefore none can tell. The fact alone is well established, *while theories fail to account satisfactorily for the earth being an irregular magnet.*

Now, on the earth, the pole nearest the geographical pole is commonly known as the north magnetic pole, and the end of the needle pointing to it is also spoken of as the north pole, whence repulsion, of necessity, would seem to result; but this is an unfortunate use of the terms that has grown up with us. The real state of the case is, that whichever of the two—the earth's pole or that of the compass—we agree to designate as north, the other, having magnetism of the opposite kind, must be called the south; and hence attraction naturally takes place.

To show the variability of this attraction in direction and amount in various parts of the globe, the mariner's compass is everywhere subject to the influence of these magnetic lines of force, and it is their influence that gives steadiness and direction to the needle. At e, e′, e″ and e‴ is a magnetic needle represented as suspended by a thread from the zenith, and assuming, as it always will, a direction parallel to the line of force. At the magnetic equator, m, m, this line is parallel to the horizon, and so is the needle, e‴; we go north and the line becomes bent, so the needle inclines as at e″; proceeding further, the line bends more, and the needle inclines accordingly; finally, at e, it is bent vertically in the vicinity of the pole. In all these cases the force or intensity of the magnetic field steadily increases from the first towards the last position of the needle, so that it will vibrate slowly at e‴, whilst at e″ it will be quicker, the arc smaller, and the time less, and so on, until it comes to e, when it will have a few quick, jerky movements, and then stop short.

Now, a needle dipping thus at every remove from equatorial regions is of no value to guide a ship. It must always be horizontal, and this is practically obtained by placing a small sliding counterpoise on the needle, to overcome the downward pull of the magnetism. It is easily adjusted to change. In this constantly horizontal direction of the needle, however, the portion of the magnetic intensity that gives it steadiness is materially changed, lessened, and more diminished as we proceed from e‴ to e′. As we proceed from the magnetic equator towards the pole, the compass becomes less steady and reliable, while at the same time the total intensity of the magnetic field increases.

Humboldt, in the first volume of the Cosmos, after discussing translatory motion, terrestrial phenomena, geographical distribution, and the figure, density and internal heat of the earth, refers to terrestrial magnetism. He says: "If we present to ourselves the interior of the earth as fused and undergoing an enormous pressure, and at a degree of temperature the amount of which we are unable to assign, we must renounce all idea of a magnetic nucleus of the earth. All magnetism is certainly not lost until we arrive at a white heat, and it is manifested when iron is at a dark red heat; however different, therefore, the modifications may be which are excited in substances in their molecular state, and in the coercive force depending upon that condition in experiments of this nature, there will still remain a considerable thickness of the terrestrial stratum which might be assumed to be the seat of magnetic currents. The old explanation of the horary variations of declination by the progressive warming of the earth in the apparent revolution of the sun from East to West must be limited to the uppermost surface, since thermometers sunk into the earth, which are now being accurately observed at so many different places, show how slowly the solar heat penetrates, even to the inconsiderable depth of a few feet. Moreover, the thermic condition of the surface of water by which two-thirds of our planet is covered is not favorable to such modes of explanation, when we have reference to immediate action and not to an effect of induction in the aerial and aqueous investment of our terrestrial globe.

" In the present condition of our knowledge (he wrote in 1844) it is impossible to afford a satisfactory reply to all questions regarding the ultimate physical causes of these phenomena. It is only with reference to that which presents itself in triple manifestations of the terrestrial force, as a measurable relation of space and time, and as a stable element in the midst of change that science has recently made such brilliant advances by the aid of the determination of mean numerical values. From Toronto in Upper Canada to the Cape of Good Hope and Van Diemen's Land, from Paris to Pekin, the earth has been covered since 1828 with magnetic observatories, in which the regular or irregular manifestations of the terrestrial force are detected by uninterrupted and simultaneous observations * * * * * * *;" and he proceeds to say: " Terrestrial magnetism and electro-dynamic forces computed by Ampère stand in simultaneous and intimate connection with the terrestrial or polar light, as well as with the internal and external heat of our planet whose magnetic poles may be considered as the poles of cold; the bold conjecture, hazarded one hundred and twenty years ago by Halley, that the Aurora Borealis was a magnetic phenomenon, has acquired empirical certainty from Faraday's brilliant discovery of the evolution of light by magnetic forces." He then follows with a beautiful description of the Aurora.

It is now nearly half a century since Baron Von Humboldt reviewed the opinions of Ersted, Arago, Ermen, Ross, Brewster, Faraday and Sabine on terrestrial magnetism and, although great advances have been since made (in the science of electricity which has many similar manifestations and in dynamical geology which may assist in studying the earth as a magnet), and presented for our guidance and instruction, still these opinions are held in as high esteem to-day as the day the first volume of the Cosmos was presented to an admiring public.

In 1873-1874 Rowland made an extensive series of experiments; the results are said to form one of the most important contributions yet made to our knowledge of magnetic induction. They were published in the Philosophical Magazine of those dates, and are quoted by Professor Chrystal in the article on magnetism in the Encyclopedia Britannica. He treated his results graphically. The general conclusions to be drawn from his experiments are as follows:

"1. The magnetic properties of iron, nickel and cobalt at ordinary temperatures differ in degree, but not in quality.

"2. As the magnetizing force increases from o upwards, the permeability of iron, nickel and cobalt increases until it reaches a maximum, and after that diminishes down to a very small value. The maximum value is reached when the metal has attained a magnetization of from .24 to .38 of the maximum.

"3. The curve showing the relation between the susceptibility and the intensity is of such a form that a diameter can be drawn bisecting chords parallel to the axis.

"4. If a metal is permanently magnetized its permeability is less for low magnetizing forces, but is unaltered for high magnetizing forces. This applies to the permanent state finally attained after several reversals of the magnetizing force; but if we strongly magnetize a bar in one direction and apply a weak magnetizing force in the opposite direction, the change of magnetization will be very great.

"5. Iron, nickel and cobalt all probably have a maximum of magnetization, although its existence can never be entirely established by experiment, and must always be a matter of inference.

"6. The permeability of any metal depends on the quality of the metal, on the amount of permanent magnetization, on the total magnetization, and on the *temperature.*

"7. The permeability of cobalt and nickel varies very much with temperature, etc. The permeability of iron is not much affected by moderate changes of temperature.

"8. The maximum of magnetization of iron and nickel decreases with rise of temperature at least between 10° C. and 220° C., the first slowly, the second very rapidly."

Professor Chrystal adds:—"The researches of Stoletow and Rowland have undoubtedly made clear the main phenomena of magnetic induction, but in doing so they have raised a host of other questions which have not as yet been settled. * * * The results of the different experiments are not seldom contradictory, and the circumstances of experiment are often so complicated that criticism with the view of reconciling them seems hopeless in the meantime."

Now, I quote these authorities to show that there exists a relation of magnetism to other physical properties of bodies that may materially affect by mechanical strain (such as jarring or vibration) the tension of iron or steel. The following parallel statements, taken from the results of Weidemann, who has devoted much careful study to these phenomena, will sufficiently illustrate the matter:—

"1. Jarring a body under twisting stress causes an increase of twist.	1. Jarring a bar under magnetizing force causes increase of magnetization.
2. Permanent twist in a wire is diminished by jarring.	2. Permanent magnetization in a bar is diminished by jarring.

3. A wire permanently twisted and then partly untwisted loses or gains twist when jarred according as the untwisting is small or great.	3. A bar permanently magnetized and then partly demagnetized loses or gains magnetization according as the demagnetization is small or great."

Mechanical strain produced by magnetization. In 1842, Joule found that a bar of soft iron lengthened when it was temporarily magnetized in the longitudinal direction. (These effects, such as shocks, jarring and vibration in aiding the action of inductive magnetic force, were known to Gilbert.) When the magnetizing force was removed the bar shortened, but in general not quite to the original length. (This last sentence seems almost incredible to an Engineer, to take as granted that the magnetic force should be such as to strain the bar beyond its elastic limit.) Then again he says: "The actual elongation of an iron bar magnetized to saturation was found to be from $\frac{1}{720.000}$ to $\frac{1}{200.000}$ of its whole length. The extension varied approximately as the square of the intensity of magnetization (temporary or permanent). The general character was the same in soft or hard bars, but the effects were smaller with hard bars." The results of Joule have been verified by Buff, Tyndal, Mayer, and others.

The effect of extreme cold was, according to Trowbridge, to diminish the moment of a steel magnet (magnetized at 20° C.) by about 60 per cent.

The temporary magnetism of bars of cast iron, smithy iron, soft iron, soft steel, and hard steel magnetized by the earth's vertical force, was found by Scoresby to be insensible at a white heat, but to be much greater at a dark red heat than at the temperature of the air.

There are many facts that go to prove that the time any magnetizing force takes to develop the maximum magnetization that is capable of being produced is very small. The most wonderful evidence on this head is the fact that the telephone, which depends essentially on varying magnetic action, can reproduce the sounds of human speech even to the consonants.

Now, I think that I have said quite enough on the theory of the subject for my purpose this evening. I shall now advert to the practical adaptations of magnetism that enter into the experience of our daily life. The compass, with its prime importance to navigation, is perhaps the most prominent, and the one that has been of the greatest benefit to man.

We have already referred to the earth as a magnet; an iron ship is a magnet, and the compass that guides the ship is also a magnet. The earth, the ship, and the needle are but magnets of different intensities; there is a very intimate though varying relationship between them; they are not amicable companions; there is a constant struggle between them for mastery; they have certain inherent properties in common; and to these properties and to this struggle we may attribute the essential character of the compass and its convenience, use and benefit to mankind.

To relate what is known regarding the early knowledge, history and development of the compass is beyond the scope of this paper. I shall merely remark that Baron Humboldt says that reference to the use of it is to be found in Chinese history so remote as 2634 B. C. From writers on the subject, it does not seem improbable that a knowledge of the mariner's compass was communicated by the Chinese to the Arabs, and through the latter was introduced into Europe. Hallam, in his *Middle Ages*, vol. 3, cap. 9, says: "the earliest definite mention as yet known of the use of the mariner's compass in the middle ages occurs in a treatise written by Alexander Neckam in the 12th century." It was not used in Scotland by King Robert in crossing from Arran to Carrick in 1306, as Barbour writing in 1375 informs us that he had no needle nor stone, but steered by a fire on the shore. In 1750, Dr. Gowan found that the needles of merchant ships were made of two pieces of steel bent in the middle and united in the shape of a rhombus, and proposed to substitute straight steel bars of small breadth, suspended edgewise and hardened throughout. He also showed that the Chinese mode of suspending the needle conduces most to sensibility.

In 1820 Professor Barlow reported to the Admiralty that half the compasses in the Royal Navy were mere lumber and ought to be destroyed. Since then many improved varieties of ships' compasses have been introduced. The most remarkable and, as shewn by trial, most satisfactory, form of compass is said to be that patented in 1876 by Sir William Thomson.

The conditions that chiefly affect the use of the mariner's compass are those of the declination and variation to which I have already referred. The magnetism of the ship itself, or that induced in it by the earth's magnetic force, was first observed in 1772-1774 by Mr. Wales, the astronomer of Captain Cook. When surveying along the coast of New Holland in 1801-1802, Captain Matthew Flinders made the discovery that there was a difference in the direction of the magnetic needle according as the ship's head pointed to the east or the west. The deviation in wooden ships can be practically obviated, but in iron ships it has to be partly allowed for and partly compensated. Barlow used a corrective plate of iron to overcome the directive action on the compass due to the magnetism of wooden vessels. On Professor Airy's method the permanent magnetism of ships is compensated by a steel magnet placed at a given distance below the compass. It is, however, liable to changes of intensity occasioned by shocks, vibration, unequal heating and other causes, a fact which led to the late Dr. Scoresby to propose the employment of a compass aloft out of the region of the ship's influence.

The induced magnetism of ships can be only imperfectly compensated, since it varies according to the ship's bearing and as she rolls and pitches ; but corrections can be made for the heeling error.

In the last January number of the Popular Science Monthly, Lieutenant-Commander T. A. Lyons, U. S. N., very graphically describes induced magnetism, and its prime importance to navigation, in his article on the guiding needle of an iron ship.

Lieutenant Lyons says :—

" Let us conceive a metallically pure cylinder of wrought iron or cast iron that has not been hammered, and let us further conceive it entirely free from magnetism, hold it vertically, and instantly the upper end becomes a south and the lower a north pole (in this latitude). Reverse it as quickly as we may, and the magnet also reverses, so that the upper and lower ends are still as they were before, a south and a north pole respectively.

"Hold it horizontally in the meridian, and the end towards the north pole becomes a south pole. Revolve it slowly or rapidly in azimuth, and the foci of magnetic polarity also move with the fidelity of a shadow, until, when the cylinder points east and west, all the side facing the north is pervaded by north magnetism, and all facing the south by south magnetism. Again: let us conceive the hull of a ship to be like our cylinder, of metallically pure wrought iron, and as susceptible of magnetic induction in its ever changing courses, as the cylinder is when turned round. Then, as the ship steers north (in this latitude), the bow will become the centre of north polarity. As she gradually changes course to the eastward so will the north focus shift to the port bow, the south focus to the starboard quarter, and the neutral line dividing them, which, while the ship headed north was athwartship, will now become a diagonal from starboard bow to port quarter. When the ship heads east all the starboard side is pervaded with south polarity, the port with the north, and the neutral line takes a general fore-and-aft direction. Continuing to change course to the southward, the poles and the neutral line continue their motion in the opposite direction, until at south the conditions of north are repeated, but this time it is the stern that is a north pole, while the bow is a south pole. At west the conditions of east prevail, only that it is now the starboard side that has north polarity. And this transitory induction in both the cylinder and the ideal ship is solely due to the mild effect of the earth's magnetic field in which they move.

"Now, to consider it in the connection with an actual ship. The hull of no vessel is metallically pure, nor has it acquired shape and stability without much hammering; moreover, it cannot be made an abstraction from a magnetic state. By hammering in the process of construction it has been made as permanent and well defined a magnet as the steel bar, with poles and neutral line as in the bar, but located according to the magnetic direction in which the ship lay on the stocks, in strict conformity to the places they occupied in the ideal vessel just described. Therefore it is not as susceptible of mild magnetic induction of the earth as the cylinder or ideal hull, although the straining when on a passage, and the buffeting of the waves do assist the inducing tendency; besides, once that induced tendency becomes lodged, it does not move and shift with the freedom and facility that it did in the cylinder; and finally, as it already finds a tenacious occupant of the vessel in its permanent magnetism, hammered into it when building, it must adapt itself to the greater power, and thus it is the resultant of both has been always found, and not the individuality of either.

"Time is a chief element in the acquisition and efficiency of this induced magnetism; for the longer a ship steers on a given course, or lies in the same general direction, the greater will be the magnetic charge, and the more slowly will it move and shift with the changing courses of the vessel.

"This induced magnetism has been dwelt upon at some length because of its prime importance to navigation.

"The other magnetic qualities of a ship are comparatively stable, but this is treacherous and changeable to a degree that necessitates constant vigilance to prevent disaster. On the great fleet of transatlantic steamers it is more likely to lead into danger than on the other routes; the ship steers a generally easterly or westerly course going to Europe and returning to America; the magnetic influence on the outward trip is the opposite to that returning; the ship runs at a high rate of speed, and the induction varies on different parts of the route according to the intensity of the magnetic field passed over, the smoothness or roughness of the sea which affects the motion of the ship, and the warmth or coolness of the weather."

"Instead of attributing the loss of vessels when approaching a coast," says Lieutenant-Commander Lyons, "to the magnetic effects of fog and land, and other improbable influences on the compass, it were much more reasonable to ascribe it to the changed conditions of her magnetism by induction during the passage, which has not been discovered or kept account of by frequent azimuths previous to closing in with the land. Suddenly a course the captain thought perfectly safe carries the ship upon a shoal or rock, and the fault is laid upon the compasses, whereas they but obeyed the magnetic influences that became altered, during a long passage, from what these influences were when the ship was last swung to determine the deviations of her compasses.

"The means taken for discovering the permanent magnetic character a ship has acquired in building is a dry dock survey. Let us suppose the ship and dry dock to be parallel to the magnetic meridian. Stations are established at the prominent points on the steps or on the side of the dock. A compass is taken to each station and the direction in which the needle points is noted. Of course, if no disturbing mass was near, it would point to the north at every station. But an iron ship is there, so that at certain stations we find the needle repelled from the vessel. Now, only north magnetism can produce this kind of deflection. It varies in degree at each station, and where greatest there is the pole. Again we find the needle's north end attracted towards the ship, hence we have discovered the body of south magnetism, so we locate its pole where deflection is greatest. Finally at several stations in an irregular path from bottom to rail we see that the needle points everywhere and this is the neutral line. A sketch of each side of the ship is drawn on paper, and the degree of deflection at every station is plotted by means of measurements from a line taken across her bow and from the ship's side.

"An iron ship, frames, plating, decks, beams, stanchions, carlings, engines, masts, &c., is not like the steel bar, a simple magnet, but a network of magnetic entanglement, yet, however complex this may be, proper means are devised for coping with it. The problem is simplified to pairs of parallel forces, each pair having its resultant parallel to the co-ordinate axis, the sum total of all three forces parallel to it, and the whole concentrates upon the north point of the compass; whence the final result that we have imaginary magnets, one laid horizontal to the axis of the vessel, the second also horizontal across the vessel, and the third vertical.

"The individual and combined effect of these three imaginary magnets is the object of investigation, but before entering upon it, it will be necessary to remark that each is not simple but complex, and that, recognizing this we shall have to consider all the component parts, that we may obtain all the prime factors, and then reduce those factors as nearly as practicable to zero."

By swinging a ship at compass buoys or steaming in a circle on the open sea, the magnetic effect of the ship, that is of the three imaginary magnets, is brought to bear on every point of the needle causing it to deflect from the magnetic meridian by different angles at different points. These various deflections being serially arranged constitute what is known as tables of deviation.

Frequently means are provided for opposing the magnetism of the ship by other powerful magnets, thus permitting the needle to point in its natural direction however the ship may head: such a contrivance is known as a compensating binnacle.

In considerable changes of magnetic latitude the magnets have to be slightly moved to counterbalance the altered condition of the deviations, and sometimes, also, to compensate for a partial loss of power in the magnets themselves.

The more immediate object of this paper is to point out what occurs to the author respecting the influence of terrestrial magnetism on iron bridges, iron rails, locomotive machinery, and such other structures and machines as undergo great stress, through blows, shocks, or violent contacts, in latitudes where terrestrial induction is of great moment. I would also wish to make some reference to the frequent and fitful changes exhibited at the different magnetic observatories, as that they might in a great degree be attributed to thermal changes in the body of the great magnet, the earth itself; but as my time is now exhausted, I should prefer deferring any further remarks to a future evening. The plates referred to in this paper will appear in that which is forthcoming.

EXPLANATION OF THE PLATES.

PLATE I,—illustrating Dr. Honeyman's paper on Two Cable Hauls,—contains figures of the various organisms and other objects found in the Sponge, *Reniera Miniœ*, viz. :—

1. Spicules, long oxeas, ac.², bent.
2. Spicules, short oxeas, ac.², fusiform.
3. Spicules, styles, trac., long, stout, slender, straight, curved.
4. Spicule, style, trac., spinous.
5. Spicules, styles, tr.², long, short.

6, 7. Radiolaria.

8, 9, 10, 11, 12, 13. Diatoms.

PLATE II,—illustrating the same paper,—contains figures of the organisms and other objects found in the Sponge, *Reniera Fundyensis*, viz. :—

1, 2 3, 4, 5. Spicules, oxeas, ac.²

6. Spicule, style, trac.
7. Spicule, style, trac., spinous.
8. Spicule, style, trac., spinous.

9, 10. Spicules, cymbas, anc.²

11, 12. Spicules, pterocymbas, anc.², bi-anchorate, bi-harnate.

13. Radiolaria.
14. Diatom.
15. Diatom ; *Bacteriastrum furcatum.*

PLATE III,—illustrating Dr. Honeyman's paper on Glacial Boulders,—contains figures of the various organisms and other objects found in the Sponge, *Stelletta Hanseni*, viz. :—

1. Spicule, oxea, ac.², fusiform.

2, 3, 4, 5, 6, 7, 8. Spicules, styles, trac., long, short, straight, curved.

9. Spicules, styles, tr.², straight, curved.

10, 11. Spicules, chiasters.

12. Spicule, spheraster.
13. Spicule, pterocymba, anc.²

14, 15, 16, 17. Diatoms.

PLATE IV,—illustrating the same paper,—contains figures of the organisms and other objects found in the Sponge, *Stelletta etoile-pistolet*, viz.:—

1. Spicules, etoile-pistolet.
2. Spicules, etoile-pistolet, double.
3. Spicules, chiasters.
4, 5. Spicules, walking-stick.
6. Spicule, tylotoxea, trac.
7. Spicule, tornote (Sollas.)
8. Spicule, style, trac., curved.
9. Spicules, styles, trac., spinous.
10. Spicule, strongyle, tr.^{2}
11. Spicule, strongyle, tr.^{2}, spinous, straight.
12. Spicule, strongyle, tr.^{2}, spinous, curved.
13. Spicules, pterocymbas, anc.^{2}
14, 15. Diatoms.

NOTE.—The figures in the above Plates, which are indicated by an asterisk, were taken with the $\frac{1}{8}$-inch objective. Those not so indicated were taken with the $\frac{1}{4}$-inch objective.

PLATE V,—illustrating Mr. Piers's paper on Aboriginal Remains of Nova Scotia,—contains the following:—

1. Pierced Tablet from Smith's Cove, near Digby.
2. Pierced Tablet in Webster Collection.
3 and 4. "Snake Stone," presented by Mr. Gilbert Seaman, of Minudie.
5 and 6. "Snake Stone," presented by Miss Frame, of Shubenacadie.
7 and 8. Pipe from Musquodoboit Harbor.
9. Pipe from River Dennis, Cape Breton.

All the figures of Plate V are half the natural size.

PROCEEDINGS

OF THE

Nova Scotian Institute of Natural Science.

VOL. VII. PART IV.

ANNUAL BUSINESS MEETING, Halifax, 9th Oct., 1889.

The PRESIDENT *in the Chair.*

The Minutes of the last annual meeting were read and approved.

The Treasurer's Accounts were audited by R. J. WILSON and H. PIERS. The following were elected Members of Council for the current year:—

President—Prof. J. G. MACGREGOR, D. SC.

Vice-Presidents—MARTIN MURPHY, C. E., A. H. MACKAY, B. A., B. SC.

Corresponding Secretary—Rev. D. HONEYMAN, D. C. L.

Recording Secretary—ALEXANDER MCKAY.

Treasurer—W. C. SILVER.

Librarian—MAYNARD BOWMAN.

Councillors without office—Prof. GEO. LAWSON, LL. D., E. GILPIN, JR., A. M., F. G. S., J. SOMERS, M.D., J. J. FOX, H. W. W. DOANE, R. J. WILSON, AUGUSTUS ALLISON.

ORDINARY MEETING, Art School Rooms, Nov. 11, 1889.

The PRESIDENT *in the Chair.*

Inter alia.

On motion of Prof. G. LAWSON, seconded by Mr. M. MURPHY, it was resolved that the following record of the sentiments of the Institute, on the occasion of the death of Rev. Dr. HONEYMAN, be placed in the Minutes:—

"Since our last meeting it has pleased the Almighty to call away from us our fellow member, the Rev. Dr. HONEYMAN, who departed this life on the 17th day of October last. We desire to embrace this first occasion of our assembling together since the solemn event to express and place on record our feelings of respect and esteem for our late colleague, as an active and enthusiastic naturalist, an earnest and devout searcher for truth, a warm friend, genial companion, and vivacious expounder of his favorite science. His assiduous researches, extending over a period of many years, on the geology of a considerable portion of the northeastern part of Nova Scotia, have made his name known wherever the science is studied. As an official of the Nova Scotian Government, at several of the International Exhibitions held in Great Britain and France, he did much to make widely known the rich treasures of mining, agricultural and marine wealth of our Province. As Curator of the Provincial Museum he was instrumental in bringing together much of the material which it contains, and was ever ready, in the most cheerful manner, to afford to visitors or students such explanation and assistance as they required. Dr. HONEYMAN's death will be widely felt, not merely as a loss to our community and to the Province, but to Science at large. Especially do we feel it in this Institute, of which it may be truly said, that he was for a long course of years the most active member.

"We desire further to express our heartfelt sympathy with his widow and daughters, who, in their sad bereavement, have yet the blessed comfort that they sorrow not as those who have no hope."

The PRESIDENT read an opening Address, chiefly on the subject of the Provincial Museum. (See p. 319).

DR. SOMERS read a paper, "Nova Scotian Fungi." (See *Transactions*, p. 464).

ORDINARY MEETING, Art School Rooms, 9th December, 1889.

The PRESIDENT *in the Chair.*

Inter alia.

The PRESIDENT read a paper by the late Rev. Dr. Honeyman, entitled, "Glacial Geology of Cape Breton." (See *Transactions*, p. 337). He also gave a short sketch of Dr. Honeyman's work in connection with investigations relating to glacial phenomena.

ORDINARY MEETING, Art School Rooms, 13th Jan., 1890.

The PRESIDENT *in the Chair.*

Inter alia.

The PRESIDENT read a paper by the late Rev. Dr. Honeyman, entitled, "Geological Gleanings in Nova Scotia and Cape Breton." (See *Transactions*, p. 345.)

The SECRETARY read a paper by E. GILPIN, F.G.S., entitled, "On the Geological Writings of Dr. Honeyman." (See *Transactions*, p. 357).

DR. A. P. REID read a paper entitled, "Stirpiculture or the Ascent of Man."*

ORDINARY MEETING, Art School Rooms, 10th Feb., 1890.

The PRESIDENT *in the Chair.*

Inter alia.

The REV. M. MAURY, D. D., read a paper entitled, "Observations on the Tentacles of the Echinus." (See *Transactions*, p. 479.)

F. A. BOWMAN, M. A., B. E., read a paper on "Potassic Iodide as a Blowpipe Reagent." (See *Transactions*, p. 363.)

The PRESIDENT read a paper, "On the Relative Bulk of aqueous Solutions of certain Hydroxides, and their constituent water." (See *Transactions*, p. 368.)

Also another paper: "On a noteworthy case of the occurrence of ice in the form of non-crystalline columns." (See *Transactions*, p. 377.)

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*This paper was published by its author in pamphlet form.

Ordinary Meeting, Art School Rooms, 10th March, 1890.
The President *in the Chair.*
Inter alia.

M. Murphy, C. E., read a paper entitled, "Our Common Roads." (See *Transactions*, p. 429).

Special Meeting, Art School Rooms, 24th March, 1890.
The President *in the Chair.*
Inter alia.

On motion of A. Allison and the Secretary, it was "resolved that this Society be hereafter called the Nova Scotian Institute of Science."

On motion of Messrs. Bowman and Allison, it was resolved "that the Council be authorized to apply to the Legislature for an Act of Incorporation."

A Paper by the Rev. Dr. Ambrose, on "Our Fishes and their Enemies," was read. (See *Transactions*, p. 394.)

Ordinary Meeting, Art School Rooms, 14th April, 1890.
Inter alia.

The President read a Paper by E. Gilpin, Jr., F. G. S., on "The Devonian of Cape Breton." (See *Transactions*, p. 381.)

Also, a Paper by H. S. Poole, F. G. S., on "The Surface Geology of the Picton Coal Field." (See *Transactions*, p. 388.)

Rev. M. Maury, D. D., read a Paper entitled, "A Contribution to the Theory of Earthquakes." (See *Transactions*, p. 475.)

Ordinary Meeting, Provincial Museum, May 12, 1890.
The President *in the Chair.*
Inter alia.

A Paper by Messrs. W. F. Ganong and H. Piers was read, entitled: "John Robert Willis, the first Nova Scotian Conchologist,—A Memorial: His life; his List of Nova Scotian Shells, and his other published works." (See *Transactions*, p. 404).

Also, a Paper by A. M. Morrison, B. A., on "The variation of density with concentration in weak aqueous solutions of Cobalt Sulphate." (See *Transactions*, p. 481).

A Paper by H. Piers, entitled: "Notes on Nova Scotian Zoology," was read by title. (See *Transactions*, *p.* 467).

ALEXANDER McKAY,
Recording Secretary.

LIST OF MEMBERS.

ORDINARY MEMBERS.

	Date of Admission.
Akins, T. B., D. C. L., Halifax	Jan. 11, 1873.
Allison, Augustus, Halifax	Feb. 15, 1869.
Bayers, Rufus, Halifax	March 4, 1890.
Bennett, Joseph	Nov. 3, 1886.
Bliss, D. M. Electrician, Amherst	Jan. 31, 1890.
Bowman, Maynard, Public Analyst, Halifax	March 13, 1884.
Brown, C. E., Halifax	Dec. 20, 1864.
Butler, Prof. W. R., King's College, Windsor	Nov. 27, 1889.
Campbell, D. A., M. D., Halifax	Jan. 31, 1890.
Campbell, G. M., M. D., Halifax	Nov. 10, 1884.
Coates, Col	April 1, 1887.
Denton, A. J.	April 13, 1884.
DeWolfe, J. R., M. D., L. R. C. S. E., Dartmouth	Oct. 26, 1865.
Doane, Harvey W. W., Halifax	Nov. 3, 1886.
Downs, Andrew, M. Z. S. L., Halifax	Feb. 5, 1863.
Egan, T. J., Halifax	Jan. 6, 1890.
Forbes, John, Halifax	March 14, 1883.
Foster, Jas G., Barrister, Dartmouth	March 14, 1883.
Fox, John J., Halifax	May 8, 1882.
Fraser, Principal C. F,, School for the Blind, Halifax	March 31, 1890.
Fyshe, Thomas, Halifax	Jan. 9, 1888.
Gilpin, Edwin, M. A., F. G. S., F. R. S. C., Deputy Commissioner of Mines, Halifax	April 11, 1873.
Gilpin, J. Bernard, M. D., M. R. C. S. L., F. R. S. C., Annapolis	Jan. 5, 1863.
Hare, A. A., Bedford	Dec. 12, 1881.
Harris, Herbert, Halifax	Jan. 31, 1890.
Keating, E. H., City Engineer, Halifax	April 12, 1882.
Kennedy, W. T., The Academy, Halifax	Nov. 27, 1889.
Laing, Rev. Robert, Halifax	Jan. 11, 1885.
Lawson, Prof. George, Ph. D., LL. D., F. I. C., F. R. S. C., Dalhousie College, Halifax	March 7, 1864.
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881.
MacGregor, Prof. J. G., M. A., D. Sc., F. R. SS. C. & E., Dalhousie College, Halifax	Jan. 11, 1877.

McInnes, Hector, LL. B., Halifax ....Nov. 27, 1889.
McKay, Alexander, Supervisor of Schools, Halifax ....Feb. 5, 1872.
McKay, A. H., B. A., B. Sc., F. S. Sc. L., Principal of Academy,
Halifax...Oct. 11, 1885.
McKay, E., B. A., Principal High School, New Glasgow........Nov. 27, 1889.
McLeod, John, F. S. Sc. L., Demerara ....Nov. 1, 1878.
Macnab, William, Halifax ....Jan. 31, 1890.
Morrow, Arthur, M. D., Halifax ....Nov. 27, 1889.
Murphy, Martin, C. E., D. Sc., Provincial Engineer, Halifax....Jan. 15, 1870.
O'Hearn, P., Principal St. Patrick's Boys' School, Halifax......Jan. 6, 1890.
*Parker, Hon. D. McN., M. D., M. L. C., Halifax ....
Pearson, B. F., Barrister, Halifax...........................March 31, 1890.
Piers, Harry, Halifax..Nov. 2, 1888.
Poole, H. S., A. R. S. M., F. G. S., General Supt. of Pictou Coal
Mines, Stellarton.....................................Nov. 11, 1879.
Read, H. H., M. D., Halifax..................................Nov. 27, 1889.
Robb, D. W., M. E., Amherst..................................March 4, 1890.
Rogers, W. H., Amherst.......................................March 4, 1890.
Rutherford, John, M. E., Halifax.............................Jan. 8, 1865.
Silver, A. P., Halifax ....Dec. 12, 1887.
Silver, W. C., Halifax ....May 7, 1864.
Smith, Capt. W. H., Halifax ....Nov. 27, 1889.
Somers, John, M. D., Halifax.................................Jan. 11, 1875.
Stewart, John, M. B. C. M., Pictou...........................Jan. 12, 1885.
Uniacke, Robert J., C. E., Halifax...........................March 9, 1885.
Wilson, R. J., Secretary School Board, Halifax ....May 3, 1889.

ASSOCIATE MEMBERS.

Bishop, W. L., Kentville. ....Jan. 6, 1890.
Caie, Robt., Yarmouth..Jan. 31, 1890.
Calkin, Principal J. B., M. A., Normal School, Truro ....Jan. 6, 1890.
*Cameron, A., Principal of Academy, Yarmouth ....Nov. 27, 1889.
Coldwell, Prof. A. E., A. M., Acadia College, Wolfville.......Nov. 27, 1889.
Faribault, E. R., C. E., Ottawa ....March 6, 1888.
Hardman, J. E., M. E., Oldham, N. S..........................March 4, 1890.
Harris, Prof. C., Roy. Mil. Coll., Kingston, Ont..............Nov. 13, 1881.
*Johns, T. W., Yarmouth......................................Nov. 27, 1889.
Kennedy, Prof., King's College, Windsor ....Nov. 9, 1882.
McKenzie, W. B., Engineer, Moncton, N. B ....March 31, 1882.
Matheson, W. G., Engineer, New Glasgow, N. S. ....Jan. 31, 1890.
Patterson, Rev. G., D.D., New Glasgow, N. S..................March 12, 1878.
Pineo, A. J., Pictou ....April 4, 1884.
Reid, A. P., M. D. C. M., L. R. C. S. E., L. C. P. & S. C. Supt. of
Hospital for Insane, Halifax..........................Jan. 31, 1890.
Wilson, B. C., Manager Acadia Powder Co , Waverley, N. S. ....March 4, 1890.

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* Life Member.

CORRESPONDING MEMBERS.

Ambrose, Rev. J., D. C. L., Digby .... Jan. 31, 1890.
Bailey, Prof. L. W., Ph. D., F. R. S. C., N. B. University, Fredericton, N. B. .... Jan. 6, 1890.
Ball, Rev. E. N., Tangier, N. S .... Nov. 29, 1871.
Dawson, Sir J. W., C. M. G., LL. D., F. R. S., Principal of McGill University, Montreal .... Jan. 31, 1890.
Duns, Prof. John, New College, Edinburgh .... Dec. 30, 1887.
Ganong. W. F., B. A., Instructor in Botany, Harvard College, Cambridge, Mass .... Jan. 6, 1890.
Harvey, Rev. Moses, St. John's, Nfld .... Jan. 31, 1890.
King, Major, R. A .... Nov. 19, 1877.
McClintock, Vice-Admiral Sir Leopold, Kt., F. R. S .... June 10, 1880.
Marcou, Jules, Cambridge, Mass .... Oct. 12, 1871.
Matthew, G. F., M. A., F. R. S. C., St. John, N. B .... Jan. 6, 1890.
Smith, Hon. Everett, Portland, Me., U. S. A .... March 31, 1890.
Spencer, Prof. J. W., A. M., Ph. D., F. G. S., State Geologist, Atlanta, Ga., U. S. A .... Jan. 31, 1890.
Trott, Capt., S. S. *Minia*, Anglo-American Telegraph Co .... Jan. 31, 1890.
Weston, Thos. C., Geological Survey, Ottawa .... May 12, 1877.

OPENING ADDRESS.

By Professor J. G. MacGregor, President.

Gentlemen:—In the few remarks which I have to make by way of opening the first meeting of the present session, the first place must be given to a reference to the loss with which the Institute has met during the past year, through the deaths of two of its oldest members,—Mr. William Gossip and Rev. David Honeyman, D. C. L.

Mr. William Gossip was born at Plymouth, England, in 1809, and came to Halifax at the age of 13 years. In 1831 he went to Pictou, where for three years he published and partly edited the *Pictou Observer.* He returned to Halifax in 1834, and established a bookselling and publishing business, which he maintained until his death. For some years after his return to Halifax, he edited and published a newspaper called *The Times.*

Mr. Gossip joined this Institute on the 2nd Feb., 1863, a few weeks after its formation. He was, therefore, practically an original member. In 1864 he was appointed Secretary, and he continued to discharge the duties of that office until 1871. From 1871 till 1874, he was a member of Council without office; from 1874 to 1878, Vice-President; from 1878 to 1880, President; and from 1880 to 1889, a member of Council, either without office or serving as Vice-President. For twenty-six years, therefore, and practically from the time of the Institute's foundation until his death, he had a hand in the management of its affairs. As a member of Council he was one of the willing few on whose shoulders the bulk of the work fell; and his special knowledge of printing and publishing enabled him to give specially valuable service in superintending the publication of our Transactions, with the editing of which he was for many years entrusted.

Mr. Gossip contributed four scientific papers to our Transactions, one geological and three anthropological. His activity and influence in the line of the Institute's scientific work, however, were much greater than is indicated by the number of his papers. Not being himself professionally a scientific man, he was diffident about putting into the form of a paper the results of his own observation and reflection. But being a very wide reader, and having not only large scientific interest, but also extensive scientific knowledge, the remarks he was accustomed to make on papers read by other members, were always full of information, and often highly suggestive; and most of our working members owe him a debt of gratitude for his intelligent and kindly criticism of their work.

Dr. Honeyman was born at Corbie Hill, Fifeshire, Scotland, in 1817. He received his early education at the Dundee High School, from which he proceeded, at the age of 17, to the University of St. Andrews. At St. Andrews he devoted himself chiefly to the somewhat strange combination of oriental languages and natural science. The former, including Hebrew, Chaldee, Syriac and Persian, he studied with such marked success, that while yet a student, he was selected to teach Hebrew to a class consisting largely of clergymen. In natural science he quickly became so well known as a collector that he was employed to assist in providing a museum for the Watt Institution of Dundee.

Having completed his university studies he selected the church as a profession, and in 1836 entered the United Secession Theological Hall, studying first at Glasgow, and afterwards at Edinburgh. He was licensed in 1841, and joined the Free Church immediately after the Disruption. Five years afterwards he came out to Nova Scotia and was appointed Professor of Hebrew in the Free Church College in this city; but after a short professoriate he resigned his chair with the intention of going to the United States. A timely call from the Presbyterian congregation of Shubenacadie, however, induced him to remain in Nova Scotia; and a few years later he accepted the pastorate of the congregation of Antigonish. Meantime neither his theological and oriental studies, nor his pastoral work had quenched his early love of science; and after a few years, during which he had acquired in his spare moments a profound knowledge of the geology of the eastern part of the Province, he resigned his charge at Antigonish and decided to devote himself wholly to scientific work. He was not long without definite employment, his reputation as a naturalist leading to his appointment by the Nova Scotian Government to make a collection of our minerals for the London International Exhibition of 1862, and to superintend the whole of the Nova Scotian section at that Exhibition. He was afterwards sent on similar service to the Dublin Exhibition of 1865, the Paris Exhibition of 1867, the Philadelphia Exhibition of 1876, and the London Fisheries Exhibition of 1883. In 1869 we find him on the staff of the Geological Survey of Canada; and, on leaving the Survey, the Nova Scotian Government shewed its appreciation of his services by appointing him Curator of the Provincial Museum, of which he had been to a large extent the creator. He held this office until his death; and under his charge the Museum has acquired such dimensions as to demand a special building for the display of its collections.

Dr. Honeyman was elected a member of this Institute on the 3rd December, 1866. In 1870 he was made a member of Council, and in 1871 was elected to the office of Secretary, which office he held, at first singly and in late years jointly with a colleague who took charge of the Institute's records, until his death, a period of 18 years. How laborious the duties of this office were, few of us have any idea. They included not only the conducting of correspondence with the learned Societies abroad, with which we have been from time to time in communication, but also the receipt and preservation of the various publications which these Societies have sent us, and the transmission to them of copies of our Transactions in return. But these services, though large in themselves, form but a small part of what he did for us. For it is to the long series of valuable papers which he communicated to the Institute, and which we had the honour of publishing in our Transactions, that the reputation which our Institute has established abroad is largely due. These papers he might in many cases have communicated to other Societies with greater advantage to himself; but he was willing to forego the more rapid recognition of his own work, which would have been gained by publication in the Transactions of older Societies, in order that the reputation of our Society might be more quickly established. And frequently when the members of the Institute have been despondent as to its progress, his characteristic enthusiasm and his readiness to intrust to it the great bulk of the result of his scientific investigations, have stimulated their flagging zeal and urged them to renewed effort.

Dr. Honeyman's communications to our Transactions, including two which were found on his desk after his death and will be read during the present session, number fifty-seven. Of these, thirty-five were devoted to a study of the general Geology of Nova Scotia, one to the Geology of New Brunswick, and one to the Geology of the Magdalen Islands. Five were on Nova Scotian rocks, their polariscopic character and metamorphism, and on metalliferous sands. Six were devoted to a special study of the Glacial Geology of Nova Scotia. Eight dealt with other subjects, such as new and rare fishes, Nova Scotian Echinoderms, Chebucto Nullipores, Sponges, and other biological subjects; and one was on Meteorites. Even this large number of papers does not represent the whole of his scientific activity; for he published also many papers in the Transactions of other scientific Societies, the number and character of which I have no means of ascertaining. He published also a few years ago a small book called "Giants and Pigmies," intended to facilitate the study of the collections of the Provincial Museum. During the last year of his life he was engaged chiefly in a microscopic study of organisms found attached to submarine cables, and entrusted to him by Capt. Trott, of the S. S. *Minia;* and the result of this study was the discovery of what appear to be a large number of marine sponges hitherto unknown.

Dr. Honeyman's scientific work was highly appreciated both at home and abroad. He received the honorary degree of D. C. L. from King's College, Windsor. He was a Fellow of the Royal Society of Canada and of the Geological Society of London, a Member of the Geological Society of France, an

Honorary Member of the Geologist's Association of London and of the London Society of Science, Letters and Art, and a Corresponding Member of the London Society of Arts and of the London Horticultural Society; and he was recently selected as one of a limited number of original members of the Geological Society of America. He was awarded the Mantuan Medal for scientific eminence, and received various medals in connection with the International Exhibitions which he attended.

To the genial kindliness of Dr. Honeyman's disposition, to his readiness at all times to give assistance from the stores of his own experience and knowledge, and to the value of his enthusiastic encouragement in the prosecution of difficult work, all our younger members will be ready to bear witness; and I am sure that all of us feel that through his death we have lost not only an able leader in our scientific work, but also a warm personal friend.

Dr Honeyman rendered important scientific service, not only to our Institute, but also to the country at large, by the energy with which he discharged the duty to which he was appointed nearly twenty years ago, of building up the Provincial Museum. And since, in consequence of his death, some action must be taken on the part of the government, with regard to the collections which he had been successful in making, it seems to me to be appropriate that I should bring before you, on the present occasion, some considerations as to what that action should be.

At the outset it may be well that I should state such facts as I have been able to collect, with regard to the Museums of other countries, though I regret very much that, partly owing to the defects of the libraries to which I have access, and partly to the fact that but few collections of museum statistics seem to have been made, the information available is very meagre. The British Association Reports on Provincial Museums show that there are in the United Kingdom 211 Museums, exclusive of those of the metropolis. They are of very different grades of efficiency, 56 being of a high order, 55 being placed in the second class, 63 in a third, and 30 in a fourth. Nearly half of them are of a general character, having no special reference to the district in which they are located;

and nearly half contain both local and general collections. With regard to their contents, nearly half are devoted for the most part to Geology, about one fourth are devoted largely to Zoology, and about one tenth are chiefly archæological. So far as support is concerned, 50 of them draw their funds from a special municipal rate; 63 are supported by local societies and institutions; 30, by colleges; 5, by general Borough funds; 8, by government, and the balance by endowments, annual subscriptions, &c. The United Kingdom thus possesses quite a large number of Provincial Museums; but the committee from whose report I have quoted, state that they have not found one which attained to their ideal of what such Museums ought to be; and with the object of stimulating them to greater efficiency, they sketch the ideal at which such Museums should aim. That the value of the influence of such Museums is recognised, is shown in the report of the Royal Commission on Scientific Instruction which recommended, in 1874, that efforts should be made to supply the deficiencies of existing Museums, and that typical Museums should be organised in connection with Science Schools throughout the kingdom.

With regard to the Museums of the United States, I have no definite data later than 1876. The reports of the Commissioner of Education shew that between 1872 and 1876, the number of Museums reporting to the Education Office had increased from 50 to 79, that the number connected with institutions of learning had increased from 35 to 44, and that the annual expenditure on Museums had increased from $46,550 to $145,520. Though definite statistics are not available for a later date than 1876, it is well known that of late years our neighbours have been making great progress in Museum organization. In a report made by Mr. Ball of the Museum of Science and Art of Dublin, he states that he was much impressed with their system, thoroughness and astonishing vigor, and with the gigantic extensions of their spheres of usefulness to which they looked forward in the future.

In the Australian Colonies, Museums are regarded as important factors in promoting industrial progress; New South Wales, for example, having sent a Commission to Europe some years ago to report on European Museums, and having subsequently, in pursuance of the report of that Commission, established in addition to the General Museum which it already possessed, one of a technological character, intended to develop into a technological school.

I have been able to obtain no definite statistics as to the Museums of the continent of Europe; but every traveller is aware that it is hard to find a town of any importance which does not boast of collections of more or less value, while the large towns, and the universities possess collections often of enormous extent and involving great expenditure. In some countries, more especially in France, district Museums, containing collections illustrating the natural history and the industrial state of comparatively small districts, exist in considerable numbers, and are found to be of great utility from an industrial point of view.

These Museums, which are thus found in such large numbers in civilised countries, are of course of very different degrees of efficiency and of quite different types. Some do not rise above the popular conception of a museum as being a collection of curiosities, affording amusement rather than instruction; and it is museums of this kind which bring discredit on the whole class. They are useless and should be cut down as cumberers of the ground. The majority, however, answer to a greater or less extent to the true conception of a museum, as consisting of collections illustrating in a systematic manner the present state of human knowledge in one or more departments, and the various stages, but more especially the present stage, of the activity of one or more sections of the human race. It will be obvious that to illustrate adequately the present state of knowledge in all departments, and present and past stages, of the activity of the whole human race, would require a far greater expenditure than even the wealthiest nations have so far seen their way to make for this purpose. Most museums, therefore, are forced to restrict themselves to special objects, and in consequence their varieties are very numerous. We find some devoted to single departments of knowledge, as geological or zoological museums; some devoted to groups of sciences, as Natural History Museums. In other cases, while the illustration of all departments of knowledge may be aimed at, the mode of illustration may be general, not entering into great detail. Of this kind are the museums established for educational purposes in schools and colleges, sometimes called typical museums, because they aim at securing only typical or representative examples of the various classes into which animals, plants, &c., have been divided. Then we have Art Museums, which aim at illustrating the artistic department of human activity, and which provide usually specimens showing the gradual development of art in past ages, the Art Exhibition being a temporary museum intended to illustrate the present state of artistic activity. Technological or Industrial Museums are also devoted to human activity, but in the department of industry. They may be restricted to some one industry, or some group of industries, or to the industrial development generally of some one country or town, or even to the present industrial condition of a larger or smaller section of the human race.

The expenditure of the various civilised nations on museums I have no means of ascertaining. But even a casual visit to the metropolitan museums of Europe and America will show, that for them alone, it must reach a very large figure; while the smaller amounts devoted to sustaining the numerous provincial or local museums referred to above, must in the aggregate reach an enormous sum. Thus the Edinburgh and Dublin museums cost about £10,000 a year each, while the English provincial museums of the first class are found to involve an annual expenditure of at least £800 a year each. In all such services connected with the education of the people, and the development of industries, the expenditure of the continental nations of Europe is on a much more liberal scale than in Great Britain. On the whole then, the world's annual expenditure on museums must reach an enormous figure.

Now, even wealthy nations do not expend money thus lavishly without definite objects; and the objects which are aimed at, and which experience shows to be secured, by the founding and maintenance of museums, are three, viz., (1) the promotion of scientific research. (2) the promotion of industrial development, and (3) the promotion of education, including the systematic education of students, and the general educational elevation of the masses. If then we advocate a continuation of the expenditure which the Province has for some years made on its museum, and still more, if we advocate increased expenditure, it must be shown that one or more of these objects which properly regulated museums are found to secure, are of importance to us, and are likely to be secured by us in our peculiar circumstances.

That industrial development is of importance to us goes without saying. Our Province is possessed of great, but only slightly developed, mineral wealth. We have fertile valleys and an abundant and varied vegetation. Our hills are admirably adapted for grazing purposes, and our seas and rivers are abundantly supplied with fish. Nevertheless, our industrial development is still in a comparatively low state. Large quantities of some of our raw materials are exported in the raw state ; others are neither exported nor worked up by ourselves; and the utilisation of waste products is only very partially carried out. All means, therefore, which are likely to accelerate the growth of our industries, are of importance to us, and should, if possible, be adopted. Now for this purpose it is clearly necessary that we should know ourselves, and make known to others, what raw materials we actually possess. And it is desirable also that we should have some means of making known to what extent and by what methods these raw materials are being worked up into finished products. Printed descriptions are doubtless of much value. But the best of all ways of obtaining this end is to collect in one place actual specimens of all our raw materials, as well as of finished products, specimens of these products in the various stages of their manufacture, and, in some cases, specimens, either actual or in model or drawing, of the tools, appliances, etc., by which their manufcture is carried on. Such a collection would constitute a technological or industrial museum. It would form a well selected permanent exhibition of the natural products of the province, and of the state of its advancement in the application of skilled labor to them. It would give to our youth the means of becoming acquainted, without undue expenditure of time and money, with the natural resources of their own country; and to travellers it would show what inducements the Province offers for the investment of capital.

Were funds available, it might be utilised in very special cases, as similar museums have been in France, for the introduction of improved industrial methods, the finished products obtained by these methods, and even models and descriptions of the appliances involved in them, being procured and exhibited; and it might be made to exert a beneficial influence on industries which are to a certain extent artistic, by including in its scope more or less extensive collections of specimens of artistic workmanship.

But while we have very considerable natural resources already known, it must not be forgotten that our knowledge of them is still incomplete, and that we may have stores of valuable material not yet discovered. Hence we must not rest satisfied with our present knowledge, but must make provision for its extension. In other words the promotion of scientific research is essential to the promotion of our industrial development. The advancement of science is of course a good thing in itself; and where wealth has been accumulated no better use can be made of it than in promoting research. But even if it be granted that our accumulated wealth is not sufficient to admit of our devoting any part of it to the advancement of science generally, it may still be true that if we wish to discover and develop the resources of our country, we must secure its advancement in some special departments. We already know some of our useful plants and animals. We must know them all; and for this purpose we must make a systematic study of the zoology and the botany of the Province. So, also, we now know some of our useful minerals and some of the places where they are to be found. We must find out all such minerals and all the places where search for them is likely to be successful. That is, we must make a thorough study of our mineralogy and of our geology. Now, the first essential of progress in knowledge is acquaintance with what is already known; and that requires, among other things, that we should have available for study a complete collection of all the animals, plants and minerals, which have so far been discovered in the Province, and collections of rocks, fossils, etc., illustrating what is already known of the geological structure of the country. But the animals, plants and minerals of any one country can be adequately studied only in relation to other members of the great biological and mineralogical classes found existing elsewhere. Hence it is desirable also that we should have typical collections in the departments of zoology, botany and mineralogy. And as the geological structure of our Province can be adequately studied only by reference to that of other parts of the earth's crust, it is desirable also that we should possess more or less extensive collections shewing the geological structure of other lands. In short, for the adequate promotion of our industrial development, we require not only an industrial museum, but also what is called a natural history museum, containing a complete collection to illustrate our own natural history and geology, and epitomised collections to illustrate these sciences generally.

The knowledge of our natural resources which, by the aid of such a museum, would be gradually obtained, would exist in the minds of investigators and in printed books. It is further necessary, if our industrial development is to make rapid progress, that it should be rendered available to our youth. Hence the treasures of our museum should be so arranged that our young men and our teachers may be able to make this knowledge their own. The museum, in fact, must be so arranged as to serve an educational purpose. This is the more necessary because the endowments and incomes of our schools and colleges are too small to enable them to provide collections sufficient for any thing more than the most elementary study; and young men who are anxious to obtain this knowledge must look therefore to the Provincial Museum. Fortunately no additional collections beyond those already mentioned, would be necessary for this purpose; for probably the collections I have sketched as proper to be aimed at, are more than we will be able to secure for a very long time. But whatever we possess, be the collections small or large, may be utilised for educational purposes by judicious arrangement. It is only necessary that the Curator of the Museum should have a wide knowledge of natural science, and experience in the fine art of arranging and labelling specimens, recognizing and giving prominence to typical ones, and relegating others to less conspicuous positions.

To those of you, who are familiar with our Museum, it will be evident that the collections, which it seems to me we ought to aim at making as soon as possible, are far in advance of what the Museum now possesses. No one who knew the late Curator could help admiring the enthusiasm and energy which he exhibited as a collector; but lack of assistance prevented him from bringing his local collections to completion, lack of funds compelled him to be satisfied with the most meagre typical collections, and lack of space made proper arrangement an impossibility. No one deplored more than he, the fact that owing to the difficulties in his way, it was impossible for him to carry the Museum to a higher stage of efficiency. Now, however, that a new departure must be made, it is well to ask what must be done to give the Museum the efficiency which the considerations I have brought before you seem to show it ought to possess.

First, then, it must be noted that the collections which have been accumulating during the last twenty years, though neither so complete nor so varied as is desirable, are of very great value, and that they are stored in a room which is so small that a study of them is attended with the greatest difficulty, and in the case of many parts of them is well-nigh impossible. Now the expenditure of large sums of money on the accumulation of a museum which has practical value only in so far as it can be studied, and the subsequent storing of it in such a way that a study of its contents is attended with the greatest difficulty, would seem to be a policy of folly. Hence it goes without saying that the museum must have a new local habitation, if the expenditure already made on it is to be justified, and still more, if the policy which has been followed for the last twenty years of continually adding to the collections, is to be continued. Let it be noted, however, by those who are jealous of demands upon the public purse, that the building which is necessary is not by any means so large as might appear at first thought, even if it be granted that we ought to aim at securing all the collections which I have specified as desirable. For of these collections, we have, and for some time to come are likely to have, but a small portion; and of those which we now have, and even of those at which I think we should aim, but a small portion would need to be displayed in cases so as to be available for use by the many. Very considerable portions, which would be used only by the investigator, whether scientific or industrial, might be stored in drawers, thus being readily available and yet occupying but little room. Judicious selection may compress a large collection into comparatively small space. Thus a relatively small building or section of a building, capable however of extension in the future, is all that is required.

But collections and a building to contain them, form only the body of the museum. Its soul is the director or curator; and as the body without the soul is dead, so collections, however large and well housed, are comparatively useless without an efficient curator. This is at once apparent if we consider what his duties are. For he has (1) to preserve his collections, allowing neither moth nor rust to corrupt. He has (2) to arrange them, taking into consideration the class and capacity of the persons for whose use the museum is intended, the extent and variety of the collections, the relative importance of the different departments of science to the needs of the community, and the space which is placed at his disposal. He has (3) to label his specimens so as to direct the attention of the observer to the main characteristics of the objects, and to show their relation to the great classes in which similar objects are found naturally to arrange themselves. He has (4) to add to his collections; and in our case since a corps of paid collectors is out of the question, that means that he must himself make a scientific study of the province, going from time to time to different districts and making collections of its plants, animals and minerals. And (5) if the museum is to be provided with an industrial department he must familiarize himself with the industrial state of the Province, and know how to make a judicious selection of its raw materials and of its finished products. The successful performance of these varied duties, which is essential to the utility of the museum, demands not only manual dexterity and general good judgment, but also a wide knowledge of the natural sciences and a working acquaintance with their economic aspects. In our special circumstances it is desirable also that the curator should possess not only the general knowledge of the natural sciences necessary for museum work proper, but also a special knowledge of Geology and Mineralogy. For our mineral resources are extensive and varied, and give promise of yielding a rich reward to careful research. And consequently it has been the wise policy of our government in the past to combine with the office of Curator of the Museum that of Provincial Geologist.

But while the primary duties of the curator are to make and preserve collections and to render them available and useful to the public, as well as to push forward especially the knowledge of our local geology, he may be expected also to make his museum an active centre for the diffusion of useful knowledge, by providing courses of lectures in connection with it. The Royal Commission on Scientific Instruction, the British Association committee on provincial museums, and the New South Wales commission on museums and technical schools all recommend this policy. And even apart from their authoritative utterances, it is sufficiently obvious, that when at considerable expense, collections have been made which form one of the main requisites of systematic instruction, such instruction should also be provided. In our community a certain demand for such teaching already exists. For some years the appreciation of the value of scientific knowledge as a basis for technical pursuits has been steadily growing, and the advocates of the founding of a technical school have gradually been gaining more and more sympathy and support. But the founding of such a school, fully developed at the outset, would involve a large expenditure, whereas the number of students who would make use of it would in the first few years be probably small and fitful. Were such a school founded all at once, the public, which is impatient of expenditure without immediate results, would not unlikely conclude in a very few years that the expenditure was too great for the results; and the legislature might find it necessary to withdraw the grant by which the school was sustained. In such matters it is good policy to hasten slowly, and in the case of the technical school the best mode of slow hastening would seem to be to develop our museum with an efficient director at its head, and to let him, by organising courses of lectures and practical classes in connection with it, make it the nucleus about which a technical school would gradually grow, as the demand for scientific instruction would gradually increase. As the importance of our mineral resources would seem to imply that the director should have a special knowledge of Geology and Mineralogy, these would naturally be the subjects in which he might be expected to give instruction himself. In other departments lectures might be given at the outset by volunteers, the lecture room and appliances being furnished in the museum itself. As little additional expenditure would be involved in the provision of these lecture courses, the occasional lapsing of classes through lack of students would, so far as the permanence of the school is concerned, be of no moment. Gradually the occasional classes would become regular, and the small classes would become large; and ultimately it might be hoped the demand for instruction would become so great that the volunteer lecturers might be replaced by a permanent staff. This seems to be in our present circumstances the only feasible way of obtaining the technical school of which we stand so much in need.

The Curator might make the Museum an active educational centre in another way, viz., by distributing among the academies and high schools of the Province small collections illustrating the various departments of natural history. Such a course would facilitate to a very great extent the introduction of science teaching into our schools.

If it be admitted that the development of our museum, involving as it does the appointment of an efficient curator and rendering possible the provision of scientific instruction, is a desirable policy, it must also be admitted that it cannot be carried out without expenditure. The new building, which is necessary, would require a considerable sum of money. The services of a curator of sufficient ability and erudition could not be secured without the offer of liberal emoluments; and a museum, cannot be maintained, still less made to grow, without at any rate a small annual allowance for running expenses. The question therefore arises: Can we with our restricted provincial income afford to adopt this policy? It would be easy, I know, for an enthusiastic educationist, who is not responsible to the people for the expenditure of the public funds, to answer this question in the affirmative. But the question is one with which not educationists but legislators have to deal. I may be allowed, however, to point out that not merely this question, but a second must be dealt with: Can we afford, in the present undeveloped condition of our natural resources, and in the face of the competition of other countries, which, with no smaller natural resources, are making greater efforts to develop them, to adopt any other policy than that which is outlined above? To me certainly it seems to be clearly the teaching of experience, that if we wish to direct the flow of capital without undue delay to the development of our resources, we must supply accurate information as to what these resources are and as to their present state of development, such as a well conducted museum only can adequately supply, and we must furnish our youth, by means of a technical school, with the means of obtaining a knowledge of the sciences and arts of which our various industries are applications.

But a few years ago there seemed to be little hope that such a policy of progress would be carried out. Lately, however, our Legislature has shown a new appreciation of the value of the application of scientific knowledge to industrial pursuits, and the founding of the Agricultural School with its Model Farm, and of Mining Schools of an elementary grade, are steps in the right direction, for which the Government deserves, and will doubtless receive, the gratitude of an intelligent public. But gratitude is a sense of favours yet to come; and these first steps give us confidence in the hope that another step may also be taken, by which our Provincial Museum will be developed and made the nucleus of a technical school.

So far I have dealt with action which can be taken only by the Government. Finally, I would like to refer to the various ways in which this Institute may give material assistance both in the development of the museum and in the establishment of the scientific school. And first, the main work of the Institute, the furthering of scientific research, especially in the department of local natural science, is directly in the line of what the museum is intended to encourage; and every new fact brought to light and every truth established will add so much to the sum of knowledge which the museum is intended to illustrate.

Secondly, no museum can be successfully managed without a library of scientific books containing the most recent results of scientific investigation; and such a library, if it has to be purchased, involves very considerable expenditure. Now our Institute, because of the fact of our publishing Transactions which are considered to be of some value, can obtain at no greater expense than is required to forward copies of our Transactions to scientific societies abroad, a very large portion of the necessary library, the portion which consists of the publications of home and foreign scientific societies. At present we exchange publications with about one hundred learned societies, and we are taking steps to increase the number to three or four hundred. For the small volume which we annually send out, we, in many cases, receive a large volume, or even several volumes in return, so that our library, already valuable, is rapidly increasing in value as in bulk; and this library the Institute will gladly place at the disposal of the curator of the museum.

Thirdly, if we can increase our membership as we hope soon to do, by recruits from the large body of teachers scattered through the Province, who are every year, through the influence and exertions of leading men among themselves, making progress in the knowledge of natural science, we may hope to give material aid to the curator in the completion of his local collections. To render these anything like complete with no undue delay, he would need to have a corps of local collectors. A corps of paid collectors is perhaps out of the question, but a corps of volunteer collectors may perhaps be organised among the members of the Institute, which could give him very material assistance, providing him not only with specimens to fill up lacunæ in his local collections, but with duplicates which he could utilise in obtaining from abroad, by exchange, specimens which are required for his typical collections and which cannot be obtained at home.

And finally, the Institute may be of assistance to the museum in discharging its functions as the nucleus of a technical school, by providing volunteer lecturers in departments of science in which the curator may need assistance. In efforts which have been made in this direction in the past, our members have been ready to assist, and in an effort such as I have sketched, which would have less of discouragement and more of hope, they may be relied upon to put their shoulders to the wheel.

I think I owe you no apology, though I have occupied so much of your time this evening with a discussion which adds nothing to the sum total of human knowledge, but is of an essentially practical nature. For the maintenance and adequate development of our Provincial Museum is of the very greatest consequence in the work in which we are engaged, of increasing, so far as our efforts can increase it, the knowledge of our local natural science. But while we have this strong scientific interest in urging upon the government a progressive policy in this respect, we have also the interest of all good citizens, believing, as I have no doubt we all do, that scientific interest and practical interest go in this case hand and hand.

TRANSACTIONS.

ART. I.—GLACIAL GEOLOGY OF CAPE BRETON*. BY THE LATE REV. D. HONEYMAN, D.C.L., F.R.S.C., &c., *Provincial Geologist.*

In our walks around STRATHLORNE the abundance of boulders of Archæan rocks attracted attention. Fortunately recent rains had washed and brightened them, rendering their characters very obvious. A collection of them would be readily mistaken for one of our representative collections made in and around Halifax. I at once recognized a relationship. The boulders are Syenites, Syenitic Gneisses, Diorites and Porphyrites. The Pre-Cambrian, or Archæan, Mabou Highlands, extending West, N. West and South-West, and corresponding with the N. S. Cóbequid Mountains, were suspected to be their source, and action similar to that established in Nova Scotia was suspected to be the efficient cause of their distribution.

Referring to Mr. Fletcher's Map, still in sheets, I observed on the margin 'glaciation signs,' which seemed to have a bearing on the distribution. Locating these I found one position at Green Point, near the mouth of Mabou Harbour, about a mile to the West of the South-western extremity, and another on the West side of Lake Ainslie, near the reputed oil region, and opposite McLean's Point, *vide* Fletcher's Map. We now purposed to adopt the method of investigation which had led to such good results in Nova Scotia.

Having mounted Fletcher's Map and extended on a wall, we extended the courses of the glacial grooves of Green Point in a S. E. direction as far as Craigneish Mountains of Archæan age. We then drew another parallel to this, so as to include the locality of the other glaciation at Lake Ainslie. This hypothetical

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* This paper was found among Dr. Honeyman's MSS. after his death. It describes observations made a few months before his death, and was probably not revised for publication.

parallel, commencing at McIsaac's Pond, north of the Mabou Highlands, passes through Loch Ban and along the major axis of Lake Ainslie, proceeding onwards to St. Patrick's Channel it avoids the Archæan areas on either side of Lake Ainslie, passes over an extension of the Malloch area at the foot of the Lake, goes through a pass of Archæan on the Channel and proceeds to the Great Bras d'Or.

We now proceed to work along and between these two parallels.

The Presbyterian 'Manse' of Strathlorne is our headquarters. It stands on the front of a range of low hills of sand and boulders, or moraine, which covers and *completely* obscures the underlying *Lower Carboniferous.* These extend north and south, to the north of our station one and six-tenths of a mile, and south of it about half a mile. Here it is terminated by a mountain with rocks outcropping on the sides. It extends towards Loch Ban and a range of Lower Carboniferous mountains which begin on the north of Loch Ban and terminate with *Dioritic* mountains. The length of this range is about two miles. The width of our sand hills is half a mile (E. and W.) Extending to the west, north and south is a broad and fertile valley, through which a river flows. This is bounded on the west by the Mabou Highlands. These extend between our parallels having a N. E. and S. W. trend, and reach to the Gulf of St. Lawrence. These are 9½ miles long. Their width E. and W. is 6 miles. Towards our Mabou Parallel the width is 8 miles. The formations of the Highlands are Archæan and Lower Carboniferous. The extreme width of the former is 4½ miles. Over this extensive area we have to search closely for outcrops of rocks. All is covered with drift and soil. We have to be guided largely by the contour in defining the lines of the several formations. The Geological Survey distinguishes the Lower Carboniferous of our hills and mountains as 'Metamorphic' Lower Carboniferous. We do not appreciate this distinction. As usual we divide the Carboniferous of the District including the Coal Measures, into Lower and Middle. Our previous examinations of the district in 1851 and 1861 were confined to the Mabou Harbour and Coal

Mines and Cape Mabou on the shore. The greater part of it is therefore to us a new field. In this paper we do not follow the order of examination as recorded in our diary. We take the shortest mode of recording the results.

We enter the Highlands by a road which turns from that to the Broad Cove Coal Mines at the Strathlorne Post Office. Crossing a brook we ascend. Red Clays with Archæan boulders large and small are exposed in the deep ruts made by recent rains. Next we see among the boulders chocolate coloured sandstones outcropping. These show that the front (?) hills are Lower Carboniferous. We come to an extensive valley having farms. Traversing this for some distance we come to the second and last outcrop of sandstones. Farther on we again ascend. On our right we have the first outcrop of the Archæan rocks. They are hornblendic. Onward we observe other outcrops on the road and sides. These are illustrated by the varied character of the boulders on the road. We have got to a considerable height, commanding an extensive and lovely view. The object of special interest is Lake Ainslie, which we can see as far as McLean's Point opposite our *second* glacial striation. We take an observation. Our station now is in the middle of what we may call the Strathlorne division of the Archæan, (taking McAuley Brook as the dividing line.) A S. E. magnetic course passes through the middle of Loch Ban and across Lake Ainslie. We continue our ascent. Outcrops still appear on the road. An extensive table land is now reached. This is largely occupied by extensive farms. We have now a guide leading us to the summit of Cape Mabou. We reach the watershed where White Brook and McAuley's Brook are only separated by the road. Here are outcrops of Gneisses, Hornblendic Schists, etc. Of these we collect specimens. We proceed and reach the summit. We take a specimen of the highest rock or rather boulder as no outcrops are to be seen. Descending, we re-examine the various outcrops and the grand supply of boulders on the road, which would furnish a glacier with a goodly freight of prepared material, as the ancient glaciers have found a like plentiful debris of the past, ready made for transportation. This and other Archæan ranges which largely constitute the island, and give it direction, were doubtless raised above the waters from the earliest periods, furnishing material for the subsequent Formations, Carboniferous and Post-Pliocene as well as Recent. Entering upon the Strath we find Archæan boulders on all sides. We again reach the Post Office. Before the examination of the Highlands we had traversed the roads in all directions in courses sub-parallel to the mountains, from first to second parallel, from McIsaac's Pond to Mabou Harbor, with S.E. offsetts. We shall now direct attention to the last. A. From the Presbyterian Church we crossed the Moraine already described to Loch Ban, and collected choice specimens of Archæan boulders. Reaching the top of the Loch we took the road to the right. For some distance boulders were absent, until we began to proceed southerly. Then they re-appeared in abundance. Coming to the extremity of the Lower Carboniferous mountains with Diorites already noticed, we observed our first outcrop of this Formation; we turned off, and for the purpose of examining it, proceeding along the road, we observed Archæan boulders in our way. Ascending toward the outcrop, boulders were still observed. We reached the outcrop. The rocks are chocolate coloured sandstones. They are raised to a high angle—70°—with a southerly dip. We collect specimens. Archæan boulders, large and small, are seen on the top of the outcrop. Of these we also take specimens. We ascend the mountains still higher. Archæan boulders are seen at the summit. We take a level and find it corresponding with that of the summits of the Lower Carboniferous elevations of the Highlands already observed. We descend on the west side of this mountain, and come to a considerable outcrop of coarse L. C. conglomerate. As this is the first observed, we also take a specimen. We also collected specimens of the Diorites on the other extremity of the range, *e. g.*, of the summit rock, which we found to be of equal elevation, with summits of the Archæan rocks of the Highlands. The elevation may be realized when (?) we noticed that the summit of this mountain is illuminated by the setting sun when all the surrounding mountains are in the shade, and the edges of the table land of the Highlands are distinctly visible from the outcrop of Diorite. The specimens are amorphous and Porphyritic, with distinct crystals of Feldspar. On the sides of the mountain are outcrops and *debris.* In the latter we collected Amygdaloids; some of these are vesicular. Among them we observed several Archæan boulders.

We continue our course along Loch Ban (S. Easterly) as far as its end. We observe Archæan boulders all the way. Turning off the main road we descend into the hollow of a Moraine and ascend. Here we have very large Archæan boulders, and boulder clay, etc. Farther progress S. E. is intercepted by Lake Ainslie and the outlet. The bed of the lake is doubtless the place of boulders.

B. We make a second S. E. offsett. To the South of the Lower Carboniferous Mountain which seems to terminate our Strathlorne Moraine and beyond McAuley's Brook that bounds the Strathlorne division of the Mabou Highlands, we turn off on the Black River Road. Ascending a hill we observe Archæan Boulders on our way. We now come in sight of Loch Ban and Lake Ainslie. Following the road we descend. On our left is a deep hollow, in which runs a brook. We continue and cross the brook, which now runs through bogs, swamps and thicket, which terminate in Loch Ban, in the distance. Black River, which runs into the Loch, stops farther progress. We have to return to our main road. Archæan Boulders were observed as far as we proceeded. The point reached was South of Loch Ban and 4 miles distant from the mountain on the north side, having the L. C. outcrop and Archæan Boulders. We hope to be able to report farther progress along this Parallel at a future time. McAuley's Brook having reached the road is now the Strathlorne River. At the Bridge where it turns northward there is an interesting section of the drift. In the bed of the river is a bed of red clay with boulders. Above it is the clay with sand and boulders. Above is a thick stratum of Archæan boulders. This is covered with a thick coat of soil with vegetation.

The boulders in the river bed are beautiful and instructive. High on the sides of a lofty mountain we observe an outcrop of rocks. We ascend to examine them. They are Syenites and

Gneisses. This is the only outcrop. Up to the summit is vegetation. Beech trees, &c., almost cover the top. There is no undergrowth. The view is extensive and beautiful. Loch Ban and Lake Ainslie and the region of Black River, which we had previously examined, are beautifully defined.

We would now proceed to work on our First Parallel.

On our way to Mabou, beyond the Black River Road, Archæan Boulders appeared the greater part of the way, then become rare or disappeared altogether, and then reappeared in abundance as we approached Mabou. We afterwards found, when we reached the Mabou terminus of the Archæan Mountains, that lofty Carboniferous Mountains intervening had intercepted or diverted transportation. Our first station was Mabou. Here I first proceeded along the road toward the extremity of the Archæan of the Highlands. Archæan Boulders, Syenites, Syenitic Gneisses and Diorites appeared in usual abundance all along the road until we were beyond the Carboniferous Mountain. We then walked some distance along a road that intervened between the Archæan and the Carboniferous, with like results. Satisfied thus far we returned to Mabou. Next we observed a Glacial Moraine section at Mabou. In this we also found Archæan boulders. I followed this drift below the Bridge until I could go no farther on account of a turn of the river. Archæan boulders were found all the way. Our next station was Donald McDonald's, at the extremity of the Archæan of the Highlands near the Harbour. Here we saw an outcrop of Archæan rocks where the road to the Pasture crosses a Brook. The rocks were syenitic. All the rocks of the Mountains are obscured with deep soil and luxuriant vegetation. The summits are covered with forest.

From this we proceeded westward to Green Point, on the shore of the St. Lawrence. We were surprised at meeting with Archæan boulders on our way, as the Formation traversed was Lower Carboniferous—Gypsiferous. This seemed to indicate a northern transportation. The apparent anomaly was explained when we reached Green Point. Our first objects of search were glacier-grooved rocks. The unusually coarse conglomerates before us were certainly not at all reassuring. After a diligent search we found a number of glacier grooves beautifully parallel, having a course S. 10 E. We failed in finding others. We were, however, satisfied. The grooves were on a comparatively smooth stratum close to the drift bank. We now examined the conglomerate itself and found it very largely composed of Archæan boulders. Here was a northern transportation effected by the seas of the Lower Carboniferous period, and a secondary source of Post-Pliocene transportation. Following the course of the grooves in a southerly direction we crossed the conglomerates, which we saw exposed in bold cliffs on the shore, as we proceeded and landed in the Mabou Harbour. Then, walking along the foot of the exposed covering of drift and conglomerates on the right side of the Harbour, we observed Archæan boulders in the drift and on the shore until we approached the Gypsums, where the apparently anomalous occurrence of boulders was observed. We have therefore a duplex transportation on the south of Macdonald's Archæan mountain. This is certainly a very striking phenomenon.

The occurrence of the grooves on the verge of the sea, like corresponding phenomena observed in Nova Scotia (*vide* Transactions of the Nova Scotian Institute of Natural Science), unmistakably show that an impulse was communicated from *beyond* Nova Scotia and Cape Breton, and that the glaciers of both are only members of a great glacier system which comprehended both Nova Scotia and Cape Breton.

Fletcher's excellent map shows that the glacier courses of Lake Ainslie and Mabou Harbour, and a third appearing north of Lake Ainslie, along Margaree and Middle Rivers, and through an intervening break in the Archæan Mountains, are parallel to the Strait of Canso. A like parallelism of the latter with the harbours (Fjords) of the Atlantic coast of Nova Scotia and our hypothetical parallels, led me to regard the Strait as, to a certain extent at least, formed by glacial action. This view seems to be farther supported by the occurrence of "glacial grooves," having a north and south course, observed by Fletcher at Eddy Point, Guysboro County, N. S., in the mouth of the Strait of Canso. On our way to Halifax, on Friday, August 2nd, we were fortunately detained at the Railway Terminus, Port Mulgrave. Here we observed a section of heavy Drift, with Archæan boulders in abundance. We had sufficient time to collect a good representation of these for our Provincial Museum. The specimens are identical with those collected at Strathlorne and Mabou. Looking at Fletcher's map, we find that this section of Drift lies southeast of the Archæan area of Cape Porcupine, and about a mile distant. We regard this as conclusive evidence of the glacial action *Hypothesis.*

This seems to remove a difficulty in the way of introducing the *Mastodon ohioticus* into Cape Breton, in consequence of the intervention of the Strait of Canso. We have only to refer the introduction to *pre*-glacial times, when the Strait of Canso may have had no existence.

Art. II.—Geological Gleanings in Nova Scotia and Cape Breton*. By the late Rev. D. Honeyman, D.C.L.

We propose to give some account of an examination of a portion of Cape Breton, which is of unusual interest, scientifically and economically. Our observations may be regarded as gleanings. The region is somewhat familiar to us as it is a field in which we did considerable pioneer work in 1851, and subsequently in 1861, when we were collecting material for the Nova Scotian Department of the London International and Great Exhibition of 1862. On the present occasion our headquarters is Strathlorne, an extension of the Mabou district, which lies on the east side of Cape Mabou. This side is chiefly known to us through the reports and sheet maps of Mr. Fletcher of the Geological and Natural History Survey of Canada.

On our way from Halifax to our destination we selected a route, a great part of which was new. Our first observations were made between Tracadie, Antigonish County, and Port Mulgrave, in the County of Guysboro'. The geology of this region was not altogether new to us, as we had often travelled between Nova Scotia and Cape Breton, and had a practical acquaintance with the rocks that lay in our way and rendered travelling somewhat rough and uncomfortable. In 1861 we had crossed from Plaster Cove, Port Hastings, to the foot of Cape Porcupine, and examined the beautiful section on the shore. Of this the Archæan crystalline rocks were found to be the centre. These were then regarded as igneous, intrusive rocks of Devonian age. On either side were stratified rocks, which we regarded as of Lower Carboniferous age. Mr. Fletcher now very properly assigns the crystalline rocks of Cape Porcupine to the Pre-Cambrian or Archæan, while he regards the stratified rocks as

* This paper, as well as that which precedes it, was found among Dr. Honeyman's MSS. after his death. It describes observations made a few months before his death, and covers very much the same ground as the preceding paper. It had clearly not been revised for publication.

of Devonian age. We have now these rocks beautifully exposed in the rear by the construction of the railway. On leaving Tracadie we took our stand on the platform of the car that we might make a kind of reconnoissance of the railway sections. We observed interesting sections of rocks, and especially the Porcupine's back, extending onward to the Strait of Canso, ruddy with the outcrops of its Syenitic masses. We hope to be able to make a more satisfactory examination of this section at some future time. Our route now was from Port Mulgrave to Baddeck by the steamer "Marion." We observed with interest the exposure of rocks, especially on the Nova Scotian side of the Strait of Canso, and compared them with those of the Cape Breton side. Our next point of chief interest was St. Peter's Canal, and the approach to it. The aspect of the Canal was in striking contrast with that in 1861. Then it was only an unsightly work. Now it is finished and of great utility. Its walls of igneous Diorite are of great geological interest. To me they were specially interesting, although the sight was very transitory. I had previously made a very close acquaintance with these rocks, through a fine collection of specimens presented to our Provincial Museum. Of one of these I had a microscopic section prepared by A. A. Julien of New York. This was subjected to a Polariscopic examination, and the results communicated to the Institute of Natural Science.

After clearing the Canal we turned our eyes in the direction of "Marble Mountain," of the East Bay Archæan range. We discovered, *in a manner*, this mountain in 1861, and collected specimens of its marble for the London Exhibition. Some years after it was *re*-discovered by Mr. Brown of P. E. I. Mr. Fletcher, in his report, gives Mr. Brown the credit of the original discovery. On all sides of the Bras d'Or to Baddeck and onward to Whycocomagh, all was familiar. We thought of the Mastodon tooth of Baddeck, and also of the noble spire of Gyracanthus magnificus, as well as the *Femur* of the Mastodon of Middle River.

At Whycocomagh, our next station, we were reminded of the Archæan Crystalline limestone which we examined in 1861, and represented by a specimen in our collection of marbles at the

London Exhibition. From Mr. Fletcher's Report and Map, this appears to be an extremity of the Pre-Cambrian Rocks of the Craigneish Mountains. We also collected a specimen of marble subsequently at the other extremity of Craigneish. Our route now is from Whycocomagh to Strathlorne, along the west side of Lake Ainslie. Cream-brown sandstones of Lower Carboniferous age are exposed in all directions. We reach the South-East end of Lake Ainslie. The beautiful sheet of water extends all the way to Strathlorne, a distance of twelve miles. Its greatest width is about four miles.

About a mile from the head of the lake we come to Archæan rocks. (See Fletcher's Map.) We collect specimens of these, granites. They extend to the lake. Where we cross them they are a mile in width. The area is sub-(isosceles) triangular, the base being on the lake. The height of the triangle is about 2½ miles and the base 2 miles. Two miles farther we come to the reputed oil region of Lake Ainslie.

About 8 miles farther we reach the manse of Strathlorne. Our position is somewhat elevated and commands an extensive view. In front is an intervale through which winds a stream. This is beautiful with luxuriant herbage, as the season has been remarkably early and favourable for vegetation. Beyond lie the Mabou Highlands with Cape Mabou, having an elevation of 1000 feet. These extend to the sea forming headlands, distinguished as Cape Mabou and Sight Point. The range of mountains has a N. E. and S. West trend. They extend from Broad Cove on the East to Mabou Harbour on the West. Like the Highlands of Scotland they have their glens and waterfalls. In anticipation, we would observe that they have also had their glaciers in the past. We observe the map of the Geological Survey of Canada represents this area as Pre-Cambrian, *i. e.*, Archaean, according to our terminology. Hills rise all around. The Geological Map of the Survey represents the Formation of the extensive area occupied by these as Lower Carboniferous Metamorphic. North of our position and at distances from two to three and a half miles are three areas, colored red, and distinguished by lettering as Dolerite and Diorite igneous rocks. The region has been very appropriately named "Strathlorne." To the north of this lies Broad Cove, with its coal mines. Loch Ban, a continuation of Lake Ainslie, is another grand physical feature.

We now proceed to examine the region in detail. There have been heavy rains which have almost caused a flood. These have been favourable for our work. Since our arrival we have had showers which have cleared and brightened surface material lying on the roads and fields. Our attention has been directed to the Superficial Geology. Boulders abound. These are largely 'Archæan,' of very familiar aspect. Of these we proceed to make a representative collection for our Provincial Museum. Thus we have a fine collection of Syenites and Syenitic Gneisses and Porphyrites, &c. Hornblendic Diorites, igneous rocks, are also represented. These boulders were collected on the way to the areas of those rocks already noticed. There can be no doubt that the Archæan Boulders came from the 'Highlands,' having been transported in a southerly direction. In addition to these we find boulders of other material and formation, chiefly Carboniferous. The bulk of the superficial material is sand. The hills show nothing but sand. The rocks are so completely covered that up to the present we have not been able to find one outcrop (Tuesday). We presume, however, that the underlying rocks are 'Lower Carboniferous,' and the surface Post-Pliocene drift of "Glacial and Champlain" Period. We observe that Mr. Fletcher found glaciation on the shore at Green Point, Mabou Harbour, and inland, at the region of Oil operations on the west side of Lake Ainslie. We shall give these due attention. It would not have been surprising if Glaciation had been altogether absent on account of the general character of the Formation and the deep covering of drift. We intend to direct our chief attention to the surface geology. In so doing we will necessarily give some attention to the other.

We will pursue the mode of investigation followed in Nova Scotia. Taking for granted that Mr. Fletcher's observations on Glaciation are accurate, we extend his lines southerly and draw two series of parallels. A line of one series passes onward to the east of Whycocomagh, and ends in St. Patrick's Channel. This traverses the centre of the Highlands, and then Carboniferous all the way to Whycocomagh, where it goes between the two great areas of Archæan rocks, *Cragneish* and *Mulloch.* Another commencing at McIsaac's Pond passes through Loch Ban, and along the major axis of Lake Ainslie, and proceeds onwards to St. Patrick's Channel, above the narrows ; extended farther it enters the Great Bras d'Or at 60° 55′ long., N. W. of Marble Mountain. It thus avoids the Archaean areas on either side of Lake Ainslie, and just touches the area at St. Patrick's Channel.

We also extend the glacial course on the west side of Lake Ainslie in the petroleum region. This in its extension to the Mabou Highlands passes into the Gulf of St. Lawrence, about half a mile north east of Sight Point. In the opposite direction it passes through the Archæan area on the west side of Lake Ainslie, and south of the petroleum region, and enters into Lake Ainslie.

In our walks we have advanced as far north on the Broad Cove and Margaree roads as the Diorites, noticed in our introductory description, and cross limestone strata on the Margaree road. Archæan boulders have for some time disappeared, as we have been receding from the bounds of the Highlands. Our last specimens were collected some time before we reached the forks of the (Broad Cove and Margaree) roads. We had also crossed our sand hills twice, in the direction of Loch Ban, and made a collection of Archaean boulders on our way, in the deep ruts. In our second walk we advance along the top of the Loch to the right. A boulder was observed lying in our way, only here and there. At length we come within their range of transport, and found them sufficiently abundant and varied. We again commenced collecting. Coming abreast of a mountain on the left, we observed an outcrop of rocks high on its sides. We ascended. On our way Archæan boulders appeared in great numbers, continuing up to the outcrop of rocks. These belong to Mr. Fletcher's Lower Carboniferous Metaphoric, and incline at a high angle. When examining them, and looking for an appropriate specimen, we observe, right at the top, Archæan boulders. Of these we also take specimens. Advancing to the summit we find similar boulders as far up as the top. We have reached an elevation which commands an extensive view. We see the Highlands over the Strathlorne sand hills, which we now regard as a glacial Moraine. We take levels and find that we are on a height corresponding with Fletcher's Archæan border and junction of the Lower Carboniferous Metamorphic. We descend the mountain in the homeward direction and find a considerable outcrop of a coarse conglomerate. Reaching our headquarters we examined Fletcher's map to locate our outcrops and found an observation 75° dip. We are not aware that he noted the occurrence of the Archæan boulders as we have not with us any of his Reports. We consider their occurrence at this elevation very important in its bearing on the height of our glacier, and its relation to the 1000 feet summit of Cape Mabou and associate elevations.

Proceeding on the road toward Mabou and in a course subparallel with the Highlands, with the strath and river on our right and the sandy Moraine on our left, we observe Archæan boulders in great abundance. The sand hills are succeeded by a mountain, on whose sides the rocks outcrop so as to be distinctly seen from the road. We cross the bridge over the river which here proceeds direct from the mountain gorge under the name of McAuley's Brook. Tracing its course on the map we find it coming from the one side of Cape Mabou, while other brooks proceed from the Cape in an opposite direction, toward the Gulf. We continue our progress along the road, still observing abundance of Archæan boulders. Coming to a road ascending the hill on the left, we turn in this direction. Archæan boulders are observed up to the top. Continuing we descend on the opposite side, still observing Archæan boulders on our way, some of them of large size. We collect specimens. Advancing we come in sight of Loch Ban and Lake Ainslie. We have now on our right a deep hollow with a brook (?). We follow this until we reach the low ground and swamp, which reach to Loch Ban. We have now the mountain with the outcropping Carboniferous rock very loftily in the rear. Away on the right Black River with its dense woods is seen, also proceeding toward Lake Ainslie. Our present position is 4 miles distant from the mountain at the side of Loch Ban on which we made our observations on the previous day. Our glacier has thus acquired a breadth of four miles and has got a fair start toward Lake Ainslie. We have planned farther examinations in the centre and extremities of the Highlands and on both sides of Loch Ban and Lake Ainslie.

Our next course was on towards the shore. We went by the road to the coal mines. Here we found Archæan boulders on our way up to a certain point, where they seemed to disappear. Coming to the shore, we examined the banks as far as the outlet of McIsaac's Pond. We did not reach the section of rocks on the shore towards Cape Mabou. Sands and clays with imbedded boulders are exposed on the shore. We collected water-worn Archæan boulders on the shore. These may have been transported along the shore from Cape Mabou. We were now at the extremity of our Lake Ainslie hypothetical line which passes through McIsaac's Pond. It has been proposed to convert this into a harbour for the coal mines. On our way we had observed the low hills having the grey Diorites which are defined on Fletcher's map. On our return we collected specimens of these, and proposed to make a more particular examination of them and the Diorites on the Margaree Road opposite, afterwards.

We next proceeded on the road to Cape Mabou, which branches off the Broad Cove and Margaree Roads. As we proceeded, we observed Archæan boulders in abundance, increasing in numbers and dimensions as we proceeded onward and upward. Coming to the branching of the Port Ban Road, we proceeded to a short distance along this road, observing the Archæan boulders. We returned, and proceeded along the road to the Cape. Crossing the bridge over a brook we ascended, observing the very deep ruts in the boulder clay excavated by the heavy rain-floods. Archæan boulders, large and small, were abundant enough. We were now near Fletcher's junction line of the Lower Carboniferous and Archæan. We had not seen any outcrop of the strata of the former on our way. All were obscured by the overlying drift. Heavy rain prevented us from proceeding further in this direction. We will return on another day.

Mabou.

We would now extend our investigation in the course sub-parallel to the Highlands and towards Mabou. We begin at the Black River Road where our course was previously diverted towards Lake Ainslie. All the way we found Archæan boulders: numerous when we approached the Archæan mountains, less so when we were at a distance and had Lower Carboniferous hills intervening. Reaching Mabou River Bridge, we found them sufficiently abundant. We next proceeded on the road to the Harbour Mouth, and towards the S. West extremity of the Mabou Highlands—Archæan mountains. We found our boulders occurring all the way, and collected specimens. We next searched beginning at the bridge and proceeding up the river or away from the mountains. We walked as far as practicable along the E. side of the ——— and found Archæan boulders all the way. We have thus advanced in opposite directions in the hypothetical parallel line on the south-west of the Mabou Highlands. This conforms with glaciation observed by Mr. Fletcher at Green Point.

Our next station is at the residence of Donald Macdonald, Esq., the extreme S. E. point of the Mabou Highlands—Archæan. We have found Archæan boulders abundant enough up to this point. We now look around us. Archæan and Lower Carboniferous boulders are seen everywhere. We go to the shore of the harbour and find them equally abundant. Subsequently we ascended the only brook which proceeds from the mountain, and where a road to the pasture crosses the brook we found a good outcrop of rocks. We examine them and collect specimens. They are Archæan, but so friable as to make it difficult to secure good solid specimens having characters which are exhibited by the transported boulders. This is the only outcrop which we can find in this quarter. We ascended the mountains. All is obscured by soil and luxuriant vegetation.

Green Point.

We proceed to this Point. As we advance the mountains retreat. We are now in a region which we examined in 1851, and subsequently when collecting specimens in 1861 for the great London Exhibition of 1862. We now traverse the enormous beds of Gypsum, with their heights and hollows characteristic of such deposits. We still observe plenty of our Archæan boulders. This perplexes us somewhat, as we expected that they would now disappear. We reach Green Point, our present *terminus ad quem.* We come to the great Carboniferous conglomerate, which we had observed on our way to the coal mines in 1851. I would remark that I then explored this region, which had not been visited by the author of Acadian Geology, and collected specimens which are now in our Provincial Museum. I have also given a record of the observations made, in my First Paper on the Geology of Antigonish County. (Transactions of this Institute.) Looking at these conglomerates, I thought that Mr. Fletcher must surely have made a mistake, as it was hardly possible that these rocks could be glacially grooved and retain the marking in a position so exposed, and on the verge of the Gulf. However, there they were. We observed parallel grooving on the edges of a stratum which was comparatively plain, and also on its face. The course of all of these is S. 20 E. magnet. Our perplexity caused by the frequent occurrence of Archæan boulders on our way to the west of the Archæan rocks of the mountains was also dispelled, thus: The great conglomerate is largely composed of boulders of Archæan rocks, as we found them on the north side of the Cobequid mountains, as well as the south side. (*Vide* Paper on the Geology of I. C. R.) These are easily detached from the rock by the action of the sea and of the atmosphere, as well as glacial action. This conglomerate may therefore be regarded as a secondary source, and a transportation northward, caused by the sea and other agencies of the Lower Carboniferous period. Superficial observers may thus have been led into error, and persuaded that both southern and northern transportation may have been effected by similar agency, viz., Post-Pliocene glacial, in opposition to pre- and post- glacial.

Following the direction of the glacial grooves and at the same time traversing the Lower Carboniferous Conglomerate, we actually passed along the hypothetical line of Mr. Fletcher's observation and reached Mabou Harbour accordingly. We then walked along the east side of the harbour at the foot of the Conglomerates and drift observing our boulders as we proceeded embedded in the drift and lying on the shore, and reached the other boulders of preceding days, which had come directly from the Archæan rocks. We have thus found transportation from the mouth of the harbour to a distance below Mabou bridge—5 miles direct.

"Our Glacial Problem."

The glaciation of Green Point suggests *influences* from beyond like the transportation on the Gulf shore in Antigonish County, and the glaciation on the verge of Cleveland Iron Mountain, Nictaux, and on the Canaan Road, Aylesford. The hypothetical parallels in Cape Breton and the natural sub-parallels of Lake Ainslie and Mabou Harbour conform with that of the Strait of Canso. We have already seen that the transportation and Harborus—Fjords—of Nova Scotia also conform with the Strait of Canso. The two thus conform with one another. *Vide* Nova Scotia on the Admiralty Chart and Fletcher's admirable and thoroughly reliable map of Cape Breton. We have the latter mounted and on the wall before us which makes all this very clear.

Loch Ban.

We advanced still farther on Loch Ban than on a preceding occasion. As we proceeded on the east side towards Lake Ainslie, we observed Archæan boulders of the usual kind and variety on the road and on both sides of it. Special attention was given as we came near to Lake Ainslie. Here the Loch becomes a narrow neck. We now turn from the main road to the right and cross what seems to be a glacial moraine of considerable magnitude. A deep hollow, a longitudinal excavation, causes a corresponding descent. Massive boulders are seen and examined. They are Syenites, Quartz-Syenites, and Diorites. Of these we collect specimens. We reach our terminus when we come to the lake.

Here it is of the greatest breadth. Its oblique axis is about 6 miles in length, the outlet being the extremity on our left. Our glacial track is now the major axis of this lake. Its length is now 6 miles from the shore and 8½ from the summit of Cape Mabou.

Cape Mabou

is readily accessible by the road that branches off the road to the Broad Cove Mines and McIsaac's Pond and Margaree. Following this road, we come to a branching road which leads to Port Ban. We proceed along this a short distance, observing an outcrop of Archæan boulders. We return. Crossing a bridge over a brook, as on a former occasion, we ascend, crossing the hilly ridge in front of the mountains. In the ruts we observe clays and boulders plentiful enough. The first outcrop of chocolate-colored sandstones is observed. This reveals the constitution of the hills. We then come to the valley between these and the mountains. We are surprised at seeing farms, the existence of which we did not expect. Proceeding along this valley, we at length ascend into the mountains. A second outcrop and the last of the Lower Carboniferous is observed. Onwards we see on the side of the road the first outcrop of the rocks of the mountain. They are diorites. Proceeding, we observe on the road, all the way, Archæan boulders of the same character as those already described in our wanderings, and outcrops of the rocks that produce them. We reach the summit and find an extensive table-land, with farms that astonish on account of their extent and excellence. Boulders are sufficiently plentiful, but the rocks are completely obscured by soil of excellent quality and dense vegetation. We are approaching Cape Mabou summit. Our guide directs attention to the watershed and White Brook. A beautiful outcrop of red syenitic gneiss is seen on the road. We have observed numerous outcrops of shaley rocks. In White Brook we collect (subsequently) Gneisses and Hornblendic Schists. We reach the summit, a height of 1,000 feet. Here we add to our collection a piece of a boulder of syenite; on our return we give farther attention to the outcrop.

Diorite Mountain.

This is the last of a short range of mountains that extend from Loch Ban in a northerly direction. We have already directed attention to the southern extremity of this Lower Carboniferous range, on which we found Archæan boulders. We now enter on the middle of the range from the Broad Cove road and at the northern end of the Sandy Hills (moraine). We find Archæan boulders on our way. We cross the moraine and ascend the mountains. We find a boulder or two, and then they disappear. We proceed along the mountains, northward, observing outcrops of chocolate sandstones, and come to Diorite Mountain. This is a very interesting mountain. The exposures on its sides and the outcrops on its summit reveal the character of the rocks. They are of the same constitution as those of Arisaig and East River, associated with the Lower Carboniferous formation. Like the Arisaig igneous diorite they are compact, amygdaloidal, porphyritic and vesicular. We collected specimens of compact rock and porphyrites on the highest outcrop.*

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* This paper is obviously unfinished.

Art. III.—The Geological Writings of Rev. D. Honeyman, D. C. L.—By E. Gilpin, Jr., Inspector of Mines, &c.

My remarks this evening are more a summary of the Geological work done by the late Dr. Honeyman, through the transactions of our Institute, than an attempt to follow him in all his Geological writings. The doctor was a steady and interesting contributor to many English and foreign Scientific periodicals and transactions which are seldom seen in this quiet corner of the world, but the Institute presents the best of his labors, his field work in the Province. His articles, extending over many pages of our volumes, exhibit bold and logical attempts to unravel problems in geology, which have been in many cases of great assistance to those working after him. While tenacious of his opinion once formed, he was open to conviction and ready to admit the arguments of those who brought experience acquired elsewhere.

I find that he made his debut as a geologist in a paper read in 1859, before the Nova Scotia Literary and Scientific Society of Halifax on "the Fossiliferous Rocks of Arisaig."

The London Exhibition of 1862, was taken advantage of by the Provincial Government for a display of Nova Scotia minerals and Drs. Honeyman and How, and Messrs. Campbell and Poole, were commissioned to prepare papers and specimens illustrative of its geology and mineralogy. The Doctor was entrusted with the charge of displaying and explaining the exhibits. During the discharge of his duties in London he had opportunities of becoming acquainted with Sir R. Murchison, Mr. Salter, and Prof. Phillips and Prof. Fritsch, and many other eminent geologists, who were much interested in his collections, and afterwards kept up a friendly intercourse with him.

The doctor performed similar duties at the Dublin International Exhibition on behalf of the Province, and a medal was awarded the Government, as had been the case at the London Exhibition.

His name, so far as I can learn, first appears in our Transactions in the record of a meeting held May 8, 1866, when he contributed a paper on the Geology of Antigonish. As at this time he was elected an associate member. I presume he had not yet removed from Antigonish to Halifax. In December of the same year he read a paper on the Gay's River Gold Field. This district has not as yet proved equal in economic importance to many others, but it is specially interesting from a geological standpoint. In many countries rivers flowing across auriferous strata have accumulated at favorable points deposits of sand and gravel carrying particles of free gold. Afterwards the courses of these rivers have been diverted by natural causes into different channels, and the gold-bearing gravels have become accessible to the miner. These deposits sometimes occur concreted or hardened or covered with trap, modern soil, etc. The interest that attaches to the Gay's River mines is that this ancient beach or bed is not a modern one but of paleozoic age, a basal conglomerate of the Carboniferous, thus proving that the gold was introduced before the Carboniferous measures began to form, and presents an interesting and almost unique proof of the similarity of Geological action in very early times to that now going on.

In 1867, at the Paris Universal Exhibition, his services were also called into requisition, and his exertions secured another medal for the Provincial Government.

About this time the Doctor began to pay more attention to lithology, and remarked:

" Before 1867 I had devoted my attention almost exclusively to paleontology—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 consideration that this field is almost entirely fallow, that its strata are so replete with organisms, that they have been exposed for ages to the Gulf of St. Lawrence, 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 in 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 paleontologists 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 an 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 paleontology."

In 1867 he read an interesting paper on the Geology of the Londonderry Iron Mines. In 1868 he returned again with renewed ardor to the study of the rocks of Arisaig, his favorite hunting ground, a series of remote hills on the Gulf of St. Lawrence, a barrier between the waves of the Gulf and the soft carboniferous measures of Antigonish County, and traced the extension of the Silurian beds into the East River district of Pictou. In March 14, 1870, he read a very interesting and valuable paper on the Geological relations of the iron ores of this district The writer was professionally engaged in this locality about this time, and remembers very well the intricate problems that were presented at every attempt to define clearly the position of the various deposits. Although much attention has been given to it by several eminent Geologists, and large sums of money expended by mining engineers in proving and extending the beds and veins of ore, there are points not yet cleared up.

From this date the Doctor became a frequent and regular contributor to our Transactions. In 1871 he was elected Secretary of the Institute, an office which he held in conjunction with his position as Curator of the Museum until his death, although for the last few years, to enable him to devote himself more especially to his scientific pursuits, he resigned the more active duties of his Secretaryship, which were assumed by Mr. McKay and Mr. Macdonald, and he became Honorary and Corresponding Secretary.

In 1871 and 1872 he read papers on the Geology of the rocks surrounding the Pictou coal field, in which he differed from the conclusions arrived at by Sir William Logan, and considered that they were an extension of the metamorphic Middle Silurian rocks of Irish and Fraser's mountains.

In 1873 he read a paper on the metamorphism of rocks in Nova Scotia and Cape Breton. In this interesting communication he dwelt upon the fact of the Lower Carboniferous Limestones not being altered when in contact with metamorphic precarboniferous rocks, and upon the metamorphic character of all other limestones found in Nova Scotia. In this year he spent some time in examining the sections exposed by the cuttings of the Intercolonial Railway in Halifax, Colchester, and Cumberland Counties, directing more particular attention to the Cobequid Mountains, in which he considered that he recognised extensions of his typical Arisaig series.

A summer spent in New Brunswick gave him an opportunity of still further extending his Geological horizons, and the results were embodied in a paper read Nov. 9, 1874. At the Centennial Exhibition the Doctor was represented again by collections of fossils and minerals, and by eleven maps showing results of his labors since 1867.

Hitherto, with the exception of his explorations on the Cobequids, Dr. Honeyman had confined his Geological work principally to the eastern part of the Province; but now, fortified by his experience, he began to extend his horizons into the Western Counties, and the country lying south of the Annapolis Valley was visited and carefully compared with the localities which he had, geologically speaking, mastered. His paper in Vol. 4 of the Transactions on the Superficial Geology of Nova Scotia, also marked a new departure, and his researches into the Glacial period in Nova Scotia henceforth occupied much of his time.

The casual discovery on the shores of the Atlantic of a boulder undoubtedly derived from the Triassic trap of Blomidon or Parrsboro, led to his efforts to delineate the march of the ice cap across the Lower Provinces. The latest contribution to this fascinating study which appeals equally to the Geologist, the Chemist, the Physicist, the Mathematician, and the Astronomer, is an extremely valuable paper in the last report of the United States Geological Survey. Much yet remains for the Glacial student in this Province. The striæ have never been studied, or classified, nor have the abnormal etchings been observed to see if they are retreat notes of a dwindling glacier, or the intermittent scoring of berg and floe ice. The course of the ice flow being assumed, the comparative strength of the rock in situ, and of the stone chisels, fast held in the ice matrix, have an important bearing on the amount of erosion to be accounted for. However, as I understand that our learned President has already referred to this part of Dr. Honeyman's labors, I need not say more, as I know that in his hands the subject has received much better attention than I can bestow on it.

The Doctor did not take as active a part in the Antwerp and Colonial Exhibitions as he did in the preceding ones, the policy of the Government having been turned more toward exhibiting the material resources of the Province. The stores of the Musueın, however, were largely drawn upon for these exhibitions, the work of collecting, forwarding, etc., being assumed by the writer.

His papers on the Geology of King's County were followed by others on Aylesford, Annapolis, Yarmouth and Digby Counties, so that his maps covered the greater part of the Province outside the granites, and the slates and quartzites of the gold fields. Polariscopic and macroscopic examinations of the rocks of various localities were undertaken by him in the search for more evidence bearing upon his theories. The results of this work were communicated in several interesting papers.

During the past two or three years his attention was turned particularly to the new and interesting deep sea sponges, etc., collected by the officers of the cable steamers while engaged in the work of repairing and replacing cables. An immense amount of work was done by him in this connection, a first instalment of which appears in the Transactions just issued, and it is to be hoped that some member of the Institute will continue it to a successful ending.

In these remarks I have not undertaken to follow the Doctor in the battles he waged with his fellow geologists, nor to enter into the details of the grounds upon which he based his geological conclusions. It may be said that his labors in working out the structures of the Arisaig rocks and tracing them into the other parts of the Province have afforded great assistance to those who have followed in his footsteps, and have given him a lasting claim on the gratitude of Provincial Geologists.

I beg in conclusion to say that I hope this brief sketch of Dr. Honeyman's Geological work will serve to us as a monument of perseverance and assiduity, and remind us of how much we owe to him for his labors in forwarding the Institute.

ART. IV.—POTASSIC IODIDE AS A BLOWPIPE REAGENT.—By FRED A. BOWMAN, M. A., B. E.

(*Read* 10*th February*, 1890.)

In the Transactions of the Royal Society of Canada for 1883 there is a paper by Prof. E. Haanel, Ph. D., " On the Applications of Hydriodic Acid as a Blowpipe Reagent." In this paper the author states how he was led to the use of iodide coatings in place of the ordinary characteristic oxides deposited on the charcoal, and his method of making and using the hydriodic acid, and also the little Plaster of Paris tablets. Many of the metals yield very characteristic coatings by this method, and the paper is illustrated by beautifully coloured diagrams of some of them.

While doing advanced blowpipe work under Prof. Kennedy at King's College, Windsor, he advised my following out Dr. Haanel's experiments. This I did, and easily got all his results. We found however one serious difficulty in the practical application of the method. Hydriodic acid is an unstable compound, the iodine tending to separate and come down as iodine crystals. These can, it is true, be re-dissolved by passing a stream of hydric sulphide through the acid for a little while, but this requires a laboratory and removes the reagent from a portable blowpipe outfit. Then again the acid must be prepared by the user.

These objections led Prof. Kennedy to suggest the use of a solution of potassic iodide and an acid. This I tried with most satisfactory results. The method of using the reagent is as follows : The assay being placed in a little hollow near one end of one of the plaster tablets, one or two drops of the solution of potassic iodide are deposited on and around it, and are absorbed by the tablet, then a drop or two of acid, preferably sulphuric, is added and the assay heated before the blowpipe. The potassic iodide is decomposed and vapours of iodine are given off. Some of the iodine unites with the assay to form an iodide of the metal in it. These iodides, many of them of brilliant hues, are deposited on the tablet at a distance from the assay varying with their volatility. The potassic iodide solution I keep in a dropping bottle similarly to nitrate of cobalt. Acids are always present in a complete blowpipe cabinet. The keeping properties of the potassic iodide solution are proved by the fact that the solution now in the bottle, and with which some of the tablets before you were prepared, has been there since February, 1887, and still does its work perfectly.

When I came to renew these experiments in preparing this paper it occurred to me that it would be a great improvement if I could produce the same results with the dry crystals of Potassic Iodide. As this reagent will only produce the proper results in the presence of an acid it was necessary to find a dry acid to be used with it. As sulphuric acid appears to be the best to use with the solution of potassic iodide, it seemed best to try a crystalline sulphate. Copper and zinc sulphates would not do, as each of these metals gives a characteristic coating with Potassic Iodide. I therefore tried common sulphate of iron, green vitriol, and found that the best method was to powder both crystals and mix the powders well before adding to the assay. By this means the method becomes as simple and convenient as the use of carbonate of soda or any of the fluxes ordinarily in use in blowpipe work. Thus we have distinctive tests by a thoroughly practical method for some metals and a second or check on the ordinary tests for others. If one wishes to take a blowpipe outfit, for determining minerals, on a tour in the country, it is a great advantage not to have to carry acids. With regard to the plaster tablets, Dr. Haanel states that when blacked in a gas flame they are equal if not superior to charcoal for oxide coatings. If so, and if they can be made to take the place of charcoal for ordinary field work, it is an immense advantage, as they are easily prepared, clean to handle and occupy little space. I adopted Dr. Haanel's method of making them, which is to spread a coating of plaster of Paris about $\frac{1}{8}$ inch thick on a sheet of glass and just before it hardens to mark out the tablets with cuts nearly through to the glass. When dry they readily break apart. This method with dry potassic iodide has added seven elements to the list of those that can be determined by a dry assay.

I have not specimens of some of the elements whose reactions are mentioned by Dr. Haanel, so could not test all his results with the dry crystals. The following are some of the results I have obtained. *Arsenic.*—The mineral used was orpiment, the common sulphide of arsenic. The characteristic reddish orange coating comes out very well with both the liquid and the dry potassic iodide. *Lead.* — The chrome yellow coating comes out very well with the dry reagents, and also with liquid potassic iodide and a drop of hydrochloric acid. *Tin.*—The coating is brownish-yellow, but is difficult to obtain, and fades rapidly so that a specimen tablet canno t be kept. With hydriodic acid the color comes out fairly well, but only poorly with potassic iodide solution either alone or with sulphuric acid and hardly at all with the dry crystals. Both metallic tin and the ore known as stream tin were tried.

The orange-red coating of *Antimony* is very easily got. A fragment of stibnite, the ordinary sulphide, giving a very decided re-action with potassic iodide solution alone or with an acid, and also with the dry crystals. *Bismuth* yields its chocolate-brown iodide readily, both with liquid and dry potassic iodide. *Gold.*—This metal gives a faint pink to purple coating, somewhat difficult to obtain, but coming out by either method. *Molybdenum* yields an ultramarine oxide coating with the liquid reagents, but I have not yet succeeded in producing it satisfactorily with the dry. A specimen of Molybdenite was the mineral used. *Tungsten* yields a faint greenish-blue coating which is an oxide. It is easily produced by potassic iodide with hydrochloric acid. *Silver.*—The iodide coating given by this metal is a canary yellow turning to greyish - yellow when cold. It fades away almost entirely ultimately. The coating comes out well with potassic iodide solution and nitric acid. It is also good with the dry reagents. *Mercury* yields a scarlet and yellow coating, the yellow very evanescent and changing to scarlet. The change may be hastened by breathing on the coating. The results with potassic iodide solution and sulphuric acid are good, also those with the dry reagents. Grey fumes of mercury are often deposited at first but may be changed to yellow and red by touching them with the blowpipe flame. *Cobalt* gives a greenish-brown coating, the brown evanescent and passing into faint green. This fades out ultimately. Selenium, Tellurium, and Thallium yield characteristic coatings with hydriodic acid according to Dr. Haanel, but I have never had specimens of them to test for myself. Tungsten I tried when at College with potassic iodide solution, but had none to test with dry reagents now. Copper, cadmium and zinc all give white coatings, but the tablets have to be blackened to perceive them and then they can only be differentiated by some wet chemical test, so I have omitted them altogether.

After writing the above it occurred to me that as hydriodic acid is prepared in the laboratory from phosphoric iodide, possibly soda-ammonic phosphate, commonly called microcosmic salt, or salt of phosphorus, might serve to mix with the crystalline potassic iodide. Time did not allow of going over all the tests again with this substance, but those that were tried gave most satisfactory results.

This is a most decided improvement as microcosmic salt is always present in a blowpipe cabinet. The following are the results obtained with this reagent. Arsenic, lead and antimony yield good results. Cobalt is better than with ferric sulphate and gold is about the same.

This method with dry potassic iodide and a dry salt, I think I am safe in specifying microcosmic salt, has added certainly six and probably seven metals to the list of those that can be determined by a dry assay. I say probably seven, as I believe that practice in manipulation will bring out the result with tin, the only one I have failed with.

Thus a mineralogist fitted out with bottles of borax, carbonate of soda, microcosmic salt, and potassic iodide, with his lamp, blowpipe, a few plaster tablets, and possibly a few pieces of charcoal, can determine twenty-one metals, four non-metals, the silicates, nitrates, phosphates, chlorides and alkalies. The only two important substances not included are alumina and magnesia, which require nitrate of cobalt. The test for alumina is hardly distinctive as a fusible silicate gives the same reaction; so that magnesia is the only one really omitted. The seven metals added by this method are tin, bismuth, gold, thallium, molybdenum, tungsten, and cadmium. Dry assay by either ordinary blowpipe methods or with this new iodide process will determine practically all ores of useful metals. One advantage of this new method is that sample tablets can be prepared and kept for comparison with results obtained from unknown specimens, as many of the colors are quite permanent. I have also tried barium nitrate with the dry potassic iodide, but it deflagrates too violently. I hope to be able to carry out some more extended experiments in this line and to communicate the results to this Institute if they are considered sufficiently valuable. In a later trial with tin and tin ore I believe I have succeeded in bringing out the proper reaction. As the color is somewhat the same as that of iodine alone on the tablet, I wish to compare my results with Dr. Haanel's before saying definitely that I have succeeded. Time did not permit of my doing this before reading this paper

ART. V.—ON THE RELATIVE BULK OF AQUEOUS SOLUTIONS OF CERTAIN HYDROXIDES AND THEIR CONSTITUENT WATER. By PROF. J. G. MACGREGOR, D. SC., *Dalhousie College, Halifax, N. S.*—(Plate I).

(*Read* 10*th February*, 1890.)

Thomsen,* in the course of his thermo-chemical work, found on determining the specific gravities of solutions of sodium hydroxide in water, of known composition, that in the case of dilute solutions of this substance, the volume of a solution was less than the volume of the water which had been used in its preparation. This seems to me so important a result that I have thought it desirable to check it by the aid of other available observations, and to determine whether or not it applies also to other hydroxides. The only other observations of the specific gravities of solutions of hydroxides to which I have access, and indeed of which I know, are those of Kohlrausch ;† and although they do not include all the hydroxides, they enable us to verify Thomsen's observations, and to make the desired determination in the case of three others.

For this purpose I have calculated, with the aid of the data furnished by both the above observers, the volume of unit mass of the various solutions examined by them, and the volume which the solvent water contained in unit mass would occupy if its temperature were the same as that of the solution. The difference of these quantities gives at once the amount by which the volume of unit mass of the solution is less or greater than that of the solvent water employed in its preparation. There is one difficulty in making the necessary calculations from Thomsen's data, viz., that he does not say to what standard his specific

* Thermo-chemische Untersuchungen. Bd. I, p. 47, (1882.)

† Wiedemann's Ann ɐlen, Bd. VI (1879), p. 21.

gravities are referred. But on repeating some of his own calculations I found their results to be consistent only with the supposition that his standard was water at the temperature at which the specific gravities of his solutions were determined.

In all my calculations I have taken for the atomic weights of the elements the values given by Clarke,* and for the densities of water at different temperatures, the values given by Volkmann,† as quoted in both cases by Landolt and Börnstein.‡

Sodium Hydroxide.—NaOH.

Thomsen's data give the following table. The temperature of the solutions examined by him was about 18° C. The headings of the various columns will sufficiently explain their contents, except in the case of the last, which to avoid circumlocution is headed expansion. Expansion here means the excess of the volume of one gramme of a solution over the volume which at the same temperature and in the free state, the solvent water in one gramme of the solution would have. Possibly I should state also that by "Percentage of a substance in solution," I mean the mass of the substance contained in 100 units of mass of the solution.

Percentage of NaOH in solution.	Density at 18° C. (grms. per cu. cm.)	Volume of 1 grm. of solution at 18° C. (cu. cm.)	Volume at 18°C. of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
1.1001	1.0111	0.9891	0.9903	—0.0012
2.1762	1.0232	0.9773	0.9795	—0.0022
4.2597	1.0472	0.9549	0.9587	—0.0038
6.9035	1.0768	0.9287	0.9322	—0.0035
12.9154	1.1435	0.8745	0.8720	+0.0025
22.8762	1.2559	0.7962	0.7723	+0.0239

The fifth column exhibits Thomsen's result that for dilute solutions of this hydroxide, the expansion is negative; *i. e.*, the

* Constants of Nature, V., Smithsonian Institution, Washington, 1882.

† Wiedemann's Annalen, Bd. XIV (1881), p. 260.

‡ Physikalisch-Chemische Tabellen, Berlin, 1883.

volume of the solution is less than the volume of the water used in preparing it. If we treat the data of the above table graphically, plotting expansion against percentage composition, we find that the contraction has its greatest value, about 0.0041 cu. cm., for a solution containing about 5.35 per cent. of the hydroxide, and that for all solutions containing less than 10.5 per cent. of the hydroxide the expansion is negative.

The following table is based on Kohlrausch's observations, which were made at a temperature of 15° C.:

Percentage of NaOH in solution.	Density at 15° (grms. per cu. cm.)	Volume of 1 grm. of solution at 15° C. (cu. cm.)	Volume at 15° C. of solvent water in 1 grm. of solution (cu. cm.)	Expansion (cu. cm.)
4.87	1.0552	0.9477	0.9521	−0.0044
10.80	1.1222	0.8911	0.8927	−0.0016
19.66	1.2224	0.8181	0.8041	+0.0140
29.67	1.3337	0.7498	0.7039	+0.0459
42.72	1.4685	0.6810	0.5733	+0.1077

Kohlrausch's observations, therefore, substantiate Thomsen's result qualitatively, though the expansions calculated from them differ from those calculated from Thomsen's to a greater extent, probably, than is accounted for by the difference in the temperatures of their solutions. The relation between expansion and percentage composition, according to Kohlrausch, both for this substance and for those considered below, is shown in Plate I. The curve gives, as the maximum contraction, 0.0045 cu. cm., and as the solution exhibiting this contraction one containing about 6 per cent. of the hydroxide, and it gives about 12.3 per cent. as the limit of concentration within which the expansion is negative.

The above observations enable us also to determine the values of the expansion when the above solutions are prepared by adding sodium monoxide (Na_2O) to water, if we assume that the oxide, when added to water, combines with a portion of the water to form the hydroxide.

According to Thomsen.

Percentage of Na_2O in solution.	Density at 18°C. (grms. per cu. cm.)	Volume of 1 grm. of solution at 18° C. (cu. cm.)	Volume at 18°C. of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
0.8528	1.0111	0.9891	0.9928	—0.0037
1.6871	1.0232	0.9773	0.9844	—0.0071
3.3023	1.0472	0.9549	0.9683	—0.0134
5.3519	1.0768	0.9287	0.9477	—0.0190
10.0126	1.1435	0.8745	0.9011	—0.0266
17.7346	1.2559	0.7962	0.8237	—0.0275

According to Kohlrausch.

Percentage of Na_2O in solution.	Density at 18°C. (grms. per cu. cm.)	Volume of 1 grm. of solution at 18° C. (cu. cm.)	Volume at 18°C. of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
3.7754	1.0552	0.9477	0.9631	—0.0154
8.3726	1.1222	0.8911	0.9170	—0.0259
15.2413	1.2224	0.8181	0.8483	—0.0302
23.0015	1.3337	0.7498	0.7706	—0.0208
33.1184	1.4685	0.6810	0.6694	+0.0116

As might be expected, the values of the expansion are (algebraically) much smaller than in the case of the solution of the hydroxide. The results of the last table are shown graphically in Plate I. The curve shows that the maximum contraction in this case is 0.0306 cu. cm., and is exhibited by a solution containing about 14 per cent. of the oxide, and that the expansion is negative for all solutions containing less than 29.6 per cent.

Potassium Hydroxide,—KOH.

The following table is calculated from Thomsen's data:

Percentage of KOH in solution.	Density at 18° C. (grms. per cu. cm.)	Volume of 1 grm. of solut'n. at 18° C. (cu. cm.)	Volume at 18° of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
1.5344	1.0130	0.9871	0.9860	+0.0011
3.0224	1.0270	0.9737	0.9711	+0.0026
5.8674	1.0536	0.9491	0.9426	+0.0065
9.4109	1.0872	0.9198	0.9071	+0.0127

Kohlrausch's observations give the following results:

Percentage of KOH in solution.	Density at 15° C. (grms. per cu. cm.)	Volume of 1 grm. of solut'n at 15° C. (cu. cm.)	Volume at 15° of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
4.19	1.0381	0.9633	0.9589	+0.0044
8.42	1.0778	0.9278	0.9166	+0.0112
16.78	1.1587	0.8630	0.8329	+0.0301
25.11	1.2430	0.8045	0.7495	+0.0550
33.33	1.3302	0.7518	0.6673	+0.0845
41.7	1.427	0.7008	0.5835	+0.1173

Kohlrausch's observations, therefore, substantiate Thomsen's result, that solutions of Potassium Hydroxide have in all cases volumes which are greater than the volumes of the water used in preparing them. Though the weakest solution examined was one containing 1.5 per cent. of the hydroxide, the trend of the KOH curve in Plate I, by which the relation between the expansion and the concentration of Kohlrausch's solutions is exhibited, and with which a similar curve based on Thomsen's results almost exactly coincides, shews that for solutions still weaker than the weakest examined, the expansion is probably positive.

The following tables give the values of the expansion when the above solutions are formed by adding Potassium monoxide (K_2O) to water:

According to Thomsen.

Percentage of K_2O in solution.	Density at 18° (grms. per cu. cm.)	Volume of 1 grm. of solut'n at 18° C. (cu. cm.)	Volume at 18°C. of solvent water in 1 grm. of solution. (cu. cm.)	Expansion, (cu. cm.)
1.2882	1.0130	0.9871	0.9884	—0.0013
2.5375	1.0270	0.9737	0.9759	—0.0022
4.9261	1.0536	0.9491	0.9520	—0.0029
7.9011	1.0872	0.9198	0.9222	—0.0024

According to Kohlrausch.

Percentage of K_2O. in solution.	Density at 15° (grms. per cu. cm.)	Volume of 1 grm. of solut'n. at 15° (cu. cm.)	Volume at 15° of solvent water in 1 grm. of solution. (cu. cm.)	Expansion, (cu. cm.)
3.5178	1.0381	0.9633	0.9656	−0.0023
7.0692	1.0778	0.9278	0.9301	−0.0023
14.0879	1.1587	0.8630	0.8598	+0.0032
21.0815	1.2430	0.8045	0.7899	+0.0146
27.9828	1.3302	0.7518	0.7208	+0.0310
35.0099	1.147	0.7008	0.6504	+0.0504

Both sets of experiments agree in showing that on adding Potassium oxide to water in sufficiently small proportions, solutions are formed smaller in bulk than their constituent water.

The expansion-concentration curve given by Kohlrausch's experiments (Plate 1) makes the greatest contraction in the case of solutions of this oxide, have the value 0.0024 cu. cm., and gives as the solution exhibiting this contraction one containing about 5.6 per cent. of the oxide, while the limit of concentration within which the expansion is negative is about 11.2 per cent.

LITHIUM HYDROXIDE.—LiOH.

The following table is based on Kohlrausch's observations of the densities of solutions of Lithium hydroxide at a temperature of 18° C.

Percentage of Li O H. in solution.	Density at 18° (grms. per cu. cm.)	Volume of 1 grm. of solut'n. at 18° (cu. cm.)	Volume at 18° of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
1.25	1.0132	0.9888	0.9869	—0.0019
2.50	1.0276	0.9763	0.9731	—0.0032
4.99	1.0546	0.9513	0.9482	—0.0031
7.71	1.083	0.9241	0.9233	—0.0008

Thus for dilute solutions of Lithium hydroxide also the expansions are negative. The LiOH curve of Plate I shews that the solution exhibiting the greatest contraction is one containing about 3.6 per cent. of the hydroxide, that the amount of its contraction is 0.0036 cu. cm., and that the limit of concentration within which contraction occurs is 8.2 per cent.

From the same data the following table has been calculated giving the expansion on adding Lithium Oxide (Li_2O) to water

Percentage of Li_2O in solution.	Density at 18° (grms. per cu. cm.)	Volume of 1 grm. of solut'n. at 18° (cu. cm.)	Volume at 18° of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
0.7816	1.0132	0.9869	0.9935	—0.0066
1.5633	1.0276	0.9731	0.9856	—0.0125
3.1203	1.0546	0.9482	0.9701	—0.0219
4.8211	1.083	0.9233	0.9530	—0.0297

As might be expected the contraction is much greater in the case of solutions of the oxide than in that of solutions of the hydroxide. The experiments are not sufficient to determine the maximum contraction, the solution which exhibits it, or the limit of concentration within which contraction occurs.

AMMONIUM HYDROXIDE,—NH_4OH.

As Ammonium is closely related in the properties of its compounds to the metals of the alkalies, it may be well to give a table similar to the above, for solutions of its hydroxide, though as the densities of these solutions are less than unity it is obvious that their expansions must be positive. The table is based on experiments by Thomsen.

Percentage of NH_4OH in solution.	Density at 18° (grms. per cu. cm.)	Volume of 1 grm. of solut'n. at 18° (cu. cm.)	Volume at 18° of solvent water in 1 grm. of solution (cu. cm.)	Expansion (cu. cm.)
1.9103	0.9954	1.0046	0.9822	+0.0224
3.7491	0.9914	1.0087	0.9638	+0.0349
6.0961	0.9865	1.0137	0.9403	+0.0734

The NH_4OH curve of Plate I. shews the results of this table graphically. It is much steeper than the others; and, if the observations are exact, has a point of contrary flexure. If we regard the experiments as not sufficiently exact to establish the contrary flexure, the curve must be regarded as practically a straight line.

BARIUM HYDROXIDE,—$Ba\,O_2\,H_2$.

For Barium Hydroxide, Kohlrausch has published two determinations which serve as the basis of the following table :—

Percentage of $Ba\,O_2\,H_2$ in solution.	Density at 18° (grms. per cu. cm.)	Volume of 1 grm. of solut'n. at 18° (cu. cm.)	Volume at 18° of solvent water in 1 grm. of solution (cu. cm.)	Expansion (cu, cm.)
1.33	1.0128	0.9873	0.9880	—0.0007
2.67	1.0271	0.9736	0.9746	—0.0010

For dilute solutions of Barium Hydroxide, therefore, the expansions are negative. But the available data are not sufficient to shew fully how the contraction varies with the concentration.

The following table shews the values of the expansions on dissolving Barium oxide in water :—

Percentage of Ba O in solution.	Density at 18° (grms. per cu. cm.)	Volume of 1 grm. of solut'n. at 18° (cu. cm.)	Volume at 18° of solvent water in 1 grm. of solution. (cu. cm.)	Expansion. (cu. cm.)
1.1900	1.0128	0.9873	0.9894	—0.0021
2.3890	1.0271	0.9736	0.9774	—0.0038

ART. VI.—ON A NOTEWORTHY CASE OF THE OCCURRENCE OF ICE IN THE FORM OF NON-CRYSTALLINE COLUMNS. BY PROF. J. G. MACGREGOR, *Dalhousie College, Halifax, N. S.*

(*Read* 10*th February*, 1890.)

ON the morning after the first sharp frost of the present winter, the ground in front of the Dalhousie College Building, to the extent of about 60 square yards, was found to be covered with little columns of ice springing from apertures in the frozen earth. They were irregularly distributed, occurring in groups separated by interspaces which were in most cases narrow, and were either without columns altogether or had only a few isolated ones. The ice columns themselves varied in length from half an inch to two inches. They were for the most part roughly circular in section with diameters ranging from one-tenth to one-third of an inch in different columns, but practically uniform throughout the whole length of any one column. The section of any one column was in general the same at all points of its length, and they had thus the appearance of being striated longitudinally. Many of them carried little pebbles on their summits, and still more carried fragments of frozen earth. The ice of which they were composed was not transparent, but had a white appearance similar to that of compressed snow, or of ice traversed by innumerable tiny fissures. They sprang from the frozen earth at no uniform inclination to the vertical, but in the great majority of cases they curved upwards, so that their upper parts were less inclined to the vertical than their lower parts.

The occurrence of ice in this form after a sudden frost is familiar enough in our changeable climate, and must probably be common in other countries with similar climatic conditions. But so far as I can ascertain, this mode of ice formation does not seem to have been adequately described or its peculiarities to have been explained. Attention was drawn to the occurrence of ice in crystalline columns rising from the soil and bearing pebbles and earth on their summits, by Sir David Brewster,* but the columns referred to above, were distinctly non-crystalline. In the earlier volumes of Nature (vols. XXI, XXII, XXV, &c.,) there is a long series of communications describing and discussing peculiar forms of ice, but for the most part they refer to the familiar occurrence of ice in the form of filaments springing from rotten wood or from a porous, clayey soil. The only description of the mode of ice formation referred to above, which I have been able to find is by J. D. Paul.† He describes ice as occurring in bundles of little rods rising from the frozen soil and carrying dirt and pebbles on their summits. He also mentions their being curved, but does not refer to any uniformity in the direction of their curvature. Nor does he give any explanation of the phenomena which he observed.

I have frequently observed this mode of ice formation in Nova Scotia, and in most respects the present case is similar to others which have come under my notice. But my attention was never before directed to the fact of the upward curvature of the little columns. And it is this observation, together with the simplicity of the conditions under which, in this case, the little columns were produced, which have led me to bring the matter before the Institute.

A short time before the date of the occurrence referred to, the ground in front of the College building, which had become quite hard through the trampling of many feet, was covered with a thin coating of loose pebbly soil for the purpose of making it more level. This layer of soil had not been rolled, and had been but slightly walked over, when several days of heavy rain ensued. As the hard soil underneath prevented the escape of the rain, the loose soil must thus have become quite saturated with water. Then came one of our sudden changes of temperature. The wind whirled round from the south to the north-west, and the temperature fell from many degrees above, to sev-

Edinburgh Journal of Science, N. IX., p. 122, and Poggendorff's Annalen, Bd. VII., p. 509.

† Nature, Vol. XXXI, p. 264.

eral below, the freezing point. I do not know what the exact variation of temperature was ; but the change was so great and so sudden, that while the layer of soil was still saturated with water, its surface must have begun to freeze. Owing to the expansion of the water on solidification, a continuation of the freezing would result in a slight elevation of the crust thus formed, until the thinner parts of the layer of loose earth had been frozen quite down to the hard ground underneath. This layer would thus become divided into little patches, with completely frozen interspaces, and its crust would be prevented from further elevation as a whole. A continuation of the surface radiation, resulting in the freezing of a portion of the water in any of the spaces in which it must now be enclosed, must, owing to the expansion of the freezing water and the rigidity of the enclosure, raise the pressure throughout this space and in the frozen crust. The rise of pressure would of course be accompanied by a lowering of the melting point, and at those parts of the crust at which the pressure was greatest the melting point might be reduced to the actual temperature of the crust. At any such part, therefore, the ice would partially melt and be driven outwards, carrying with it the earthy portion of the crust, and, through the aperture thus produced, the ice would continue to be protruded so long as freezing continued.

That a column of ice formed in this way would have, in general, a section of the same form throughout, is obvious. That the ice would likely be opaque, follows from the fact that the protrusion of a column of so brittle a substance must result in the formation of innumerable cracks and fissures, giving it the appearance of compressed snow. The presence of these cracks enables us also to explain the upward curvature of the columns. For at the base of any column which is in course of protrusion, melting is going on at various points. At no one point will there be much ice melted, for a slight melting will result in reduction of the pressure. But here and there throughout the base melting will occur. The water thus formed will flow downwards into the little fissures ready to receive it, and filling some of them will then freeze, expanding during solidification. If the axis of such a column at its base be inclined to the vertical, more water will flow into the fissures of its lower side than into those of its upper side, if we assume the distribution of the maximum pressure and of the fissures to be practically the same throughout. The elongation of the lower side, which will be produced by the freezing of this water, will thus be greater than the elongation of the upper side ; and the column will therefore curve upwards. Should the conditions be such that the pressure in the upper part of a column is greater than in the lower part, or should there be comparatively few fissures in the lower part, it may happen that the upper part of such column will receive more water than the lower part, and will undergo consequently a greater elongation, in which case the column will curve downwards; but columns formed under such conditions will be exceptional, and in general therefore it may be expected that their curvature will be upwards.

ART. VII.—THE DEVONIAN OF CAPE BRETON. By E. GILPIN, JR., A. M., F. G. S., *Inspector of Mines.*

(*Read* 14th *April*, 1890.)

In my last paper on the Geology of this Island, I described the minerals of the Carboniferous Division, and have now to touch upon the horizon next in descending order. The exact delimitation of this horizon palœontologically speaking may yet be among the unsettled problems, and the knowledge so far learned of its relations in Cape Breton may perhaps be summed up by saying that it carries back a step the conditions so widely prevailing here at the opening of the Carboniferous. No distinctive harvest of the flora permits the correllation of its divisions It may however be asserted that the position is of more importance than the name, and that here it fills a gap, more or less completely, between the Silurian and Carboniferous. As exposed here it is a formation not of special interest from a geological or mineralogical point of view, and at present the most interesting field for study offered by it are the numerous dykes and their metamorphic powers.

Geographically speaking it begins at Loch Lomond, near the county line, and runs toward MacNab's Cove, having a selvage of Carboniferous between it and the Pre-Cambrian felsites of East Bay. From MacNab's Cove it runs to St. Peter's, shewing itself at the head of the various coves and indentations, the islands and points of land being covered by the Carboniferous. From St. Peter's it fills the shore eastward as far as Lower L'Ardoise, where it meets the Pre-Cambrian, and skirting these measures runs north-easterly to the Grand River which it follows to the place of commencement. Several outliers of it are met on the east bank of the river, resting on the felsites which occupy almost all the shore as far east as

Mira Bay. All Isle Madame (Arichat Island) is occupied by it, except a narrow fringe of carboniferous extending from Grandique westwardly along the north shore, and a few patches of felsites, etc., near Arichat town and Petit de Gras Harbor. It is met again on the Guysboro' shore, and extends nearly to the mouth of the Strait of Canso where it crosses into Cape Breton again. Here it stretches along the shore from Port Hastings to Low Point, and extends inland about six miles, among the spurs of the band of crystalline limestones, gneisses, etc., which is best known by its exposure at Whycocomah. From this it will be seen that the extent of these measures in Cape Breton is limited, and that they do not form mining or agricultural districts. They are most particularly presented to the traveller passing through Lennox Passage, where he sees the low, monotonous, spruce-covered hills of Arichat Island, broken by few clearings and animated only by the huts and stages of the fishermen.

In the district lying east of St. Peter's, the presence of great masses of igneous rocks, has permitted of bolder outlines, and the Devonian is presented in rolling hills, with narrow irregular valleys. Prior to the surveys made by Mr. Fletcher, of the Geological Survey, these measures were generally referred, without much comment, to the lower Carboniferous. In reporting on the field work of 1877, he says of the two basins of metamorphic rock running parallel to the great felsite series, that the first, stretching from Mira River to Upper Marie Joseph, is characterized by primordial fossils. The second, probably Devonian, is characterized by more recent shells and plants. It contains masses of granitoid and trappean rock, and the associated strata bear a close lithological resemblance to the Cordaite shales and Dadoxylon sandstones of St. John, New Brunswick.

These strata, in the St. Peter's district, present numerous outcrops, but are so contorted that no continuous section can be given; nor can any reliable estimate be formed of their thickness.

The various sections are composed chiefly of coherent grits, sandstones, areno-argillaceous shales, sometimes quartzo-felspathic, greenish, blueish, reddish, purple, gray or whitish. Carbonized plants, cordaites, ferns, calamites, and sphenophyllum are met. Argillites of varying degrees of hardness are found, with green, black, and red colors, and are frequently nacreous. The conglomerates are red and greenish, and compact; the pebbles being quartzite, with sandstone and felsite, and they are frequently banded with sandstone.

Limestones are met at many points and they differ from those of the carboniferous, in being in all cases highly altered, in places approaching marble in texture. The limestone seen at many points between St. Peter's and Macnab's cove is bluish and grey, compact, crystalline, concretionary or slatey. Galena is sometimes observed in it, and layers of chloritic matter. At Robertson's cove the limestone contains conularia, strephtorynchus, and stems of plants and other organic forms. It contains veins and nests of crystalline spar, hematite, etc. Another limetone near MacNab's cove is described as blackish, bluish, grey, yellow weathering, dressed with hematite, veined with calcspar, with cone in cone concretions, and holding dark purple fluorspar.

In the northern part of the district these measures are rather more compact and altered than near the shore. At numerous points they have their joints filled with calcspar. These measures are cut by numerous masses and ridges of trap and diorite. The St. Peter's Canal is excavated in a mass of greenish, grey and yellow mixtures of hornblende and felspar, etc. Dykes of coarse greenish diorite are met, slightly altering in their immediate vicinity the sandstones and grits they intersect. Black, bluish and greenish trap passing into felsite or diorite occurs at Alex Island. Its cavities contain hematite, calcspar, chlorite and zeolites.

These strata cut off by the sea emerge again, and as already noted, occupy nearly all the island of Arichat.

Mr. Fletcher, during the seasons of 1878 and 1879, continued the work of tracing the geological formations of Richmond and Inverness Counties. He, however, raises a question if part of the beds on this Island may not be older, and refers to the opinion of Sir William Dawson, who is inclined, on specimens of a species of Rhynchonella found by him at Rocky Bay, near Arichat, to refer some of the strata to the Silurian, on the analogy of other parts of Nova Scotia. To clear up these questions, which are more easily asked than answered, a much more detailed survey and study would be required.

Good examples of the unconformability between the Carboniferous and Devonian are met here, where the former, little altered, come into contact with and hold pebbles of the metamorphic rocks. Between Rocky Bay and Lennox Passage there seems to be a vertical thickness of 10,000 feet of strata.

In general character the rocks of this district resemble those of the same formation, as exposed about Loch Lomond and Grand River. Mr. Fletcher appears, upon more mature reflection, to question if the limestones of St. Peter's may not be at the base of the Carboniferous, and that their alteration by the igneous rocks of the locality mark the Carboniferous date of the metamorphic action. I do not myself recognize much resemblance between any of the St. Peter's diorites, etc., and undoubted Carboniferous dykes which I have seen elsewhere. However this may be viewed, the limestone, whether placed at the top of one formation or at the bottom of the succeeding one, may be looked upon as marking a period of change, with differences in level, and the consequent change in nature of sediments.

Over large parts of Arichat Island are beds of quartzite and sandstone, with reddish and purplish conglomerates, giving a rocky, rough surface, barren, and intersected by swamps. Petit de Gras Island is largely made up of conglomerates. At Rocky Bay coherent grit and fine conglomerate, with their irregular veins of quartz, are succeeded by purple, greenish, and gray grits, Indian red, gray, flaggy, arinaceous, cleft and jointed rocks, sometimes friable, and pearly with quartz in films, blotches and veins containing much chlorite. The different varieties seem to be confusedly mixed, the sandstone passing on one hand into fine granular quartzite, and on the other into compact sandstone, often almost replaced in the bedding and across it by veins of quartz and calcspar. The abundance of calcspar in all the rocks on the island is noteworthy, but I am not aware that it carries any notable amounts of metallic sulphides, etc. Fossil plants are frequently found. The general trend of the measures appears to run lengthwise through the island and to connect naturally with the St. Peter's and the Guysboro' districts. The exposures of diorite, etc., are not as prominent a feature here as in the former district, but examples can be noticed where the dykes cut the beds and pass laterally between them, with comparatively local amounts of metamorphism.

Passing to the third area of Devonian rocks, we find them exposed beneath the limestone of Plaster Cove. They consist of greenish quartz, felspathic sandstones, associated with dark greenish, veined, very coherent shale and sandstone, conglomerate, and black shales. On the Victoria Road, a mile and a half from Hastings, are whitish coherent grit, and conglomerate, with many veins of quartz. Some of the exposures of grit and shale are soft and crumbly, while others are hard and flinty. Dykes of diorites are met, but as a rule their effect on the strata is very local, and the metamorphism has been regional. Frequent junctions with the precambrian syenites and felsites are observed. In general, these strata resemble those of Arichat and St. Peters, and the fossils they present are similar.

The minerals of the Devonian of Cape Breton are limited in number. I am not aware of any quarries having been opened in them for building purposes, although the surface blocks are locally used for foundations, bridges, etc. Limestone is met at several places. That of St. Peter's inlet has been quarried and burned to a small extent, and was utilized during the construction of the canal. The bed of limestone between Pirate's Cove and Mulgrave was quarried on quite an extensive scale some years ago, and exported chiefly to Prince Edward Island. Behind the chapel at Arichat there is a quarry in a dark grey compact limestone, veined with calcspar. The limestone at Pirate's Cove is said to be somewhat hydraulic, and contains fluorspar.

The occurrence of fluorspar in these measures leads to a hope that this mineral, which is of considerable value, may be found in amounts of economic importance. In 1887, 3,000 tons were mined in the United States and valued at the mines at $20.000. About two-thirds was used in iron, brass and steel works; the remainder in glass works, and for the production of fluoric acid and other chemicals. In the States fluoric acid to the extent of 6,000 tons, valued at $3.00 per ton, is produced as a by-product from the manufacture of cryolite into various sodium salts, alum, aluminium, etc.

Galena occurs in limestone near the head of Arichat harbor, and has been prospected several times. The ore carries small amounts of gold and, I am informed, up to ten ounces of silver.

Barytes occur in small quantities near McMillan's Point, on the Strait of Canso.

So far, the Devonian rocks of Cape Breton have shown the greatest mineral value in iron ore, and inferentially it may be expected that future valuable discoveries will be made. In strata of this age in Annapolis County are known the valuable bedded hematites, sometimes altered into magnetites, of Clementsport and the Nictaux district. So far, similar deposits have not been met in the counterpart of these rocks in Cape Breton. In Guysboro' County, however, important deposits have been opened, and their mode of occurrence has a direct bearing upon the probable ore-yielding localities on the opposite side of the Strait of Canso. At Erinville is a large and important deposit of specular ore. Some years ago a test was made of the extent of this deposit. A shaft was sunk in the ore fifty feet, and a tunnel driven, exposing a body of ore sixty-five feet wide; another bed in the vicinity was twelve feet wide. The ore is fairly compact, running from 55 to 62 per cent. of metallic iron, and very low in phosphorus, and not holding above the amount of sulphur usually found in ore of this character. The walls of the veins are composed of greenish, dioritic, felspathic, trappean, brecciated rock. About a mile further west, promising indications of ore have been found in altered slates, and shales with quartz. In the vicinity are large masses of dark gray trap, in contact with conglomerate. On the seashore, near the east side of the mouth of Milford Haven, are large beds of altered clay slates, veined with calcspar and quartz, and penetrated by dioritic rocks. Veins of ore up to two feet in thickness, of the compact specular variety, have been opened here and worked to a small extent.

The ore, which was of excellent quality, was not carefully mined, and the admixture of stone which was sent away caused the Londonderry works to stop buying it.

At the Indian Reserve, near Robinson's Cove in Richmond County, similar deposits of specular iron ore are met, cutting the shales and sandstones. Some explorations have shown the presence of deposits of workable size. As in Guysboro' County they are in the immediate vicinity of igneous rocks. The ore is of good quality, and not excessively sulphurous. The fact of the connection between the igneous rocks and the iron ore veins is of value to the prospector, as by bearing it in mind, he is able to contract the area in which he may be searching. It is true that deposits of this character, owing their existence to irregular masses of intrusive rocks, have not the uniformity of bedded deposits, but they are not necessarily more irregular than the normal vein deposits of specular ore.

Some attention has been given during the past year to the iron ores of St. Peter's mountain, some miles south of MacNab's Cove, but I am not acquainted with the ore or its surroundings. The ores of this district are favorably situated for shipment, and of fair quality, and it appears, so far as our present stock of information goes, any future mining activity of the localities we have been considering will be found in their extraction and transportation.

Mr. Fletcher's reports, as issued by the Geological Survey of Canada, give fuller details about the Devonian of Cape Breton, and I am indebted to him for much of the information I included in this paper.

ART. VIII.—SURFACE GEOLOGY OF THE PICTOU COAL FIELD.

BY H. S. POOLE, F. G. S., &c., STELLARTON, N. S.

(Received 19th May, 1890.)

BOULDER clay covers large portions of this field; it often contains pebbles of the rocks immediately underlying, mixed with fragments of those passed over by the ice flow from the higher ground lying to the south and southwest, and with occasional boulders well rounded and travel-worn of still older rocks from more distant localities.

One of the largest of these known in the neighborhood lies on the edge of the Pictou Town Branch Railway, near Stellarton, and must weigh not less than forty tons. Some of the smaller are striated, but much of the rock of which the pebbles and boulders in the clay are composed is of too perishable a nature to retain surface markings after exposure to the elements, and striæ are rare.

In the clay there are frequently found grains and small pebbles of coal, which there is every reason to believe are from the outcrops of beds proved to be close at hand, and these, it is noticeable, have their edges rubbed off as from exposure to much abrasion, although removed but a comparatively short distance from their parent source.

In places the clay has been cut through, and the outcrop of soft measures in a friable condition exposed. The dark shales, coal and fireclays appearing in the clay as darker streaks, which gradually take on the character of individual beds decomposed in lessening degree until a compact form is acquired, and although the direction of the outcropping may be contrary to that assumed for the flow of the drift, no folding back of the streaks has been noticed in the sections.

Thin beds, or partings of sand, are occasionally seen in the clay. and streaks of various tints of red may be detected.

One interesting drifted fragment was observed on the side of the abandoned Drummond railway, passing through the lands of James Cameron.

In making a drain outside a cutting at this point, broken coal and black shale were turned up, so trial-pits looking for a possible seam of coal were, in consequence, put down. But instead of the expected coal measures the excavations only showed a mass, a couple of feet thick, thirty feet or so wide, of coal and shale partly imbedded in the clay, which in turn rested on undisturbed mottled, reddish beds of the millstone grit series. The probability being that this particular mass of broken measures had drifted from a point southwestward, half-a-mile or more from where it was found stranded.

The drift in some parts lies in well-defined ridges, gently rounded and coursing in the western portion of the coal basin about N. 40 E. The parallelism of the ridges west of Stellarton is well marked, and their course seems entirely unaffected by the elevation and direction of the subjacent surfaces.

It was at first supposed that the ridges near the river may have been old banks of the stream when it flowed at higher levels, closer inspection made it clear that there had been no such erosion as a river bears on the face of its banks, the sides of the ridges being equally rounded and uniformly graded.

These ridges may be seen on both sides of the river, where it enters the coal basin, and on the flank of McGregor's hill, in a series of elevations, some seven in all, having very much the appearance of river terraces.

It is also evident that the depressions between adjoining ridges are not due to subærial denudation, the area drained in many cases not being sufficient to supply the necessary flow of water to mould the surface into its present form, and this opinion is strengthened by the knowledge that it is not a characteristic of mining water to traverse a country in straight lines. Some of the depressions are at times water-runs which do not confine themselves to one course but in places break through to an adjoining depression, the deviated course apparently following the strike of some underlying stratum of soft or friable material.

And at such places the extent of the denudation, where not only has the boulder clay been washed away, but the older formations have been further eroded, may be taken as some gauge of the time since the present condition of things began.

One of the more convincing evidences of the glacial character of these ridges is a depression perfectly straight from the slightly raised centre of which water flows, when there is any to flow in diametrically opposite directions.

To the mineral explorer a knowledge of the nature of these deposits leads him to sink his trial pits in the lower ground where he may expect to find the surface offer less depth than on the crest of the ridges, and this knowledge is of no small value in the field under review since the excessive thickness of the diluvium is in many parts a great bar to the study of the structure of the older rocks beneath.

Twenty and thirty feet is a common depth, while sinkings sixty and even eighty-six feet have failed to pierce these deposits. The deepest spots are where it is supposed the river and larger brooks at one time ran previous to the deposition of the drift.

The position of these beds of drift is also a matter of no small worth to the Railway contractor, for there have been several instances where men accustomed to the soil of other sections of country have been disagreeably surprised to find the cost of earthwork in Nova Scotia far exceeded their estimates and experience elsewhere.

After the agreement in 1858 between the Local Government and the General Mining Association threw open the unreserved mineral lands to other lessees, an endeavor was made to trace the coal beds outside the Association's areas, but beyond a few chains distant this endeavor to the westward was for many years a failure. West of a certain line, the depth of the surface material was found to suddenly increase, and several trial pits and boreholes were abandoned when they failed to reach the rock at forty feet and more. This western limit of shallow drift probably indicates the eastern bank of McCulloch's brook in pre-glacial times, and studied in the light of our present knowledge of the underlying strata, it marks also the eastern side of the McCulloch's

Brook fault,—that great dislocation* of some 2600 feet which separates the Westville from the Albion field, and down tilts the former in the direction of the latter.

The influence of this fault on the surface configuration still remains, on the one hand a uniform slope towards it, on the other ranges of low hills abrubtly terminating against it.

In the pre-glacial stage of its existence, the brook doubtless flowed at a lower level than at present over part of its course, and as erosion proceeded, and influenced by the inclined strata on the one side, it pressed eastward against the broken measures of the fault, or crossed over and skirted the Albion section.

After the deposition of the glacial drift ceased, and the brook renewed its existence, and in part guided by the form of the ridges already referred to, and partly by the general trend of the old contour not entirely obliterated by the new coating it had received, it began again its work of erosion at a higher level than at which it left off, and it traversed almost, if not altogether, on the eastern side of the fault in question. To what extent the fault and the old bed of the brook coincide can only for the present be conjectured, but as the working of the Westville collieries proceeds into the improved ground, it cannot be long before the actual position of the great break will be determined at one or more points along its course.

If the theory be tenable that it was the ancient brook that made the valley, now filled so deeply with drift, it is equally probable that the depth of clay, 35 to 70 feet thick, near the railway station at Stellarton, indicates that the river channel in pre-glacial times ran under what is now its left bank, and flowed in a course to which its deviations to and fro across the broad interval have not since restored it.

In Acadian geology, page 61, it is stated:—"A very large proportion of the present feature of the surface is due to the denudation in the production of the boulder deposits. The ridges of Cumberland, the deep valley of Cornwallis and Annapolis, the great gorges crossing the Cobequid Mountains and the

* Mr Hartley, in the Survey Report for 1869, gives it as 1600 feet only.

western end of the North Mountains in Annapolis and Digby Counties: such eminences as the Greenhill in Pictou County and Onslow Mountain in Colchester are due in great part to the removal of soft rocks by denuding agencies of this period, while the harder rocks remained in projecting ridges. On the other hand it might be shewn that many masses of rock which once projected above the surface have been greatly diminished or entirely removed."

This supposition, that the glacial was a period chiefly of denudation, the deposits being little more than sufficient to leave a record of its existence is somewhat at variance with that already implied in this paper. But while there can be no doubt that denudation in part was a result of the glacial period, and the rounding of the Atlantic Coast hills certainly effected by ice in that and probably similar periods of previous ages, observations in the small section of country now under consideration seem to point to other conclusions, at least with regard to part of its configuration.

Some influence other than relative hardness of the strata to resist the abrading influence of ice would seem to have been at work in determining the positions of the hills and hollows. Take the case already referred to, the conjectural ancient valley of McCulloch's brook, it is not easy to suppose that ice in any form could have plowed it out, and worked in a deposit 60 and 80 feet thick, and at the same time left at levels two and three hundred feet higher measures of much softer texture. The conditions observed would be more readily accounted for by imagining that the face of the country previous to the drift period had very much the same general contour that it has to-day though somewhat less reduced in height no doubt, and that that contour was acquired by subærial denudation subsequent to the period of stratigraphical disturbance.

It would seem to be something more than a coincidence, the association of lines of lesser elevation and well marked dislocations. The bed of the east river follows through a very broken section of ground, the entrances into, and the exits from, the basin of other water courses are invariably associated with disturbed strata, and if it be rightly inferred that in the shattered rocks of dislocations subærial agencies would exert most influence, the association of the two is readily explained.

On the other hand, if it is assumed that the inequalities of the surface have been formed by the action of ice and marine currents, the reasoning applied to the clay ridges should be applicable to the hills and hollows, and approximate form and direction in rocks of uniform texture might fairly be expected.

This is not seen in the pre-glacial surfaces, which have been protected from subsequent erosion by the covering of drift.

But the faults that have circumscribed the basin and severed it into sections would rather appear to have been the primary cause for the hills and hollows assuming their present form under the hand of agents conveniently classed as subærial, acting through the ages that have been since the time when elevating and lateral pressures broke the uniformity of the carboniferous strata.

To clearly show this would require the field to be carefully mapped and contoured, which, unfortunately, has not yet been done. Such a map would further shew that the highest beds in the Marsh pit series, in fact the highest in the coal measure, is at the lowest elevation above the sea in the eastern section of the basin, and is overlaid by a small pond in shape of an arrow-head, whose edges are parallel to the strike of the strata on two sides of a subordinate fold.

ART. IX.—OUR FISHES AND THEIR ENEMIES. BY REV. JOHN AMBROSE, D. C. L., DIGBY, N. S.

(Read 24th March, 1890.)

THE fisheries have been truly described as "the harvest of the sea," "the harvest that never fails;" for although fish may easily be destroyed in vast quantities, or driven away from their accustomed haunts, still their amazing power of reproduction, and the impossibility of finding them in all the labyrinths of their surroundings, seem to set man's power of destruction at defiance. The fish harvest, however, cannot always be depended on, especially in localities where man's greedy interference with the laws of nature defeats his own purpose, and expels beyond his reach that which he would fain destroy.

The same short-sighted greed works still more rapid destruction in other productions of nature for the wants of man. From over-cropping and forest fires (mostly the result of carelessness), our timber supply, in this Province especially, is everywhere shewing premonitory signs of approaching exhaustion. Yet iron and other materials are largely taking the place of wood in building for marine and land purposes. Arboriculture will ere long be a matter of imperative necessity, and already legislators are beginning to protect the harvest of the seas and rivers, for the benefit of the present generation as well as of posterity. Our Republican neighbors are thus endeavoring to replenish some of their own denuded forest-lands, and also re-people their coasts and rivers with the finny tribes, and our own Government perceives the necessity of guarding our fisheries from depletion and ruin through modes of fishing which experience has shewn to be injurious to that country, as well as our own.

No other food-supply can take the place of fish, and the fisheries of our Dominion—under adequate protection and judicious management—will always furnish an unfailing and increasing source of wealth. I find by the Government Report of 1886 that for that year the fisheries of the Dominion reached a total value of $18,679,888. This was exclusive of the quantity of fish consumed by the Indian population in British Columbia, estimated at 25,000,000 lbs., and also of the total yield of Manitoba and the North-West Territories, of which only approximate data were available, which would increase the total value to fully $22,000,000. This was capable of great enlargement, yet we find the total value of the Dominion fisheries of 1888 was $17,418,570, shewing a shrinkage of no less than $1,260,718 in two years, largely attributable—as the Reports of Fish Overseers and Inspectors shew—to destructive agencies perfectly within the possibility of repression.

I have alluded to the possibility of man's selfish greed and folly neutralizing, to a large extent, the bounty of Providence by driving fishes from their usual haunts, or greatly reducing in these localities the effect of their marvellous reproductive power. To make this clear, it will be necessary to speak of the habits of our migratory food-fishes. The Creator, Himself, has informed us that fish—like birds—were produced from the water, and I may observe that not only in point of fertility did their native element place them in advance of animals formed from the ground, but the great similarity in the habits of fishes and birds seems to be a further confirmatory proof of their kinship. All birds and most fishes are oviparous. Now, as there is no surer way to change the ordinary habits of birds and cause them to forsake their accustomed haunts than by disturbing them when laying their eggs,—so fishes, obeying the great law of reproduction, forsake, after a time, the localities where this law of nature is subjected to persistent and destructive interruption. Were it not for the persistent denials of mill owners and other self-interested parties it would be unnecessary to state and insist on these self-evident preliminary facts.

Again, fishes, like birds, resent by change of *habitat* any continuous interference with their food-supply, or on the other hand can be tempted to leave their accustomed feeding grounds by more abundant bait at even more dangerous places. For example, our line-fishery along shore is now nothing to be compared with what it was before the commencement of trawl, or more properly, bultow fishing. "Trawls" or bultow lines were first introduced in 1874 off the shore of Digby County. As an example of the previous abundance of halibut along those shores, Capt. James Cousins, of Digby, states that in 1873, with six 'hands' in a small boat he caught, abreast of Gulliver's Hole*, in one slack of tide, with hand lines, 14 halibut. Now, he says, it would require four trawls, *i. e.*, bultow-lines with 2,400 hooks in all, to make an equal capture in the same time. The universal opinion of our fishermen is that bultow-lines destroy the inshore catch of all line fish to a very great extent. One cause assigned for this is that those set lines destroy too large a proportion of the gravid fish; another that they attract from their former inshore haunts all such fish to the distant banks at sea, where bultows abound, (and where so many fishermen attending them in their dories are, in foggy weather, lost or run down). Another means of destruction to line fishing is the offal of fish taken off the trawls and then thrown overboard, or eaten with the fish hangings from the set hooks. The "sound-bone" *i. e.* part of the vertebrae with the ribs attached, is swallowed by codfish, resulting in prolonged emaciation or death.

But a greater evil by far, as being infinitely more expensive and injurious to our shore fishing, arises from interference with the bait supply, formerly plentiful within our headlands and at the mouths of our rivers. Saw-mills and other mills in possession of the greedy and unscrupulous, have not only robbed posterity of their due share of the forest-trees, but by impassible dams, and vast accumulations of rotting sawdust and other decaying debris, have done and are now doing immense damage. Salmon, thus prevented from reaching their ancient spawning-grounds, or even if they could reach them from depositing their spawn amidst the gases of decomposing mill refuse, have been utterly expelled from streams formerly teeming with those delicious and gamesome fish. Nor is this all, for greater evil remains behind. Those dams have at the same time shut out alewives or

* Off Digby Neck.

gaspereaux, not only useful to man as a food-fish, but what is more important, one of the favorite bait fishes by which cod and other line-fish, so-called, were in other days drawn within the bays, estuaries and river mouths, and within reach of poor men, fishing near home with hand-lines. By means of the in-shore fishing many poor men in our country were enabled to obtain a livelihood in by-gone days, whereas this class of men in the present day, for want of means to prosecute the deep-sea fishery, are driven to seek employment in foreign vessels, poaching along our coasts, or find themselves compelled to forsake fishing altogether, and betake themselves to other and less congenial pursuits in other places. Even in my day, I have seen villages along our shores prosperous and growing, which are now half-deserted, whilst I have since met many of their former inhabitants, skillful and hardy fishermen, toiling at far less congenial employment in the neighbouring Republic and elsewhere.

> "Princes and Kings may flourish and may fall,
> A breath can make them as a breath hath made;
> But a bold peasantry, their country's pride,
> If once destroy'd can never be supplied."

The "exodus," of which some people in the Maritime Provinces complain, is clearly traceable in many instances to causes which a patriotic and unselfish foresight and wise legislation might in a large measure prevent. There is no better country for a poor man than that provided with abundant natural resources and a healthy climate, if these resources are properly developed and husbanded by those who take the trouble to understand and appreciate them, and work together towards the common benefit.

It may be said that our deserted fishing villages, being for the most part rocky and barren, were not worth preserving, but this cannot be said of the thriving villages on the shores of Digby Basin. But here a most valuable fishery is being very rapidly destroyed, and the delicate and delicious smoked herring, known all over the world as "Digby Chickens," will soon be a thing of the past. The mode of capture is by closely-woven brush weirs, not like net-weirs, permitting the immature fish to escape, but indiscriminately slaughtering all,—some to be smoked and salted, and the remainder to be carted ashore for manure. Not satisfied with this destruction of captured fish, an ingenious method has been discovered of breaking up and expelling the schools of fish swimming outside the weirs and near the spawning-grounds. Boats, carrying torches of oakum, saturated with kerosene oil, are to be seen any dark night in the fishing season in front of the Town of Digby, and in other parts of the Basin, catching with dip-nets the herring attracted to the boat by the light. Kerosene oil, abominable to the fish, dropping from the torches on the water drives away the fish, and, though but recently introduced, has already greatly injured the once famous Digby herring fishery.

Brush weirs have in like manner wrought much injury to the shad and gaspereaux fishery by their indiscriminate slaughter of the young as well as the mature fish. A net-weir, on the contrary, having the size of its meshes regulated and enforced by law, captures only the mature fish, leaving the rest to grow and multiply. Even net weirs should be kept open a certain number of times in each week—not less than five—to permit the gravid fish to ascend the rivers to spawn.

Outside the mouths of harbours, the purse-seine used within the three-mile limit by our own people, and outside of it by the Americans, is the means of destroying all fish captured by its use, except those sought by its owners, viz., mackerel, for large quantities of herring and other fish are killed and cast away. Purse seines, also, break up the schooling of mackerel and prevent their trimming the shore.

Another very injurious implement of fishing is the bag-net, enclosing, as it does, not only food-fishes, but many other species not used for human food, but very attractive as bait to line fish. The "lump fish," for example, boiled for the pigs by fishermen, are nevertheless, when not captured by bag-nets, very prolific depositors of large-sized spawn, eargerly sought for by line fish. Indeed, to mill-dams and sawdust in the stream, bag-nets and brush-weirs in the coves and harbours, and purse-seines and trawls, or bultow lines outside, may be fairly attributed the remarkable failure of our shore fisheries in recent years.

The so-called "sardine" factories in Maine make it their business to cut off the reproductive power of herring by purchasing none but immature fish. Most of the full-grown herring enclosed with them are first salted and next pressed for the extraction of their oil, the "pomace," or residue being sold for manure.

Eel weirs across our streams do much injury by preventing the egress of young gaspereaux and other small fish to the sea, and thus largely discounting the benefits which would here, as in western Canada, result from fish-culture in our lakes.

A word in parting with the subject of sawdust, shavings and other mill-refuse in our streams. Mill-owners are probably no worse, in a general way, than other people, but when direct pecuniary interest is the temptation it is but natural, though selfish, that reason becomes perverted. The conviction of all interested, in the fisheries, produced by actual observation and experience is that if our inland lakes and coves are to be thus filled up our fisheries will be ruined, not only by the prevention of spawning, but the expulsion of line-fish from our shores. It is of no use to insist on efficient fish-ways over mill dams, so long as the mill refuse prevents the accomplishment of the purpose which impels the struggle up the fish-ways.

Want of space forbids mention of other modes of destruction, waste or expulsion of our fish from our shores, formerly a favorite haunt for the finny tribes. We pass on, then, to a few remarks on the means at present in operation for similar destruction of our crustacean.

Oysters.—In the first place, to show the capabilities of our oyster-beds in the harbours bordering on the Gulf of St. Lawrence, it is well-known that comparatively a few years ago the abundance of oysters in those beds was so great as to effect their destruction. The beds so rapidly increased in height and diameter that the oysters in the midst of the mass were smothered by those above and around them, and when the accumulations approached the ice-level, those on the top were destroyed by the cold. The harbour of Shediac affords an illustration of this,—once famous for the abundance of its oysters, but now raked only for its dead shells, with their surrounding mud, to be used for agricultural purposes. Hence also the so-called mussel mud-beds of P. E. Island. The remedy in these cases is keeping the catch equal with the production, after these old beds are cleaned out and re-planted. But over-fishing is rapidly destroying the productive beds. For this reason, as Inspector Duvar reports:— "The oyster fishing in P. E. Island is in a deplorable state—overfished in some places, and in others not producing enough. There are no regulations whatsoever, except a close season from 1st of June to 15th Sept., to prevent the ultimate ruin of the beds, as they are open to be fished by everybody, and private culture has not been encouraged. Reckless fishing and continual shell-digging threaten a ruin to the oyster-fishing similar to that which from over-fishing has befallen the lobster industry. . . . It is time such profligate misuse of public resources should be checked.

"The oyster beds of New York give 7,000 oystermen a permanent living, and $6,000,000 is invested in culture therein. In the whole of Canada no one man makes his whole living from oysters, but less than 1,000 men give themselves occasional employment in oyster-catching in a perfunctory kind of way, and the total annual product at $3 a barrel is no more than $187,580, of which P. E. Island provides $109,324."

As a remedy against these evils, Mr. Duvar suggests: "(1) to reserve certain natural beds for fishing by the public; (2) to offer liberal encouragement for full development of the fishery under private culture; (3) to plant new beds and re-plant old ones (cleared of their dead accumulations, as a preliminary necessity, we presume, and a benefit to agriculture); (4) these improvements to be effected under efficient Government inspection, such as would guard against over-fishing and give leases from the Minister of Marine to plant, transplant or restock exhausted fisheries."

By the prevention of undue accumulation and consequent smothering of the parent-oysters, the spat or spawn would have full opportunity of rising and attaching itself to the hurdles or other objects in its native locality, thus insuring the natural and rapid increase in such protected beds. The capital required for oyster culture is very small and yields an amazing profit, as the oyster is in four years developed from the spat to marketable size, and in the meantime is nourished without cost to its owners. It is, moreover, a sure crop, if guarded with ordinary care; and there are abundant locations for oyster culture in the sheltered bays and estuaries bordering on the Gulf of St. Lawrence. The bed should be covered with tidal water, from one to six fathoms deep. Such bottoms as these are Government property, and the price of licenses to occupy them would yield an annual revenue more than sufficient to pay for their thorough protection, whilst conserving a great public benefit. But in the present unprotected state of the fishery, no one will venture on oyster culture. When at Shediac in March, 1887, I saw gangs of men with machinery propelled by horses scooping up dead oyster-shells and weed in large quantities for agricultural purposes, and was then informed that the vast quantities of oysters in those old beds have perished through their own fecundity, being either smothered or frozen, as I have already described. But, on enquiry, I found that all attempts at oyster planting in other parts of Shediac harbour had been frustrated by the interference of people living on the opposite shore. The hurdles placed for catching the floating spat had been pulled up, and the planted oysters taken out.

Lobsters were literally crawling in vast numbers near our shores but a few years ago. Very few canneries were then in operation. One was started, however, on a pretty vigorous scale at Sambro, by an American. There being then no legal protection against over-fishing, large and small, light and gravid, were canned, and soon—as I was informed by fishermen on the spot—the lobsters in-shore began to diminish in number very rapidly, as also to exhibit fewer individuals of large size, so that it became necessary to sink the traps much further from shore. This was an indication that the factory was rapidly cutting off the supply at head quarters, for these creatures invariably have the habit of coming in from deep water outside so soon as the tenants of coveted holes along shore are out of the way. The fishermen conversing with me at that time—when as yet canning on our shores was in its infancy, and lobsters in other harbours were abundant—predicted that the system pursued at Sambro, if imitated elsewhere, would in a very few years destroy the supply. The Sambro factory at first attempted boating lobsters from the neighboring harbours, which were so soon depleted as to compel the owner to remove it to Peggy's Cove at the mouth of St. Margaret's Bay, and shortly afterwards to collect from places still more distant from his factory.

Since my removal to Digby in 1870, where lobster canning did not commence until some years afterwards, I have noticed the same exterminating process in operation. Lobsters, until the canning began, could be captured by hand occasionally, crawling amongst the sea-weed on the flats at low tide, at Smith's Cove and the mouth of the Joggin, near this town. After the Digby factory began its operations, depletion soon became manifest. Lobsters are now brought to this factory, in the open season, from places as distant as Gulliver's Cove, some eight miles from this town. When the traps are brought ashore, too often containing small lobsters, these—instead of being returned to the water—are, in some cases, carried ashore for family consumption, or boiled for the pigs. Considering that it requires three years from the ova before the lobster is capable of reproduction, and that the average life of the creature is but about nine years, the evils of over-fishing and the destruction of the immature can scarcely be over-estimated. And yet, like some saw-mill proprietors, some lobster-catchers can be found in this selfish world clamouring in political newspapers and otherwise for larger extension instead of reasonable restriction of their destructive methods.

In the first case, the improved fish-way over mill-dams, with its lower end always in deep water, should be insisted upon in every instance, as also the utter prohibition of saw-dust and all other mill-refuse from our streams. In the other, lobster-traps should never be permitted near shore in shoal water, but at a reasonable distance outside, in not less than a depth of four fathoms. This, with an annual close season, certainly not shorter than the present length, would go a long way towards preventing the destruction of lobster-fishing, which at present seems inevitable, and in the near future. But restrictions such as these will require the appointment of active, impartial, and fearless inspectors and overseers in adequate numbers,—whilst the occasional and unexpected visit of a chief inspector, as in the case of Banks and Post Offices, would be of salutory effect in some places.

Last, but by no means least, let us hasten to avail ourselves to the fullest extent of the extraordinary facilities afforded by the very great number and suitableness of the lakes in this Province for fish-culture. The increase of salmon by this means, even under present protection, in Nova Scotia is very perceptible, as shewn by the Dominion Fishery Report of last year. This is capable of very great extension if not only human hinderers, but the lower order of depredators, such as eels, otters, etc., are circumvented.

The result of salmon culture in Nova Scotia lakes since 1876 is a return of six dollars for every dollar expended, as is shewn by the Report for 1889. But this system of fish culture in our lakes may be largely increased in its results by the introduction of white fish, (already begun). These delicious fish have already been multiplied to an amazing extent in Ontario,—and in Pennsylvania at an expenditure of $7,000, a business in these fish has been established worth one hundred thousand dollars a year by this means.

In short, for the protection and increasing benefit of our fisheries we need not only a 3-mile limit, but mainly an inshore limit, to protect "the harvest of the sea" from the blindly-selfish, who have no regard for the rights of those who come after them, no patriotic desire for the benefit of their country. Protection against such people is a matter of prime necessity, and should extend far within the 3-mile limit.

ART. X.—JOHN ROBERT WILLIS,

THE FIRST NOVA SCOTIAN CONCHOLOGIST.

A MEMORIAL.

HIS LIFE; HIS LIST OF SHELLS OF NOVA SCOTIA, AND HIS OTHER PUBLISHED WORKS.

Edited by W. F. GANONG, A. M.

INTRODUCTION.

It has been for some time past a source of much inconvenience and regret to some at least of the students of the Mollusca of Eastern Canada and New England, that the lists made by John Willis have been quite inaccessible. These lists have been frequently quoted by Gould, Stimpson, Dawson, Dall and others, and must form the basis for any future work of a similar character in this region. Yet they are not found in any of our large libraries, scientific or otherwise; neither the British Museum, nor those at Washington, at Philadelphia, at Boston, at Cambridge, at Ottawa, at St. John, nor at Halifax possess them, and so far as careful and systematic inquiries have been able to discover, there are but four or five copies of the principal list in existence, and all of them are the property of private individuals. There is no question as to its value, and the call for its preservation is imperative. Published as it was, privately and on a single large sheet, it was given to the world under conditions the worst possible for its preservation, and it is not surprising that it has been almost totally lost even from the carefully-guarded shelves of our largest libraries. Such lists can be sure of a permanent existence only in the pages of a regularly issued periodical of recognized standing, every number of which is jealously cared for by every good library receiving it. Nowhere could John Willis' list be so appropriately reproduced as in these volumes devoted to the Natural History of Nova Scotia, published in the city which reaped the benefits of all his life work, by the Institution of which he was one of the honored founders and first officers.

Moreover, it is not right that there should be lost to future students such records of the life and details of the personality of this man as may throw light upon his work or prove a stimulus to others. He may well be called the Father of Nova Scotian Conchology, and all Canadian students who have delight in this "fascinating science," as he himself calls it, must ever hold him in grateful remembrance.

These considerations have induced the Directors of this Institute and the editors of these notes to present the sketch of his life and his work and the reprint of his list, which are found herewith.

I.

JOHN ROBERT WILLIS.

BY HARRY PIERS.

JOHN ROBERT WILLIS was born in the city of Philadelphia, U. S A., on 14th February, 1825. His parents were John and Dorothy Willis. The former came from Cavan, Ireland, and the latter was a native of Durham, England. From Philadelphia his father proceeded to Kingston, Canada, where he settled his family for a short time, and then finally removed to Halifax, N. S. Here, in the old National School, young Willis* received his earliest education under the instruction of Abel S. Gore and his successor, James Maxwell. As a scholar he was diligent and ever ready for instruction. In 1846 a teacher was required to succeed Maxwell, and Willis was chosen to fill the position. He was thus transformed directly from a scholar into the principal of this important school† — no mean honour for one of his age. About 1850 he turned his attention to the special study of our mollusca, and at the N. S. Industrial Exhibition, held four years later at Halifax, we find him gaining a prize for the best collection of native shells. He also obtained another for the finest case of insects. From this time he seems to have been deeply engaged in collecting. In 1855 he desired to exchange his specimens for others, and thereupon opened a correspondence with Professor S. F. Baird, of the Smithsonian Institution—a correspondence which was kept up for very many years and established a great friendship between these two naturalists. It was at Baird's request that Willis compiled one of his earliest publica-

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*John had a younger brother named Edward, who was afterwards a member of the New Brunswick Government, and also well known as a journalist.

†The National School was then managed according to the principles of the Madras system of education, now fallen into disuse.

tions, a list of the birds of Nova Scotia,* from notes made in 1852–5 by Lieutenants Blakiston and Bland.

By 1857 Willis had gathered an extensive collection of our shells, which he forwarded to Dr. A. A. Gould for examination and identification In a similar way Dr. E. Foreman lent him a helping hand. Thus at various times we find boxes laden with precious shells being despatched to and from these naturalists for determination, examination or exchange. He also corresponded and exchanged with many other scientists, who seemed to be only too anxious for any information they might obtain regarding the natural history of our Province. Among these may be mentioned Dr. Wm. Stimpson, Dr. P. P. Carpenter, Sir J. W. Dawson, Sir Wm. Denison (Governor of Madras), Professor John Capellini (of the University of Bologna, Italy), Hon. Rawson Rawson (of the West Indies), Dr. C. J. Cleborne, Prof. E. D. Cope, and many others. It was in 1857 that his first known list of Nova Scotia shells was published.

Willis gave to the museum of King's College, Windsor, a large collection of native shells, consisting of about 123 named and 124 unnamed specimens. To this he added in after years. He presented a similar collection to Acadia College, Wolfville. His gifts, however, were not confined to conchology alone, for we find him repeatedly quoted as a donor of various articles to these and other institutions.

In 1859 he sent a box of Nova Scotian shells to the Smithsonian Institution where they were to be compared by P. P. Carpenter and W. Stimpson with the types in the museum of that Institution, and labelled accordingly. In reference to these shells Stimpson, in a letter to Willis, says: "I have as yet had time only to look them over in a general way, but I assure you even this cursory examination has convinced me that you have done a great service to our noble science, by discovering several shells on our coast which had escaped us all, thereby enriching our fauna and extending the geographical range of North European species." He adds a list containing nine species new to this coast and remarks: "There! If that starts your enthusiasm as it does

*See Bibliography on a later page, No. 2.

mine I have no fears that the conchological fauna of Nova Scotia will not be soon and well worked up." Mr. W. G. Binney and Dr. E. Foreman undertook the examination of the land and fresh-water species. Other boxes of shells were sent at various times to the Institution, a part to be kept, and the rest returned after examination.

The British Museum is indebted to him for a large collection of our shells which he presented in 1861, while the Boston Society of Natural History and the Philadelphia Academy of Natural Sciences, also received numerous specimens from his cabinet. He sent a fine set of Nova Scotian edible mollusca and pearls to the International Exhibition of 1861. For these he received honourable mention. A similar collection was forwarded to the Dublin Exhibition of 1865. He presented a large collection to the Smithsonian in 1863, the greater part of which, including all the small and critical species, was loaned to Stimpson for study, and was lost in the great Chicago fire of 1871.

Meanwhile his educational work was going steadily forward, and he was fast gaining fame as a thorough and painstaking teacher. In 1856 military drill was introduced and practiced in the National School, through the efforts of Willis and his friend, Dr. Charles Cogswell. Other schools adopted the novel and beneficial system, and four years later it was introduced into England and became very popular. Halifax, therefore, has the honour of taking the lead in this salutary movement, not only on this continent, but in Great Britain also.

Willis was one of those who were present at the formation of the Nova Scotian Institute of Natural Science in 1862, and he was elected its first Corresponding Secretary. During the same year he read a lengthy paper before the Nova Scotian Literary and Scientific Society (Halifax). It treated mainly of the edible mollusca of our Province, but a complete catalogue of Nova Scotian shells was also attached.* This paper was intended for the Smithsonian Institution, and Baird proposed to insert it in the Report. For some unaccountable reason, however, Willis did

*At this time Willis' collection is said to have consisted of over 8,000 distinct native and foreign varieties, embracing examples of most of the species then known to naturalists. It is doubtful whether there was a finer collection in this department throughout British America.

not take advantage of this offer, but published it instead, under the title "Our Edible Mollusca," in an obscure local periodical called the *Colonial Review*. With the exception of the list of species, Mr. T. F. Knight quotes this article almost entire in one of his pamphlets on the fisheries of Nova Scotia.*

Willis' worth was now being acknowledged abroad. In 1862 he was unanimously elected a corresponding member of the Liverpool (G. B.) Natural History and Microscopical Society; and in the following year he received the same honour from the Boston Society of Natural History.

In November, 1863,† he issued a privately printed list of Nova Scotian shells, his most important published work, which is reprinted in the present volume.

In 1863 an Industrial School was started in Halifax, and in the following year Willis was appointed to superintend the institution. On April 18th he formally resigned his position in the National School, much to the regret of those in charge. He was unquestionably an efficient and successful teacher. His school was described as being a model of good order and discipline, and his treatment of his pupils such as was intended to secure their confidence and respect. It was his honest boast that not one of his scholars had been known to turn out in a manner that would reflect discredit on his teacher. They ever entertained for him a warm affection, which in days of adversity was like a gleam of sunshine to his soul.

Sir J. W. Dawson had long exchanged and corresponded with Willis, and was his warm personal friend, and in 1864 he named a new species of Polyzoan in his honour—*Gemellaria Willisii*.‡

Willis was mentioned in connection with Dr. D. Honeyman as being well suited to take charge of a Provincial Museum, should one be founded in Halifax. These two gentlemen in 1865 ‖ pre-

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* Descriptive Catalogue of the Fishes of Nova Scotia. Halifax, 1866, pp. 43–53. See Bibliography on a later page, No. 4.

†At this time Willis says there were several of his collections of Nova Scotian shells—one in the Smithsonian Institute; one in King's College Museum, Windsor; one in Acadia College, Wolfville; and one in his own possession; and also the remains of what was once a good collection in Dalhousie College, Halifax, presented by him many years before.

‡ See full description in *Trans. of N. S. Institute of Natural Science*, vol. I, part 3, p. 3. Sir William Dawson tells us that Dr. Hinks regards it as a variety of *G. loricata* of Europe, but it is a very marked varietal form.

‖ Four years previously the Rev. Mr. J Ambrose and Mr. J. M. Jones had suggested to Willis the propriety of taking some steps in the matter, and the first-named gentleman had sent a communication upon the subject to "tune" the newspapers, as he termed it.

sented a memorial to the Government strongly advocating the establishment of such an institution, and Willis appeared personally before a committee which was to report upon the matter. Out of this movement grew the present Provincial Museum of Nova Scotia.

Having done good service in the Industrial School, Willis was appointed, in 1865, secretary of the newly-formed Board of School Commissioners for the City of Halifax. A year or so after this he was elected a corresponding member of the Academy of Natural Sciences of Philadelphia.

In 1875 he retired from his position on the school board, which he had occupied for ten years. From this time he was without an appointment and in poor circumstances. Finally, he was forced to part with the collection * which he had made with such care, and which represented the result of many years patient and unremitting labor. This almost broke his heart, and when the precious specimens left his house he wept like a child.

During the following year (1876) he was taken ill, and died on March 31st. He was buried in the Camp Hill Cemetery.

Mr. Willis was twice married. His first wife was Mary Anne, daughter of Wm. H. Artz, by whom he had three sons and three daughters. Of these, one son and two daughters are still living Mrs. Willis died in 1865. He married secondly Eliza Moseley, and they have had two sons and two daughters, of whom one daughter is dead. His second wife is still residing in Halifax.

In character Willis was eccentric. His great enthusiasm, however, made up to a large extent for this short-coming, and enabled him to persevere in most of his undertakings. It is said that on one occasion Mr. Hutton, formerly gardner to the Horticultural Society, possessed a century plant which was about to bloom. Willis, hearing of this, sat up patiently for two nights in order that he might witness the unfolding of the curious blossom. To his friends he was good and true. Being of a merry disposition, he was constantly interspersing his quick, animated.

* A great part of it still remains in Halifax, and is now the property of Mr. W. D. Harrington and Mr. E. J. Lordley.

talk with many a jolly laugh, which showed that even care could not altogether dampen his jovial spirits. He was an ardent conchologist, entomologist, floriculturist, and mineralogist, and it has been remarked of him that he added to a great store of knowledge a simple and unassuming nature, which perhaps stood more in the way of his prosperity than anything else—for the busy world crowds out the possessors of such qualities.

His conchological operations were carried on chiefly in the vacinity of Halifax. The "Harbour," Bedford Basin, Eastern Passage, and many of the outlying bays and inlets were constantly visited by his dredge, while fresh water ponds and streams were also duly ransacked and made to contribute to his growing cabinet. Whatever spare time he had, was thus spent in pursuit of his favorite study. He also made regular visits to the fish-markets, where he examined the contents of fish stomachs—those rich treasuries to the shell-collector. He left no field unsearched which could yield anything in his line of work, and this enthusiastic thoroughness was one of the marked features of his character. All who knew him speak of this, and of his amiability and quiet generosity.

II.

BIBLIOGRAPHICAL AND CRITICAL NOTICE OF WILLIS' PUBLISHED PAPERS.

The Publications of John Willis were not numerous, and so far as they are known to the editor they are as follows, arranged chronologically :

(1). 1857 (?). [A list of Shells of Nova Scotia, with explanatory letter.] *Church Record* (?), Halifax (?), Oct. 17, 1857, (?).

THE only copy known to us of this interesting list, which as the citation below shows, was the first written by Willis, is owned by Mr. W. H. Dall, of Washington, to whom we are indebted for the opportunity of examining it. It is a clipping from a newspaper and has the date given above (Oct. 17, 1857) written in ink clearly upon it. It is unfortunately torn irregularly across the top so as to partly obliterate the printed name of the paper in which it appeared. But the words " FOR THE CHURCH " can be clearly seen, with some fragments of letters following, from which Mr. Piers has surmised that the paper was the " Church Record," a paper published about that time in Halifax. Mr. Piers has found several clippings among Mr. Willis' papers which were taken from the " Church Record " acknowledging donations made by him to King's College, etc., so it seems quite certain that Mr. Piers' surmise expresses the truth. We have no reason to believe that the written date is not the correct one, and the shortness of the list compared with later ones proves that it is much earlier that these of 1862 and 1863.

The list gives generic and specific names only, arranged alphabetically, with no localities. It includes ninety-one species, some of which are shelled Crustacea or Echinodermata. It contains many misprints. It is signed " John R. Willis, National School, Halifax," and is preceded by a short letter which is so characteristic of the man that we reproduce it entire :

"Mr. Editor,—With you [*sic*] kind permission, I avail myself of the columns of your useful journal to publish a list of Testaceous Mollusca of Nova Scotia, collected by me up to the present time. I did not intend doing so until my collection, already pretty extensive, was completed, and I am now only induced to alter my plans, that I may not give offence to many impatient friends and correspondents, to whose opinion due reference should be paid—and who are anxious to know how much or how little Nova Scotia can produce in the conchological field. As many of the genera are but thinly represented in this Province, instead of classifying, I have merely arranged them, for the sake of reference, in alphabetical order, premising, of course, that many of your readers have some knowledge of the fascinating science of shells.

I will be pleased to give the localities, depths of water, &c., where any specimen can be procured, to any correspondent who may think proper to address me a *post-paid* communication on the subject. The name of any specimen marked * is new to the Province."

(2). 1859. List of Birds of Nova Scotia. Compiled from notes by Lieutenant Blakiston, R. A., and Lieutenant Bland, R. E., made in 1852-1855, by Professor J. R. Willis, of Halifax. *Smithsonian Annual Report for 1858.* Washington, 1859, pp. 280-286.

An annotated list of species containing occasional comments signed "J. R. W." It is the only publication of his known to us which does not deal with Mollusca. A "List of the Birds of Bermuda," by Lieut. Bland, R. E., in the same volume (pp. 286-289) is said to be "communicated by John R. Willis."

(3). 1862. Catalogue of the Marine Shells of Nova Scotia. By T. R. Willis *(sic)*, of Halifax. *Proceedings Boston Society of Natural History,* VIII., 1862, pp. 61–62.

This list was read before the Society in January, 1861. It is a list of names only, and gives only Marine Mollusca, of which 129 species are enumerated. As far as it goes it is very like the list in the *Colonial Review* described below (No. 4), like it including two species of *Cellularia* (a Polyzoan), and like it omitting several species to be found in his latest list (No. 5). Further comment on this is not called for; it is easily accessible.

in the proceedings of the Society. Its lack of localities greatly lessens its value.

(4). 1862. Our Edible Mollusca. *Colonial Review*, Halifax, Nov. 29th, 1862, and the three following numbers.

Only a single copy of this list is known to be extant, and that is in the possession of Mrs. John Willis, of Halifax. Its rather curious history has been carefully studied out by Mr. Piers. In March 1852, Professor Baird asked Willis to send him the MSS. of the article on Edible Mollusca for publication, a request which he repeated in June. In April of the same year Willis read it before the N. S. Literary and Scientific Society. "previous to its transmission to the Smithsonian." But it apparently was never sent, for it does not appear in the Smithsonian publications, but was published in November in the *Colonial Review*. This journal, as Mr. Piers has discovered after much careful inquiry, was published in Halifax and suffered an early demise after the issue of only half a dozen numbers. It was a four columned (10x11½ inch) paper whose editor was known only by his *nom de plume*, and the place of publication of which was not generally known.

Three numbers contain the interesting paper on Nova Scotian Economic Mollusca, while the fourth contained a complete list of all known Nova Scotian shells. The date of the first issue alone is known to us, those of the other three not appearing on Mrs. Willis' copy. The first three articles, with the exception of a single paragraph and one or two sentences, were reprinted word for word in Thomas F. Knight's "Descriptive Catalogue of the Fishes of Nova Scotia" (Halifax, 1866, pp. 43–53), a work which is easily accessible. This was an admirable statement of the value of Nova Scotian Mollusca to man, and has been freely quoted and its substantial assistance acknowledged in a late work on the "Economic Mollusca of Acadia," published by the New Brunswick Natural History Society.

The fourth number contained a list of Nova Scotian shells. Mr. Piers tells us that this was very like his latest list, which is reprinted below. It included only two names which are not in the latter, which are *Cellularia fastigiata*, Blum., and *Cellularia turrita*, Desor, two Polyzoans. With these exceptions everything in the *Colonial Review* list is in the list below, and the latter includes ten names not in the former, *i. e.*, Nos. 4, 55, 57, 78, 87, 158, 196, 199, 200, 201, of the following list. It therefore included 193 names, a large advance over the 1857 list, which included 91. Further comment on this list is needless, since its substance is embodied in the one below. It has probably been seen by very few naturalists.

Another list of Economic Mollusca of Nova Scotia, which was probably written by Willis, appeared in the Catalogue of the Nova Scotian Department of the International Exhibition of 1862 (Halifax, 1862, p. 13). The list includes 18 species, with notes on their abundance, and it is stated that they are to be furnished by J. R. Willis.

(5). 1863. Nova Scotia Shells. *Privately printed list, issued in November*, 1863.

This is Willis' latest, longest, and in all ways most important list of Nova Scotian Molluscs, and it is reproduced in full, word for word, below. It was printed on a single sheet, 14x8 inches in size, with the introductory notes printed across the top of the entire sheet and the list itself arranged in three columns. Mr Piers has found amongst Willis' correspondence, now in possession of Mrs. Willis in Halifax, several newspaper clippings and letters of acknowledgment from various persons to whom the list was sent, the dates of which make it certain that it was issued in November, 1863. It is this list which has been quoted by various writers. As Mr. Piers suggests, he appears to have taken his *Colonial Review* list (No. 4), and having struck out two names, to have added some others with additional notes on distribution, etc., and to have published this as the list we are now considering.

As already referred to, the list is now very rare, no large libraries owning copies. The only copies known to us are those belonging to Mrs. Willis of Halifax, to Sir William Dawson, to Mr. Dall of Washington, and to the editor of these notes, into whose hands it came from the library of the late J. Matthew Jones, as the gift of the son of the latter. Each of these copies has pen and ink corrections of misprints, etc., by Willis himself, none of which are important.

That all the facts contained in it are reliable we have not the slightest doubt. Not only was Willis an exceedingly careful man, but he had the advantage of constant correspondence with Stimpson and Gould, Foreman and Binney, and these men determined for him his doubtful species. They had themselves confidence in him, as shown by their frequent citations of facts on his authority, Stimpson especially, having quoted him frequently in his unpublished work on Northeast American Molluscs. Gould, in his splendid work on the Invertebrates of Mass. (2nd ed.) constantly quotes Willis, and Sir William Dawson does also in his works on the Post-Pleiocene Geology of Canada. We can have no better proof of the reliability of his work than is shown by the confidence reposed in him by his contemporaries.

The value of his list must consist chiefly in the fact that it was the first detailed list of Nova Scotian Mollusca which gives exact localities, range, and relative abundance; and this means more than appears on the surface, for not only has it enabled American naturalists to extend the range of species on our coast, and therfore has helped to wider and more accurate generalizations, but it preserves a record tolerably complete and accurate, as far as it goes, of distribution of forms at that period. The fauna of this region is not stable, but is constantly changing, and a century from now some of the forms will have a range very different from that described by Willis, and the Zoologists of that date will thank him for having preserved a precious record for them. He was the first man to point out the occurence of Southern forms upon our coast, in the Gulf of St. Lawrence, and on Sable Island, living surrounded by cold-water forms, far north of their proper home, which is to the south of Cape Cod. Sir William Dawson had discovered these facts, it should be said, as soon as had Willis, or sooner, but Willis was the first to publish them. This subject has attracted the attention of later students, including Professor Verrill, Sir William Dawson, and the present writer, and all of them have found Willis' discoveries, as embodied in his list, of the highest value.

(6). 1863. On the Occurrence of Littorina Littorea on the

Coast of Nova Scotia. *Transactions Nova Scotian Institute*, vol. I., 1863, pp. 88–90.

In this paper Willis describes his discovery of the occurrence of this European species on the shores of Nova Scotia, and gives the facts then known to him as to its distribution. He found it pretty widely scattered in Nova Scotia, and inclined to the opinion that it is indigenous. This was not, however, his first announcement of his discovery, for in the proceedings of the Philadelphia Academy for 1860, p. 148, occurs a note in which it is stated that he announces the discovery of this species, along with a European Brachiopod, in Nova Scotian waters, and he had, moreover, included it in the earlier "Church Record" list described above (No. 1).

But the paper under consideration was the first of a number of papers on and references to the subject, the chief of which are those by Professor Verrill in *American Journal of Science*, Vol. IV, 1874, p. 133, and again in the same, Vol. XX. p. 251; by A. F. Gray in *Science News* for 1879; by Professor E. S. Morse in *Bulletin of the Essex Institute*, Vol. XII, 1880, pp. 171—176; and by W. F. Ganong in *American Naturalist*, Vol. XX, 1886, pp. 931—940 and Vol. XXI pp. 287—288. It cannot be said that the question as to whether this species be native or introduced is yet settled, for though the weight of evidence and opinion points to the latter conclusion, some others whose opinion in such matters is of high value, hold the contrary view. But Willis undoubtedly is entitled to the credit of being the first to announce the discovery of this species in America, though its presence in the Gulf of St. Lawrence was observed by Sir William Dawson about the same time that Willis found it near Halifax.

In estimating John Willis' position among naturalists, and his services to science, it must be remembered that the circumstances of his early life and surroundings were not such as to develop a naturalist of broad training and sympathies. Under different circumstances, the tastes and perseverance which found vent in enthusiastic collecting and careful classifying might have fitted him for wide knowledge and deep research. It is as a careful, persevering, and discriminating collector in a limited field that he rendered service to conchology. It cannot be said that he added anything of importance to science as a whole, facts of distribution within limited areas hardly deserving such a rank, but, content to work a limited field, he drew from it all it had to offer him and freely shared its fruits with all who cared to share them. Others saw better than he the significance of the facts he collected, and made the proper use of them. Such work as his is needed by science, and the man is a benefactor who does it well, no matter how limited his field may be, and the moral effect of work well done is as wholesome in science as it is in other affairs.

Willis was a naturalist of an old, but happily not yet extinct type, one who loved nature for her own beautiful sake and not as those who make her works playthings for their delicate anatomical tools and an excuse for their own self-glorification. Such men as Willis have a distinct value, and they are too rare in these days of much closet-work. They cannot do much as a rule to add to science, but they do much to utilize its advances and translate its necessary technicalities into pleasant knowledge for themselves and others.

Such was John Willis, a man whose name will not be found among those which mark the line of scientific advance, but one who made the most of what circumstances allowed him, and who gave to the world the best that the limited field in which he worked was capable of yielding.

III.

WILLIS' LIST OF NOVA SCOTIAN SHELLS, 1863.

The following list, which has been described in the preceding bibliography (No. 5), is re-printed as nearly like the original as possible, even mis-prints being retained, and without explanation where they are not misleading. No attempt has been made in editing it, to correct the synonymy except where it is very misleading, or to add any information except where such is contained in other papers by Willis. Comments on localities are added, not when the range has been extended by later researches, but only where these researches seem to show that the list is in error. It is in a word a re-print of John Willis' list, and we have not attempted to make it a modern list of Nova Scotian Mollusca. The editor is of course responsible for all of the foot-notes.

Nova Scotia Shells: By John Robert Willis, Principal N. School, Halifax, Nova Scotia.

The following Catalogue of a collection of the MARINE, LAND and FRESHWATER SHELLS of Nova Scotia Mollusca, which I presented a short time ago to the Smithsonian Institute, Washington, D. C., embraces all the species which I have been enabled to collect during many years study and labour, up to 1862.

I am greatly indebted for specimens to Prof. J. W. DAWSON, F. R. S., Montreal; to Dr. J. BERNARD GILPIN, Halifax; THOS. BELT, Esq.; P. S. DODD, Esq., Sup'tdt Sable Island; Rev. J. AMBROSE, M. A., St. Margaret's Bay; Mr. JAS. FARQUHAR, Sable Island, and some other kind friends. I am also under grave obligations to Dr. A. A. GOULD, Boston, Prof. STIMPSON, Cambridge and Dr.

E. FORMAN, late of the Smithsonian Institute, for identifying obscure specimens for me.

It will afford me much pleasure to supply any information relative to the habitats, and mode of collecting any of the species I have been enabled to secure, so far as my experience and limited acquaintance with the fascinating science of Conchology will warrant.

From an examination of the Catalogue it will be seen that the Serpula and Vermetes are missing therefrom—though I have a number of species on hand, I have as yet been unable, from press of other matters, to turn my attention to these beautiful and interesting classes.

PALLIOBRANCHIATA.*

Rhynchonella psittacea, † GM. Banks of St. Margaret's Bay, &c.

Waldheimia cranium, † MULL. Banks of St. Margaret's Bay, &c.; very rare.

Terebratulina septentrionalis, COUTH. Halifax Harbor, &c.; common.

Terebratula Labradorensis. *Stimpson Fishery Banks Rare.* ‡

LAMELIBRANCHIATA.

Anomia Ephippium, LIN. From the wreck of the frigate "Tribune," lost off Herring Cove, about 70 years ago; specimens procured by a diver; not rare.

Anomia Aculeata, GM. Parasitic on lobsters, &c.; common. Vars. Squamula et Electrica.

Ostrea Virginiana, LISTER. Wallace, Tracadie, Mabou, &c.; abundant. } Perhaps syn.

Ostrea Borealis, Lam. Tatamagouche, &c.; abundant. § } Perhaps syn.

Lima Sulculus, LEACH. Sambro Bank, Sable Island Bank; very rare. ||

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* These divisions are crossed out by Willis in some of his lists.

† Sars, in his splendid Mollusca Regionis Arcticae Norvegiae gives both of these as occuring on the north-east coast of America. Did he take Willis' authority for it?

‡ These words are added to the list in Willis' handwriting.

§ Shells of this species, or rather, variety, are said to have been found at Sable Island. A. L. Adams, "Field and Forest Rambles," p. 35.

|| Has not been found elsewhere in American waters. Binney, in his edition of "Gould's Invertebrata of Mass.," 1870, p. 200, appears to accept the identification of the species as correct

Pecten Magellanicus, LAM. Sable Island, Mahone Bay, Lunenburg, &c.; common.

Pecten Islandicus, CH. Halifax Harbor, St. Margaret's Bay, Sable Island, &c.; common.

Pecten Concentricus, SAY. Sable Island only.*

Nucula Tenuis, MONT. Sambro Banks, &c.; com.

Nucula delphinodonta, MIGH. Fishery Banks; rare.

Nucula proxima, SAY.	Do.	do.
Yoldia pygmaea, † MUNCEY.	Do.	do.
Yoldia thracieformis, STOKER.	Do.	do.
Yoldia sapotilla, GOULD.	Do.	com.
Yoldia limatula, SAY.	Do.	do.
Yoldia Myalis, COUTH.	Do.	do.
Leda tenuisulcata, COUTH.	Do.	do.
Leda Minuta, MULL.	Do.	rare.

Modiolaria substriata, ‡ GRAY. Halifax Harbor; do.

Modiolaria nigra, GRAY. Do. do.

Modiolaria discors, LIN. Sambro Bank; not uncommon.

Modiolaria corrugata, STM. Sable Island; rare.

Modiola plicatula, LAM. Wallace, Tracadie, Sable Island, Pictou, &c.; not scarce.

Modiola vulgaris, § FLEMING. Whole coast; com.

Mytilus edulis, LIN. Do. do.

Unio complanatus, LEA. Common to most lakes in Nova Scotia.

Unio radiata, LAM. Grand Lake, on line of Nova Scotia Railroad; not common.

Unio ———, (?) Dartmouth Lakes, perhaps new to Nova Scotia. J. R. W.

Anodonta Ferussaciana, ‖ (?) Dartmouth Lakes; common.

Anodonta Implicata. Lakes on line of Railroad; rare.

Anodonta ——— (?). Two varieties, from Prof. McCULLOCH, probably new to Nova Scotia; St. Mary's River, Truro.

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* Either this species, or the preceding, probably this, occurs in the shallower parts of the Gulf of St. Lawrence. See Bull. Nat. Hist. Soc., N. B. No. VIII., pp. 68, 69

† *Leda pygmaea*. A European species, not yet reported elsewhere in American waters except by Jeffreys (Brit. Conch. V., p. 173), who gives Scandinavia and Maine.

‡ *Montacuta substriata*, Mont. It has not been reported from American waters by any other writer.

§ *M. modiolus*.

‖ Undoubtedly some other species. Lea (Obs. genus Unio., X, p. 87), gives this species only from the Ohio Valley.

Alasmodonta margaritifera. Rivers in Annapolis; Sackville River also; pearl producing.

Cyclas Partumeia, SAY. Nearly all of the N. S. Lakes; common.

Cyclas similis, SAY. St. Mary's River, Truro, from Prof. McCULLOCH, Truro.

Pisidium dubium. Dartmouth Lakes, &c.

Thyasira Gouldii, ST. (?) Whole coast; common.

Serripes Groenlandicus, * CH. St. Margaret's Bay, Bedford Basin; rare.

Cryptodon Gouldii, PHIL. †

Cyprina Islandica, LIN. Whole coast; common.

Astarte Striata, LEACH. ‡ Fishing banks; rare.

Astarte semisulcata, LEACH. Do. common.

Astarte crebricostata, FORBES. Do. do.

Astarte lactea, BR. & SOW. §

Astarte castanea, SAY. Halifax Harbor; common.

Astarte elliptica. N. S. (?); doubtful.

Cardita Borealis, CON. Fishing banks; common.

Cardium Islandicum. Bedford Basin, Halifax; rare.

Cardium pinnulatum, CON. Fishing banks.

Cardium edule, CON. Fishing banks; rare, young only; doubtful species. ‖

Mercenaria violacea, ¶ SCHUM. Wallace, Tracadie, Sable Island; common.

Kellia Rubra, GOULD. Sable Island, &c.; common.

Gemma Tottenii, STM. Fishing banks; rare.

Turtonia Minuta, F. ET H. Sable Island; common.

Callista covexa, SAY. Sable Island; rare.

Tapes fluctuosa, GOULD. Fishing banks; rare.

Mactra gigantea,** (?) GOULD. Sable Island; com.

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* *Cardium Grœnlandicum.*

† The same species as *Thyasira Gouldii* above, though *Cryptodon Gouldii* is the proper name. Its repetition in the list must have been an oversight.

‡ *Astarte compressa*, according to Jeffreys (Brit. Conch. II., 316 and V. 183), occurs on north-eastern coast of America.

§ Now considered a synonym for *A. semisulcata.*

‖ The presence of *C. edule* in American waters has not been confirmed. This was almost certainly the young of another species, probably of *C. Islandicum.*

¶ *Venus mercenaria.*

** In his account of the "Edible Mollusca of Nova Scotia" (reprinted in Knight's Descr. Catalogue of the Fishes of N. S.), Willis shows us clearly by his description of their size and shapes, that by *M. gigantea* he meant what is now called *M. solidissima*, and by *M. solidissima* he meant our *M. ovalis.*

Mactra solidissima,* (?) CHEMN. All of Nova Scotia sand beaches: common.

Ceronia arctata, CON. Fishing banks, Sable Island; rare.

Ceronia deaurata, TURT. Do. do.

Tellina Fusca,† PHIL. Whole coast; common.

Tellina proxima,† BROWN. Fishing banks; scarce.

Tellina tenera, SAY. Fishing banks; scarce.

Macoma subulosa,‡ SPENGL. Do. rare.

Macoma fragilis, ‡ O. FABR. Do. do.

Solen Ensis, LIN.§ All of Nova Scotia sand beaches, Sable Island; common.

Machæra Squama, BLAMR. Fishing banks; rare.

Solenomya velum, SAY. Fishing banks; very rare, have only fragments to identify by.

Solenomya borealis, TOTT. do. do.

Mya truncata, LIN. Dredged in Bedford Basin, Halifax. Dead specimen.

Mya arenaria, LIN. Whole coast; very common.

Crytodaria Siligua, SPENGL.|| Fishing banks; very common.

Petricola Pholadiformis, LAM. Sable Island; rare.

Saxicava Arctica, LIN. Whole coast; common.

Savicava Distorta,¶

Aanatima Papyracea,** SAY. GOULD, Sable Island.

Cochlodesma Leana, CON. Fishing banks; scarce.

Thracia truncata, MIGH. Do. do.

Thracia Myopsis, MOLL. Do. do.

Lyonsia arenosa, MOLL. Fishing bananks; rare.

Pandora trilineata, SAY. Sable Island; rare.

Pholas crispata, LIN. Sable Island; gigantic specimens.

Teredo dilatata, STM. Do. do.

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* In his account of the "Edible Mollusca of Nova Scotia" (reprinted in Knight's Descr. Catalogue of the Fishes of N. S.), Willis shows us clearly by his description of their size and shapes, that by *M. gigantea* he meant what is now called *M. solidissima*, and by *M. solidissima* he meant our *M. ovalis*.

† *Macoma fusca* and *proxima* respectively.

‡ Considered by Gould as synonymes of *Macoma proxima* and *fusca*, respectively.

§ Meaning, of course, what is now considered var. *Americana*, Gould, or by some a distinct species.

|| *Glycymeris siliqua*.

¶ Synonom for *S. rugosa*, which is probably but a variety of *S. arctica*.

** Misprint for *Anatina papyracea*.

TEREDO ———, (?) J. R. W. Perhaps T. Navalis. Collected for me by Mr. FRANCIS BENTLEY, from one of the rough logs in his father's spar yard; very fine specimen.

GASTEROPODIA

OPISTHOBRANCHIATA.

Philine quadrata, WOOD.	Fishing Banks;	rare.
Philine lineolata, COUTH.	Do.	do.
Scaphander puncto-striata, M.	Do.	do.
Diaphana debilis, GOULD.	Do.	do.
Utriculus pertenuis, MIGH.	Do.	do.
Cylichna alba, BROWN.	Do.	do.

PROSOBRANCHIATA.

Chiton marmoreous, O. FABR. On stones, Halifax Harbor; ten fathoms.

Chiton laevis,* PENN.	Do.	do.	do.
Chiton albus, LIN.	Do.	do.	do.

Chiton Emersonii. Bedford Basin; common.

Tectura Testudinalus; common; whole coast.

Tectura ———, (?) new to me; from Professor MCCULLOCH, Truro, N. S.

Lepeta caeca, MULL. Fishing Banks; very rare species.

Pilidium rubellum, O. FABR.† Do. do.

Crepidula unguiformis, LAM. Sable Island, Wallace, Bay of Fundy.

Crepidula convexa, SAY. Sable Island.

Crepidula fornicata,‡ LIN. Whole coast; common.

Crepidula glauca. By T. BELT, Esq., F. G. S.

Cemoria Noachina, LIN. Fishing banks and Halifax Harbor, ten fashoms.

Margarita Helicina. O. BARR. Halifax harbor; common.

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* This is a European species which has not been reported from American waters by any other writer.

† We are not sure to what species Willis here refers.

‡ Probably too broad a statement. It is not found on Bay of Fundy coast of N. B., and probably not on Bay of Fundy coast of N. S., except in sheltered situations.

Margarita argentata, GOULD. Fishing banks.
Margarita obscura, COUTH. Do.
Margarita varicosa, MIGH. Do.
Margarita cinerea, COUTH. Do.
Margarita Groenlandica,* MIGH. Do.
Ianthina fragilis, GOULD. Only a fragment found at Sable Island to identify by; probably a drift shell.
Paludina decisa, PAY. Many lakes of Nova-Scotia—not rare.
Amnicola porata, GOULD. Dartmouth lakes; common.
Amnicola limosa, GOULD. Block-house Pond, vicinity of Halifax.
Skenea Planorbis, FABR.
Rissoa minuta, TOTT. Common at low water.
Lacuna vincta, MONT. Fishing banks; common.
Littorina littorea, LIN. Whole coast; very com. Extends to P. E. I., N. F. L., and Labrador.†
Littorina paliata, SAY. Do. do.
Littorina rudis, Mont. Do. do.
Lacuna fusca.‡ Fishing banks; common.
Scalaria Groenlandica, PERRY. Fishing banks; scarce.
Turritella erosa, COUTH. Fishing banks; scarce.
Turritella reticulata, MIGH. Do. do.
Aporrhais occidentalis, BECK. Bay of Fundy, Sable Island; rare.
Bittium nigrum, TOTT. On eel-grass, Pictou. Prof. J. W. DAWSON.
Menestho albula, MULL. Fishing banks; very rare.
Velutina zonata, GOULD. Fishing banks, Halifax Harbor; very rare.
Velutina haliotoides, MULL. Do. do.
Marsenina Groenlandica, M.§ Do. do.
Natica clausa, SOW. Do. do.

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* This is probably a variety of *M. undulata*.

† Its presence in Newfoudland and Labrador has not been confirmed by other writers. We cannot find that Mr. Willis gives elsewhere in his writings any authority for the statement as to its occurrence in either place.

‡ We are not sure to what species Willis here refers.

§ *Lamellaria perspicua*. St.

Lunatia heros, SAY. Sable Island, Nova Scotia sand beaches.*
Lunatia triseriata, SAY. Sable Isld. Fishing banks.
Lunatia Groenlandica, MULL. Do. do.
Mamma (?) immaculata, TOTT. Do. do.
Bulbus flavus, GOULD. Do. do.
Amauropsis helicoides, JOHNS. Do. do.
Bela turricula, MONT. Do. do.
Bela harpularia, COUTH. Do. do.
Bela violacea, MIGH. Do. do.
Bela decussata, COUTH. Do. do.
Bela pleurotomaria, COUTH. Do. do.
Columbella rosacea, GOULD. Do. do.
Purpura lapillus, LIN. Whole coast; very com.
Nassa obsoleta, SAY. N. W. Arm, Halifax Harbor, Pictou, &c.
Nassa trivittata, SAY. Whole coast; common.
Buccinum undatum. Do. do.
Buccinum ciliatum, O. FABR. Fishing banks; rare.
Fusus pygmaeus, GOULD. Whole coast; common.
Fusus Islandicus, CHEMN. Annapolis Basin, Sable Island, &c.
Fusus decemcostatus. Annapolis Basin, Sable Island, St. Margaret's Bay.
Trophon craticulatus, O. FABR. Fishing Banks.
Trophon clathratus, LIN. Fishing Banks.
Trophon scalariformis, GOULD. Do.
Trichotropis borealis, B. & S. Do.
Trichotropis Atlanticus.† Do. very rare.
Admete viridula, O. BABR. Do.
Fasciolaria ligata, MIGH. Do.
Auricula denticulata, GOULD (?) Halifax harbor; common.

PNEUMOBRANCHIATA.

Ancylus parallelus, HALD. In most lakes and ponds; common.
Limnea culumella, SAY. Do. do.
Limnea catascopeum, SAY. Dartmouth lakes; rare.
Limnea elodes, SAY. Pond near King's College, Windsor, N. S.

* In his account of edible Mollusca, Willis tells us he has specimens of this species from Sable Island four or five inches in length, and broad in proportion. They are not known to attain this size elsewhere in Acadia, though to the south, on the New England coast, they become as large

† Now considered a synonym for *T. borealis*.

Limnea modicella, SAY—GOULD. Pond near Fort Needham, Halifax, N. S. J. R. W.

Physa heterostropha, SAY. Common.

Physa ancillaria. Dartmouth.

Physa aurea. Dartmouth; T. BELT, Esq., F. G. S.

Succinea obliqua. Common.

Succinea avara. Common.

Succinea ———, (?) Sable Island; a wonderful fact;* collected for me by P. S. DODD, Esq.

Planorbis bicarinatus, SAY. Dartmouth lakes, &c.; common.

Planorbis deflectus, SAY. Do. do.

Planorbis Trivolvis, Do. do.

Planorbis dilatata, Do. do.

Pupa ovata. J. M. JONES, Esq., Halifax; environs of Halifax, T. BELT, Esq.; rare.

Helix nemoralis, LIN. Perhaps imported; common.

Helix hirsuta, LAY. Do. do.

Helix hispida, GOULD. Do. scarce.

Helix cellaria, MULL. Do. do.

Helix minuta, SAY. In the woods west of Halifax; scarce.

Helix lineata, SAY. Do. do.

Helix chersina, SAY. Do. do.

Helix electrina, GOULD. In the woods, about 12 miles west of Halifax; scarce.

Helix striatella, GOULD. Do. do.

Helix arborea, GOULD. Do. do.

Helix alternata, SAY. Environs of Windsor, N. S.; common.

The following specimens were accidentally omitted.

Spirula Peronii, LAM. Sable Island.

Coronula Diadema, GOULD. Sable Island, Whales Back.

Balanus miser, LAM. Whole coast.

Balanus Geniculatus, STM. Dredged in Bedford Basin. Fine.

Balanus elongatus, GOULD. Common.

Anatifa vitrea, LAM (?). About Sable Island,

Anatifa laevis. Common.

Anatifa ——— (?), Perhaps new to Nova Scotia. J. R. W.

* Probably carried by aquatic birds.

Valvata ——— (?). J. M. JONES, Esq.

Panopœa Norvegica. Dredged by me in Bedford Basin, Halifax, but all dead specimens.

Buccinum ——— (?). Entirely new to me; differs distinctly from B. Undatum. Collected for me by MR. JAS. FARQUHAR, on Sable Island; only one specimen.

Fissurella ——— (?). Also new to me; from Sable Island. Collected for me by P. S. DODD, Esq., Sup'tdt. Sable Island.

Testacella Haliotoidea (?). FORBES & HANLY. Collected for me by MR. HARRIS, Richmond Nursery; perhaps imported; only one specimen.

Art. XI.—Our Common Roads—By M. Murphy, *C. E., Provincial Government Engineer, N. S.*

There is a very great amount of labour employed, not only in bringing the product into existence, but in making it when in existence accessible to those for whose use it is intended. Many important classes find employment in some function of this kind. The distribution of our products is just as important as their production. There is the whole class of carriers by land or water distributing the products of the sea, the farm, and the mine, and in doing so rendering just as important services as if they were the producers. It is enough if the producer and the carrier contribute sufficiently towards necessary consumption; they are all agencies of production, and all are essential, and influence the progress of society. No less important are the arteries of distribution or transport, such as railways, roads, water conveyance, etc. Roads are frequently, in our Colonies, made by the Government, and opened gratuitously to the public, and in this case each producer, in paying the quota of taxes levied, pays for the use of those roads which conduce to his convenience, and if they are made with any tolerable degree of judgment, they increase the returns of his industry by far more than an equivalent amount.

One of the problems of to-day—one that must largely affect the future of this country, and upon which a large proportion of public money is annually being expended — is that of road-making. We cannot say that the day of the ordinary highway is past or has become less important because we are introducing railways. Each means of communication has its own use, and the office of each is, not to displace the others, but to supplement them; and although the study of road-makiug for the past fifty years has been eclipsed by the great structural works resulting from scientific research and engineering skill, which have contributed so much to the advancement of civilization, it is not of so trivial and subordinate a nature as it may at first appear. It is to be hoped that it will be shewn this evening that the subject of this paper is one which, however it has been neglected in our Province, offers a wide and promising field for the skill of those who may be intrusted with the control and maintenance of the highways of this country, and that it is brought before you in such manner as may be acceptable to the President and members of this Society.

Now, the author holds that there is just as much science and engineering skill required in the practice of road-making as there is in any one of the branches of the engineering profession with which he is acquainted. He is not, however, to be understood to say that the practice of road-making is an exclusive one. On the contrary, there is room for all. There is too often a mutual distrust between scientific and practical men, and though it is year by year decreasing as progress and civilization increase, it still exists, and is largely to be ascribed to the misinterpretation of a term, which term is in this case "science." What, then, does the term science actually signify ? Simply:

A knowledge of facts the result of observation ; or

A knowledge of laws obtained by reasoning on combined facts.

If we add a power and a habit of reflection, that may help us in extending or developing the law itself beyond the limits of the observed facts, and enable us to advance into new regions of inquiry, we may be able to foretell facts which are at the time beyond the range of our practical experience.

We have the rules and laws that govern road-making in Great Britain, as practised by McAdam, Telford and Parnell, as well as those of more modern experience, to which we shall refer further on, and we doubt much if any of these systems would be judicious to adopt in our climate. We must, therefore, adapt ourselves to the science, the ordinary experience, of our daily life, and reduce them to rules of precision. We want a proper method of locating country roads with due regard to grades, tractive force and economy of construction. This is science, and may be made familiar to any intelligent non-professional reader. We want a better knowledge with respect to the selection of such materials as seem necessary and desirable, having regard to practical worth and greatest endurance; and thirdly, we require better systems of application. All these requirements can only be obtained by a knowledge first acquired by induction from facts observed, and to the mechanical skill applied in aid of it.

The formation of public roads and carriage ways, with their accessories, bridges and viaducts, was possibly the first manner in which the occupation of the engineer was developed. The author may therefore be pardoned for introducing the subject by reference to the road-making of the ancients, from which our systems have to a large extent been gradually evolved. The ancient capital of Mexico was approached from various directions by paved roads, from two to three miles in length, and thirty feet in width. Bernal Diaz, companion of Cortez in his conquest of Mexico, so describes it. When the Spaniards under Pizarro first invaded Peru, they found, among other indications of civilization, a net-work of highways superior to those in their own country. Roads traversed Quito, passing through Cuzco, into the empire of Chili. It is on historical record that there were over 1,700 miles of these roads, and that they were paved with large flags of freestone, and in many places set in asphaltic cement.

The earliest roads about which anything definite is known are those of ancient Rome, one of which, the most celebrated —the Appian Way—commenced 312 B. C. The Roman roads, preserved generally a straight course, which is said to be due to the convenience of laying them out. Others say they were principally constructed with the view of transporting the Roman legions, and, like those of Peru, were generally laid out in the direct line of route from one city to another, seldom avoiding any obstacle, and usually, for defensive purposes, keeping to the higher ground. In solidity of construction, they have never been excelled, and many of them still remain. Their construction is thus described by Mr. Thomas Codrington, C. E.: "Two parallel trenches were first cut to mark the breadth of the road; loose earth was removed until a solid foundation was reached, and it was replaced by proper material consolidated by ramming, or other means were taken to form a solid foundation for the body of the road. This appears to have been, as a rule, composed of four layers, generally of local materials, though sometimes, they were brought from considerable distances. The lowest layer consisted of two or three courses of flat stones, or, when these were not obtainable, of other stones, generally laid in mortar ; the second layer was composed of rubble masonry of smaller stones or a coarse concrete ; the third of a finer concrete, on which was laid a pavement of polygonal blocks of hard stone, jointed with the greatest nicety. The four layers are found to be three feet or more in thickness, but the two lowest were dispensed with on rock. The paved part of a great road appears to have been almost 16 feet wide, and on either side, and separated from it by raised causeways, were unpaved sideways, each of half the width of the paved road. Where, as on many roads, the surface was not paved, it was made of hard concrete, or pebbles or flint set in mortar. Sometimes clay and marl were used instead of mortar, and it would seem that where inferior materials were used, the road was made higher above the ground and rounder in cross-section."

With the disruption of the Roman empire came a period at which road-making and maintenance became neglected, and seems to have fallen into general disuse, until about the twelfth or thirteenth century. About the middle of the 12th century the principal streets of large towns were protected by stone. The streets were prepared with a gravel or concrete bed, and on this a pavement was laid, consisting of deep rectangular blocks of such rock as granite, trap, or quartzites, of 10 to 12 inches in depth, and of irregular widths, and of from 1 to 2 feet in length, bedded and jointed in strong mortar. In many continental cities this method of street paving is yet adhered to.

The bad state of the roads in England in 1685 is given by Macaulay's History, pp. 339, 340, vol. 1 : "It was by the highways that both travellers and goods generally passed from place to place, and these highways appear to have been far worse than might have been expected from the degree of wealth and civilization which the nation had even then attained. On the lines of best communication the ruts were deep, the descents precipitous, and the way often such as it was hardly possible to distinguish, in the dusk, from the unenclosed heath and fen which lay on both sides. Ralph Thurseby, the antiquarian, was in danger of losing his way on the great North road, between Barnaby Moore and Tuxford, and actually lost his way between Doncaster and York. * * * It happened almost every day that coaches stuck fast until a team of cattle could be procured from some neighbouring farm to tug them out of the slough. But in bad seasons the traveller had to encounter inconveniences more serious. * * * The great route through Wales to Holyhead in 1685 was in such a state that the Viceroy going to Ireland was five hours in going 14 miles from St. Asaph to Conway."

The roads in England were at that period in a much worse condition than those of most European countries, and they were sometimes almost impassable, even in the heart of the great cities. Long after this, so late as 1736, the roads in London were so bad that in wet weather it sometimes took no less than two hours to drive from Kensington to St. James' Palace. About the middle of the last century, some decisive steps were taken for improvement in both construction and maintenance, and shortly afterwards much improvement was effected by the introduction of the systems of Telford, McAdam and Parnell, and some other roadmakers well known as equally efficient, but not so fortunate as to be brought, through their work, into such prominent notice. During the present century a great deal has been done to improve the highways of Europe, more especially in France and Great Britain.

It is not proposed to touch upon any of the engineering operations connected with the successive improvements that have been effected, and that have now become so numerous within city or town limits, in the construction and maintenance of public streets and footways, such as pavements, pitched or stone block pavement, asphalt, wood, iron, and other pavements, or to enter into their merits or demerits. The object of this paper is to assist in enquiring into and formulating a system that may in some measure tend towards the improvement of our common roads in Nova Scotia.

MACADAMIZED ROADS.

All roadways having a surface of hard, roughly-broken stone are generally classed under the above general head. The most important of these are the two separate and distinct systems introduced by McAdam and Telford. The pavement of the latter is well described thus: "The cross-section of the surface should be that of a flat elipse, as this shape assists the water to pass from the centre towards the sides, without making the sides too round and greatly contributes to drying the road, by allowing the the action of the sun and air to produce a great degree of evaporation. When the materials are quarry or field stones, the hardest part of them should be used, each stone so broken that it may in its largest dimensions pass through a ring 2½ inches in diameter. When the materials consist of gravel, the stones only which exceed 1½ inches in size should be taken from the pits for the use of the middle part of the road, and every gravel stone exceeding 2 inches in diameter should be broken."

In constructing a new road (Fig. 1) he directs that a gravel foundation should be carefully laid by hand 7 inches deep in the middle, and reduced to 3 inches on the sides; the stones, none of which should exceed 5 inches in breadth on its face, to be set on their broadest ends, and the cavities filled with stone chips. For a width of 18 feet over the centre of the pavement, six inches of broken stone or hard pebbles, not exceeding 2½ inches in diameter, should be laid. The six-feet roadway on each side may be made with good clean gravel or small stones, the whole to be covered with a coating of small gravel 1 inch in thickness. He directed that all such roads should have a total depth of 14 inches of firm material in the centre, and 5 inches at the outer edges.

That all layers of stone should be placed only in wet weather and during the winter months.

Telford subsequently modified his practice, and in the first instance spread four inches of stone, broken to 2½ inch gauge, which was to be worked in by the traffic, all ruts to be raked in as formed, till the surface was firm; after which he laid 2 inches more of similar material, treated in a like manner, and the whole was covered with $1\frac{1}{2}$ inches of good clean gravel. At Coventry he covered the pitching with a six-inch layer of Nuneaton stone, broken to a gauge of $2\frac{1}{2}$ inches, and well raked into the surface of these a covering of good gravel blinding $1\frac{1}{2}$ inches in thickness.

The method introduced by Mr. McAdam was as follows (see Fig. 2): He dispensed with the foundation of large stones, and if anything preferred a soft substratum to a hard artificial one, and selected angular fragments of granite, basalt, or whinstone, broken sufficiently small to pass through a ring $2\frac{1}{2}$ inches in diameter, preference being given to stones from 1 to 2 ounces in weight, and he in no case allowed the use of stone exceeding 6 ounces, the larger ones being broken to the regulation size, which after much experience and many carefully experiments, was still further reduced to cubes of 1 inch to $1\frac{1}{2}$ inches in every direction.

If we compare Telford's mode of pavement with Tresaguet's method of constructing roads as described by the latter and generally adopted in France sixty years before Telford's time, we cannot help but surmise that he borrowed his system or that it was evolved largely from the French. Tresaguet says, so early as 1775; "The bottom of the foundation is to be parallel to the surface of the road. The first bed on the foundation is to be placed on edge and not on the flat, in the form of a rough pavement, and consolidated by beating with a large hammer, but it is unnecessary that the stones should be even one with another. The second bed is to be equally arranged by hand, layer by layer and beaten and broken coarsely with a large hammer, so that the stones may wedge together and no empty spaces remain. The last bed 3 inches in thickness, is to be broken to about the the size of a nut with a small hammer on a sort of anvil, and thrown upon the road with a shovel to form the curved surface. Great attention must be given to choose the hardest stone for the last bed even if one is obliged to go to more distant quarries than those which furnish stone for the body of the road; the solidity of the road depending on this latter bed, one cannot be too scrupulous as to the quality of materials which are used in it."

Telford held that when the bottom is soft and wet, and the sub-soil cannot be properly drained, a bottoming of some sort was desirable, and where stone can be easily got for a pitched foundation, it will be found a most economical as well as most convenient way of making a road if it is required to be of considerable strength.

McAdam considered a bottoming of large stones useless, and even went so far as to condemn it as mischievous, on the ground that the large stone at the bottom caused motion of the materials and kept open passages for water to the sub-soil beneath. He contended that the thickness of the road should only be regulated by the quantity of materials necessary to form a stable and impervious covering, and never with any reference to its power of carrying weight, and that if water passed through a road it would go to pieces whatever was its thickness. (Remarks on Road-making, by J. L. McAdam, p. 40.)

McAdam's doctrines are generally condemned as contrary to the first principles of science. (Parnell's Treatise on Roads, p. 78.) He also said that he preferred a soft substratum to a hard one, provided it were "not such a bog as would not allow a man to walk over it." (Evidence of Select Committee on Highways, 1819, p. 23.)

To McAdam, nevertheless, is due the credit of having been the first to introduce the proper method of breaking and preparing road materials, and to the possibility of forming them into a compact road surface. To him also is due the establishment of a regular system of road maintenance under properly qualified surveyors.

Various forms and modifications of McAdam's and Telford's systems have been since adopted with varying success. Mr. Baylis, in his suburban practice (see Fig 3), laid a 3-inch coat of 2-inch cubes, which were allowed to become consolidated by the traffic, when he spread a second coat of the same thickness, and covered it with a thin gravel blinding. Others have tried slag or hard foundry refuse from 6 to 8 inches in depth, and the result justifies its continuance in certain localities. Mr. Joseph Mitchell, of Inverness, has introduced in the summer of 1865, one of the best modifications of macadamized roads. This consists of granite cubes, broken to the usual size, and spread over the road to the required thickness, a strong grout of Portland cement and sharp sand well rolled to an uniform surface. Such roads are said to possess great solidity, and are less productive of dust than ordinary Macadams. The wear under the ordinary traffic was about half an inch in three years, but after nine years the surface had worn very irregularly, owing principally to its rigidity and the difficulty of spreading the material in uniform proportions. (Transactions Society of Engineers, 1878, p. 66.)

The covering of most of the common roads in the United States is pretty much the same as our own. In mostly all new countries the same practice, being the cheapest and readiest, is adopted. The natural soil is excavated from the side ditches and plastered or thrown on the middle of the roadway. General Gilmore, in his treatise on roads, streets and pavements, says: "In many cases, especially in sandy or gravelly soils, even the side ditches are omitted, and the road is simply a wagon track upon the natural surface, which soon becomes a broad. shallow ditch, collecting and retaining the surface water from both sides of the track.' (pp. 66 and 67.)

The management of public highways is, at the present time, receiving much attention both in Europe and America. Improved systems of road construction and repairs is one of the problems of the day. The amalgamation of districts in central boards has been advocated and is attended with many advantages. Uniformity of system and maintenance on correct principles, under the supervision of persons of wider experience than the ordinary road maker, tend to economy and not only generalize the system but improve it. The Administration des Pouts et Chausses in France is a good instance. The opportunities which an organization offers for investigation and for generalizing information are shewn by the documents issued by it and many valuable memoirs on subjects connected with road maintenance are translated and largely circulated over the world.

The excellence of road making in Ireland is due to management by county areas. In Scotland many of the counties managed both turn-pike and statute labor for many years, and by the Roads and Bridges Act of 1878 the system of County management was extended to all parts of Scotland. The Highways and Locomotive Amendment Act of the same year enlarged the areas of road management in England in several important respects.

I have so far touched upon the evolution and history of road making abroad. Let us now examine the cost, and see if we could judiciously apply the practice being adopted in Europe or how much of it, to our own Province.

The following table gives some of the results obtained on the roads in the Department of the Loire, France, and the daily traffic over them, as reported by M. Graeff, engineer in chief, des Points et Chausees. The road covering was schist and 21 feet wide.

Length of Road.	Mode of Maintenance.	Daily Tonnage.	Annual Wear in Cubic Yards.
1 mile....	Periodical reconstruction	1400	579
1 "	Minute and constant repairs..	1400	727
1 "	Periodical reconstruction	1800	1866
1 "	Minute and constant repairs..	1800	2104
1 "	Periodical reconstruction	2300	2794
1 "	Minute and constant repairs..	3200	4635
1 "	" " ..	5400	9934

Some of the roads in the arrondisement of St. Etienne, built with basalts, furnished the following data:

Length of Road.	Mode of Maintenance.	Daily Tonnage.	Annual Wear in Cubic Yards.
1 mile....	Periodical reconstruction.....	1200	175
1 "	" "	2000	372
1 "	Minute and constant repairs..	2000	480

The foregoing tables shew, (1) that the destruction of the road material increases more rapidly than the tonnage; (2) that the tough basalts are much more valuable for road covering than soft schist; and (3) that for roads of large traffic, the system of maintenance by periodical reconstruction, accompanied by such intermediate repairs, more or less constantly, as will secure hardness, and smoothness of surface and uniformly diminishing thickness, is superior to the one on minute and constant repair exclusively. It is now generally admitted in France that this last-named system is not advantageously applicable to roads on which the daily tonnage exceeds 600 tons. The same principles will apply to the repairs and maintenance of road coverings composed of gravel or a mixture of gravel and broken stone (Gilmore.)

COST OF ROAD MAINTENANCE.

The whole cost of the macadamized national roads of France taking an average year, was:

Materials	$ 89 06	per mile.
Manual labor.........	71 54	"
	$160 60	per mile.

The average quantity of materials was 78 cubic yards per mile, the mean rate of wages was $0. 45 per day. and the labor per cubic yard of material $0.91, of which $\frac{1}{3}$ day's work per cubic yard was for the maintenance of the surface of the road.

The cost of maintenance of course varied a good deal in different departments, the average in some being as low as $73.00 or $77.86 per mile, but in the majority the cost was not very far removed from the average.

The cost of repairs for four roads in the county of Edinburgh is given as follows, and may be taken as a fair average of the annual expenditure:

Lasswade and Wright's Houses, 186½ miles	$109 98
Dalkeith and Post Road, 85¾ miles	237 74
Cramond, 29½ miles	315 85
Calder Slateford and Costerphine, 139 miles	137 96

In each district the roads extend from Edinburgh to the boundaries of the county, so that the cost per mile are the average of rates, which widely differ with the traffic and the situation of the roads. The wages are about $4.38 per week, and the materials cost from $1.07 to $1.72 per cubic yard on the average.

The average cost of the parish roads included in highway districts in England and Wales ranged from $16.55 to $183.22 per mile in different counties, the mean of the whole length of roads being $65.94 per mile.

It will be observed that comparing whole districts, the average cost of maintenance varies considerably, and if single roads or parts of roads were to be taken , the difference of cost would be greater, some being as little as $24.33 per mile, while others with heavy traffic cost upwards of $1703.33 per mile for short lengths. The wages from $3.65 per week in the cheapest counties to $4.38 or more in Glamorgan, aud the cost of material per cubic yard ranged from $0.61 in some parts of the cheapest counties to $1.25 near Swansea. (Codrington.)

General Gilmore, U. S. Army, in his treatise on Roads and Street pavements, 1888, classifies American country roads as follows :

1. Earth roads.
2. Corduroy roads.
3. Plank Roads.
4. Gravel Roads.
5. All broken stone (or Macadam) roads.
6. Stone sub-pavement with top layers of broken stone. (Telford.)
7. Stone sub-pavement with top layers of broken stone and gravel.
8. Stone sub-pavements with top layers of gravel.
9. Rubble stone bottom with top layers of broken stone, gravel, or both.
10. Concrete sub-pavement with top layers of broken stone, gravel or both.

He proceeds to say :

EARTH ROADS.

Earth Roads necessarily possess so many defects of surface that whatever amelioration their condition is susceptible of by careful attention to grade, surface, drainage and sub-drainage, should be secured. The grades should be easy, not exceeding 1 in 30; the road surface should slope not less than 1 in 20 from centre towards the sides; the ditches should be deep and capacious, with a fall of not less than 1 in 120, and trees should be removed from the borders to admit the wind and sun. In soils composed of a mixture of sand, gravel and clay, the road is formed of this material, and requires only that the ditches be kept open and free, and that the ruts and hollows be filled up as fast as they form in the surface, in order to render the road a good one of its kind.

In loose, sandy soils, a top layer of 6" thick, of tough clay, will be an effective method of improvement, which to save expense may be restricted to one half the width of the roadway. Sand may be added to adhesive clay soils, with equal benefit, the object in either case being to produce an inexpensive road covering that will pack under the action of the traffic during the dry season, and will not work up into adhesive mud during rainy weather.

" A pernicious custom prevails throughout a large portion of the United States of repairing country roads only at certain seasons of the year, The cost of maintenance would be greatly reduced by frequent repairs, and especially by keeping the side ditches clear and open to their full width and depth, but promptly filling in the ruts, and by maintaining the required slopes from the centres towards the sides. It will seldom be found that the material obtained by cleaning out the side ditches is fit to put upon the roadway." These remarks so largely apply to the clay roads of our own province, to the methods of repairing them and the material being used that I quote them fully.

Corduroy Roads.—So called from their ribbed character scarcely deserve the name of road, but are, nevertheless, useful to the settler. They are generally made over marsh and swamp, which in wet seasons would be otherwise absolutely impassable for wheeled vehicles. Nearly all the logs for such construction are usually procured in clearing a width of four rods or 66 feet prescribed for most country roads, the width of the corduroy or covering being restricted to 15 or 16 feet so that two vehicles can pass without interference. The logs are cut to the same length, which should be that of required width of road; and if proper selection is exercised so that their size or diameter is uniform, and if they are properly laid on sleepers placed lengthwise so that their top surfaces will be even, then covered with a layer of brush, and finished off with a coat of soil or turf, they will answer their purpose until the settlement becomes more populous and warrants the construction of a better and more desirable roadway.

"*Plank Roads*," says Gilmore, " were much in vogue 25 or 30 years ago, and are still used in localities, where lumber is cheap and stone and gravel scarce and expensive. They are usually about 8 feet wide and occupy one side of an ordinary, well drained and properly graded earth road, the other side being to turn out upon and for travel during dry season. The method of construction most commonly followed, is to lay down lengthwise of the road, two parallel rows of planks called *Sleepers* or *Stringers*, about 5 feet apart between centres, and upon these to lay cross-planks of 3 to 4 inches in thickness and 8 feet long, so adjusted that their ends will not be in a line but form short offsets at intervals of two to three feet, to prevent the formation of long ruts at the edges of the road, and aid vehicles in regaining the plank covering from the earth turnout. New plank roads possess many advantages for heavy haulage, as well as for light travel, when the earth road is muddy and soft, but in a short time the planks become so worn and warped, and so many of them get displaced, that they are very disagreeable roads to travel upon. They are so deficient in durability that a common gravel road as hereinafter described, will in the end be found more profitable in most localities. The ease and rapidity with which they can be constructed renders them a popular and even a desirable makeshift in newly settled districts and towns where lumber can be procured at low cost, but they lack the essential features of permanence and durability, which all important highways should possess. The sleepers ought always to be treated by some effective wood preserving process to prevent decay. In the planks ordinary rot will be anticipated by their destruction from wear and tear."

Gravel Roads.—The American as well as the European practice, is to screen pit gravel before applying it to the surface layer. Two wire screens, one with wire 1 to 2 inches apart, the other ½ to ¾-inch apart, are necessary. The pebbles that will not pass the larger screen are rejected, and are afterwards broken up into smaller fragments, while the earth, gravel and sand that pass through the smaller one, although unsuitable for the road surface, will answer for blinding or for a sub-layer or side walk covering.

A layer from 4 to 6 inches thick of good unscreened pit gravel in its natural state is first spread upon the road bed, which is then thrown open to travel, until it becomes tolerably well consolidated, after which a second layer of screened gravel is added of sufficient depth to suit the requirements of traffic. The whole is generally consolidated by a roller. The aggregate thickness of the layers does not exceed 8 to 10 inches.

The sides of the road should be rolled first to such a degree of firmness that when the roller is placed upon the highest portion along the middle, the tendency of the gravel to spread and work off towards the side gutters will be resisted. A gravel road, carefully constructed in the manner above described, will possess all the essential requisites of a good road.

McAdam and *Telford* roads have been already described. A few remarks on rolling of McAdam roads, by Mr. William H. Grant, Superintending Engineer of the New York Central Park, in his report on the park roads, are so interesting that I quote them: "At the commencement of the McAdam roads, the experiment was tried of rolling and compacting the stones by a strict adherence to McAdam's theory—that of carefully excluding all dirt and foreign materials from the stones, and trusting to the action of the roller and the travel of teams to accomplish the work of consolidation. The bottom layer of stone was sufficiently compacted in this way to form and retain, under the action of the rollers (after the compression had reached its practical limit), an even and regular surface, but the top layer, with the use of the heavy roller loaded to its utmost capacity, it was found impracticable to solidify and reduce to such a surface, as would prevent the stones from loosening and being displaced by the action of wagon wheels and horses' feet. * * * The rolling was persisted in, with the roller adjusted to different weights up to the maximum load" (12 tons) " until it was apparent that the opposite effect from that intended was being produced. The stones became rounded by the excessive attrition they were subjected to, their more regular parts wearing away, and the weaker and more smaller ones being crushed. The experiment was not pushed beyond this point. It was shown that broken stone of the ordinary sizes and of the best quality for wear and durability would not consolidate in the effectual manner required for the surface of a road *while entirely isolated from, and independent of, other substances.*"

Shell Roads.—Along the Atlantic and Gulf coasts of the United States, stone suitable for road-making does not in many districts exist. Oyster shells are used, and when applied upon sandy soil, it is said, form an excellent road for pleasure driving or light traffic, and when properly maintained possess most of the essentials of a good road.

Charcoal Roads.—A good road is said to have been made through a swampy forest in Michigan in the following manner: " Timber from 6 to 18 inches through was cut 24 feet long, and piled up lengthwise in the centre of the road, about five feet high, being nine feet wide at the bottom and two at the top, and then covered with straw and earth in the manner of coal pits. The earth required to cover the pile taken from either side leaves two good-sized ditches, and the timber, though not split, is easily charred; and when charred the earth is removed to the side of the ditches, the coal raked down to a width of 15 feet, leaving it two feet thick at the centre and one at the sides, and the road is completed." Its cost was $600 per mile, and contracts for two such roads were given out in Wisconsin at $499 and $500 per mile respectively. (Gillespie on roads)

Such, then, is the history, evolution and practice of road-making around us. Let us see if we carry on such a combination of facts as present themselves, reason and reflect and adapt ourselves to the best methods for the construction and maintenance of the highways of our Province. We must be guided by the particular materials or mode of construction, by the locality, the facility for obtaining suitable material, and the necessity and purpose which the traffic may be intended to serve. The surface of Nova Scotia is so varied that it presents nearly all the steps of geological sequence. Our road-making material is accordingly diversified, and may require different modes of application in different districts. Laws of a local nature interfere and operate many modifications, even in limited areas. Along the Atlantic shore we have the Lower Cambrian rocks, with occasional depositions of moraines, boulder clays and quartzites, out of which may be also selected, here and there, a gravelly road covering. Along our northern boundary we have trap rock, which is excellent for road-making, but in the carboniferous districts, such as Cumberland, Pictou, and along the Northumberland Strait, the common clays of the country yield but a poor covering for our highways.

There are many matters connected with road-making which should be considered, as the modern modes of road construction could not be adopted in many districts. In fact, the country is not fully ripe at the present moment for adopting the most improved methods. Therefore engineers and road-makers must, as far as possible, deal with the materials they have at command, and inculcate correct principles in the use of such materials. One great point upon which stress should be laid was the formation of the cross-section of a road. No road could long remain perfect in this country unless the drainage from it was good, considering the ordinary materials with which the engineer had to deal, and which to a greater or less extent are pervious to moisture. The great question seemed to be that of price. Engineers cannot impress governments or municipal bodies with all the advantages which accrue from any particular form of road or method of construction, unless they could first of all, demonstrate that it would be the cheapest, either as the first cost or ultimately. The cost and durability of the various systems depend so much upon the nature of the traffic, gradients, care in original construction, and material available, that no rigid rule can be adopted; it is only by careful study and judicious application that we can arrive at the best and most economical system.

The systems of McAdam and Telford, being those which will doubtless continue to be most generally adopted for country roads and those of small towns and suburban districts, and as there is a growing feeling throughout the Province that McAdam's system should be adopted, it may be opportune to discuss its desirability here.

We must begin by grading the road to some degree of uniformity, and draining it thoroughly. The latter is absolutely necessary, otherwise the coating of broken stones forming a compact road surface would be frequently hove by the frost in this fitful climate. Next we would require steam stone-crushers. Generally speaking, stone-breaking machines can be used to the greatest advantage when the material is difficult to break, and where there are facilities for distributing large quantities from one, or a small number of sources of supply. The economy of substituting machinery for hand labor will generally be almost entirely a question of transport of the broken stones to the road. In many parts of the Province good stones for road material, whin or quartzite, encumber the ground. We can in this case save the cost of quarrying.

The stone-breaking machines of Blake's, Hope's, and Archer's have been thoroughly tried. The quantity of whinstone broken by a 16" x 9" Hope machine is about 40 tons per day, supposing that the machine was kept in regular work, which can very rarely be realized in practice. Gilmore says the American breakers yield from 3 to 7 cubic yards per hour. From all the information I can gather, I doubt if one can get 40 tons per day one day with another. The cost is as follows:

Engineer or driver	$2 50
4 men and 1 boy	5 50
Coal, $\frac{3}{4}$ ton	3 00
Oil cotton waste	0 85
	$11 85

To use stone-breaking machines to advantage they must be kept steadily at work. It may be moved from place to place by the engine. The former when mounted on wheels, weighs 5 or

7 tons, and the engine which draws it must be capable of removing it from one place to another. The cost of the broken material will be approximately, where boulders are available, without the expense of quarrying,—

Collecting, sledging and supplying to machine	$0 35
Breaking by machine	0 30
Carting from depot to road	0 20
Wear and tear of machinery, removing machine, screens, etc.	0 05
Per ton of broken stone	$0 90

Owing to the large quantities of whin stone, iron stone, trap and other metamorphic and igneous rock available with quarrying in Nova Scotia, it may be possible to get the broken material for the price given above. Ninety cents per ton will, however, be considered a minimum price by parties who have used the stone-breaking machine now in common use.

From these data we may be able to estimate what a mile of road would cost treated according to the system of McAdam, but with proper drainage to suit our climate.

M. Ducreux, M. Gasparin, and Mr. Leahy give about 55 per cent, as the amount of solid stone contained in broken stone metalling of 2 to $2\frac{1}{2}$ inch diameter or gauge, the other 45 per cent, being void. A simple proportion will show that in this case a ton of stone will produce rather less than $\frac{9}{10}$ of a cubic yard.

Now if we assume our typical road to be well drained, properly formed, eight feet of the centre to be coated with 6 inches in thickness of McAdam, the remainder, or wings, to make 21 feet, to be of clay or gravel, a blinding of 1 or $1\frac{1}{2}$ inches of the fine material (run through the screens at the crusher), to be spread over the broken stones and the whole consolidated by a roller, we may approximately estimate the cost of a mile thus:

For drawing, forming and spreading material, 320 rods at $1.00 per rod	$ 320 00
Broken stone, $5280 \times 8' \times 7'' = \frac{913}{9}$ cubic yards $= 1041$ at 90c	912 60
Rolling 1500 sq. yards per day, according to Codrington, about 3 days to a mile, say 12 horses at $1.50	18 00
Per mile	$1250 60

The estimate is a minimum one compared with prices in other places. The materials being so convenient a large saving, comparatively considered, might be effected. It should, however, be understood that in districts where there are no such materials at hand and where long carriage would be necessary, the cost would be accordingly much larger. The progress would be for one steam crusher $\frac{1014}{40} = 25$ days, or roundly speaking one mile per month, which would give a day or two for repairs and removal.

Even with this expenditure we must not consider we would have perfect roads without much attention to repairs. The weather in Nova Scotia will act to some degree on the materials. Frost expands the moisture in the crust, and when the thaw comes a general disintegration will take place. Rain following frost and thaw is very damaging, and alternations of these without repairs and attention would soon destroy the best Macadam road coverings. The extent to which these various effects may be injurious will depend on the nature of the road materials, on the drainage, subsoil, situation, and many other accidental circumstances.

There is a general wish for steam stone crushers and for Macadam roads throughout the Province. The author would recommend that the Government introduce them into such municipalities as would be most likely to ensure their successful operation, where the material is plentiful and possibilities of success most promising.

THE TELFORD SYSTEM.

We have already described this system. In some localities there may be an abundance of stone, such as sandstone and the softer varieties of slate and limestone, which would be suitable for the Telford bottoming but would not possess the requisite hardness and toughness for the top covering of broken stone. In some cases, after the bottoming is set, the road may be finished with three to four inches of good gravel in the manner described for gravel roads. We would prefer having all the pavement stones of equal depth, and obtaining the requisite transverse convexity by forming the sub-strata to the desirable degree of curvature to receive them. A better drainage of the road-bed would doubtless be secured by forming the bed of the road parallel to the finished road surface.

The advantages and disadvantages of the sub-pavement or "bottoming" which forms the characteristic difference between the Telford and McAdam roads, have been the subject of lengthy discussion; both systems have their respective advocates, and both can claim respective merits; the materials at hand, the facilities for thorough drainage, and the extent and nature of the traffic, as well as the liability of displacement by freezing must all be considered. From the experience of the writer in Nova Scotia, now extending over a period of 20 years, if either is adopted he would prefer the Telford system of road-making, for the following reasons:

1. A foundation of this kind is believed to be as firm and durable as one of the same thickness composed entirely of broken stone, while it consists of considerably less.

2. A carefully-laid Telford pavement, covered with screened gravel, may answer all the purposes of our present country traffic, and can be constructed without the aid of expensive machinery.

3. It adapts itself more generally to the materials at hand, comes more within the scope of our resources, whilst the possibilities of success are more promising.

We might fairly assume that the cost of drainage and forming of road will be necessarily the same to receive a covering of either system. The cost of the Telford sub-pavement of 8 feet wide (same as the McAdam) 7 inches in depth, with a covering of 2 inches of screened gravel and a blinding of 1 inch of finer material, the whole to be consolidated by a roller, and all else being equal with the McAdam road, might be estimated approximately as follows:

Cost of draining, forming, etc..........	$ 320 00
Stone pavements 7″ deep, 5,280 × 8′ × 7″ = c. yds. 913 at 45c.......	410 85
Paving 320 rods at 50c..............	160 00
Gravel and blinding 5,280′ × 8′ × 4″ = 511 c. yds. at 50c................	260 50
Rolling..........................	18 00
Per mile............................	$1169 35

The same remarks will apply to this estimate as to the McAdam, viz., it is a minimum one, and could only be applied where suitable stone encumbers the surface, where the haul would be short, and where no quarrying would be necessary. The voids in stone are not in this case deducted, as the gravel and blinding will under the weight of a roller fill up all or nearly all the interstices.

It will be seen that both the Telford and McAdam systems of road-making, to be adopted as fixed principles, are entirely beyond our means. There are, however, situations where their employment might be judiciously adopted in Nova Scotia. We know that the animal power or force necessary to move a load over our highways is to often restricted by bad or defective sections, and that the measure of the load is that which can be moved over them. In yielding muddy or loamy situations that so frequently intervene and retard travel, either the Telford or McAdam systems might be employed, whilst on higher and drier ground, where the bottom is solid and good, gravel alone might be used with much advantage. If we carefully examine any one of our principal highways in the western districts of the Province, we will find alternating stretches of good and bad road, and if we again select some of these—the worst—stretches that more frequently require attention for treatment under either of these systems, we may find that the construction of a few miles, perhaps very few, in a more permanent manner, will make the whole more uniform and equalize the necessary tractive force over the whole distance. If we can effect such improvement by such treatment, we may fairly conclude that the necessary expenditure would be a judicious one, and that its adoption might be well worth consideration.

GRAVEL ROADS.

Penfold (Practical Treatise on Roads) recommends "that pebble gravel should be first cleansed from dirt and useless matter by sifting and screening, and then the stones above one inch in diameter should be separated by another sifting and then broken." The general practice in both Europe and the United States, is to screen pit gravel and remove the earthy material from it, before spreading on the road. In Nova Scotia the custom is to apply it as road covering just as it comes from the pit. Our roads are therefore classed, according to our idea, good or bad roads, as the pit may turn out good or bad gravel. Gravel roads will have to serve our purpose in this country for some years longer, and as the mode of construction and maintenance now in vogue are susceptible of many improvements, it may be acceptable to shew how this material is being dealt with in its employment abroad, hoping that such suggestions and the discussion that may arise thereon, may tend towards developing greater practical worth and realizing a greater degree of endurance.

"A capital distinction," says General Gilmore, "must be made between gravel that will pack under travel and clean rounded gravel which will *not*, due to a small proportion of clayey or earthy matter contained in the former which unites and binds the material together. Sea-side or river-side gravel, consisting almost entirely of water-worn and rounded pebbles of sizes which easily move and slide upon each other, is unsuitable for a road covering unless some other materials be mixed with it, while pit gravel contains too much earthy matter." We have, however, seen very little gravel, even from our sea beaches, that will not, with a little blinding, pack under the traffic. Our roads are mostly gravel roads, yet it is doubtful if there is one continuous mile of a gravel road in Nova Scotia, outside of town limits, treated as the same class of roads in Europe and in the United States are treated. The gravel, if at all mixed with earthy material, should be screened; it should be spread to a depth of from 4 to 6 inches, or to such depth and width as may be considered necessary according to the volume of traffic to run over it, blinded with fine material and rolled.

If the bed of the road is rock, a layer of earth is frequently interposed between it and the gravel to prevent the too rapid wear of the latter, and assist in forming the crust. Where the road has already attained the desirable shape or form, and where the drainage is good, different treatment may be necessary for economy, and in many cases more judicious, especially for traffic not very heavy.

The relative strength and durability of different road material is a difficult matter to determine. No test but actual wear on the road can be fully relied on, and though it is easy to see that some pebbles or stones wear three or four times as long as others, it is almost impossible to take into account all the circumstances under which they are exposed to wear. The nature of the traffic, the moisture or dryness of the crust, and susceptibility to disintegrate from freezing and thawing, has often a great effect on the wear of the same material. It is only by studying such effects and by practical application we can find the most suitable materials and discover the best methods to employ them, for their necessary treatment and behaviour, may vary as the nature of surface and the conditions under which they are placed, may vary.

PLANK ROADS.

Eight years ago a planked road was laid over a swamp or bog near Liverpool, Queens County, on the leading highway from Milton to Caledonia, with some degree of success. It is claimed by the members representing the County of Queens that the result justifies the practice, and that in certain situations their adoption might be judiciously extended. The planks were laid on sleepers or stringers, in the same manner as General Gilmore describes the method generally used in the United states, and it is claimed that they answered their purpose admirably, and that the roadway over them is in good condition to-day. The writer considers their preservation from decay is largely due to their partial submersion in the bog and the tannic acid which it contains. Vehicles seem to pass easily over it, the bending and cross-breaking tendency of the road produces no sensible effect, there is no movement in the body of the road, and the wear is confined to the grinding and crushing of the surface of the planks, and although there is a continuous stream of daily traffic, the wear does not seem to have the same effect as on planked covering in other situations. In localities where lumber is cheap, and stone and gravel scarce and expensive, planked roads might be judiciously employed in crossing peaty stretches or bog or swamp.

EARTH OR CLAY ROADS.

Clay is a poor substitute for road covering. If we could only bake it and drive off the water, in combination with the oxide of iron which it contains, we might obtain a crust more impervious to water. Frequent attempts have been made to burn and calcine clay for railway ballast and road material in situations remote from stone or gravel, and it is said with some degree of success. It is, however, a costly operation, which we would not be justified in adopting. We are not ripe enough for costly experiments, and must content ourselves with other and cheaper means. We may, however, reason thus:—Sand stones are made from sand by some slow process, clay stones from clay, and so on, for all geologists believe that rocks are made from secondary causes. Now we can pretty thoroughly imitate rock-making by an admixture of lime and sand, or by the use of certain natural and artificial cements we can consolidate such material into solid rock in a short space of time, six or seven days, and the induration will improve in time. Adobe for roads, as well as for buildings, may yet be capable of practical application. At present in our climate we need a harder and more endurable material than clay or earth to sustain any sort of heavy traffic in the spring and fall seasons. Nevertheless, the writer has seen within our own borders several effective attempts to maintain clay roads, where the traffic is light, by material which is always within easy distance in Nova Scotia. By taking the tops of spruce or fir trees, removing all wood larger than ¾-inch in diameter, and intermixing them with clay to the consistency of adobe, and applying the mixture to the depth of from 9 inches to 1 foot, a tolerably fair road may be maintained. I have been informed that this class of road will wear well for four or five years' traffic. Hemlock tops, wood shavings, straw, or coarse dry grasses might be made use of where the spruce or fir could not be had conveniently. These make shifts should not, however, be attempted on roads where the traffic is heavy. A well-drained road, with a Telford pavement and McAdam covering, is the best we know of at present to meet any requirement of heavy traffic.

SLAG FOR COVERING.

The slag from the furnaces of the Acadia Iron Mines, Londonderry, has been very successfully employed for repairing roads in the neighbourhood of the Mines, and its employment is being year by year extended to quite a distance. The town of Truro has made use of it for repairs of the streets, but not with much success. The writer is under the impression that it has not had a fair trial at Truro. It was made use of in lumps too large, when its proper application should be as near as possible to a powder or very small pebbly state. It may be excellent for a binding material, and should not be denounced without a further and better trial. In a paper by the writer, read before the Canadian Society of Civil Engineers (pp. 92, 93, vol. 2, Transactions Canadian Society of Civil Engineers), the result of experiments on this slag as a mortar was given, and although as a mortar or cement it did not behave so successfully as expected, still as a road covering it might have large possibilities. The barrel of slag supplied from which the briquettes were made, showed the silica in a vitrified condition, also fused silicate of lime already formed with the alumina burnt to a white dry cinder. When there are thousands of tons of this material available, and so situated that it can be loaded into the railway cars from the embankment, where it is dumped, without the cost of repeated removal, we would wish to see it receiving a better and fairer trial before its value as a road covering is condemned.

GYPSUM AS A COVERING.

A coarse crystaline gypsum has been made use of as a covering for clay roads, in the neighbourhood of Maitland. It is the most unlikely kind of material we would consider to adopt as a road material (the Maitland gypsum is an anhydrate, as it contains but little water), yet its application is being continued as an useful and economical substitute for gravel or broken stone. It is applied in lumps as large as 3 and sometimes 4 inches across; it is reduced to powder by the wear of traffic, and seems to intermix with the clay and form a tolerably fair road surface.

Cinders and Coal Shales are made use of in a road in the neighbourhood of our colleries. They make a poor road. They are reduced under the wear of traffic to a fine dust in the summer season, which is blown away by the wind like sand dunes.

There is generally some choice of road materials to be had even from local sources of supply, and if that at hand is not suitable or strong enough to stand the traffic to which it is exposed, it will always be a question whether it will be more economical to go farther for a better material at an increased cost.

It may be desirable that all roads should be made strong enough for any traffic that may come upon them, but that will be a question of expense. However, until they are so made it is unfair to expect a road to bear heavy loads which it is not intended for. The Highways and Locomotives (Amendment) Act of 1878, whereby highway authorities in England may recover the excessive expenditure occasioned by extraordinary and exceptionally heavy traffic, is a protection to roads in that country and might be well adopted in this. In such neighbourhoods as Bay Verte, where so much material is being hauled, and along the roads affected by the extraordinary traffic caused by railway construction, companies, or contractors, should be required to repair the highways to the extent they may be damaged by such exceptional or extraordinary traffic.

There would be much advantage obtained by having a man in charge of certain lengths of wet or clayey roads. Even if a man is not constantly employed on the surface work of the road, but is engaged in cleaning up drains and some harvest work, in the busy season, he becomes familiar with the peculiarities of his length and with the best way to deal with it, and if he is a good workman he soon will learn to take an interest in the road, which is his business to keep in order.

In a well-built road the process of deterioration will be gradual, if the road has been originally strong enough, when skilfully managed, a careful surveyor can tide over a year or two with reduced expenditure, for expenditure on road maintenance has often to be reduced below what is desirable, that it may not exceed a certain amount.

WIDTH AND TRANSVERSE FORM OF ROADS.

In France four classes of roads are prescribed as follows:—

First, 66 feet wide, of which 22 feet in the middle are paved with stone.

Second, 52 feet wide, of which 20 feet in the middle are stoned.

Third, 33 feet wide, of which 16 feet in the middle are stoned, and

Fourth, a width of 26 feet, of which 16 feet in the middle are stoned.

Telford's Holyhead road, which runs through a hilly country, is 32 feet wide between the fences on flat ground, 28 feet wide on side cuttings, and 22 feet along steep and precipitous ground.

The Cumberland or National road in the United States has a prescribed width of 80 feet, but the prepared roadway is only 30 feet

Wide roads are sometimes finished with a road covering in the middle only, of sufficient width for vehicles to pass each other, whilst the sides are maintained as earth roads for light and fast travel when the soil is comparatively dry and firm.

Engineers differ as to the most advantageous form of cross-sections, some recommending a convex curve approaching to the segment of a circle or a semi-elipse, whilst others prefer two plains gently sloping towards the side gutters and meeting in the middle of the road by a short connecting convex surface. There are obvious objections to both forms in certain situations.

To the former, the convex-road, they are: that the water will stand in the middle; that carriages will keep in or near the middle and cause undue or excessive wear along one line in order to run on the level and avoid the tendency to overturn near the side ditches. To the latter, that if carriages will not run along the centre there must be, owing to the transverse inclination or fall from the apex or centre towards the gutter, an undue tendency for the carriages or vehicles to slide upon the road surface. Regularity of section and evenness of surface is of much more consequence than the slight difference between curves and straight lines. It is essential that rain should flow freely off the surface for the proper and economical maintenance of a road. Water standing in ruts or depressions must be avoided, it greatly increases wear, deepens and enlarges hollows, and weakens or destroys the whole crust of the road. Such a cross-section should therefore be given as will throw the rain-water off quickly, and the necessary inclination to practically effect the purpose must vary with the different materials of which the road is composed. We cannot have, as in Great Britain, one typical form of road or method of road-making, because we must adapt ourselves to the materials at hand or within easy distance.

It is necessary to give a somewhat greater convexity to a new road than it is intended to have eventually; the middle consolidates more by the traffic, and the surface material is scattered towards the sides, so that however carefully it is raked or attended to the road will become flatter as it consolidates.

Cross-sections, showing the form proposed for roads in Nova Scotia, are submitted to illustrate this paper. The volume of traffic to be moved, their suitability to meet the requirements of traffic, and the materials near at hand for construction and repairs, must in a large measure influence the selection.

No. 1—Is a Telford pavement which could be made rapidly and with the drainage shewn would form an excellent highway; it might be covered with gravel or broken stone.

No. 2—Is a cross-section of a road coated with gravel or broken stones.

No. 3—Is a clay road with a six inch gravel covering 8 to 10 feet in width, with a centre drain of stones.

No. 4—Is a clay road with a centre drain of poles where stone cannot be had.

No. 5—Is a cross-section of road made over bog or marsh.

No. 6—Is a section of road to be made over a peat bog.

No. 7—Is a section of road to be made on hill side ground.

No. 8—Similar to No. 7, but with embankment retained by crib-work or a stone wall.

No. 9—Similar to No. 8, but both plank and cutting are retained by crib-work.

Nos. 10 and 11 are sections that could be adopted to rock side-hill.

In locating a line of road departures from a straight line are determined by many considerations. In crossing a dividing ridge between two valleys the lowest depression in the summit is generally taken. A continuous hill side without serrated ravines or secondary water courses is also sought for. Next find by an aneroid barometer the height to be overcome and the distance along the side hill which it is practical to climb to or descend from the summit. If the height is divided into the distance it will give the rate of incline or the gradient obtainable, and if with a level the engineer or surveyor commence above and descend with that rate of grade following an inclining contour, he must obtain the best location available. It may be necessary to diverge from such an ideal line to avoid bridging ravines, crossing expensive rock ledges, avoiding swamps and many other causes, all of which, and many others, may have to be considered, but are seldom taken into account in Nova Scotia. If any thoroughly practical system of road making is adopted in this country it will be necessary to alter many of our present great roads so as to obtain easier traction and better surface.

"In selecting among the different lines of survey the one most suitable for a common road, the engineer is less restricted, from the nature of the conveyance used, than in any other kind of communication. The main points to which he should confine his attention are, (1) to connect the points of arrival and departure by the shortest or most direct line; (2) to avoid all unnecessary ascents and descents within the smallest practical limits; (3) to adopt such slopes or gradients for the centre line of the road as the kind of conveyance used may require; (4) to give the centre line such a position with reference to the natural surface of the ground, and the various obstacles to be overcome, that the cost of labor for excavations and embankments required by the gradients adopted and also the cost of bridges and other accessories, shall be reduced to the smallest amount." (Prof. Mahan.)

GRADES AND TRACTIVE FORCE.

"Upon common roads the grades, or the angles which the axis of the road should make with a horizontal line, depend so much upon the kind of vehicles employed for traffic, the character of the road coverings adopted for the surface, and the condition in which the surface is maintained, that no empyrical rule can be laid down. The grade should not be as great as to require the application of brakes to the wheels in descending, or to prevent ordinary vehicles carrying passengers at a trot. In general, the gradient should be somewhat less than the angle of *repose*, or angle upon which the vehicle in a state of rest would not be set in motion, by its own weight, but would descend with slow, uniform velocity if very slight motion be imparted to it. The grades, therefore, suitable for any road will depend upon the condition with respect to smoothness and hardness, in which the surface is to be maintained, and hence upon the kind of road-covering used; and as the force of gravity is the same whether the road be rough and soft, or smooth and hard, steep grades are more objectionable on good roads than upon bad." (General Gilmore.)

The general conclusions arrived at by M. Morin from his experience on draught are as follows:—

The resistance to rolling of vehicles on solid metalled roads and pavements is proportional to the weight and inversely proportional to the diameter of the wheels.

On solid roads the resistance is very nearly independent of the width of the tires when it exceeds 3 to 4 inches, but on compressible surfaces it decreases in proportion to the width of the tire.

The resistance increases with velocity on hard roads, but is independent of velocity on soft surfaces.

Springs diminish the resistance at high speeds, but not at slow speeds.

From trials made with a dynomometer attached to a wagon, moving at a slow pace upon a level, the following table gives the force of traction in pounds upon several kinds of road surfaces in a fair condition, the weight of the wagon and load being one ton of 2.240 pounds:

1.	On best stone trackways.........	$12\frac{1}{2}$	pounds
2.	A good plank road..............	32 to 50	"
3.	A cubical block pavement........	32 to 53	"
4.	A macadamized road, small broken stone......................	65	"
5.	A Telford road, made with broken stone on a pavement.........	46	"
6.	A road covered with 6 inches of broken stone or concrete foundation..........	46	"
7.	A road made with a thick coating of gravel laid on earth... ...	140 to 147	"
8.	A common earth road...........	200	"

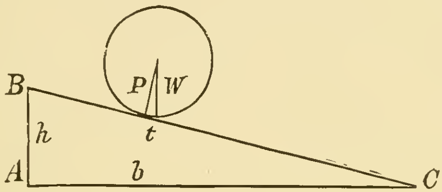
In order to apply these results in establishing suitable grades take the case of the macadamized road, No. 4, in which the tractive force is 65 pounds on a level road:

Let W=the weight of the vehicle and load in pounds.

p=pressure normal to the road surface.

t=force of traction in pounds on a level road.

At the angle of repose of an inclined road, the force, acting parallel to the line of grade, necessary to sustain a carriage and its load in its position on the incline, or to prevent its moving back by its own weight, is equal to the traction force t, which would just move the carriage and load on a level road. Let h be the perpendicular and b the base of a right angle triangle, of which the hypothenuse $B\ C$ represents the slope of the angle of repose :



which somewhat exceeds the greatest admissable gradient. For simplicity the load may be supposed to rest on a single wheel, shewn in the figure. In the smallest triangle T is the perpendicular, P the base, and W the hypothenuse in which

$$P = \sqrt{W^2 - t^2}$$

From the two similar triangles

$$t : p :: h : b \text{ or } \frac{t}{P} = \frac{h}{b}$$

by substitution

$$\frac{t}{\sqrt{W^2 - t^2}} = \frac{h}{b} \text{ but } \frac{h}{b}$$

being the perpendicular divided by the base, represents the angle at the base or the angle of repose, and this is the maximum admissable gradient. Hence the gradient should not exceed the quotient obtained by dividing the force of traction by the square root of the difference between the square of the load and the square of the traction. Upon good roads t is so very small in proportion to W that it may be omitted in the denominator, and we have practically for the angle of repose $\frac{t}{W}$ or the force of traction divided by the weight of vehicles and load.

For No. 4 the formula becomes.

$$\frac{65}{\sqrt{2240^2 - 65^2}} = \frac{1}{34} \text{ nearly.}$$

or 1 perpendicular to 34 base, and generally the proper grade for any kind of road, or the ratio of the vertical to the horizontal line will be equal to the force necessary to draw the load and the load itself upon the same road when level.—Gilmore, pp. 24, 25. (Experiments from Morin, and Sir J. McNeil.)

In practice the steepest grades on good roads is about 1 in 20, it having been determined by experience that a horse can draw up this incline his ordinary load for a level road without the help of a second animal; also that he can attain at a walk, a given height, upon a gradient of 1 in 20 without more apparent fatigue, and in nearly the same time as he would require to reach the same height over a proportionally longer slope so gentle—say $\frac{1}{34}$—that he could ascend it at a trot.

WHEELS AND WEIGHTS ON THEM.

The regulation of the form of construction of wheels has been the subject of legislation in Great Britain since the beginning of the century. One of the results was to bring into use an excessively broad conical wheel with a tire considerably rounded. The conical or dished wheel had its advocates and its enemies. The width of the wheel and the weight carried on them have an important influence on the wear of roads. The restrictions at present in force in England are those of the General Turnpike Act (3 Geo. IV. cap. 126), which regulates the weights to be allowed to wagons, carts, &c., in winter and in summer according to the following table:

Description of Vehicles.	Weight of Carriage and Loads.				Pressure per inch. Width of Tire.	
	Summer.		Winter.		Summer.	Winter.
	Tons.	Cwt.	Tons.	Cwt.	Cwt.	Cwt.
Waggon with 9 in. wheels,	6	10	6	0	3.6	3.3
Cart " "	3	10	3	0	3.9	3.3
Waggon, 6 in. wheels.....	4	15	4	5	4.0	3.5
Cart "	3	0	2	15	5.0	4.6
Waggon with 4½ in. wheels,	4	5	3	15	4.7	4.1
Cart " "	2	12	2	7	5.8	5.2
Waggon with less than 4½ in. wheels............	3	15	3	5	2½ inch tires } 7.5	6.5
Cart with less shan 4½ in. wheels...............	1	15	1	10	7.0	6.0

The pressure per inch of width of tire cannot always be taken as a fair measure of the load on a road ; a good deal will depend upon the sort of road. A strong, hard road, on a good foundation, will bear a considerable load on narrow tires without perceptible damage being produced, while a more yielding road will break down, although the pressure per inch of tire is far less.

The table given applied to McAdam and Telford roads, and would not at all apply to the soft or more yielding surfaces of roads in Nova Scotia.

The diameter of the wheels, as influencing the pressure on the road, may be left out of account for wheels of common size on ordinary road surfaces.

Art. XII. — Nova Scotian Fungi.—By J. Somers, M. D.

(Received July 7th, 1890.)

(An addition to the list.)

1. Agaricus (Aman) vernus *Bull*, a large and handsome plant with bulbous base, free gills, reflexed ring, white all over, ovate when young, then expanding forming a perfectly flat surface, finally depressed, though pronounced very poisonous, "yielding muscarine, a powerful narcotic;" it is a host for numerous Larvæ, mostly of coleopterous insects; growth rapid, pileus six inches in diameter, stipe, tall ring measures in length when reflexed one-half inch. (Prince's Lodge, Hx.) July, 1887.
2. A. (Amanita) phalloides, *Fries*, growing in same situation, variously colored, brown, straw, or dirty white, odor fœtid.
3. A. Coprinus sterquilinus, *Fries*, on cow droppings in the woods.
4. Cantharellus, infundibuliformis, *Fries*, egg yellow, funnel shaped, margin waved. Woods above Melville Island, Halifax.
5. Lentinus, cochleatis, *Fries*, tough and fleshy, polymorphic, *habitat*, decaying stumps. Our sps. grew in tufts, all were misshappen. Sherwood, Hx., Sherwood, Oct., 1887.
6. Polyporus, nigricaus, growing on birch, Sherwood.
7. Lactarious affinis, *Teck*, in the Park, Hx., in clear spaces under spruce (Abies, balsamea.) Char. of Pileus stipes, Lamellæ and spores, correspond to Professor Peck's diagnosis, Oct., 1887.
8. Hypomyces, lactifluorum; growing in gomphidium and cantharellus.

9. Hydnum, corraloides, *Scop*, very beautiful; like a small cauliflower, with numerous spines on the under surface of the divisions of the pileus.*

10. Ditiola, radicate, *Fries*, rooting ditriola disk, golden yellow, growing on pines leaves, amongst mosses and lichens.

11. Apyrenium, liguatile, *Fries*, (wood loving Apyrenium). Subglobose, hollow, yellow or reddish; growing on decaying wood.

12. Scorias,† spongiosa, *Schwt.* "The spongy mass which you say grew on alder is the fungus." It is a curious thing, and I wish we could get more definite information about its development. I have never collected it myself. It generally grows on birch. I would be glad to get very young stages of it, yours is an intermediate one. When mature it is black like a cinder. Perhaps you will get mature specimens later. True enough, later Mr. Gibson collected specimens which presented the character indicated by the Prof. In a note received afterwards from Prof. Farlow, he informed me that he had collected the fungus in New Hampshire growing as in Nova Scotia, on the alder.

13. Rostella lacerata, *Tul.*; Peridia, clustered, brick colored, splitting into numerous segments, thread-like at the top; threads white, spores brick red, scattering freely from the fungus, growing in unripe fruit of Amclanchien Canadensis. It penetrates the epiderm of the fruit, and feeds upon its fleshy part, in fact, when developed, it seems to grow from within outward, thrusting its filaments thro' the epiderm, discharging its spores abundantly in the form of powder, having a brick-red color. The spores are large, oval or rounded, easily seen " individually " with an ordinary lens.

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*This was brought to me by Mr. W. Gibson, one of our city officials. He found it growing on a chopping block made from a section of a bole of a large birch.

†This was also brought to me by Mr. Gibson who found it at Bedford Range, Halifax, growing on twigs of alder. I sent it to Prof. W. J. Farlow, of Cambridge, Mass., for diagnosis, who writes to me as per extract from his letter in regard to it.

14. Cladosporium. Sp.?
15. Ustilago. Carbo.
16. Stigmatia. Sp.?

On leaves of the Linden.

Mushrooms* editable, "*only ones* brought to Halifax market, being *A Psal campestris*," extremely abundant later weeks of August and first week of September, 1887. Appeared after a spell of wet weather. Later in the season but little rain, fungi scarce. Many species not appearing corresponding date months of August and September, 1888, less rain, mushrooms not so abundant as in former years. Later season of '88 being very dry, fungi, except in situations favorable for their growth, were very scarce. J. S.

Taken from record ot observations, 87.88.

Art. XIII.—Notes on Nova Scotian Zoology.—By Harry Piers.

(Received Sept. 15th, 1890).

The following notes were principally made during the past year. As they record either new or interesting facts in the zoology of our Province, I have thought that possibly they will prove useful to those who are engaged in investigating the fauna of this region.

Mammals.

Virginian Deer *(Cariacus virginianus)*. In the middle of November, 1888, a Virginian Deer was shot by Mr. Fitch of Shubenacadie. The animal, which was a fine buck, was found among the sheep near that gentleman's place. The head was sent to Mr. Andrew Downs of this city for preservation. Although this deer is met with in the adjacent Province of New Brunswick, yet there is no previous record of its capture in Nova Scotia. Dr. J. Bernard Gilpin, in his papers on the Mammalia of Nova Scotia (*Trans. I. N. S.*, vol. III., p. 125), writes as follows: "Of animals not identified by myself, but sometimes to be found in the Province, I think the Virginian Deer (Cervus virginianus) will be found in the Cobequid hills, as I personally know they have been taken at Dorchester, N. B., near the boundary line." We thus see that this opinion has been confirmed. Mr. J. B. Tyrrell, in his Catalogue of the Mammals of Canada,* gives its range as south-western New Brunswick, Central Quebec and Ontario.

Grey Sqirrel *(Sciurus carolinensis)*. On July 18th of this year (1890), a fine Grey Squirrel was brought to Mr. W. A. Purcell, taxidermist, of Halifax. It had been shot a day or two before at "the Gore," Hants County, N. S., by Mr. McDonald. The specimen was skinned and mounted, and is now in the possession of that gentleman. There were no indications that the animal had been kept in confinement, and Mr. McDonald

* See *Proceedings Canadian Institute*, 3rd series, Vol. VI, (1887-88), p. 69.

says that it appeared very wild, and was only shot after some difficulty. This squirrel has not previously been taken in our Province—at least I can find no such record. Dr. Gilpin, in one of his papers* before quoted, states that "a large black squirrel skin (Sciurus carolinensis) with nigritism" was given him from Cumberland. He did not, however, include it in his list, probably considering that it had been obtained outside of the Province. Mr. J. B. Tyrrell, whose catalogue of mammalia is one of the latest contributions to our knowledge of Canadian zoology, speaks of it as ranging "from western New Brunswick, through southern Quebec and Ontario as far west as the north shores of Lakes Huron and Superior."†

Birds.

Purple Gallinule *(Ionornis martinica).* A specimen of this bird, which is very rare in Nova Scotia, was captured alive in April, 1889, and is now in the aviary of Mr. Andrew Downs. It is very healthy, washes regularly, preens its feathers, and seems perfectly at home. When first placed in confinement, it subsisted on bread and milk only. It has since, however, abandoned this diet and now lives principally on canary-seed with, at times, a little hemp. It also enjoys picking the seeds out of a cucumber, and is occasionally seen catching flies at the window. At night it perches near the top of a spruce tree which is placed in the aviary, although its immense web-feet seem but ill adapted to such a position. This is probably the only Purple Gallinule which is kept in captivity, and any notes upon its habits in this state are doubtless of interest.

Woodcock *(Philohela minor).* An albino Woodcock which was shot a year or two ago at Kentville, N. S., is now in the collection of Mr. Harry E. Austen, of Dartmouth.

American Crossbill *(Loxia curvirostra minor).* During the spring of 1889, Mr. T. J. Egan twice noted this species breeding in the woods at Point Pleasant, Halifax. I need not at

* On the Mammalia of Nova Scotia. *Trans. N. S. Inst. Nat. Science*, vol. III., p. 125.

† Mammalia of Canada. *Proc. Can. Inst.*, 3rd series, vol. VI, (1887-88), p. 86.

present give any details, as I understand he intends to lay before the Institute some notes regarding the observation, in which full information will doubtless be furnished.

White-winged Crossbill *(Loxia leucoptera)*. This species was found breeding in the same place, and about the same time, as the American Crossbill with which it will be probably treated in Mr. Egan's notes. The nesting habits of both these birds are not at all well known and any information upon the subject is of much interest to ornithologists.

Slate-coloured Junco *(Junco hyemalis)*. On June 11th, 1889, I shot an albino Junco at Dutch Village, near Halifax. Its eyes were brown or hazel-coloured.

Golden-crowned Kinglet *(Regulus satrapa)*. Mr. Harry E. Austen obtained the nest and eggs of this Kinglet at Dartmouth shortly before the 3rd of June, 1889. The nest was found in a black spruce, fastened to a twig at a distance of about nineteen feet from the ground, and at some distance from the trunk of the tree. There were nine eggs, two of which were nearly white and the rest white marked with little dirty brown spots. The female bird was shot and served to identify the nest. The nest and eggs are now in the possession of Mr. Frank B. Webster, publisher of the *Ornithologist and Oologist*, Boston. On June 14th, 1890, the same enthusiastic collector found another nest at Dartmouth. It was hung near the top of a tall spruce and contained young birds.

Ruby-crowned Kinglet *(Regulus calendula)*. Mr. Austen has also been so fortunate as to discover four nests of this species at Dartmouth. The first was found late in May, 1889, in a black spruce, suspended from a twig in a similar manner to thatof the last mentioned bird, and at nearly the same distance from the ground. It was formed of moss and birch-bark, and was altogether different from any description which Mr. Austen has seen. It was fully identified; the male bird being shot with a catapult. Unfortunately the female deserted the nest before any eggs were laid. Mr. Webster has also possession of this nest which he highly values. On the 9th of June, 1890, Mr. Austen obtained a second nest of this species, in the same locality and similarly situated

—in a black spruce, about fifteen feet from the ground. He found that it contained eleven eggs. During the process of blowing, one of these was broken; the others are still in his collection. Not long after this he found two more nests. They contained young birds. The breeding habits of this kinglet are almost wholly unknown to naturalists and Mr. Austen is exceedingly fortunate in having obtained its nest together with eggs and young.

Reptiles.

Leather Turtle *(Sphargis coriacea).* About August 30th, 1889, Mr. William Saul found a large turtle entangled in his mackerel net which was set a few miles from the harbour of Prospect, near Halifax. The animal was secured alive and brought to Messrs. Boak & Bennett's wharf at Halifax, where it was placed in a tank and supplied with salt water. I examined it on the 2nd and 3rd of September and found it to be the Leather Turtle, a native of tropical seas. It has never been taken so far north on this coast and therefore is entirely new to Nova Scotia. I can find no record of its capture to the northward of Massachusetts. Owing to its powerful fore-paddles this species is much given to wandering and is sometimes driven by storms far from its native seas to strange and distant lands. In this way it has been found on the shores of England and France and now on the coast of our own Province. In some details our specimen differs from any discription to which I have access. This may probably be accounted for by a variation in age. For the sake of comparison I shall give the measurements of our specimen along with those of one described by Professor T. Bell: *

* History of British Reptiles, London, 1849, p. 17.

	Nova Scotian Specimen.		*Bell's Specimen.*		
	Ft.	ins.	Ft.	Ins.	Lines.
Total length	5	0	8	0	0
Length of head	0	8½	0	11	4
Greatest breadth of head	0	7	0	9	6
Breadth between the orbits	0	3¾	0	3	4
Length of the fore-paddles	2	0	2	10	0
Greatest breadth of the fore-paddles	–	–	0	9	6
Length of the hinder-paddles	0	10½	1	2	0
Greatest breadth of hinder-paddles	0	6½	0	8	8
Length of tail	0	4	0	3	9
Length of dorsal shell or carapace	3	7½	6	6	0
Weight	250 lbs.				

We thus see that, in proportion, the Nova Scotian specimen is much broader between the eyes and across the head at widest part.* The fore-paddles are also much larger and the tail longer. The greatest difference, however, between our turtle and all figures and descriptions I have seen, lies in the shape of the hinder-paddles. In the specimen I have examined, each of these has *a well-defined notch about two inches deep* on the posterior margin. This peculiarity does not seem to have been previously noted. The best representation of the head is to be found in Professor Bell's work.† Two diverging ridges extend backward from the nostrils of our specimen. The ridges on the dorsal shell were very distinct and slightly nodulous (more so on the anterior portion). The colour of the back was black, or very dark brown, with a slight bluish tinge appearing in some lights. The head was the same colour as the back, but with whitish dashes and spots. Lip, from just in front of nostril to jaw, white. Chin, white. Throat, livid pink. Fore-paddle on top, colour of back, margined on outside with white, and obscurely spotted with soiled white at the end ; beneath, black marbled and spotted with white and pink, the latter colour most conspicuous in the "arm-pits." Hind-flipper, colour of back, obscurely spotted with whitish on the inside half.

BLACK SNAKE *(Bascanion constrictor).* Three or four summers ago I captured a Black Snake as it was crossing a grassy

* My measurements were made *over* the head, not *through*.

† History of British Reptiles, page 13.

road to the east of Blockhouse (Stanford's) Pond, near the Three-mile House. It was a couple of feet in length and answered perfectly the description of this species. I know of only one previous record of its capture in the vicinity of Halifax. Dr. J. B. Gilpin, in his paper on the Serpents of Nova Scotia,* says that it is exceedingly rare in our Province, and he was indebted to Mr. J. M. Jones, F. L. S., for the only adult specimen he had identified. Mr. Jones' specimen was one which he had obtained many years ago from my father, Mr. Henry Piers, who had captured it in a damp place about three-quarters of a mile to the south of the locality whence my own had come.

Fishes.

Sunfish *(Orthagoricus mola).* On August 11th, 1889, while walking on the shore of Bedford Basin, near the Four-mile House (Rockingham), I saw a dark-coloured object bobbing up and down in the smooth water, about half or three-quarters of a mile from the land. It appeared and disappeared at pretty regular intervals and at the same time progressed slowly through the water. After some delay several men left the shore in a boat and succeeded in securing the animal. It was brought to land and, to my surprise, proved to be a Sunfish. This is a rare fish in Nova Scotian waters. Mr. J. M. Jones in his list of the fish of our Province,† mentions only one specimen which has been taken here. This was an individual five feet six inches in length, which was taken in Halifax harbour, October 1873, and was described by Dr. J. B. Gilpin in the Transactions of the Institute.‡ It is the only recorded specimen. Another, however, was taken many years ago by Mr. James Doyle near the Mill Cove at Bedford.

The Sunfish, it is said, is very fond of feeding upon Jelly-fish *(Medusæ).* The specimen recently captured must have been attracted by these animals, myriads of which were in the Basin at the time. On examining the fish as it lay upon the shore immediately after it was taken from the water, I noticed upon the sides

* *Transactions of N. S. Institute of Natural Science,* Vol. IV, p. 84.
† *Trans. N. S. Inst. Nat. Sc.*, Vol. V, p. 95.
‡ Vol. III, p. 343.

groups of tubercles or blisters, each tubercle about an inch in diameter and each group consisting of about five tubercles. I did not examine them very closely, but they appeared to be filled with a semi-fluid matter. The presence of these tubercles is not noticed in any description which I have seen.

On August 12th and 13th I made a minute examination of the animal. The tubercles had then disappeared. They were probably only present during life. In most particulars, both external and internal, our specimen agreed with Dr. Gilpin's description as given in his paper before referred to. The broad, dark band round the posterior part mentioned by DeKay and other writers was not apparent during life; but after death it became noticeable, although not distinct. DeKay likewise says that the dorsal and anal fins are connected with the caudal fin. I do not find this to be so—there was not the slightest connection whatever. Owing to the thickness of the fins there have been great discrepancies as regards the radial formula. After thoroughly drying the dorsal, pectoral and anal fins of the specimen now under consideration, I found that the rays stood out very clearly from beneath the shrunken membrane. This has enabled me to give the following enumeration with certainty:—dorsal, 17; pectoral, 12; anal, 16. Nothing could be more beautiful than the pure, pearly whitness of a piece of the flesh when just cut from the body. It soon, however, dissolved away, leaving only the rasp-like skin. From the liver may be easily obtained * a clear, reddish oil, which is of use as a remedy for rheumatic affections. This I have seen tried with the greatest success.

The following are some of the principal measurements of the fish :—

Total length from tip of snout to the end of the most remote digitation of the tail †	61½ inches.
Depth of body half way between tip of snout and dorsal fin	39 "

* A piece of the liver dissolved almost entirely to oil in a few days.

† These measnrements were mostly made with a measuring tape, and therefore follow somewhat the contour of the body.

Tip of dorsal to tip of anal fin	$73\frac{1}{2}$	inches.
Dorsal fin, height	$21\frac{1}{2}$	"
" length	about 14	"
Anal fin, height	$20\frac{1}{2}$	"
" length	12	"
Pectoral fin, length	7	"
" breadth	$5\frac{3}{4}$	"
Snout to anterior part of pectoral fin	20	"
Snout to nearest corner of eye	$8\frac{3}{4}$	"
Eye, diameter	$2\frac{1}{2}$	"
Snout to branchial opening	17	"
Mouth, across	$3\frac{1}{2}$	"

From this Sunfish I obtained a number of curious PARASITES which answered the description and figure of *Pennella filosa* given in Cuvier's Animal Kingdom.* The head and neck of these torturing enemies had penetrated from two to three inches into the sides of their victim—indeed, in some places I think the most anterior parts must have bored entirely through the flesh, as the belly averaged only two inches in thickness. The bushy posterior portions when seen hanging from the body of the fish, had much the appearance of pieces of seaweed. In extracting some from their burrows the heads were broken off and blood trickled abundantly from theruptured parts. A perfect specimen (in alcohol) measures as follows:—

Total length when straightened out, 6 inches;
Length of portion in fish, about 2·6 inches;
Length of plumose portion, 1 inch;
Length of the two filaments arising from near the posterior end, 5·8 inches.

*The Animal Kingdom, 4 v. with 4 v. of plates by Latreille, London, 1834-7. Vol. IV (text), p. 410, and vol. IV. (plates), Zoophytes, pl. 9, fig. 3.

Art. XIV.—A Contribution to the Theory of Earthquakes —By Rev. Mytton Maury, D. D.

(Received Sept. 15th, 1890.)

Trifling facts very frequently involve exceedingly important conclusions. The Fraunhofer lines which, to the observer, were mere meaningless curiosities, involve and have suggested the marvellous and prodigiously interesting laws of spectroscopic analysis; and the curious and once inexplicable phenomena which puzzled, not Fraunhofer alone, but for a long time such investigators as Brewster and Draper, are at this moment enabling us to explain the question, What are the stars made of? I need, I think, offer no further apology for asking the attention of this Society to a very insignificant fact which was brought to my notice on the occasion of a recent visit to the Steel Works at New Glasgow. A charge had just been drawn from the furnace, and the foreman was standing with me watching the process of casting the large ingots of steel. The pot, into which the molten steel was allowed to flow from the furnace, was provided with a hole in the bottom to permit the molten steel to pass into the casting moulds, and these were ranged in a row underneath a rail track, along which track the pot with its contents of 18 tons of melted steel was made to pass. One after another of these moulds was filled by the opening of the hole in the bottom of the pot. The necessary opening and closing of this hole were accomplished by the elevation and depression of a larger stopper cased with fire clay. The foreman observed how needful it was that the casing of fire clay should be thoroughly dried before use. On one occasion the upper portion had been very slightly damp. As soon as the white hot metal and floating slag filling the pot had reached the damp portion, instantly an explosion occurred. Suddenly, a certain very small quantity of moisture—only a few drops, indeed—had been enclosed by the rising mass of metal and slag as it rapidly filled the pot. The temperature of that moisture was raised to a point above 2,000 degrees Fahr. We know what occurs when the boilers of a racing Mississippi steamer are overheated and the supply of water is low. A slight lurch of the boat will bring a quantity of water suddenly into contact with the heated wall of the boiler. Superheated steam is generated and an explosion occurs. Now the temperature to which such a boiler wall is raised does not of course compare with that of the molten steel and slag of the casting pot. And hence a similar result is perfectly natural, only that what occurred at New Glasgow was probably even more violent. It is not surprising that when the explosion took place portions of the circumjacent metal and slag were shot out of the casting pot high into the air.

I observed to my informer that this was an extremely interesting fact. He therefore went on to tell me that according to his observation, molten slag, when brought into contact with moisture, is productive of much more violent explosions than molten steel. Some time ago a casting from a small pot of steel had been made. The slag which remained in the bottom of the pot was carefully poured upon the ground. This was done very near the wall of one of the buildings belonging to the Steel Works. The foreman (my informant) was in a distant part of the works. He heard a violent explosive report like that of a heavy cannon, and ran to the spot from which the sound came. He imagined that the boiler of the engine had burst. He found that the explosion had been occasioned simply by pouring out an inconsiderable quantity of slag upon ground where there was a little ice or snow. Such, however, was the violence of the concussion that portions of the roof of the building, which was about twenty feet high, were ripped off and blown away, although the explosion, be it remembered, had taken place in the open air, outside the building.

Now let me ask your attention to what seem to me to be the weighty suggestions involved in these seemingly trifling facts.

You are well aware that two prominent theories are offered for the explanation of earthquakes. According to one they are the result of the sliding and grinding of immense masses of rock one upon another,—such sliding being itself a consequence of the secular cooling and shrinking of the crust of the earth.

Without desiring to exclude this as a possible cause of earthquakes, I incline much more strongly to the theory which connects earthquakes and volcanoes as closely related phenomena, — both mainly due to one cause, viz.: the explosive force of enormous volumes of superheated steam. The difference between the two, I believe to be largely this,—that in the case of volcanoes there usually is a vent already existing, while in the case of earthquakes there is none. My idea (not however at all exclusively my own) is, that water, percolating through the crust of the earth, finding its way from some superficial source, the ocean or a river, far down into the interior of the earth, encounters intense heat. It meets with those very elements in a state of incandescence or of fusion, which form the slag of the casting pot. It is not necessary that the water in question should descend to the depth of more than 2,000 or 3,000 feet to encounter such heat. If you walk a few hundred feet down into crater of Vesuvius, you will soon find the soles of your feet uncomfortably warm, while from orifices in the walls of the crater hot jets of gas suggest to you that there must be somewhere near, a blowing engine of enormous capacity unweariedly driving its current of heated gas. And if you descend into the shaft of the famous silver mine near Virginia City, you will find the heat at the depth of 2,500 feet so intense that the workmen labor almost naked, that they can work only a few hours at a time, and must have ice to apply every now and then to their wrists to keep down the temperature of their bodies. Between the strata of rocks situated near the scene of an earthquake, or near a volcano, especially if such strata are tilted, it requires no stretch of imagination to understand how water from the sea or river bed may glide into lower regions, where the materials of which rocks are made are in the molten state. A volcanic eruption or an earthquake would be the natural and necessary consequence.

I consider that this view receives corroboration from the fact that volcanic regions are generally in seaboard regions. Vesuvius, Stromboli and Ætna, the long line of Andean volcanic heights which bristle along the Pacific coast of South America, the volcanoes of Krakatoa, and her companions in the Eastern Archipelago, all tell the same tale. Great oceanic cisterns, with copious supplies of moisture at all times ready to follow the grading surfaces of tilted rock strata are near them all.

The same is true of the scenes of our most noted earthquakes. Their law of distribution confines them to the vicinity of large bodies of water. I need only remind you of those which have occurred at Lisbon, in the south of Italy, in the valley of the Mississippi, at Charleston, on the South American shores of the Pacific, and in Japan.

I note in this connection, as shewing on a small scale the percolating power of water, an interesting fact mentioned in Brown's "Coal Fields of the Island of Cape Breton." He relates that "in working the main seam of the Sydney Mines, some years ago, the sea water found its way into the exploring levels which had been pushed out underneath the water of the harbor. It percolated through a thickness of 300 feet of strata," and insisted on pursuing this course so persistently, that, in spite of strong dams built to bar the entrance of the enemy, the mine had to be abandoned.

Besides all this, it appears to me, that while those who advocate the crust contraction theory, are persons entitled to great respect, the phenomena of earthquakes have characteristics which are better explained by the other theory. In the first place they are marked by great suddenness:—and secondly, in the case of the majority of the more important, they have not that duration which might naturally be expected, if they were the result of any such extremely gradual and continuous process as the cooling and contraction of the earth's crust must be. They are emphatically explosive. Lisbon and Caraccas were both destroyed in less than five minutes; and I am constrained to believe that such phenomena are fairly illustrated on a small scale by the slag explosions at New Glasgow.

Art. XV.—Observations on the Tentacles of the Echinus—By the Rev. Mytton Maury, D. D.

Having captured an Echinus on the shore of the harbor of Halifax, I placed him in a basin of sea-water for convenience of observation. A plentiful allowance of sea-weeds furnished him with vegetable diet, and almost gorgeously decorated his domicile with coloring such as modern æsthetic art delights in. His term of residence began at four p. m. At that time his tentacles were *all entirely pellucid.* Having noted this, I left him to ramble amid the floral beauty of his new abode. At ten p. m. I observed him again. To my surprise, the tentacles presented now an altogether different appearance. They were opaque, and bore a decided purplish tint. I snipped off a portion of one and placed it under the microscope, using an inch objective. The accompanying cut (Plate IV, Fig. 1) is copied from the drawing which I made of the amputated part. The corrugations indicated, and the quintuple division of the terminal disc, were perfectly distinct.

Applying the 8th objective, I obtained views represented in Plate IV., Figs. 2 and 3. Fig. 2 shews a pair of the corrugations on one side of the axis of the tentacle, which axis must be imagined as running at right angles to the length of the figure. Inside the walls are seen fine radiating muscular fibres which contract the organ toward the axis. But of greater interest are the contents of the interior of the sections. The dark irregular blotches indicate pieces of a purple seaweed which had been placed in the basin with the Echinus, while the hooked forms irregularly distributed in each and all of the corrugations convinced me that sponge spicules were present. I had unfortunately no nitric acid at hand to test them, but their shape and general appearance would almost identify them.

The question naturally forced itself on my mind, How did these materials find their way into the tentacles? For it was not one or one row that presented the recorded appearance, but nearly all. Writing now from recollection, my impression is that a portion of one row was still pellucid. I hazard the conjecture that besides their locomotive function and their function of resisting motion, the tentacula of the Echinus have also the office of aiding in the nutrition of their possessor.

Fig. 3 presents a view which explains most interestingly the minute anatomy of the terminal disc. It exhibits, of course, only a portion of the organ. The area *cdex* is composed of a formless material in which irregularly roundish masses (probably calcareous) are embedded. They are independent one of another. This secures perfect freedom of movement and enables the disc to apply itself to any conceivable form of surface, smooth or rough. Moreover, projecting in pairs from the outer portion of this plastic foot (?) are denticles (x x x) which serve, I conjecture, the double purpose of clinging and of comminuting food. Their plasticity gives them a clawlike grasp.

It is to be observed that the bundles of muscular fibre, which seem in the figure to radiate from the points of the denticles, are not attached to these points. For, focussing upon the denticles, it is perfectly clear that the tendons of the muscular bundles are in a different plane from that of the denticles. They are hazy when the denticles are clear. They must, therefore, be attached at points interior to the denticles, these being absolutely superficial.

The double circular band, *yy*, is quite distinct. Whether it is nervous or muscular I could not safely say.

ART. XVI.—NOTE ON THE VARIATION OF DENSITY WITH CONCENTRATION IN WEAK AQUEOUS SOLUTIONS OF COBALT SULPHATE.—By A. M. MORRISON, B. A.

(Read 12th May, 1890.)

In a paper by your President, read before the Royal Society of Canada in 1885, and in another by the same author, read before the same Society in 1889, it was pointed out that, in sufficiently weak aqueous solutions of certain salts, the excess of their density over that of water at the same temperature, is very nearly proportioned to the mass of salt they contain. Or, in symbols, $D_t = d_t + k\,p$, where D_t represents the density of the solution, i. e., the mass in grammes of 1 cu. cm. of it, at the temperature t°; d_t, the density of water at t°; p, the percentage of anhydrous salt in the solution, and k, a constant for any given substance and temperature.

It was for the purpose of discovering to what extent this is true for Cobalt Sulphate, which was not mentioned in the papers cited above, that the following determinations were made.

The solutions were formed by mixing weighed quantities of crystallised Cobalt Sulphate ($Co\ SO_4 + 7\ H_2O$) with weighed quantities of water. The salt was purchased as pure from Queen & Co., Philadelphia. It was found to be free from mechanical and was assumed to be free from chemical impurities. Only clear, well-formed crystals were used so as to make sure that each elementary crystal contained exactly seven molecules of water.

A new solution with freshly-distilled water, boiled to drive out air, was made for every determination; for it was found that solutions left standing a day or so threw down sufficient precipitate to interfere seriously with the correct working.

All weighings were made in stoppered bottles, by the method of "double weighing," and were, of course, reduced to "*in vacuo.*" The relative errors of the standard weights employed were neglected. The balance was a delicate one by Collot, of Paris. In the calculation of the percentages of anhydrous salt in the various solutions, the atomic weights given in Clarke's "Constants of Nature" were employed.

All the density determinations were made for 20° C. by means of a specific-gravity bottle of about 50 cu. cm. capacity. This was light, of thin, hard glass, and not easily deformable, and was provided with an accurately-fitting, perforated ground glass stopper. When a determination was to be made this bottle was filled with the solution slightly below 20° and, held by its neck, was plunged, up to the neck, in a bath of water kept constantly stirred and at a temperature of 20° C. The solution, being increased in volume by being thus raised in temperature, oozed out through the perforation in the stopper, whence it was removed by means of a bit of lintless blotting-paper. When the oozing ceased the solution had acquired the temperature of the bath, and the bottle containing it was taken out and wiped dry with a clean, lintless rag,—care being taken to exert very little pressure and to avoid direct contact of the hand with the glass. These precautions were necessary to prevent deformation and heating of the bottle and consequent expulsion of the liquid through the perforation in the stopper. The temperature of 20° C. was chosen as it is some degrees above the usual laboratory temperature, so that, when the solution is removed from the bath, it contracts, and thus loss from running over and evaporation is avoided.

As the result of these experiments, it was found that the concentration and density of solutions containing not more than 2.5 per cent. of anhydrous Cobalt Sulphate are connected by the equation—

$$D_{20} = .99827^{*} + .01116\, p.$$

The following table contains, in the first column, the percentages of anhydrous salt in solution; in the second column, the corresponding densities observed at 20°; in the third column, the densities calculated from the above formula, and, in the fourth

* The density of water at 20° C., according to Volkmann, Wied. Ann., XIV (1881), p. 260.

column, the differences between the observed and calculated densities.

Percentage of anhydrous salt in solution.	Density at 20° C.		Difference.
	Observed.	Calculated.	
.6507	1.00552	1.00553	+ 0.00001
1.5324	1.01535	1.01537	+ 0.00002
1.7368	1.01766	1.01765	— 0.00001
2.4265	1.02541	1.02535	— 0.00006
2.7755	1.02954	1.02924	— 0.00030
5.0252	1.05498	1.05435	— 0.00063
8.0207	1.09047	1.08778	— 0.00269

Subjoined is a more exact empirical formula with tabulated results. The smallness of the co-efficient of p^2 shews that the concentration-density curve is practically a straight line to nearly 2.5 per cent.

Formula : $D_{20} = .99827 + .01109\, p + .00005\, p^2$.

Percentage of anhydrous salt in solution.	Density at 20°. C.		Difference.
	Observed.	Calculated.	
.6507	1.00552	1.00550	— 0.00002
1.5324	1.01535	1.01538	+ 0.00003
1.7368	1.01766	1.01768	+ 0.00002
2.4265	1.02541	1.02548	+ 0.00007
2.7755	1.02954	1.02943	— 0.00012
5.0252	1.05498	1.05525	+ 0.00027
8.0207	1.09047	1.09044	— 0.00003

I know of only two determinations of the density of Cobalt Sulphate solutions with which mine can be compared. Nicol* gives 1.04303 as the specific gravity at 20° C. relatively to water at the same temperature, of a solution containing half a molecule

* Phil. Mag. (5), XVI, (1883), p. 122.

of hydrated salt to 100 molecules of water. Hence, according to him, 1.04123 is the density at 20° C. of a solution containing 4.1434 per cent. of anhydrous salt. My experiments, as represented by the above formula, give 1.04508 as the density of this solution. Wagner† gives 1.0860 as the specific gravity at the temperature of the laboratory (not given) of a solution containing 7.239 per cent. of anhydrous salt. If we take the temperature of the laboratory to have been 15° C., and assume that his specific gravities were referred to water at 15° C., the density of this solution according to him would be 1.08581. My experiments would make it 1.08117. Wagner's result is thus about as much greater than mine for this solution as Nicol's is less than mine for the solution which he examined.

The above observations were made in the Physical Laboratory of Dalhousie College, Halifax, N. S.

† Wied Ann, XVIII, (1883), p. 269.

APPENDIX.

LIST OF INSTITUTIONS TO WHICH COPIES OF VOL. VII., PART 3, OF THE PROCEEDINGS AND TRANSACTIONS HAVE BEEN SENT.

I. AMERICA.

(1.) Canada.

Antigonish, N. S.—St. Francis Xavier's College.
Cap Rouge, Qu.—Le Naturaliste Canadien.
Charlottetown, P. E. I.—Prince of Wales College.
" P. E. I. Natural History Society.
Fredericton, N. B.—New Brunswick University.
Hamilton, Ont.—H. Association for promotion of Literature, Science and Art.
Halifax, N. S.—Nova Scotia Historical Society.
" The Provincial Secretary.
" The Commissioner of Mines.
" The Attorney-General.
" The Legislative Library.
" The Halifax Teachers' Professional Library.
" Dalhousie College.
" The Halifax Academy.
London, Ont.—Entomological Society of Ontario.
Montreal, Qu.—Natural History Society of Montreal.
" Antiquarian and Numismatic Society.
" Redpath Museum, McGill College.
" Horticultural Society.
" Canadian Society of Civil Engineers.
Ottawa.—Royal Society of Canada.
" Geological and Natural History Survey of Canada
" Field Naturalists' Club.
" Ottawa Literary and Scientific Society.
" Department of Marine and Fisheries.
" Parliamentary Library, House of Commons.
" Canadian Mining Review.
Pictou, N. S.—The Pictou Academy.
Prince Albert, Sask.—The Saskatchewan Institute.
Quebec, Qu.—Geographical Society.
" L'Institut Canadien.
" Literary and Historical Society.

St. John, N. B.—New Brunswick Natural History Society.
Sackville, N. B.—Mt. Allison College.
Toronto, Ont.—The Canadian Institute.
" Director of the Meteorological Service.
" University of Toronto.
Truro, N. S.—Normal School.
Windsor, N. S.—King's College.
Wolfville, N. S.—Acadia College.
Winnipeg, Man.—Manitoba Historical and Scientific Society.
Yarmouth, N. S.—Milton Library.

(2.) United States.

Albany, N. Y.—New York State Museum of Natural History.
Baltimore, Md.—Peabody Institute.
" John Hopkins' University.
Beloit, Wis.—Chief Geologist.
Boston, Mass.—American Academy of Arts and Sciences.
" Boston Society of Natural History.
Bridgeport, Conn.—Bridgeport Scientific Society.
Brooklyn, N. Y.—Entomological Society.
Brookville, Ind.—Brookville Society of Natural History.
" Indiana Academy of Science.
Buffalo, N. Y.—Buffalo Society of Natural Sciences.
Cambridge, Mass.—Museum of Comparative Zoology, Harvard College.
" Cambridge Entomological Club.
" Peabody Museum of American Archæology and Ethnology.
Champaign, Ill.—Illinois State Laboratory of Natural History.
Chapel Hill, N. C.—Elisha Mitchell Scientific Society.
Charleston, S. C.—Elliott Society of Science and Art.
Chicago, Ill.—Academy of Sciences.
Cincinnati, Ohio.—Cincinnati Society of Natural History.
" Ohio Mechanics' Institute.
" Historical and Philosophical Society of Ohio.
Columbus, Ohio.—Geological Survey of Ohio.
Davenport, Iowa.—Davenport Academy of Natural Sciences.
Denver, Col.—Colorado Scientific Society.
Indianapolis, Ind.—The State Geologist of Indiana.
Iowa City, Iowa.—State University of Iowa.
Jefferson City, Mo.—State Geologist, Geological Survey of Missouri.
Madison, Wis.—Academy of Science, Arts and Letters.
Meriden, Conn.—Meriden Scientific Association.
Minneapolis, Minn.—Minnesota Academy of Natural Science.
" Geological and Natural History Survey of Minnesota.
New Haven, Conn.—Connecticut Academy of Arts and Sciences.
New Orleans, La.—Academy of Natural Sciences.
Newport, R. I.—Newport Natural History Society.

New York, N. Y.—New York Academy of Sciences.
" American Museum of Natural History, Central Park.
" New York Microscopical Society.
" American Institute of Mining Engineers.
" School of Mines, Columbia College.
" New York Academy of Anthropology.
Philadelphia, Pa.—Academy of Natural Sciences.
" American Philosophical Society.
" Franklin Institute.
" Wagner Free Institute of Science.
" Pennsylvania University.
" American Entomological Society.
" Zoological Society of Philadelphia.
Portland, Me.—Commissioner of Game and Fisheries.
" Society of Natural History.
Poughkeepsie, N. Y.—Vassar Brothers' Institute.
Princeton, N. J.—E. M. Museum of Geology and Archæology, Princeton College.
Salem, Mass.—Essex Institute.
" American Association for the Advancement of Science.
" Peabody Academy of Sciences.
San Diego, Col.—San Diego Society of Natural History.
San Francisco, Cal.—California Academy of Sciences.
" California State Mining Bureau.
" Technical Society of the Pacific Coast.
St. Louis, Mo.—St. Louis Academy of Science.
Sedalia, Mo.—Sedalia Natural History Society.
Topeka, Ka.—Kansas Academy of Science.
Trenton, N. J.—Trenton Natural History Society.
University of Virginia, Va.—Leander McCormick Observatory.
Washington, D. C.—Smithsonian Institution.
" Bureau of Ethnology, Smithsonian Institution.
" U. S. National Museum.
" U. S. Geological Survey (Department of the Interior.)
" U. S. Commissioner of Fish and Fisheries.
" U. S. Commissioner of Agriculture.
" The Chief Signal Officer (War Department.)
" The Chief of Engineers (War Department.)
" U. S. Coast and Geodetic Survey.
" Office of Indian Affairs (Department of the Interior.)
" The Surgeon-General of the U. S. Army.
" The Commissioner of Education.
" The Bureau of Navigation.
" The National Academy of Sciences.
" The Philosophical Society.
" The Biological Society.
" The Anthropological Society of Washington.

(3.) Mexico.

Mexico City.—Museo Nacional.
" Sociedad Cientifica "Antonio Alzate."
" Observatorio Meteorologico-magnetico Central.

(4.) Costa Rica.

San Josè.—Museo Nacional.

(5.) Cuba.

Habana.—Sociedad Antropologica de la Isla Cuba.

(6.) Hayti.

Port-au-Prince.—Société des Sciences et de Geographie.

(7.) Brazil.

Rio de Janeiro.—Museu Nacional.
" Escola de Minas de Ouro Preto.

(8.) Argentine Republic.

Buenos Aires.—Museo Nacional.
" Instituto Geografico Argentino.
Cordoba.—Academia Nacional de Ciencias.

II. EUROPE.

(1.) England.

Barnsley.—Midland Institute of Mining and Mechanical Engineers.
Birmingham.—Birmingham and Midland Institute.
" Birmingham Philosophical Society.
" Birmingham Natural History and Microscopical Society.
Bristol.—Bristol Naturalists' Society.
Camborne.—Mining Association and Institute of Cornwall.
Cambridge.—Cambridge Philosophical Society.
Carlisle.—Cumberland and Westmoreland Association for the Advancement of Literature and Science.
Falmouth.—Royal Cornwall Polytechnic Society.
Leeds.—The Philosophical and Literary Society.
" The Conchological Society.
Liverpool.—The Liverpool Polytechnic Society.
" The Geological Association.
" The Literary and Philosophical Society.
London.—The Linnean Society.
" The Royal Microscopical Society.
" The Zoological Society.
" The Victoria Institute.

London.—The National Fish Culture Association.
" The Geologists' Association.
" The Entomological Society.
" The Mineralogical Society of Great Britain and Ireland.
" The Anthropological Institute of Great Britain and Ireland.
" The British Museum.
" The British Museum (Natural History Department).
" The Geological Society of London.
" The Essex Field Club.
" The Iron and Steel Institute.
" The Physical Society.
" The Quekett Microscopical Club.
" The Royal Colonial Institute.
" The Royal Institution of Great Britain.
" The Royal Society.
" The London Mathematical Society.
" The Society of Arts.
" The Society of Antiquaries.
" The Mining Journal and Railway and Commercial Gazette.
Leicester.—The Literary and Philosophical Society.
Manchester.—The Literary and Philosophical Society.
" The Owens College.
" The Field Naturalists' Society.
" The Geological Society.
Newcastle-on-Tyne.—North of England Institute of Mining and Mechanical Engineers.
" Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne.
Penzance.—Royal Geological Society of Cornwall.
Plymouth.—The Plymouth Institution and Devon and Cornwall Natural History Society.
Taunton.—Somersetshire Archæological and Natural History Society.
Truro.—Royal Institution of Cornwall.
York.—The Yorkshire Philosophical Society.

(2.) Scotland.

Dumfries.—Dumfriesshire and Galloway Natural History and Antiquarian Society.
Dundee.—Dundee Naturalists' Society.
Edinburgh.—The Edinburgh Geological Society.
" The Royal Physical Society.
" The Royal Society.
" The Royal Observatory,
" The Royal Scottish Society of Arts.
" The Botanical Society.
Glasgow.—The Geological Society of Glasgow.
" The Natural History Society.

Glasgow.—The Philosophical Society.
" The Andersonian Naturalists' Society.

(3.) Ireland.

Belfast.—The Naturalists' Field Club.
" The Belfast Natural History and Philosophical Society.
Dublin.—The Royal Dublin Society.
" The Royal Geological Society of Ireland.
" The Royal Irish Academy.

(4.) France.

Bordeaux.—Academie Nationale des Sciences, Belles Lettres et Arts.
" Société de Geographíe Commerciale de Bordeaux.
Cherbourg.—Société Nationale des Sciences Naturelles.
LeHavre.—Société Geologique de Normandie.
Lille.—Société Geologique du Nord.
Montpellier.—Academie des Sciences et Lettres.
Paris.—Academie des Sciences de l'Institut de France.
" Ecole Polytechnique.
" Faculté des Sciences de la Sorbonne.
" Musée d' Histoire Naturelle.
" Société d' Anthropologie de Paris.
" Société de Biologie.
" Société d' Encouragement pour l' Industrie Nationale.
" Société Entomologique de France.
" Société Geologique de France.
" Société Francaise de Mineralogie.
" Société Francaise de Physique.
" Société Philotechnique.
" Société Zoologique de France.
" Société Mathematique de France.
" Association Francaise pour l' Avancement des Sciences.
" Annales des Mines.
" Feuille des Jeunes Naturalistes.
St. Etienne.—Société de l' Industrie Minerale.
Toulouse.—Academie des Sciences, Inscriptions et Belles Letters.

(5.) Germany.

Berlin.—Gesellschaft für Erdkunde zu Berlin.
" Königlich preussische Akademie der Wissenschaften.
" Physikalische Gesellschaft.
" Deutsche Geologische Gesellschaft.
" Gesellschaft naturforschender Freunde.
" Berliner Gesellschaft für Anthropologie, Ethnographie und Urgeschichte.
Bonn.—Naturhistorischer Verein der preuss. Rheinlande, Westfalens u. d. Reg.-Bezirks Osnabrück.

Braunschweig.—Verein für Naturwissenschaft zu Braunschweig.
Bremen.—Naturwissenschaftlicher Verein.
Carlsruhe.—Naturwissenschaftlicher Verein zu Carlsruhe.
Cassel.—Verein für Naturkunde.
Chemnitz.—Naturwissenschaftliche Gesellschaft.
Dresden.—Königliches Mineralogisches Museum.
" Gesellschaft für Natur-und Heilkunde.
" Naturwissenschaftlicher Verein "Isis."
Erlangen.—Physikalisch-medizinische Societät.
Frankfurt, a. M.—Senckenbergische Naturforschende Gesellschaft.
Frankfurt, a. O.—Naturwissenschaftlicher Verein.
Freiberg (Saxony).—Naturforschende Gesellschaft.
Freiburg (Baden).—Naturforschende Gesellschaft.
Giessen.—Oberhessische Gesellschaft für Natur-und Heilkunde.
Göttingen.—Königliche Gesellschaft der Wissenschaften.
Halle, a. S.—Kaiserlich deutsche Akademie der Naturforscher.
" Naturwissenschaftlicher Verein für Sachsen und Thüringen.
Hamburg.—Naturhistorisches Museum.
" Verein für Naturwissenschaftliche Unterhaltung.
" Naturwissenschaftlicher Verein.
Hannover.—Naturhistorischer Verein für Niedersachsen.
Heidelberg.—Naturhistorisch-medizinischer Verein.
Jena.—Medizinisch-naturwissenschaftliche Gesellschaft.
Königsberg.—Königliche physikalisch-ökonomische Gesellschaft.
Leipzig.—Verein für Erdkunde zu Leipzig.
" Königlich sächsische Gesellschaft der Wissenchaften.
" Naturforschende Gesellschaft.
Marburg.—Gesellschaft zur Beförderung der gesammten Naturwissenschaften.
Mulhouse (Alsace).—Société Industrielle de Mulhouse.
München.—Königlich baierische Akademie der Wissenchaften.
" Deutsche Gesellschaft für Anthropologie, Ethnologie und Urgeschichte.
Nürnberg.—Naturhistorische Gesellschaft zu Nürnberg.
Stuttgart.—Verein für vaterländische Naturkunde in Württemberg.
Wiesbaden.—Nassauischer Verein für Naturkunde.
Würzburg.—Physikalisch-medizinische Gesellschaft.
" Unter-fränk. Kreisfischereiverein.

(6.) AUSTRIA-HUNGARY.

Agram.—Société Archeologique.
Prag.—Königlich böhmische Gesellschaft der Wissenschaften.
" Naturhistorischer Verein "Lotos."
Trieste.—Societá Adriatica di Scienze Naturali.
" Museo Civico di Storia Naturali di Trieste.
Vienna.—Anthropologische Gesellschaft.
" Kaiserliche Akademie der Wissenschaften.

Vienna.—K. K. geologische Reichsanstalt.
  "   K. K. naturhistorisches Hofmuseum.
  "   K. K. Zoologisch-botanische Gesellschaft.

(7.) Italy.

Acireale (Sicily.)—Societá Italiana dei Microscopisti.
Bologna.—Accademia delle Scienze dell' Istituto di Bologna.
Florence.—Istituto di Studi Superiori.
  "   Societá Entomologica Italiana.
  "   Societá Italiana di Antropologia, Etnologia e Psichologia comparata.
  "   Societá Botanica Italiana.
Genoa.—Museo Civico di Storia Naturali.
  "   Societá di Letura e Conversazione Scientifiche.
Milan.—Reale Istituto Lombardo di Scienze, Lettere ed Arti.
  "   Societá Italiana di Scienze Naturali.
Modena.—Academie Royale des Sciences Lettres et Arts.
Naples.—Societá Reale di Napoli (Accademia delle Scienze Fisiche e Matematiche.
  "   Stazione Zoologica (Dr. Dohrn).
Palermo.—Circolo Matematico di Palermo.
  "   Accademia Palermitana di Scienze, Lettere ed Arti.
Pisa.—Societá Toscana di Scienze Naturali.
Rome.—Accademia Pontificia de Nuovi Lincei.
  "   R. Accademia dei Lincei.
  "   R. Comitato Geologico Italiano.
  "   Bullettino di Bibliografia e di Storia delle Scienze Matematiche e Fisiche.
Siena.—R. Accademia de Fisiocritici in Siena.
Turin.—Reale Accademia della Scienze.
Venice.—Reale Istituto Veneto di Scienze Lettere ed Arti.

(8.) Switzerland.

Bern.—Naturforschende Gesellschaft.
Geneva.—Institut National Genevois.
  "   Société de Physique et d'Histoire Naturelle.
Lausanne.—Société Vaudoise des Sciences Naturelles.
Neuchatel.—Société des Sciences Naturelles.
Zürich.—Naturforschende Gesellschaft.

(9.) Belgium.

Brussels.—Société Royale de Malacologique de Belgique.
  "   Academie Royale des Sciences des Lettres et des Beaux Arts.
  "   Musée Royal d'Histoire Naturelle de Belgique.
Liége.—Société Geologique de Belgique.
  "   Société Royale des Sciences de Liége,
Luxembourg.—Institut Royal Grand-ducal de Luxembourg.

(10.) Netherlands.

Amsterdam.—Koninklijke Akademie van Wetenschappen.

Amsterdam.—Koninklijke Zoologisch Genootschap.
Harlem.—Bibliothéque de Musée Teyler.
" Société Hollandaise des Sciences.
Leiden.—Nederlandsche Dierkundige Vereenigung.

(11.) Denmark.

Copenhagen.—Société Royale des Antiquaires du Nord.
" Kongelige Danske Videnskabernes Selskab.
" Kongelige Universitetet.

(12.) Norway.

Bergen.—Museum.
" Selskabet for de Norske Fiskeriers Fremme.
Christiania.—Det Meteorologiske Institut.
" Kongelige Norske Fredericks Universitet.
" Videnskabs Selskabet i Christiania.
" Norges Geografiske Selskab.
" Polytekniske Forening.
" Norges Geografiske Opmaaling.
Throndjem.—Videnskabernes Selskab.
Tromsö.—Museum.

(13.) Sweden.

Stockholm.—Kongliga Svenska Vetenskaps Akademien.
" Kongliga Universitetet.
" Svenska Sällskapet för Antropologi och Geografi.
" Geologiska Förening i Stockholm
" Acta Mathematica.
Upsala.—Kongliga Universitetet.

(14.) Russia.

Helsingfors (Finland.)—Société des Sciences de Finlande.
Moscow.—Société Imperiale des Naturalistes.
" Société Imperiale des Amis des Sciences Naturelles d'Anthropologie et d'Ethnographie.
St. Petersburg.—Comite Geologique de la Russie (Institut des Mines.)
" Jardin Imperial de Botanique.
" Academie Imperiale des Sciences.
" Société Physico-chimique Russe à l'Université.

(15.) Portugal.

Lisbon.—Academie Royale des Sciences de Lisbonne.

III. ASIA.

(1.) India.

Bombay.—Anthropological Society.

Calcutta.—Survey of India Department.
" Geological Survey of India.

(2.) JAPAN.

Tokio.—The Imperial University.

IV. AFRICA.

(1.) CAPE COLONY.

Cape Town.—South African Philosophical Society.

(2.) MAURITIUS.

Port Louis.—Royal Society of Arts and Sciences.

V. AUSTRALASIA.

(1.) AUSTRALIA.

Adelaide, South Australia.—Royal Society of South Australia.
" The Government Geologist.
Brisbane, Queensland.—Acclimatization Society of Queensland.
" Royal Society of Queensland.
Melbourne, Victoria.—Tne National Museum.
" The Field Naturalists' Club of Victoria.
" The Mining Department.
" The Royal Society of Victoria.
Sydney, New South Wales.—The Australian Museum.
" The Mining Department.
" The Royal Society of New South Wales.
" The Technological Museum.

(2.) NEW ZEALAND.

Auckland.—The Auckland Institute.
Christchurch.—The Philosophical Institute of Canterbury.
Dunedin.—The Otago Institute.
Wellington.—The Colonial Museum.
" The New Zealand Institute.

(3.) TASMANIA.

Hobart Town.—Royal Society of Tasmania.

GENERAL INDEX TO VOLS. I.–VII.

OF THE

PROCEEDINGS AND TRANSACTIONS

OF THE

NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE.

[N. B.—In the following Index, Roman numerals refer to Volumes, Arabic numerals enclosed in brackets to Parts of Volumes, and Arabic numerals not thus enclosed to pages. Thus II (4), 63, means Vol. II, Part 4, Page 63. References to Parts are given only in the case of Vols. I. and II., the pagination in the succeeding volumes being continuous. It should be noted that on the first page of Vol. I, Part 2, and of Vol. I, Part 3, respectively, Vol. II, Part 2, and Vol. II, Part 3, were printed by mistake.

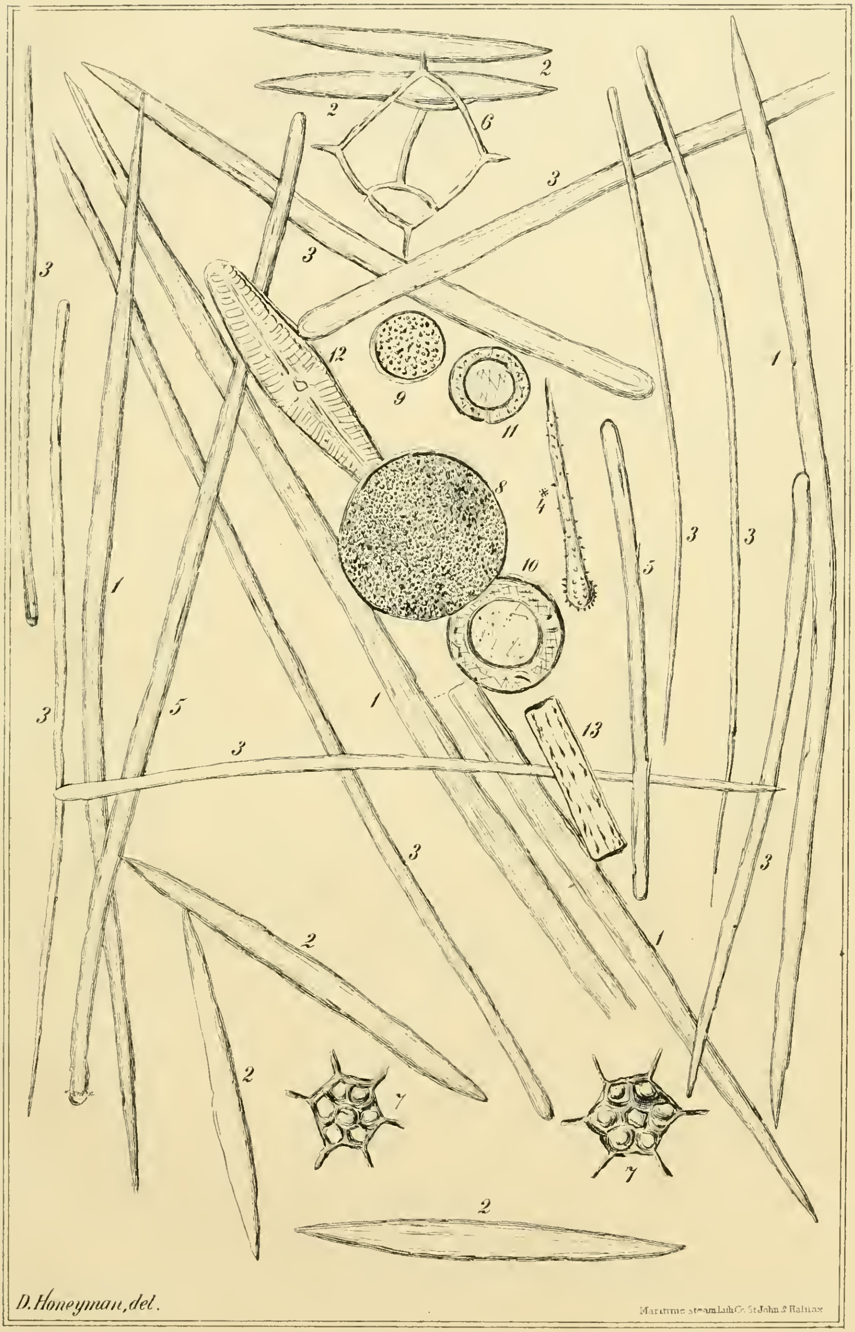
The specific names of plants, animals, etc., which occur in this Index are the names of plants, animals, etc., either forming the subjects of separate communications, or referred to in papers whose titles would not lead the reader to look for references to them there, or referred to in the minutes of the Proceedings of the Society. It has not been thought desirable to include in the Index references to species of plants, animals, &c., which are discussed in papers whose titles would lead the reader to turn to them for such species.

Plants, animals, &c., are referred to under their common or their scientific names according to the usage of the author cited. Hence readers seeking information should turn both to the scientific and to the common name.

Under names of places have been entered all papers referring to such places in their titles, and papers which discuss the geology, &c., of such places, but whose titles would not lead the reader to suspect such discussion. But no attempt has been made to give a complete index to places referred to in the Transactions; and thus places referred to in general papers (*e. g.*, The Superficial Geology of Nova Scotia) are not cited in the Index.

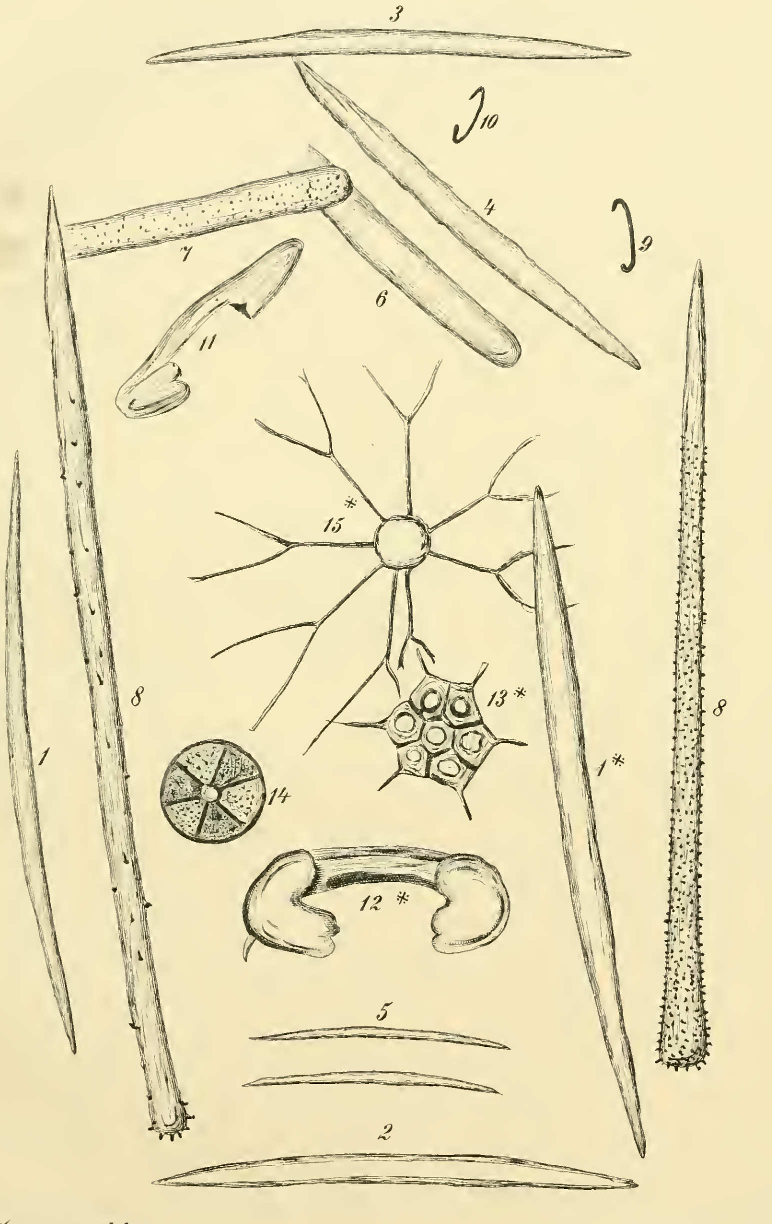
Under such general headings as Zoology, &c., only those papers are cited whose titles do not admit of more specific references.]

PLATE I



Spongiadae: Reniera Miniae.-

Illustrating Dr. Honeyman's paper on Two Cable Hauls.



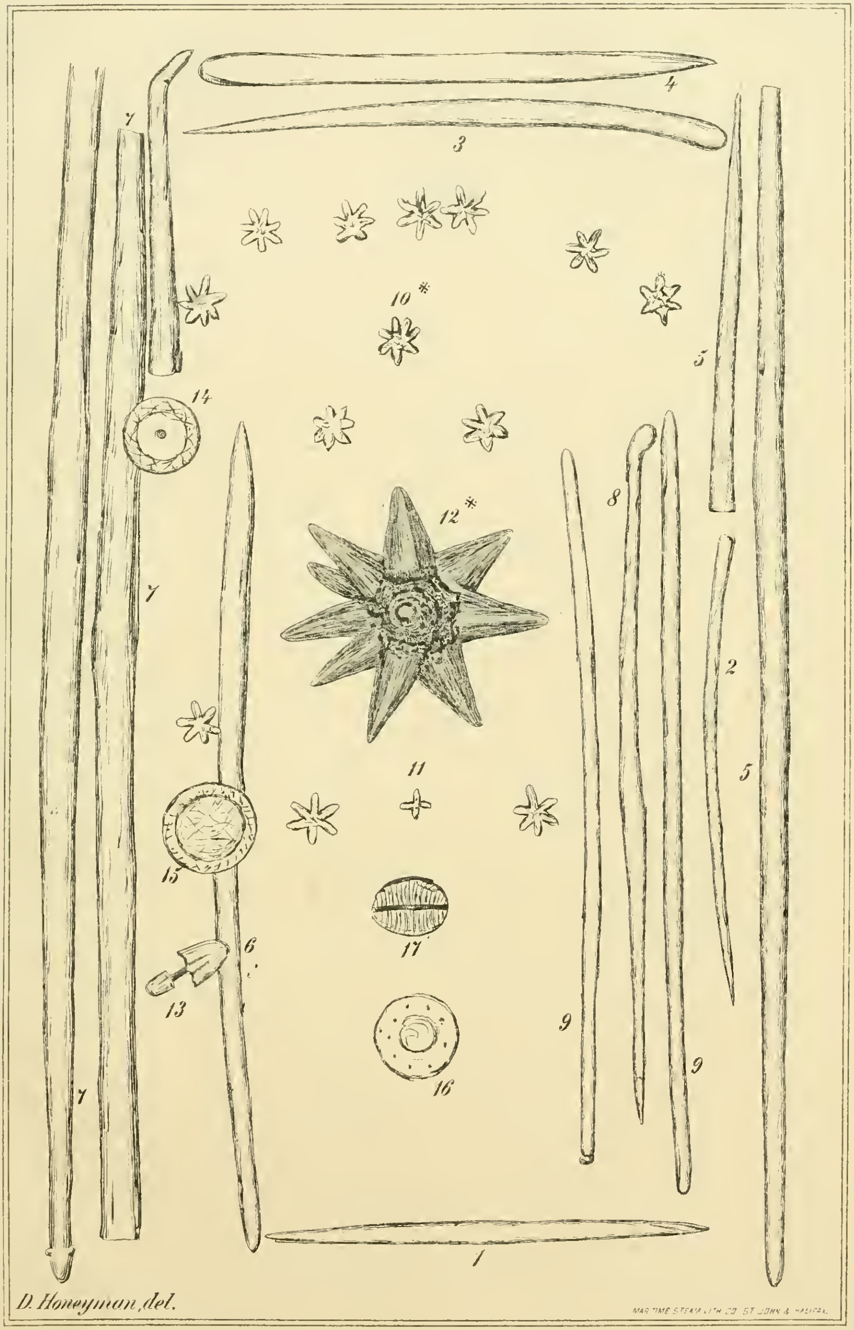
D. Honeyman, del.

MARITIME STEAM LITH CO ST JOHN & HALIFAX

Spongiadae: Reniera Fundyensis.
Illustrating Dr. Honeyman's paper on Two Cable Hauls.

TRANS. N. S. INST. NAT. SCI., VOL. VII 1889.

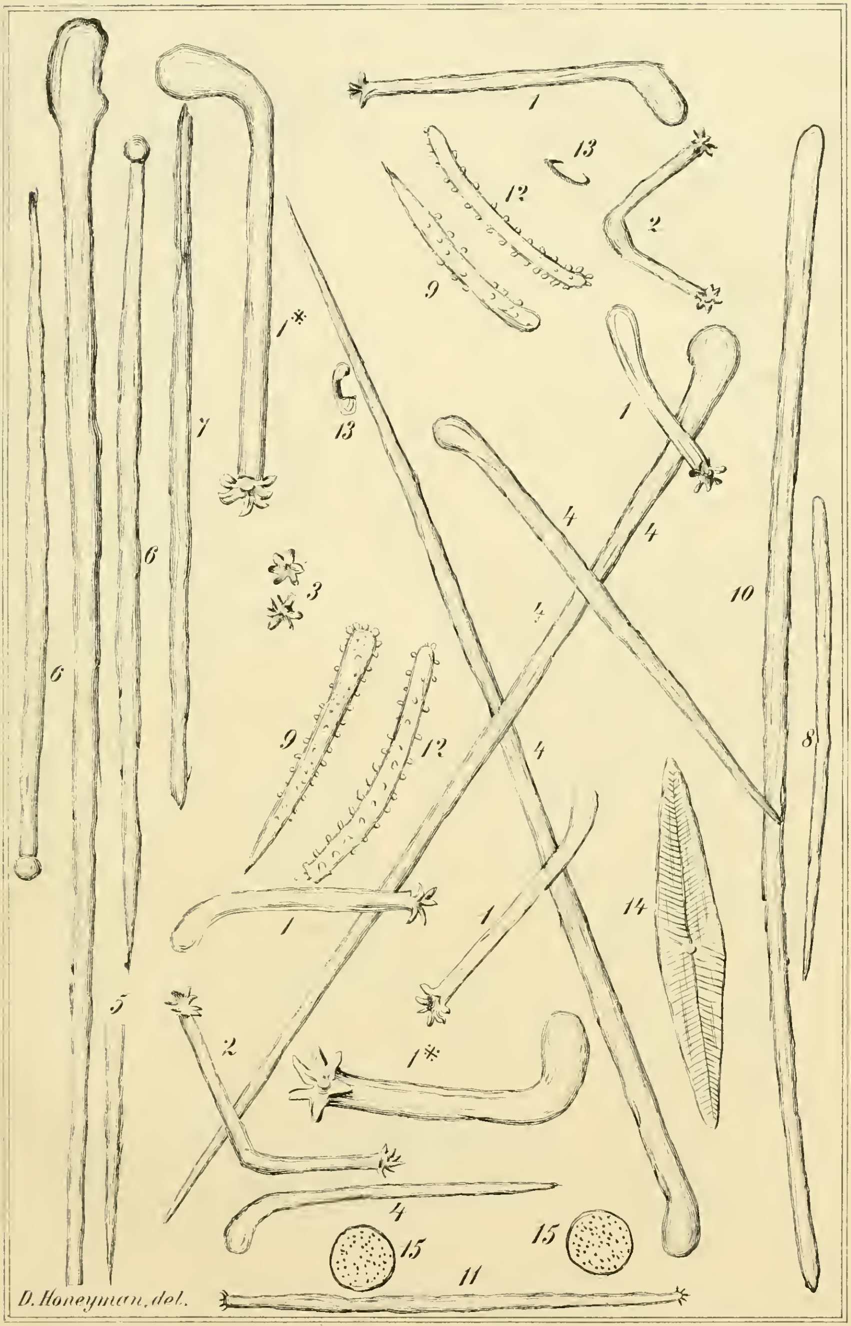
PLATE III



Spongiadae: Stelletta Hanseni

Illustrating Dr. Honeyman's paper on Glacial Boulders.

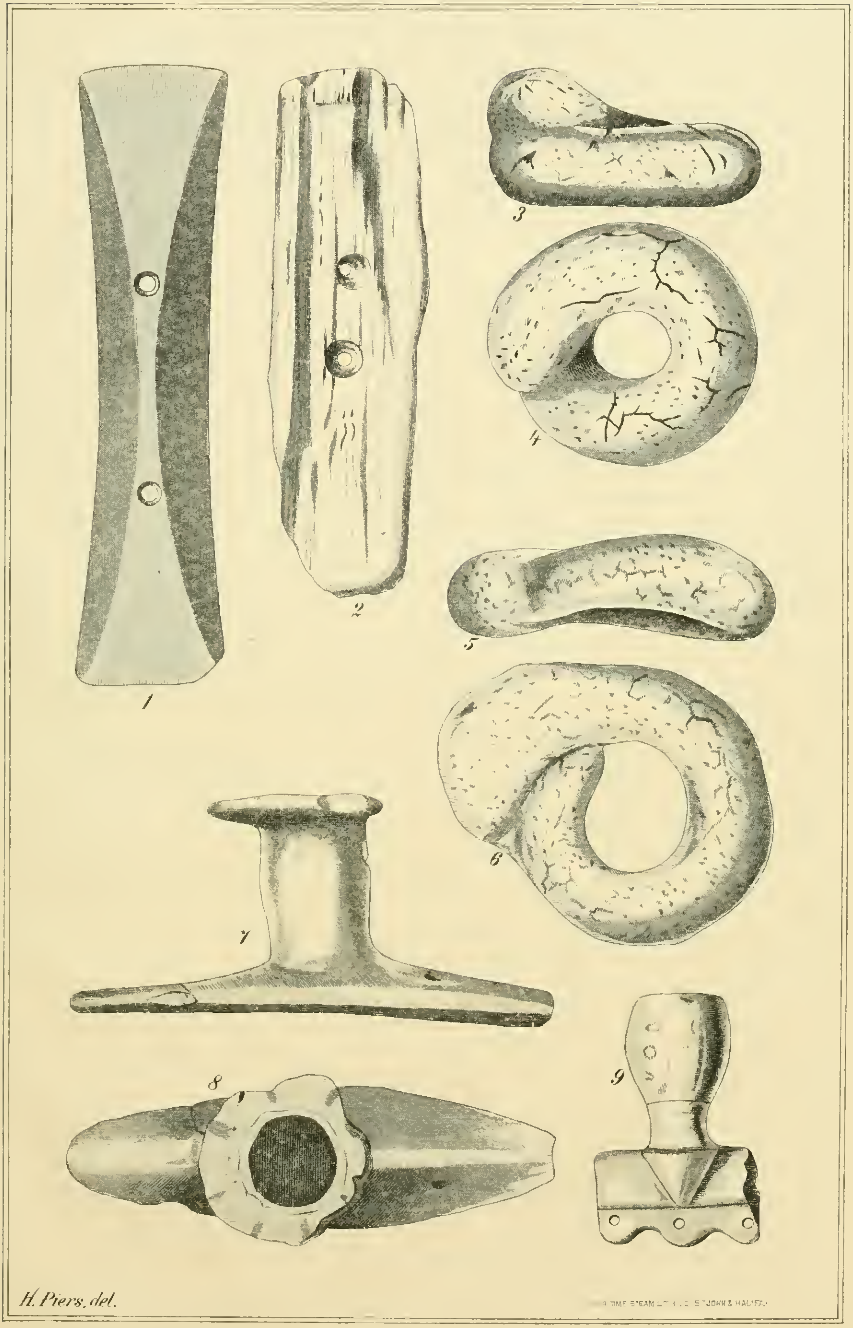
PLATE IV



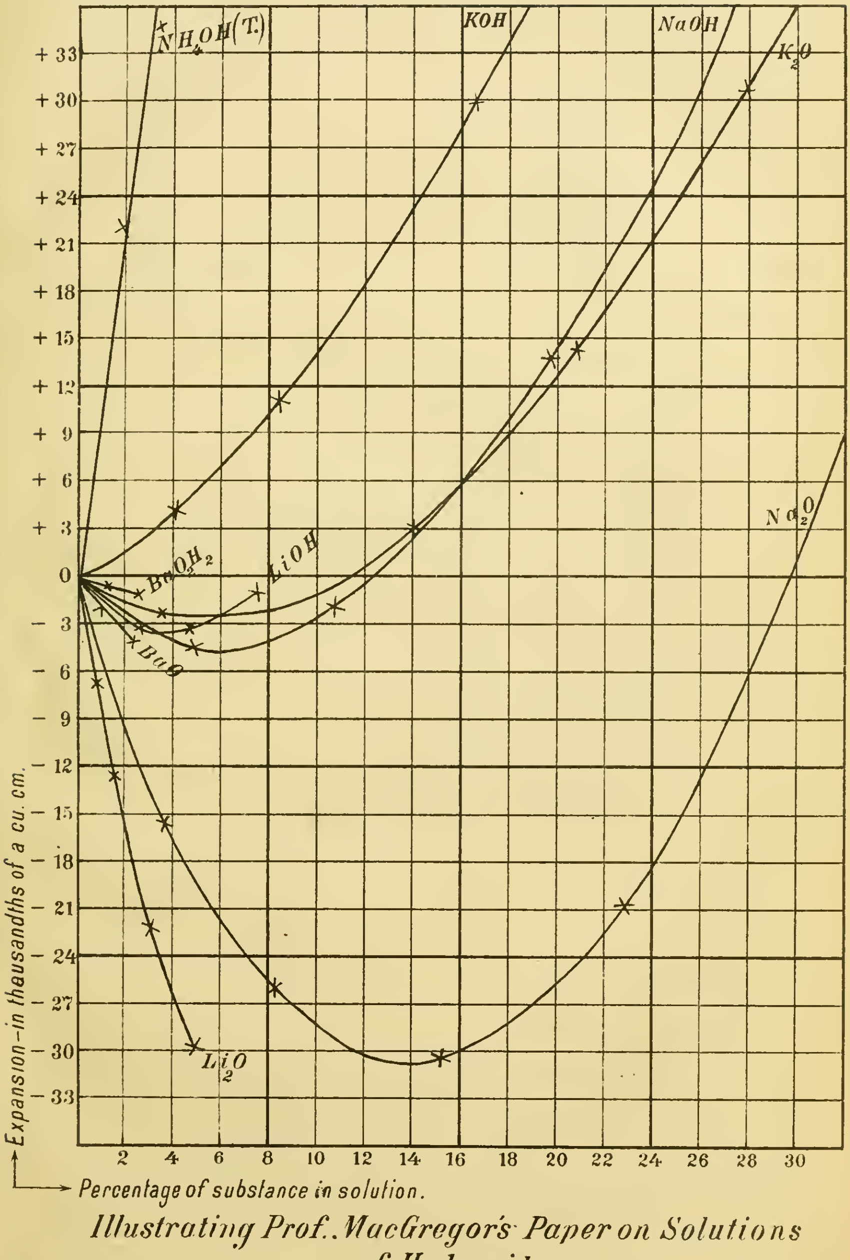
MARITIME STEAM LITH CO ST JOHN & HALIFAX

Spongiadae: Stelletta etoile-pistolet.
Illustrating Dr. Honeyman's paper on Glacial Boulders.

PLATE V

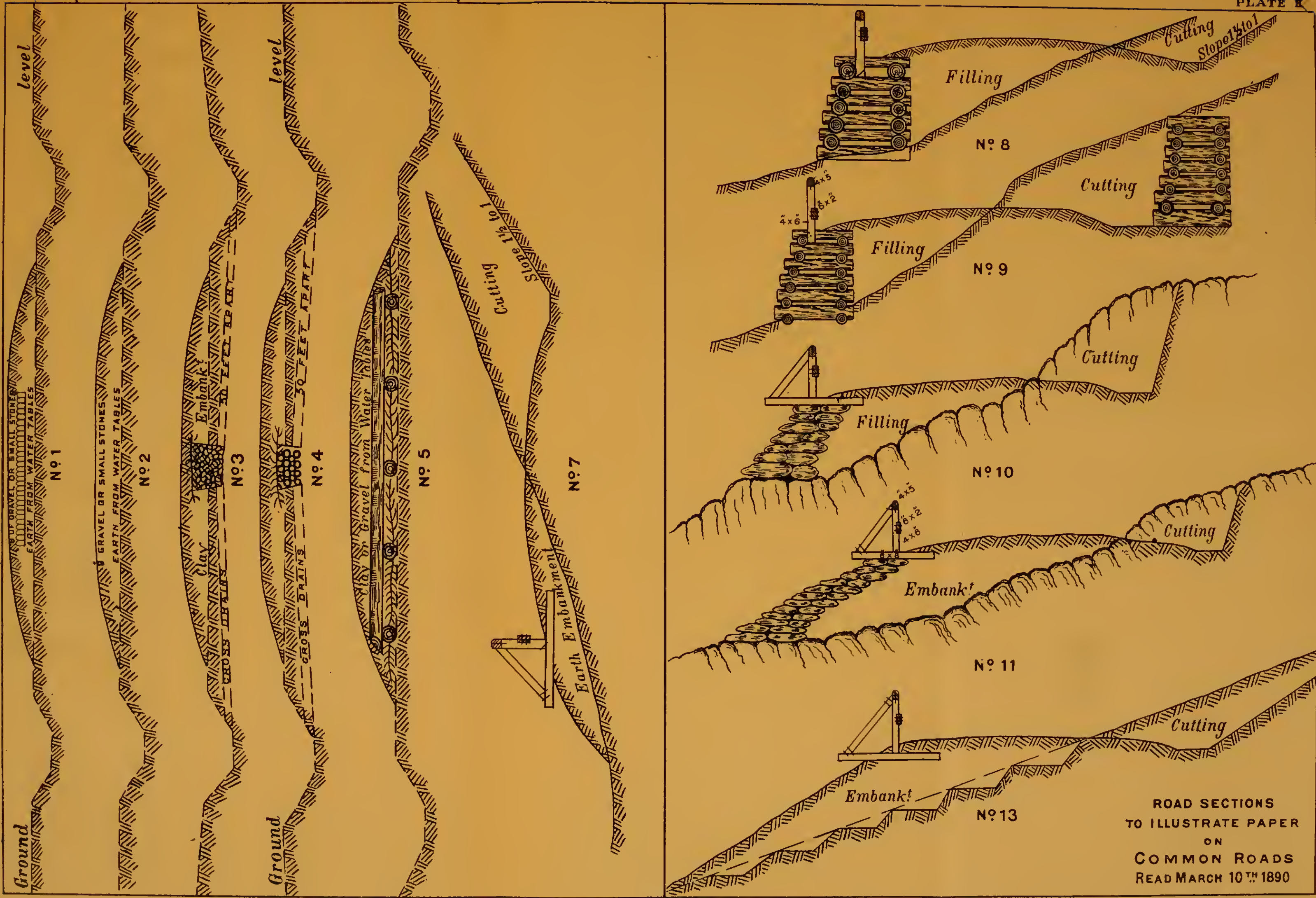


To illustrate Mr Piers' paper on Aboriginal Remains of Nova Scotia.



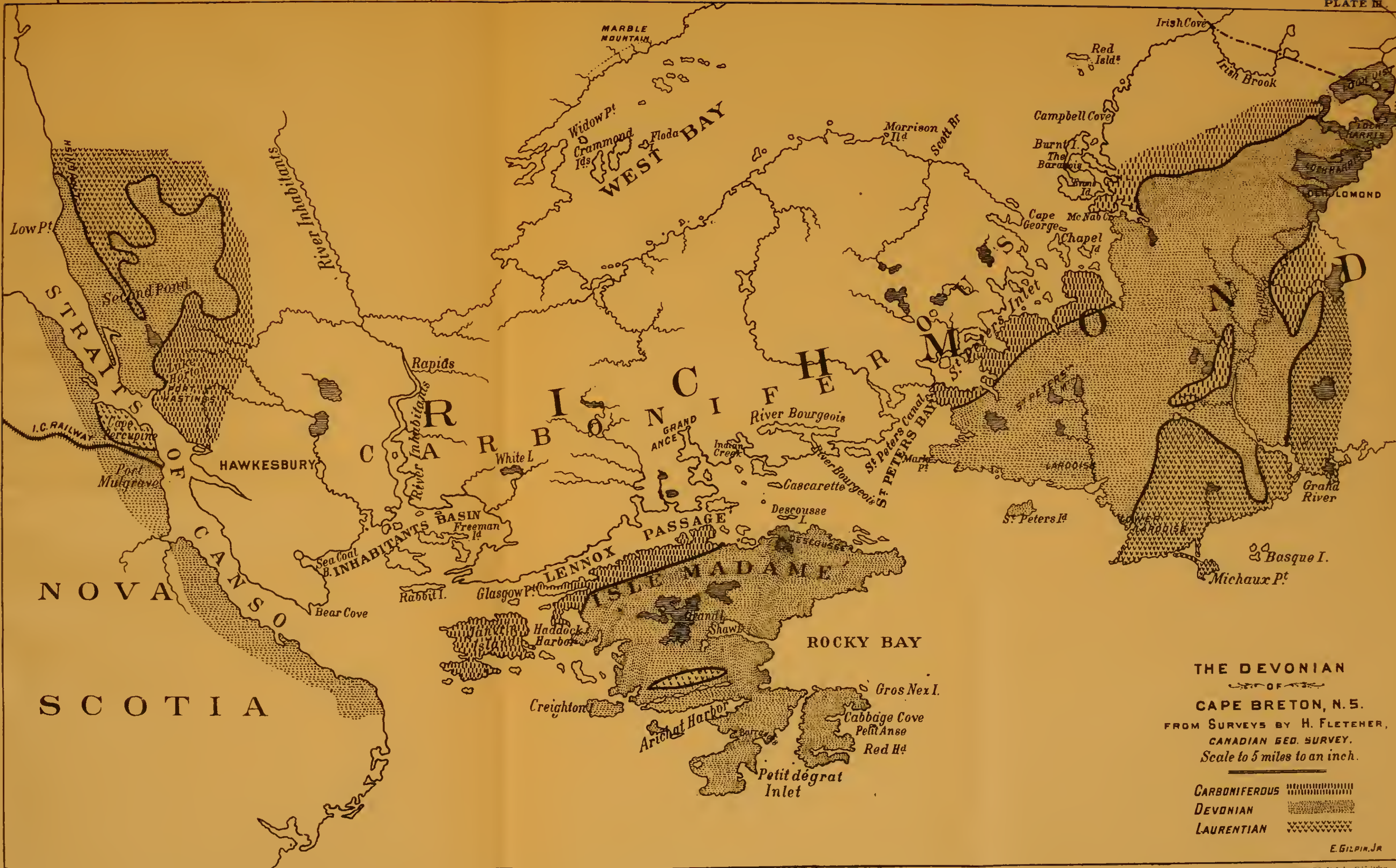
Illustrating Prof. MacGregor's Paper on Solutions of Hydroxides.

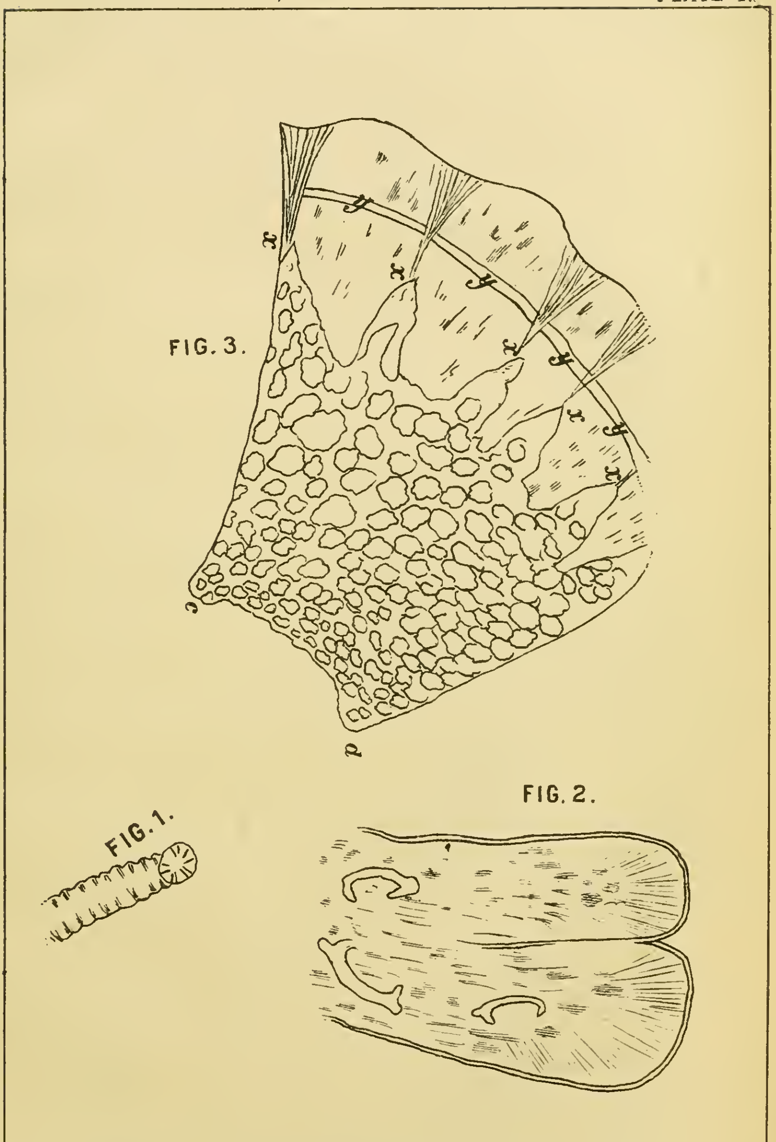
PLATE X.



ROAD SECTIONS
TO ILLUSTRATE PAPER
ON
COMMON ROADS
READ MARCH 10TH 1890

PLATE III.


THE DEVONIAN
OF
CAPE BRETON, N.S.
FROM SURVEYS BY H. FLETCHER,
CANADIAN GEO. SURVEY.
Scale to 5 miles to an inch.
CARBONIFEROUS
DEVONIAN
LAURENTIAN
E. GILPIN, JR.
NOVA SCOTIA
STRAITS OF CANSO
CARBONIFEROUS
RICHMOND
HAWKESBURY
ISLE MADAME
ROCKY BAY
WEST BAY
LENNOX PASSAGE
INHABITANTS BASIN
ST. PETERS BAY
MARBLE MOUNTAIN
Widow Pt.
Crammond Ids.
Floda
River Inhabitants
Low Pt.
Second Pond
I.C. RAILWAY
Cape Porcupine
Port Mulgrave
Port Hastings
Rapids
White L.
GRAND ANCE
Indian Creek
River Bourgeois
St. Peters Canal
Cascarette
Descousse
Morrison Id.
Scott Br.
Campbell Cove
Red Islds.
Irish Cove
Irish Brook
Burnt I.
The Barasois
Cape George
Chapel Id.
St. Peters Inlet
St. Peters Id.
Marks Pt.
LOCH LOMOND
Grand River
Basque I.
Michaux Pt.
Sea Coal B.
Freeman Id.
Bear Cove
Rabbit I.
Glasgow Pt.
Janvrin Island
Haddock Harbor
Creighton
Arichat Harbor
Gros Nez I.
Cabbage Cove
Petit Anse
Red Hd.
Petit dégrat Inlet



Illustrating Rev. M. Maury's paper on the Tentacles of the Echinus.

PROCEEDINGS AND TRANSACTIONS

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Nova Scotian Institute of Natural Science,

OF

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VOL. VII. 1886-87. PART I

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1888.

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