

**CIHM
Microfiche
Series
(Monographs)**

**ICMH
Collection de
microfiches
(monographies)**



Canadian Institute for Historical Microreproductions / Institut canadien de microreproductions historiques

© 1996

Technical and Bibliographic Notes / Notes technique et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming are checked below.

L'institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modifications dans la méthode normale de filmage sont indiqués ci-dessous.

- | | |
|---|--|
| <p><input type="checkbox"/> Coloured covers /
Couverture de couleur</p> <p><input type="checkbox"/> Covers damaged /
Couverture endommagée</p> <p><input type="checkbox"/> Covers restored and/or laminated /
Couverture restaurée et/ou pelliculée</p> <p><input type="checkbox"/> Cover title missing / Le titre de couverture manque</p> <p><input type="checkbox"/> Coloured maps / Cartes géographiques en couleur</p> <p><input type="checkbox"/> Coloured ink (i.e. other than blue or black) /
Encre de couleur (i.e. autre que bleue ou noire)</p> <p><input type="checkbox"/> Coloured plates and/or illustrations /
Planches et/ou illustrations en couleur</p> <p><input type="checkbox"/> Bound with other material /
Relié avec d'autres documents</p> <p><input type="checkbox"/> Only edition available /
Seule édition disponible</p> <p><input type="checkbox"/> Tight binding may cause shadows or distortion
along interior margin / La reliure serrée peut
causer de l'ombre ou de la distorsion le long de
la marge intérieure.</p> <p><input type="checkbox"/> Blank leaves added during restorations may appear
within the text. Whenever possible, these have
been omitted from filming / Il se peut que certaines
pages blanches ajoutées lors d'une restauration
apparaissent dans le texte, mais, lorsque cela était
possible, ces pages n'ont pas été filmées.</p> <p><input checked="" type="checkbox"/> Additional comments /
Commentaires supplémentaires: Pagination is as follows : p. [301]-312.</p> | <p><input type="checkbox"/> Coloured pages / Pages de couleur</p> <p><input type="checkbox"/> Pages damaged / Pages endommagées</p> <p><input type="checkbox"/> Pages restored and/or laminated /
Pages restaurées et/ou pelliculées</p> <p><input checked="" type="checkbox"/> Pages discoloured, stained or foxed /
Pages décolorées, tachetées ou piquées</p> <p><input checked="" type="checkbox"/> Pages detached / Pages détachées</p> <p><input checked="" type="checkbox"/> Showthrough / Transparence</p> <p><input type="checkbox"/> Quality of print varies /
Qualité inégale de l'impression</p> <p><input type="checkbox"/> Includes supplementary material /
Comprend du matériel supplémentaire</p> <p><input type="checkbox"/> Pages wholly or partially obscured by errata
slips, tissues, etc., have been refilmed to
ensure the best possible image / Les pages
totalement ou partiellement obscurcies par un
feuilleton d'errata, une pelure, etc., ont été filmées
à nouveau de façon à obtenir la meilleure
image possible.</p> <p><input type="checkbox"/> Opposing pages with varying colouration or
discolourations are filmed twice to ensure the
best possible image / Les pages s'opposant
ayant des colorations variables ou des décolorations
sont filmées deux fois afin d'obtenir la
meilleure image possible.</p> |
|---|--|

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The copy filmed here has been reproduced thanks to the generosity of:

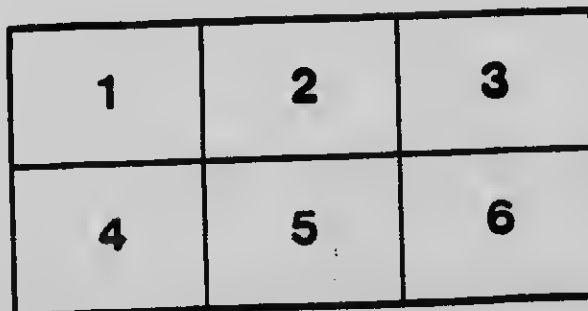
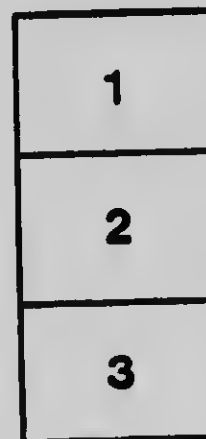
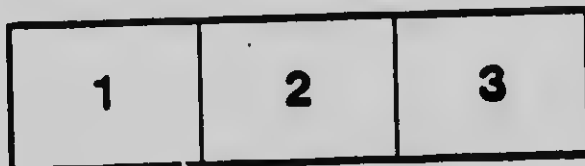
National Library of Canada

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche sheet contains the symbol \rightarrow (meaning "CONTINUED"), or the symbol ∇ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:



L'exemplaire filmé fut reproduit grâce à la générosité de:

Bibliothèque nationale du Canada

Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaît sur la dernière image de chaque microfiche, selon le cas: le symbole \rightarrow signifie "À SUIVRE", le symbole ∇ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



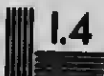
1.0



1.1



1.25



1.4



1.6



1.8

2.0

2.2

2.5

2.8

3.2

3.6

4.0

4.5

5.0

5.6

6.3

7.1

8.0

9.0

10

11.2

12.5

14.3

16

18

20

22.5

25

28

31.5

36

40

45

50

56

63

71

80



APPLIED IMAGE Inc

1853 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 286 - 5989 - Fax

14
BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA
Vol. 12, pp. 301-312, Pl. 26

KNOYDART FORMATION OF NOVA SCOTIA

BY

HENRY M. AMI



ROCHES TER
PUBLISHED BY THE SOCIETY
August, 1901



FIGURE 1.—JUVENILE SHALES AND SANDSTONES OF THE KNOYDART FORMATION
McArty's brook, Antigonish county, Nova Scotia



FIGURE 2.—SILURIAN STRATA, MOYDART FORMATION
Arbrog coast between McPherson's brook and Moydart point, Antigonish county, Nova Scotia

KNOYDART AND MOYDART FORMATIONS OF NOVA SCOTIA

KNOYDART FORMATION OF NOVA SCOTIA*

BY HENRY M. ME

(Read before the Society December 28, 1900)

CONTENTS

	Page
Introduction.....	301
Typical area under discussion	301
Contact of Silurian and Devonian strata.....	302
Classification and views of various writers.....	302
Discovery of fossils and their interpretation.....	304
Fletcher's section of the Knoydart formation along McArras brook.....	306
Name and fauna of the Knoydart formation.....	309
Barlow's description of volcanic ash rock.....	309
Paleontologic notes and faunal relations indicated.....	310
Conclusions.....	312

INTRODUCTION

While engaged in making a paleontological survey of the rock formations of the Upper Paleozoic in Nova Scotia, and also studying material placed at his disposal from previous collections in the Geological Survey Department, the writer has discovered what appears to be sufficient evidence for the determination of the geological horizon of a series of strata which occur in the western corner of Antigonish county, extend into the adjacent county of Pictou, Nova Scotia, and measure probably not less than 1,000 feet in its greatest development. One of the best natural sections where this series may be examined and studied to advantage occurs in the valley of erosion through which flows McArras brook. A measured section recently made by Mr Hugh Fletcher, of the Geological Survey of Canada, and cited below, gives a total thickness of 684 feet. The strata in question are placed in the Lower or Eo-Devonian, inasmuch as they contain fossil remains characteristic of the typical "Old Red Sandstone" of Europe.

TYPICAL AREA UNDER DISCUSSION

On sheet-map number 34 of the series of geological maps of Nova Scotia, issued by the Geological Survey of Canada in 1893, there is rep-

* Published by permission of the Director of the Geological Survey of Canada.

represented a lozenge-shaped area of so-called Upper Devonian strata adjacent to the Silurian of the Arisaig Coast region and extending from the headwaters of Arisaig brook on the east to those of Baileys brook on the west, and from "The Hollow," or "Bruin's Highway," on the south, to the line of contact and overlap of Carboniferous strata to the north and west.

This area is described as "Upper Devonian" on page 69 F of the "Annual Report" of the Geological Survey of Canada for 1886. Here the first mention of the occurrence of organic remains found in this series is given in what appears to be the lowest portion of the series. These include "plants, fish teeth, and Protichnites." A number of small streams cross this area of Devonian rocks and afford many interesting outcrops, of which one of the two photo-sections reproduced in the plate opposite this page, occurs near the bridge over McArras brook, along the shore or postroad from Merigomish to Arisaig and cape George. These streams include the headwaters of McAdam brook, Joseph McDonald brook, Stenshouse brook, McArras brook, Knoydart* brook (giving the name to the formation discussed), Yumey brook, and of one of the southeastern branches of Baileys brook.

CONTACT OF SILURIAN AND DEVONIAN STRATA

The line of contact between this area and the adjacent Silurian appears to mark an unconformity, the precise amount and significance of which has not yet been fully determined. According to the dips and strikes given by Mr Hugh Fletcher and Mr J. A. Robert on the map just cited, it would follow that, on the whole, the general trend and behavior of the strata referred to the Silurian and Devonian systems are fairly uniform and generally identical, both having evidently been subjected to the same physical forces and disturbing agencies since they were deposited (see plate 26, figures 1 and 2).

The actual dips of the Devonian strata vary from 16 degrees to 80 degrees, and those of the Silurian from 7 degrees to 70 degrees, with local variations in both. The number of post-Silurian and post-Devonian eruptive masses of amygdaloidal trap present in the vicinity have done much to disturb the rocks of the two sedimentary series, not to speak of the older and the newer sedimentaries of the district (see map, figure 1).

CLASSIFICATION AND VIEWS OF VARIOUS WRITERS

Touching the McArras brook area in question, the conclusion cited below was reached by Mr Hugh Fletcher by correlating the same with

* Pronounced Krodiart.

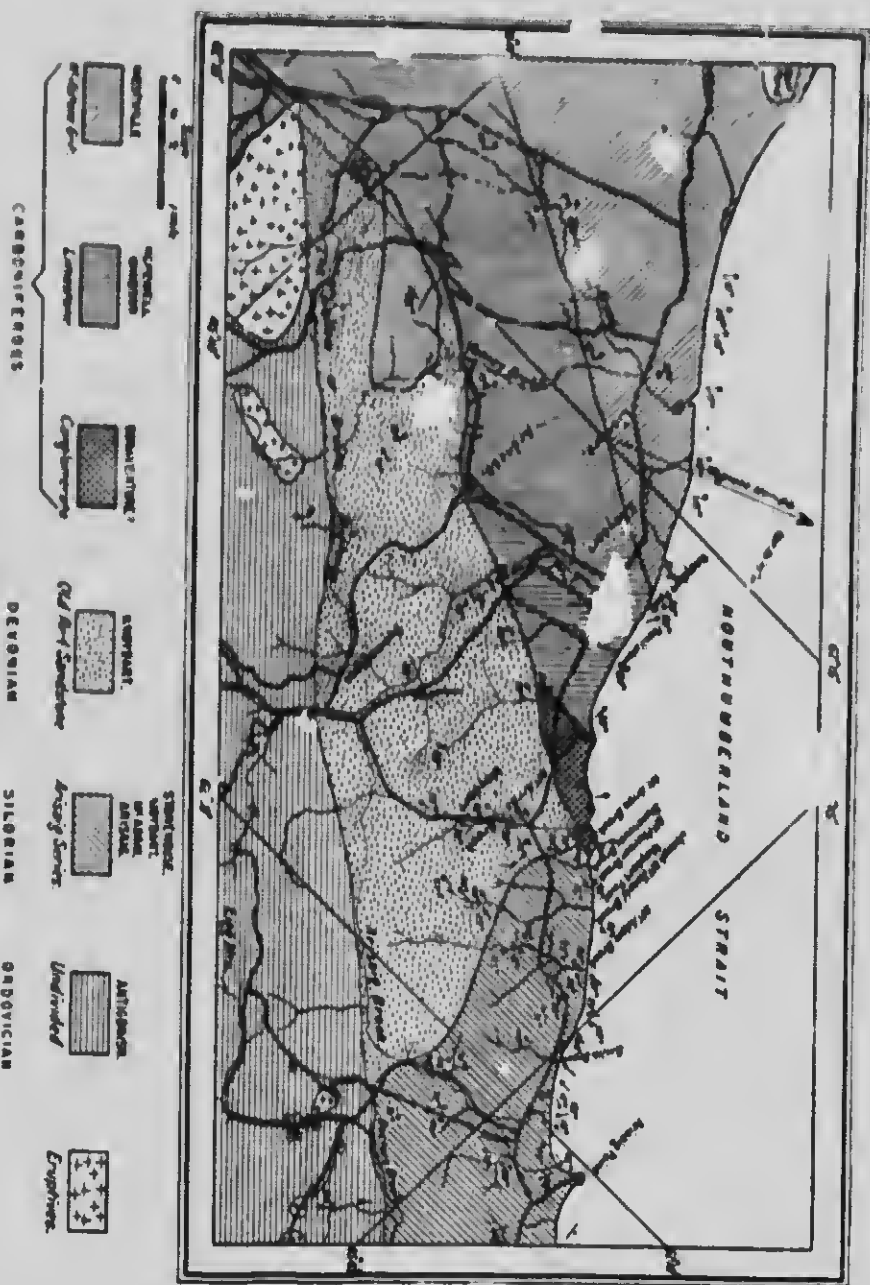


FIG. 1.—Geological Map of Portions of Pictou and Antigonish Counties, Nova Scotia, indicating the relations of the Kenogish formation (the Red Sandstone) and associated formations.

the New Brunswick equivalents in his "Report of geological surveys and explorations in the counties of Gnyssborough, Antigonish, Pictou, Colchester, and Halifax from 1882 to 1886."

In this Annual Report, 1886, new series, volume ii, under the head of "F. Devonian," on page 49 P, Mr Fletcher describes three distinct groups of Devonian strata corresponding closely with those of New Brunswick, and gives the following table of equivalencies:

<i>New Brunswick</i>	<i>Nova Scotia</i>
3. Mlapeck group.	3. Upper Red slate and sandstone group.
2. Dadoxylon sandstone and Cordaites shale.	2. Middle gray sandstone and slate group.
1. Bloomsbury conglomerate.	1. Lower Conglomerate group.

After giving the distribution of the above in Nova Scotia in general, the first reference to the age of the McArras Brook strata is then made on page 49 P, which reads as follows: "The upper rocks" (*i. e.*, the Upper Red slate and sandstone group) "are found again near Union Railway station, and also at McArras brook."

On page 67 P Mr Fletcher quotes Dr Honeyman's* views on the age of these rocks: "They are certainly not Lower Helderberg, and may therefore be Devonian;" and on page 68 P the same writer quotes Sir William Dawson,† in which he regards them as "pre-Carboniferous, although not separated from the Silurian."

Mr Fletcher describes the strata on McArras brook as follows:

"Good exposures are also cut by McArras brook behind the mass of amygdaloid at the shore, consisting of red, flinty, micaceous, jointed sandstone and slate, often concretionary, interstratified with greenish thick bedded and flaggy sandstone, containing traces of carbonate of copper and iron pyrites, the brook being rocky up to the shore road.

"From the latter a collection of fossils was made by Mr Weston, comprising fragments of plants and fish teeth, not certainly determinable, together with certain interesting footprints, *Protichnites carbonarius*." ‡

DISCOVERY OF FOSSILS AND THEIR INTERPRETATION

Up to 1886 but little had been done with a view to determining the exact geological horizon to which this Devonian area belonged, the area in question having been generally dismissed with the statement that they were certainly non-Silurian. In that year Mr T. C. Weston and

* Trans. Nova Scotian Inst. Sci., vol. 3, pp. 13, 188.

† Acadian Oology, p. 516, line 4, and Supplement to the same, p. 40.

‡ These tracks have since been described by the writer under the name *Ichthyoidichnites acadianis* in a paper read before the Nova Scotian Institute of Science in May, 1901.

Mr J. A. Robert carried on a successful paleontological survey of the Silurian as well as of the Devonian rocks of the region. The Silurian fossils obtained were submitted to a preliminary examination by the writer in that year, and a list of some 160 species of organic remains was recorded in the Silurian formations of the Arisaig coast, referable to the various subdivisions A, B, B', C, D, and D' of Dr D. Honeyman, as adopted by Mr Fletcher, exclusive of the species recorded by J. W. Salter, J. W. Dawson, James Hall, E. Billings, and Dr H. Honeyman.

From the Devonian strata Messrs Weston and Robert obtained what appeared to be series of obscure fishes, together with tracks and trails of some organism. These were not determined, however, until the writer undertook to submit the fish material to Mr A. Smith-Woodward, of the British Museum. The result of the study of the fish fauna has led the writer to conclude that instead of Upper Devonian strata in the McArras Brook, Upper Knoydart Brook, and Upper Vamey Brook exposures, there occurs a series of strata of lowermost Devonian age, equivalent to the Lower Old Red sandstone of Britain or Cornstone of England. The highest fossiliferous strata of the Silurian series adjacent are so remarkably similar in their lithologic and paleontologic or biologic characters to the facies of the Silurian of western Europe—especially to the Silurian of the Ludlow type in Herefordshire, England—as to warrant a close relationship to be instituted with the European equivalents: quite distinct from the Silurian succession as known in the Gaspé peninsula, in the valley of the Saint Lawrence, on the island of Anticosti, and in the state of New York or the province of Ontario to the south and west as defined and described by Vanuxem, Hall, Logan, Billings, and other geologists.

This Lower Devonian area is bounded on the east by the highest member of the Silurian examined, the Stonehouse formation, and on the south by a range of hills which has been assigned to the Cambro-Silurian (Ordovician) by Mr Fletcher.* From this series, however, no organic remains or definite paleontologic evidence of any value have as yet been obtained upon which might be determined the precise position of this older series in the Paleozoic succession. To the north and west of this Devonian area are seen newer measures referable to three distinct horizons of the Carboniferous system as developed in this portion of Nova Scotia. These include—

(a) The so-called "Carboniferous Conglomerate" formation described in the above report.† This series is presumably equivalent to the Bonaventure formation of Gaspé, and is doubtfully referred to it here.

(b) The "Carboniferous Limestone" series with its marls, sandstones,

* Annual Report of the Geological Survey of Canada for 1886, pp. 17 P and 99 P.

† Loc. cit., supra, pp. 71 P, 85 P, and 124 P, and on page 173 P of the Annual Report for 1890-'91.

and marine limestones and gypsum, designated (in part at least) by the writer, as the Hopewell formation.*

(c) The so-called "Millstone Grit" series, for the most part very flat lying and undisturbed, showing that the physical disturbances and agencies to which the Silurian and Devonian strata have been subjected which have dislocated and tilted their strata had disappeared previous to the time when these Carboniferous grits were laid down. This so-called "Millstone Grit" series, which is very doubtfully the equivalent of the true "Millstone grit" of England, was designated by the writer as the *Westville* formation, on page 178 of the paper cited above, in order to separate it from other formations in the district.

FLETCHER'S SECTION OF THE KNOYDART FORMATION ALONG McARRAS BROOK

In 1897 Mr Fletcher made a careful re-measurement of the red marls, sandstones, shales, and calcareous bands holding fish remains along the valley of McArras brook, a copy of which was kindly furnished me by him with the sanction of Doctor Dawson, director of the Geological Survey. In order to give the reader more detailed information on the succession of the strata in this bit of the "Old Red Sandstone" his valuable section has been incorporated in this paper.

From the mass of trap near the mouth of McArras brook the following is the section in ascending order:

	Feet.	Inches
Amygdaloidal trap, probably Lower Carboniferous, as described in Report P for 1886.		
Measures concealed. On the left bank of the brook trap is in the cliff, while on the right bank there are indications of red stratified Devonian rocks.....	30	0
1. Red, argillaceous shale, more or less slaty, with coherent under-clay full of rootlets, dip north 230 degrees angle 32 degrees (magnetic).....	3	0
2. Red, argillaceous, slaty rock, not well seen.....	4	0
3. Red, broken, argillaceous shale, with greenish and gray blotches.	6	0
4. Red shale, nearly all concealed.....	6	0
5. Red, very coherent, concretionary, calcareous rock at the mouth of a little brook from the eastward.....	1	6
6. Red, argillaceous shale.....	7	6
7. More coherent, flaggy rocks, which may be called sandstone....	1	0
8. Red, argillaceous shale.....	8	0
9. Red, coherent, somewhat sandy flags, in two layers.....	3	0
10. Red, argillaceous shale, in part blotched with green.....	46	0

* Proc. and Trans. Nova Scotian Inst. Sci., vol. 10, pt. 2, Halifax, 1900, p. 177.

FLETCHER'S SECTION OF THE KNOYDART FORMATION 307

	Feet.	Inches
11. Greenish and reddish, coherent, micaceous sandstone and flags, with fossils (no. 1).....	4	0
12. Red, argillaceous shale, with coherent layers.....	22	0
13. Red, somewhat coherent, massive, argillaceous rock.....	6	0
14. Red, coherent flags, containing fish remains.....	11	6
15. Red, argillaceous shale.....	5	0
16. Greenish, calcareous flags, from which Doctor Ami collected many fossil fish remains in 1897. The upper part contains broken carbonized plants, fish, etcetera (no. 2).....	2.	0
17. Red and green, somewhat massive, mottled, calcareous rocks, with nodular, rounded, and oval spots and fish remains, dip 230 degrees angle 20 degrees on fine long faces.....	7	0
18. Red, argillaceous shale, with layers of more coherent concretionary flags.....	5	0
19. Red, micaceous flags.....	1	6
20. Red, somewhat crumbly, argillaceous shale, forming fine ledges in the brook.....	2	0
21. Red, argillaceous shale, with layers of fine, more coherent flags.....	14	6
22. Greenish, flinty, argillaceous, and siliceous flags, micaceous and sometimes spotted with red, containing much carbonaceous matter and cut by veins of quartz (no. 3).....	3	0
23. Greenish, coherent, massive, fine sandstone in two layers.....	4	0
24. Red and greenish mottled shale, in regular layers, more massive toward the top, for the most part red.....	8	0
25. Reddish, coherent flags and argillaceous shale.....	32	0
26. Red, crumbly, argillaceous shale, not well seen.....	11	0
27. Red, crumbly, argillaceous shale, with harder bands, not well seen.....	10	0
28. Red, argillaceous shale, with flaggy layers.....	17	0
29. Red, argillaceous shale, not well seen.....	25	0
30. Red, coherent, thick bedded sandstone, in two layers, at a small waterfall.....	6	0
31. Red, coherent, argillaceous shale, with green layers and blotches.....	5	0
32. Measures not well seen, but evidently chiefly red.....	6	0
33. Greenish, argillaceous shale at the mouth of a little brook from the westward (no. 4); from this the seeds and plants were obtained by Doctor Ami in 1896. One coarse, rusty layer is full of pyrites and plant remains.....	2	6
34. Measures concealed, probably greenish shales cut by quartz veins and containing plants.....	3	0
35. Greenish quartzite or fine sandstone, over which the little brook from the westward falls into the main stream at water level..	3	0
36. Gray and greenish and red coherent argillaceous rock in three layers.....	3	0
37. Red, argillaceous shale, with coherent layers. The top comes to the foot of the falls in a gorge from which Mr Weston is supposed to have obtained his fish remains (no. 5).....	12	0
38. Red, coherent, argillaceous shale, forming a little fall.....	15	0

	Feet.	Inches
39. Red, coherent shales, forming a higher fall.	14	0
40. Red, argillaceous shale, containing greenish blotches, harder layers, and small nodules; to the water level of the lower side of the culvert at the shore side.	31	0
41. Red, argillaceous rock, with green layers and blotches, in cliffs at the road, dipping 235 degrees angle 32 degrees.	30	0
42. Red and green mottled, argillaceous shale, principally red	15	0
43. More coherent, red, siliceous and argillaceous rock, with a few fish remains.	10	0
44. Greenish and mottled lenticular limestone from which Doctor Ami obtained the fish remains <i>Pterania</i> , etcetera, first sent to Doctor Woodward (no. 6).	0	6
45. Red, argillaceous and siliceous rock with green bands and blotches.	20	0
46. Reddish, altered rock at the level of the road under the school-house, not well seen.	20	0
47. Greenish, argillaceous flags and shales (no. 7)	4	6
48. Red, argillaceous shale.	3	0
49. Red and greenish sandstone in two layers.	4	0
50. Red, argillaceous shales, with layers of more coherent rock, some of which contain rootlets.	17	0
51. Measures concealed.	13	6
52. Bright red, soft, argillaceous shale; to the first bridge where the brook crosses to the eastward.	4	0
53. Red, argillaceous shale, with a few more coherent layers.	31	0
54. Greenish, somewhat massive, argillaceous and arenaceous rock (no. 8); at the second bridge where the brook runs to the westward. The dip now changed to 80 degrees, and this layer is concealed for some distance, but again appears to return to the road farther south. Assuming that this is the case, the section is continued beyond as follows.	11	0
55. Red, argillaceous shale, with coherent layers.	18	0
56. Greenish and dark-gray crumbly, argillaceous rock.	2	0
57. Greenish and gray, argillaceous rock, the upper part greatly altered.	4	0
58. Trap.	4	0
59. Red, argillaceous shale, greatly altered.	6	0
60. Measures concealed dip 250 degrees angle 23 degrees; to a little brook from the eastward.	5	0
61. Red, argillaceous shale and thin flags, in which fish remains were found (no. 9)	14	0
62. Red, argillaceous shale and flags.	43	0
63. Trap, thickness undefined, perhaps.	120	0
This trap begins about 550 yards above the main road. In the brook west of the road there is a green flinty shale which yielded no fossils.		
Total thickness of the stratified rocks in the section.	683	3

Mr Fletcher adds :

"This section is only approximate. It represents only a small portion of measures, apparently as thick as at Union; seen also in Knoydart brook and other streams of the vicinity. It is not supposed that either the base or the summit of the series is here given."

NAME AND FAUNA OF THE KNOYDART FORMATION

The name "Knoydart formation" is proposed for the series of strata of which the 684 feet recorded above constitute a characteristic section holding a typical "Old Red Sandstone" fauna. This name is given in order to be able to better designate the strata in question and separate them from other Paleozoic formations in that portion of eastern Canada where the sedimentation has a wonderfully close resemblance to European types. This striking resemblance to the European succession is a feature which has been pointed out by Sir William Dawson, Salter, Billings, Honeyman, and other writers.

The following species of fossils obtained from the above strata are provisionally recorded as characteristic of the Knoydart formation. These and other forms will, no doubt, sooner or later be found in other parts of Antigonish, in Pictou, and in other counties of eastern Canada along the Atlantic border of the continent. The fossil ostracoderms, which constitute a very primitive and early type of fishes, were identified by our friend Doctor A. Smith-Woodward, of the British Museum, and to him is due the credit of identifying the fish fauna and indicating the precise geological horizon to which to refer the beds, while the remains of *Pterygotus* were submitted to and identified by Doctor Henry Woodward when Keeper of the British Museum.

1. *Pterygotus* sp.
2. *Onchus murchisoni* Agassiz.
3. *Pteraspis* sp. cf. *Pteraspis crouchii*.
4. *Psammosteus* sp. cf. *Psammosteus anglicus* Traquair.
5. *Cephalaspis* sp. Probably a new species.
6. *Ichthyodichnites acadensis* nobis. Impressions made by a pair of sharp-pointed organs or spines, probably those of a fish.

The specimens are for the most part imperfectly preserved in a hard, compact, fine grained, and brecciated volcanic ash-bed, and are consequently difficult to identify and obtain.

BARLOW'S DESCRIPTION OF VOLCANIC ASH ROCK

With a view of ascertaining the exact nature of the rock materials in which the pteraspidians were preserved, microscopical sections were pre-

pared and submitted to Doctor A. E. Harlow, of the Geological Survey of Canada. He kindly undertook to describe these, and gave the following interesting note regarding the tufaceous or volcanic origin of locality number 6, and number 41 of Mr Hugh Fletcher's section:

"The rock of McArras brook is a dark gray to greenish gray thinly bedded graywacke, weathering yellowish or brownish, owing to the decomposition of the iron ore. It is composed for the most part of angular, subangular, and rounded grains of quartz and feldspar embedded in a matrix of the same materials in a finer state of division. Calcite is present, and in some sections is a rather abundant component of the groundmass. Chlorite in occasional plates and small scales of sericite is also present. The rock is probably of tufaceous origin. Small seams or veins of calcite and quartz frequently traverse the rock."

PALEONTOLOGIC NOTES AND FAUNAL RELATIONS

In reporting upon the fish fauna from this formation, Doctor Smith-Woodward writes: "The McArras Brook specimens represent the base of the Lower Old Red sandstone of Britain."

The presence of pteraspicians, cephalaspicians, and acanthodians, as well as Pterygotus, as determined by Mr A. Smith-Woodward and Doctor Henry Woodward, of the British Museum, would seem to indicate clearly the presence of a fauna precisely similar in facies to that of the Hereford beds, referable to the Lower Devonian (Old Red Sandstone) or Cornstone.

The Pteraspis found in the tufaceous rock in the series of strata is one which Mr Woodward refers to as very closely allied to, if not actually identical with, *P. crouchii* of the English rocks.

The horizon indicated is low down in the Devonian and not far from the summit of the Silurian. From the nature of the sediments, their composition, origin, and general characters they appear to be much more closely related to European Devonian or Old Red Sandstone strata than to the usual type of North American Devonian, such as are met with in synchronous western epi-continental formations.

Sir Archibald Geikie* points out the occurrence in Nova Scotia and New Brunswick of the two divergent Devonian and Old Red Sandstone types of Europe, but does not attempt to give any of the subdivisions of the rocks of this system nor any of the fossil organic remains found in them. The fauna of the Arbroath flags or Lower Old Red Sandstone of Murchison is remarkably similar to that of the Knoydart formation.

In his "Geology, Chemical, Physical, and Stratigraphical," Sir Joseph Prestwich† makes the following statement regarding the "Old Red

* Text Book of Geology, 1895 edition, book vi, part 2, sec. 3, chap. 2, par. 2, p. 203.

† Chapter vi, "The Devonian system: 'The Old Red Sandstone,' p. 82."

Sandstone" of Herefordshire, which enables geologists to correlate the strata with a marked degree of proximity to certainty:

"The Old Red Sandstone" of Herefordshire was long thought to be non-fossiliferous, a few fragmentary specimens only having been found when in the railway cuttings near Ledbury, the Rev. W. B. Symonds (see Quart. Journ. Geol. Soc., vol. 16, p. 193, and vol. 17, p. 152) discovered in the lowest beds (the Ledbury shales) of that formation remains of *Pterygatus*, *Ouelms Pteraspis*, and *Cephalaspis*, together with large numbers of the head shields of *Anchenaspis*."

It is impossible to read over the association of forms in the strata near Ledbury, in Herefordshire, without recognizing in them a fauna and horizon similar to that met with at McArras brook, in Antigonish county, Nova Scotia.

In 1843 Doctor Abraham Gesner described* an "Old Red Sandstone" or Devonian group, which he recognized above Silurian beds In several parts of the province, . . . consisting of . . . "a bright red micaceous sandstone or conglomerate, accompanied by thin beds of red shale and marly clay, and in some places containing seams of fibrous gypsum." He adds: "Hitherto no organic remains have been found in it." He recognizes it at Advocate harbor and on the Moose river, where it is "seen lying unconformably beneath the Coal Measures."

Mr Fletcher classes the rocks of Advocate harbor as Devonian, so that the "Old Red Sandstone or Devonian group" of Gesner must therefore be classed with the rocks of Union and Riversdale, which, from the fauna and flora found in them, are referable to the Carboniferous system, and from their position in the stratigraphic succession may be referable to the Meso-Carboniferous. The gypsum-bearing strata of Gesner are likewise also Carboniferous and not Devonian.

In November, 1899, in a communication on a number of fossil fishes sent him by the writer from various localities in Nova Scotia, in which the geological horizon and precise affinities of the species sent were doubtful, Mr Smith-Woodward, the eminent authority on Paleozoic fishes, gives the following notes on the specimens from McArras brook, adding that they had been submitted by him to Doctor R. Traquair, of Edinburgh:

"The specimens from McArras brook are extremely interesting, and represent the base of the Lower Old Red Sandstone of Britain. The pteraspidian remains are sufficient to prove that they belong to the genus *Pteraspis*. Both dorsal and ventral shields are so much like those of *P. crouchii* that if these Nova Scotian fossils had been found in western England we should have referred them to the latter species. Perhaps the rostral plate may prove to distinguish your form when it

* Proc. Geol. Soc. London, 1843, vol. 4, part 1, no. 65, p. 187.

is completely known. One piece of dorsal shield in counterpart shows the impression of the supposed branchial pouches on one side.

"The pointed fragments in the collection may be *Cephalaspizian cornu*, but are uncertain. There is also present the typical *Onchus Murchisoni*.

"Most interesting is one small fragment of *Pramnotus*, with ornament identical with that of *P. anglica*.* In this fossil the chambers of the middle layer are larger than in our unique plate.

"On the whole, I should place the McArras Brook beds on the same horizon as the Lower Old Red Sandstones-Cornstones of the Hereford district of England above the passage beds."

CONCLUSIONS

It may thus be safely concluded, with the evidence at hand, together with the learned opinion of Messrs Arthur Smith-Woodward and R. H. Traquair, that we have in Nova Scotia an area of Lower Devonian rocks which represent well in America the lower portion of the Old Red Sandstone of Europe. This latter series of strata, together with the Devonian rocks proper, Sir Roderick Murchison held to be the result of "different geographical conditions of the same period." The same statement may be uttered with all truth in North America. From the character of the strata, it is evident that lacustrine deposits were laid and shallow-water conditions prevailed throughout the Knoydart area in Eo-Devonian times, and a lake similar to lake Orcadie, lake Caledonia, lake of Lorne, the Welsh lake, etcetera, of Great Britain, so graphically described by Sir Archibald Geikie, existed in Canada, to which the name *lake Pictou* might appropriately be given.

It may here be remarked that the Knoydart formation of Nova Scotia finds a near equivalent in the Eo-Devonian strata of the Campbellton formation in the Bale des Chaleurs region. To the lake in which *Coccosteus* (*Phlyctænaspis*), *Cephalaspis*, *Protodus*, *Ctenacanthus*, *Acanthoiles*, *Cyclorus*, etcetera, once flourished in the Bay des Chaleurs region, the name "lake Chaleur" is suggested.

It is an interesting fact to note that much contemporaneous volcanic ash materials constitute the deposits of both these ancient Paleozoic lake basins—"lake Pictou" and "lake Chaleur."

* See Traquair, Ann. Mag. Nat. Hist., ser. 7, vol. 11, 1898, p. 67, pl. 1, figs. 1, 2.

