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SILURO-DEVONIAN ROCKS OF LAKE MEMPHREMAGOG AND THEIR CORRELATIVES IN THE EASTERN TOWNSHIPS

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QUEBEC DEPARTMENT OF NATURAL RESOURCES

Honorable Paul-E. Allard, Minister

MINES BRANCH

SPECIAL PAPER 1

# SILURO-DEVONIAN ROCKS OF LAKE MEMPHREMAGOG AND THEIR CORRELATIVES IN THE EASTERN TOWNSHIPS

by

Arthur J. Boucot and Georges Drapeau

GEOLOGICAL EXPLORATION SERVICE

QUEBEC
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# PREFACE

Since 1937 the Department of Natural Resources (and its predecessors) has published the final results of its geological investigations in the Geological Report series. These Reports have been, with few exceptions, accounts of the systematic geologic mapping of geographically restricted and clearly defined areas of the Province. In recent years, although the systematic mapping programme has been continued with even greater vigor, an increasing amount of research has been directed towards the investigation of particular geologic problems or features without regard to geographic limits. It therefore seems appropriate at this time to commence the publication of a new series of Special Papers to embody reports on the latter type of research and to distinguish them from the Geological Reports on formal map-areas.

This Paper, which has been selected as the first of the new series, brings together two closely related studies: firstly, a description of the stratigraphy of the fossiliferous Siluro-Devonian rocks of the Lake Memphremagog area, the largest area of such rocks in the Eastern Townships, and, secondly, a summary and interpretation of the Siluro-Devonian paleontology of the whole Eastern Townships region.

Paul-E. Grenier

Director of Geological Services

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# SILURO-DEVONIAN ROCKS OF LAKE MEMPHREMAGOG AND THEIR CORRELATIVES IN THE EASTERN TOWNSHIPS

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## INTRODUCTION

### General Statement

Realization that the virtually unfossiliferous Siluro-Devonian rocks in the Eastern Townships of Quebec form part of the Gaspé - Connecticut River synclinorium has caused renewed interest in the fossiliferous Siluro-Devonian rocks of Lake Memphremagog that crop out between the synclinorial rocks and the Sutton axis. Published faunal lists showed discrepancies that justified some re-mapping. Drapeau spent the field season of 1960 in mapping the rocks near Lake Memphremagog, and his work forms the basis of the first part of this report. The second part presents the arguments for correlating the fossiliferous with the almost unfossiliferous Siluro-Devonian rocks. A discussion by Boucot of the ages of the faunas of the Siluro-Devonian rocks follows. Appendices give localities and faunal lists.

The available collections of fossils show that both Lower Ludlow and early Middle Devonian rocks occur at Lake Memphremagog. Unfortunately no locality has yet been found where the relationships between the Silurian and the Devonian can be determined. The assignment to the Silurian of rocks exposed on Ronde (Round) island, previously mapped as Ordovician, implies that the Lake Memphremagog syncline joins the Gaspé - Connecticut Valley synclinorium near Fitch bay.

### Acknowledgements

The field studies for this paper were done by Drapeau in 1960 under the auspices of the Department of Geology, Massachusetts Institute of Technology, as part of the requirements for an M.Sc. degree.

The writers gratefully acknowledge the courtesies and assistance accorded to Drapeau before and during the field work by officers of the Quebec Department of Natural Resources. Dr. T.H. Clark arranged for the examination of the controversial graptolites from the Tomifobia Formation, and Dr. H.B. Whittington and Dr. William Oliver provided determinations of some fossils.

Previous Work

It is customary to consider Logan as the first geologist to concern himself with this part of Quebec. Logan (1845, p. 18), writing in December 1842, indicates the probability that Siluro-Devonian rocks form a band extending from St-Georges-de-Beauce, in the Chaudière River valley, to the vicinity of Sherbrooke. Logan (1849, p. 46) delimited the rocks near Lake Memphremagog, and supposed that the limestones there form "two distinct long parallel-sided troughs". He further stated (p. 57) that the limestones are not older than Upper Silurian, and he then goes on to give the first description of the distribution of the rocks in the Gaspé - Connecticut River synclinorium from Gaspé into the southern part of Vermont.

Logan's report of 1863 gives essentially a summary of earlier statements, and these conclusions were accepted until Ells started to work on the Eastern Townships' map-areas. Ells, in maps and reports dated 1887, 1888, 1896, and 1900, assigned most of the rocks that belong to the Gaspé - Connecticut River synclinorium to the Ordovician and disposed of the rocks with post-Ordovician fossils by considering them infolded remnants; nevertheless, his map indicates correctly the distribution of Siluro-Devonian rocks near Lake Memphremagog.

Harvie, in the field seasons of 1911, 1912, and 1913, mapped in the southern part of the Eastern Townships and discovered some localities for fossils which are mentioned elsewhere in this report. Only summary reports of his work have been published. In 1923 F.A. Kerr mapped in the area east of Lake Memphremagog, but no report on his work has been published.

T.H. Clark made a study of some rocks near Lake Memphremagog, and his results were presented in a brief paper published in 1936. He proposed the name Glenbrooke Group as well as the names for the Silurian formations used in this report.

The report by H.C. Cooke (1950) on the southwestern part of the Eastern Townships is based on previous work by Cooke and others. For the area discussed in the present paper, Cooke has drawn on the work of Ambrose (1942, 1943) and Fortier (1945). Cooke's conclusions in some instances differ substantially from those of previous and later workers.

TABLE 1

PALEOZOIC SUCCESSION IN THE LAKE MEMPHREMAGOG AREA

UPPER SILURIAN OR YOUNGER:

Rocks intrusive into the Glenbrooke Group

EARLY MIDDLE DEVONIAN:

Mountain House Wharf limestone

Dark, fine-grained limestone

UPPER SILURIAN:

Sargent Bay limestone:

Grayish blue, fine-grained limestone

Glenbrooke Formation:

Glenbrooke Group

Siltstone member: Volcanic member

Non-calcareous to very calcareous siltstone

Slate member:

Non-calcareous to moderately calcareous dark gray slate

Peasley Pond conglomerate:

Quartz conglomerate, some sandstone

MIDDLE ORDOVICIAN:

Magog Formation (Normanskill)

Black, pyritic, and carbonaceous slates

ORDOVICIAN AND CAMBRIAN (?)

Basic volcanic rocks

Quartzite, including some graywacke

# SILURIAN AND DEVONIAN STRATIGRAPHY

## INTRODUCTION

The Silurian and Devonian strata of the Lake Memphremagog area are associated with Middle Ordovician (Magog Formation) and possibly older units. Previous studies of the Silurian and Devonian strata of the area had not established paleontologic zones, and previous work did not tie in the available lithologic and paleontologic information in as much detail as would be useful today. The main purpose of Drapeau's mapping and Boucot's paleontologic studies was to attempt a more detailed synthesis of this information, and in addition to try to correlate the Silurian and Devonian rocks of the Lake Memphremagog area with those of nearby areas.

The Silurian rocks of the area belong to the Glenbrooke Group, which, in ascending order, consists of the following units: Peasley Pond (Peasley Lake) conglomerate, Glenbrooke Formation (which includes a lower slate member, a volcanic member, and an upper siltstone member), and Sargent Bay limestone. The Devonian rocks of the area belong to the Mountain House Wharf limestone.

## GLENBROOKE GROUP

### General Statement

The name Glenbrooke in the sense proposed by Clark (1936) is retained for the group. The formation names Peasley Pond conglomerate, Glenbrooke Formation, and Sargent Bay limestone are used almost as defined by Clark. George Pond breccia is dropped as a formation name. Mountain House Wharf limestone (new name) is not considered to be part of the Glenbrooke Group.

As Logan realized, the Glenbrooke Group forms two parallel, narrow synclines separated by a septum of older rocks. Ambrose (1942) referred to the western and shorter one as the Sargent Bay syncline and to the eastern one as the Lake Memphremagog syncline.

The Glenbrooke Group rests unconformably on Ordovician* rocks. In places the underlying formation is gray or black slate with some quartzite

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* The available fossils indicate an Ordovician date for the black slate. Some rocks have been assigned without cogent reason to the Cambrian. "Ordovician" is used in this report to designate known Ordovician rocks as well as any that may be Cambrian.

beds and some chert and cherty conglomerate. The well-known Middle Ordovician fossil locality at Castle brook is in the black slate. St-Julien has found other fossils of the same age north of Castle brook (Berry, 1962) and has thus been able to establish the sequence of beds along the north side of the Lake Memphremagog syncline.

Near Peasley lake (pond), the Glenbrooke Group overlies a volcanic rock that has been assigned to the Bolton igneous series. The Bolton lavas have been considered to post-date the Taconic orogeny (Clark, 1934, p. 12; Clark and Fairbairn, 1936, p. 13-18; Cooke, 1950, p. 79), although, as noted by Ambrose (1957), Bolton lavas are interbedded with Ordovician slates.

The Glenbrooke Group rests unconformably on different members of an Ordovician sequence, but the amount of erosion cannot accurately be estimated with the data now available. Ambrose (1957, p. 169) shows that a fault cuts the lavas but does not extend into the overlying Peasley Pond conglomerate. It is reasonable to consider that folding, metamorphism, and erosion occurred between the deposition of the Middle Ordovician and Upper Silurian formations. Despite this, such contacts as can be seen show a local accordance of structure between Ordovician and Silurian formations.

Peasley Pond Conglomerate

Peasley lake is 3 1/2 miles west of Verte (Green) point, which is 3 miles from the north end of Lake Memphremagog. The type locality for the Peasley Pond conglomerate (Clark, 1936, p. 33) is on the north side of the lake, where about 190 feet of conglomerate and sandstone overlie meta-volcanic rocks. South of Knowlton Landing the conglomerate can be seen overlying similar metavolcanic rocks, but elsewhere it is close to Middle Ordovician slates. At Cerises river, the conglomerate is only 10 feet thick and can be seen in contact with the Ordovician slates. Near Vale Perkins the formation is more than 200 feet thick.

The formation consists of pebble conglomerates and siliceous sandstones. In some places, beds of conglomerate are 20 feet thick; in others, scattered pebbles in a sand-sized matrix, or lenses of conglomerate, occur.

The conglomerates are polymictic, and the pebbles, few of which exceed one inch in diameter, are composed of quartzite and chert with smaller pebbles of slate and metavolcanic rock set in a matrix of sand-sized grains of quartz with some feldspar. Recrystallization has destroyed any evidence of the nature of the original cement, but it may have been siliceous and argillaceous. One specimen from near Vale Perkins is a small-pebble conglomerate that has a dolomitic cement.

Cooke (1950, p. 64) states that the conglomerate "is a striking and unusual rock that cannot be mistaken for any other conglomerate in the district". If this statement is accepted, conglomerates of the East Branch Pond Formation (St-Julien, 1963) and of the Sherbrooke Formation would belong to the Glenbrooke Group, because, as shown by Lamarche (1962), the sorting, rounding, and composition of the pebbles are similar in all the formations mentioned. However, fossils from the East Branch Pond and Sherbrooke formations indicate a late Middle Ordovician age for them.

The sandstones, most of which are gray or light tan, are composed of subangular to subrounded grains of quartz similar to those forming the matrix of the conglomerate. In most of them metamorphism has rearranged the silica, forming quartzites.

This formation has not yielded fossils but is believed to be not much older than the conformably overlying Glenbrooke Formation. At Cerises river the exposed lower contact with Ordovician slate is sharp and parallel, but no Ordovician slate fragments occur in the conglomerate. At Peasley lake the contact of the conglomerate with the underlying dark volcanic rock is undulating and is parallel to the bedding in the overlying strata.

Glenbrooke Formation

The type section for the Glenbrooke Formation extends for 800 feet along the small stream that enters the south side of Sargent bay. Clark (1933) called the dominant rocks of the formation "slate"; Cooke (1950, p. 65) termed them "argillite". Both terms are applicable at different places, but for the purposes of this report "shale" and "siltstone" are used as names for parts of the formation. The lower third of the formation is commonly shale with little or no carbonate, whereas the upper two-thirds is silty and in places has enough carbonate to be called a calcareous siltstone. A volcanic member about 300 feet thick occurs near Molson Landing. It appears to interfinger with the siltstones not far below the lower contact of the Sargent Bay limestone.

In the Rivière Cerises section the Peasley Pond grades conformably upwards from a conglomerate, through a quartzite, to a siltstone of the Glenbrooke Formation.

The "shales" of the lower part of the formation are blue gray and weather rusty. Along streams they are commonly smooth-weathering. In fields, weathering has caused the cleavage, at most localities seemingly parallel to bedding, to be more apparent than in stream and shore exposures.

The siltstones are greenish gray and weather to a pitted or punky surface. In places the cleavage is clearly visible, but many exposures are massive.

Detailed measurement of the type section gives a thickness of 800 feet, but projection of dips and strikes suggests that as much as 1,800 feet of this formation may be present elsewhere in the Sargent Bay syncline. Similar methods disclose a possible thickness in excess of 3,000 feet in the Memphremagog syncline northwest of Channel bay. This estimate of thickness is unreliable.

The volcanic member, estimated to be 300 feet thick, is near the top of the Glenbrooke Formation. The rocks of the lowest part of the volcanic member are greenish gray, but near the top they are pinkish white and they pass into an agglomerate just below the base of the Sargent Bay limestone. The rock is amygdaloidal, and calcite amygdules, commonly 1/8 inch in diameter, are particularly abundant in the massive greenish gray rock. The pinkish white rock is not only less amygdaloidal than the greenish gray variety but also more sheared. A tuff layer, about two feet thick, outcrops in the Glenbrooke Formation on Austin bay.

This formation has yielded fossils, most of which are mentioned in Appendix A to this report. Dr. H.B. Whittington, Harvard University, has made the following comments on collections of fossils:

"Trilobites in the collections of the Geological Survey of Canada and the New York State Museum include the following:

| | |
|---|---|
| Dalmanites cf. lunatus Lambert, 1904 | Cheirurus sp. |
| Calymene sp. | Ceratocephala sp. |

The species of Dalmanites is not exactly the same as D. lunatus from the Fitch of New Hampshire, but is like that from the Silurian (Ludlow) of Baker Pond, Maine. Raymond compared the Memphremagog fauna to that of the Niagaran dolomites of the Mid-continent. The presence of Cheirurus is suggestive of Silurian and not Devonian age, and it seems likely that these beds are Middle or Upper Silurian."

Sargent Bay Limestone

The type section of the Sargent Bay limestone is downstream from that of the Glenbrooke Formation. The contact between the two formations is gradational in some places and abrupt in others.

The limestone is fine grained, bluish gray on fresh surfaces, light gray on altered surfaces, and characteristically so massive that

bedding cannot be recognized easily. In some exposures cleavage and joints are conspicuous. In places, particularly near the base of the formation, the limestone is shaly. Goudge (1935, p. 241) has published the analyses given in Table 2.

TABLE 2

Analyses of Sargent Bay Limestone
(taken from Goudge, 1935, p. 241)

| Sample | 205 | 206 | 207 | 208 | 209 |
|---|---|---|---|---|---|
| $SiO_2$ | 5.10 | 12.00 | 4.72 | 16.76 | 1.72 |
| $Fe_2O_3$ | 0.29 | 0.44 | 0.88 | 1.82 | 0.62 |
| $Al_2O_3$ | 0.61 | 0.66 | 2.92 | 3.70 | 0.32 |
| $CaCO_3$ | 92.39 | 84.82 | 88.43 | 73.47 | 91.68 |
| $MgCO_3$ | 1.38 | 1.71 | 2.34 | 3.25 | 4.79 |

Sample location:

| | |
|---|---|
| 205 Magog | Abandoned quarry, lot 1, Range XVI, Magog twp. |
| 206 Georgeville | Abandoned quarry, lot 27, Range II, Stanstead twp. |
| 207 Georgeville | Just north of brook emptying into MacPherson bay, 1 mile south of village. |
| 208 Georgeville | Shore of MacPherson bay. |
| 209 Magoon Point | Abandoned quarry; stone used for making lime. |

The analyses, largely of stone used industrially, show that the limestone has siliceous impurities, but is a high-calcium variety.

The top of the formation cannot be recognized in the area. The type section has about 500 feet of beds, but one interpretation of the structure suggests that the limestone is as much as 4,000 feet thick in the Memphremagog syncline near the latitude of Sargent bay. However, such a thickness appears to be excessive and may be a result of failure to recognize some structure that could give an exaggerated notion of the thickness of the formation.

Corals are moderately abundant in the purer limestones, as are brachiopods and bryozoa in the more shaly limestones. Despite the fact that most of the fossils have been severely deformed, many collections have been made. The faunas, together with comments, are listed in Appendix A.

Halysites found in these rocks indicates a Silurian age, and Kirkidium (Plate 1) serves to establish the age as Ludlow (Upper Silurian).

## MOUNTAIN HOUSE WHARF LIMESTONE

Mountain House Wharf is here proposed as a formation name for some limestones that crop out at Quai Mountain House (Wharf) on the west side of Lake Memphremagog at the foot of Owl Head mountain. These limestones resemble the Sargent Bay limestone but contain a Middle Devonian rather than an Upper Silurian fauna.

The type section is along the shore of Lake Memphremagog, extending northward from the small bay, and along the brook that enters the lake at the head of the bay. If the section is neither folded nor faulted, it may have as much as 700 feet of beds.

The limestones are bounded on the south by volcanic rocks assigned to the Ordovician. On the shore of the lake at the north end of the outcrop, they are within a few inches of Middle Ordovician slates, but the nature of this contact is not clear; it may be a fault or an unconformity along which there has been movement. In any case, overturning is indicated because the Ordovician rocks structurally overlie the Devonian rocks.

The limestone is dark bluish gray and moderately pure to shaly. The section exposed along the brook appears to be purer limestone than that on the shore, but this may reflect only differences in the nature of the weathering. Volcanic detritus was recognized in one bed.

The corals and brachiopods suggest an early Middle Devonian (Eifel) age for the Mountain House Wharf limestone. Dr. W.A. Oliver of the United States Geological Survey has written as follows regarding collections from the Geological Survey of Canada and the New York State Museum (Appendix A, item 23):

"The following collections from the vicinity of Mountain House, Lot 11, Range IX, Potton Twp., Quebec, are probably of Devonian age if they can be considered as a unit. The corals are badly crushed and largely recrystallized and identification is difficult. The tabulates have little age significance here but are similar in the various collections.

"Siphonophrentis ranges from the Helderberg (New Scotland? age) to the Hamilton in eastern North America, but is elsewhere reported only from the Middle Devonian. The species on hand could be Zaphrentis incondita Billings, from the Grande Grève limestone.

"A metriophylloid (Stereolasma? sp.) supports a Devonian age. The species on hand may be Zaphrentis cortica Billings, also from the Grande Grève (?).

"Heliophyllum is probable in the collections but cannot be certainly identified. The generic name has been carelessly applied to anything with septal carinae but I know of no occurrence of Heliophyllum s.s. below the Bois Blanc (? = Schoharie).

" 1. The rugose corals limit the collection to a Helderberg to Hamilton age range.

" 2. There are possible ties to the Grande Grève (Oriskany).

" 3. Heliophyllum suggests a post-Oriskany age.

" Ties to the Famine limestone turned out to be more apparent than real.

" No meaningful comparison can be made with the 'Silurian' Memphremagog collections that you sent. These have been examined in a preliminary fashion with no similarities being noted."

Brachiopods from this formation identified by Boucot are listed in Appendix A (item 24).

## STRUCTURAL GEOLOGY

Lake Memphremagog is 681 feet above sealevel, and the outcrops of Silurian and Devonian rocks are at elevations less than 300 feet above this. Cover of unconsolidated sediment is extensive, and exposures are common only on the shores of the larger lakes and along streams. Extrapolation between exposures has been guided by the following principles: the sequence and thicknesses of the formations of the Glenbrooke Group are consistent; the projection of strikes and dips into areas without exposure is justified. These principles may be at fault if the surface on which the Glenbrooke Group was laid was very irregular. The possibility that the pre-Glenbrooke surface was one of considerable relief can be determined only by mapping the region surrounding the Glenbrooke Group.

Structurally, the Glenbrooke Group forms two parallel, narrow synclines, called by Ambrose (1942) the Sargent Bay syncline and the Lake Memphremagog syncline.

The structural relations of the Mountain House Wharf limestone to the Ordovician and to the Glenbrooke Group are not clear.

Sargent Bay Syncline

The western or Sargent Bay syncline, which is the smaller and simpler of the two, contains the type sections of the formations of the Glenbrooke Group.

The Sargent Bay syncline is about 13 miles long, but its exact length is hard to determine because exposures are sparse near both its north and south ends. South of Sargent bay it is about one-half mile wide, but at the latitude of Austin (East Bolton) it is about 1 1/2 miles wide. The axial plane cleavage is within 10° of vertical, in most places vertical, and its strike is parallel to the trend of the syncline. The bedding is so obscure in many places that there is a tendency to consider it as parallel to the schistosity. Near Vale Perkins, bedding in the Glenbrooke Formation dips at 45° towards the axis of the syncline. At the latitude of Austin, where the syncline is widest, the Sargent Bay limestone forms three bands suggesting two minor anticlines within the syncline.

Two major east-west faults cut the syncline. North of Peasley lake, Ordovician slates are in the projected position of the Glenbrooke Formation, suggesting a fault whereby the formations to the south are displaced a mile west of those to the north. The second fault crosses the mouth of Sargent bay and separates the wider and more complex part of the syncline from the narrower and simpler part. The rocks on the north are apparently offset 1 1/2 miles west by this fault. Two faults approximately parallel to these are also shown on the map, but their existence is uncertain.

Lake Memphremagog Syncline

The eastern, or Lake Memphremagog, syncline is more complex than the Sargent Bay syncline. There is some uncertainty as to its extension at both ends, and much of it is covered by the waters of the lake.

The syncline extends for at least 19 miles southward from the vicinity of Cerises river, and its greatest width is about 3 miles. The east side of the synclinal structure has part of the "following anticline", which is cut off by a fault that strikes almost parallel to the trends of the axes of the major folds. This fault causes rocks of the Glenbrooke Formation or of the Sargent Bay limestone to crop out adjacent to Ordovician slates.

The Peasley Pond conglomerate was seen near Cerises river, at a locality 1 1/4 miles west of Verte point, and a mile west of Lords island. South of Molson island, the Glenbrooke Formation appears to overlie

the Ordovician directly. Most of the Lake Memphremagog syncline is, from its inferred width, considerably more openly folded than the Sargent Bay syncline; however, opposite the massif of volcanic rock underlying Owl Head mountain the folds are close, as though the massif acted as a buttress against which the Silurian rocks were shoved.

Cooke (1950) shows a fault bounding the east side of the Lake Memphremagog syncline. Ambrose (1942) does not show this fault, but shows a fault that could be the southern prolongation of it cutting the Ordovician rocks. The present studies confirm the existence of a fault slightly south of Magog, as shown by Cooke, and suggest that the movement, west side downward, is approximately equal to or somewhat greater than the thickness of the Glenbrooke Formation. The fault crosses the lake and passes into Ordovician rocks near the outcrop of the Mountain House Wharf Formation.

In addition to this longitudinal fault, several transverse faults have been recognized. One is near Cerises river, and two others are about 4 miles south of Magog. The latter two faults are about 7,000 feet apart and offset the longitudinal fault in such a way that the fault contact of the Middle Ordovician rocks and the Glenbrooke Formation is shifted about 1/4 mile west between them. The northern of these two faults may be the same as that which causes the offset of the Glenbrooke rocks north of Peasley lake. Faults probably played a role in producing the peculiar distribution of formations suggesting an anticline at a locality one mile west of Lords island

Three separated exposures of formations of the Glenbrooke Group occur east of the longitudinal fault. Widening of the road opposite the head of MacPherson bay in 1961 disclosed black slates with Middle Ordovician graptolites, and, along the same road about one-quarter mile south of the fossil locality, St-Julien found a small patch of conglomerate similar to that of the Peasley Pond conglomerate resting on the slates. Round island is composed entirely of Glenbrooke Formation, whose relationship here to other rocks is not clear. Sargent Bay limestone crops out near the shore between Magoon point and the entrance of Fitch bay. Other formations of the Glenbrooke Group may be present near the limestone, but if so, they are not exposed.

Mountain House Wharf Area

The Mountain House Wharf limestone comprises one isolated area. Its Devonian age makes its structural relationship to the Glenbrooke Group and particularly to the Sargent Bay limestone an enigma. The formation is bounded on two sides of its triangular area of outcrop by Ordovician volcanic rocks, but no interpretable contact with them is visible.

Part of the contact on the remaining side is against Ordovician slate, but the nature of this contact, whether fault or unconformity, is not clear, although its dip, 65°NW., can be measured.

With the scanty available evidence, it is impossible to make any categorical statement about the structural relationship of the rocks at Mountain House Wharf to those of the Glenbrooke Group.

## REGIONAL CORRELATION OF SILURO-DEVONIAN ROCKS IN THE EASTERN TOWNSHIPS AND IN ADJACENT PARTS OF VERMONT, NEW HAMPSHIRE, AND MAINE

The accompanying sketch map shows the localities from which critical fossils have been collected, and faunal and locality lists are given in Appendix A. The fossils provide a firm date for the rocks near Lake Memphremagog, and they raise the problem of correlation of these rocks with some other fossiliferous formations in the Eastern Townships. Therefore, the discussion of the Memphremagog fossils is integrated into that of the relationships over a wider area.

As mentioned above, Logan (1845, p. 45; 1849, p. 46) recognized the existence of Siluro-Devonian rocks in the western part of what is now called the Gaspé - Connecticut River synclinorium. The Esquisse Géologique du Canada (Logan and Hunt, 1855) gives a colored map of eastern Canada and parts of the United States on which is shown a narrow band of "calcaire de Niagara" extending from Gaspé into Massachusetts. The description of this band (p. 52) can be translated as follows: "The fossiliferous limestones of Gaspé can be followed southwestward to Lake Memphremagog on the boundary of the United States, and from there they continue southward in the Connecticut valley to where they are covered by the Triassic sandstones of Massachusetts. They thus crop out for a length of 250 leagues (690 miles). The Devonian rocks which are entirely siliceous in Gaspé have towards the southwest beds of limestone, which occur in the same trough as the Silurian limestone just mentioned." On two later maps (1863, 1865) the western boundary of the Siluro-Devonian is shown in approximately the same position as on the 1855 map, but the eastern boundary of the belt is moved much farther east to include sparsely fossiliferous or non-fossiliferous slates and dirty sandstones with some calcareous sandstones.

The Logan interpretation of the geology of the Eastern Townships was generally accepted until Ells (1887, p. 14) decided that the parts of Logan's unit that do not contain obvious Siluro-Devonian fossils were "Cambro-Silurian, probably Trenton Utica". His reason for the change was that the obscure fossils found were similar to some found in areas to the west in rocks then assigned to the Ordovician. Some of the western

"fossils" on which the change was predicated have since proved to be non-biogenic. In 1871 Weston (1899, p. 72) collected corals of Devonian aspect near Eaton, which is 14 miles east of Sherbrooke. Surprisingly, there is no other mention of these corals.

Ells inferred that the rocks with Siluro-Devonian fossils were infolded into the rocks that he assigned to the Ordovician or were separated from them by faults. These devices proved popular and were used by later geologists, notably by Mackay (1921, p. 33), Burton (1931), and Cooke (1950, p. 52). The Ells interpretation was consistently accepted in Quebec for about 60 years, and rocks belonging to the Gaspé - Connecticut River synclinorium were mapped as Beauceville or new names were introduced generally with the rocks considered Ordovician. These new names included: Tomifobia, proposed by Kerr in an unpublished report (Clark, 1934, p. 12); Lower and Upper St. Francis groups, proposed by Cooke (1950, p. 29) for the same rocks; and Compton and Frontenac, proposed by McGerrigle (1935, p. 71).

The Ordovician assignment was largely influenced by Clark's account (1934, p. 12) of presumed Middle Ordovician graptolites in the Tomifobia [now not accepted after re-examination of the evidence by Cumming and McLaren (personal communication 1953)], by Ruedemann's identification of Beekmantown to Lower Trenton graptolites (now considered lineations of tectonic origin; Currier and Jahns, 1941, p. 1505) from the Waits River Formation of Vermont, and by Okulitch's report (in Cady, 1950) of possible Ordovician tetracorals in the Waits River Formation. Billings (1948, p. 49) indicated that these rocks were probably Silurian and Devonian, and in more recent years most geologists working in this region have come to consider these rocks as of Siluro-Devonian age. The positive identification of Siluro-Devonian brachiopods in the Shaw Mountain Formation* of Vermont provided final proof of the Siluro-Devonian age of the Shaw Mountain - Gile Mountain sequence.

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* The Shaw Mountain Formation yielded fossils reported on by Boucot in 1960 as follows:

> The two brachiopods (one brachial and one pedicle valve) from a locality in the Hardwick quadrangle, 2 miles S.37°W. of the center of the village of Albany, on an east-facing hill slope, 0.25 mile north of the Seaver Branch of Black river, belong to a strongly plicated form of the genus Howellella. Howellellids of this type have been found elsewhere in strata of Upper Llandoverian (C3 or younger; Williams, 1951) to Lower Gedinnian age. In the Appalachians similar forms have been found from the Clinton to the Coeymans. In the Eastern Townships of Quebec a similar form occurs in the Lake Aylmer formation which Boucot has dated as of Ludlovian (sic Pridoli) age as both Eccentricosta and Protathyris are present in a collection made by J.W. Laverdière, near Marbleton, which was submitted to me by F.F. Osborne for dating. The Howellella from the Fitch formation at Fitch farm is similar to that from the Shaw Mountain formation, whereas that from the Clough formation on Hetty Brook has very subdued plications. The Fitch is of Ludlovian age, whereas the Clough is of Upper Llandoverian age. However, the above should not be taken to prove that the Shaw Mountain is of Ludlovian age as elsewhere strongly plicated species of Howellella range well above and below the Ludlovian.

More recent studies by geologists in Canada and the United States have confirmed the earlier interpretation of Logan. All of these rocks are now considered to be of Siluro-Devonian age.

This belt of Siluro-Devonian rocks continues from the Eastern Townships south into eastern Vermont and northwestern New Hampshire. The stratigraphic nomenclature used to the south, in ascending order, is: Shaw Mountain Formation (lithologically similar to the Peasley Pond conglomerate), Northfield slate (lithologically similar to the Glenbrooke shale), Waits River Formation (the bulk of this unit resembles the punky-weathering Lower Devonian Cape Bon Ami and Grande Grêve limestones of the Matapédia Valley region), and the Gile Mountain Formation (lithologically similar to, and continuous with, the Upper St. Francis Group). The part of the belt in eastern Vermont (Doll, et al., 1961) has been recently assigned to the Siluro-Devonian, although most papers dealing with these rocks in the past thirty years have assigned the rocks to the Ordovician.

In 1950 work was started in the Quebec Appalachian region north of the Eastern Townships. It was found that rocks heretofore considered to be Ordovician could be separated into an Ordovician formation and a younger formation, later called St. Juste (Béland, 1957, p. 24). The St. Juste Formation has traces of the tissue of woody plants and therefore cannot be Ordovician. It is not cut by some of the intrusive rocks that cut the Ordovician, and its lithology differs subtly from that of the Ordovician Beauceville. Gorman (1954; 1955) traced the St. Juste Formation southwestward through the Devonian fossil localities at Ste-Justine, Morisset Station, and St-Georges. In addition, regional aeromagnetic maps show consistent differences in the general pattern of rocks assigned to the Ordovician and Cambrian as compared to those assigned to the St. Juste Formation.

Boucot, in working on fossiliferous Siluro-Devonian rocks in Maine from 1948 to 1954, noted that their probable extension into Quebec was assigned to the Ordovician. This led him to believe that a wide band of Siluro-Devonian rocks lithologically similar to those studied by him extended through the Eastern Townships, and, like the workers in Quebec, he concluded that the St. Francis Group might be Siluro-Devonian rather than Ordovician.

Age of the St. Francis Group

The Upper and Lower St. Francis Group includes the Tomifobia Formation, which was named in an unpublished report by Kerr. Clark (1934), who first published the name, stated that the formation was Ordovician because he found graptolites in it at a locality close to Tomifobia Station. With Clark's co-operation, the fossils were later submitted to L.M. Cumming and D.J. McLaren of the Geological Survey of Canada. Cumming reported (written communication, Nov. 20, 1953): "Specimens of the Tomifobia formation from localities 9D1, 10E1, 12F1, show, on bedding surfaces, anastomosing bands

of lighter colored surficial material. There is no evidence of positive graptolite structure, but the markings might be interpreted as sheared distal portions of very elongate graptolite colonies. Definite age determinations cannot be made from this material." McLaren (written communication, Nov. 19, 1953) stated: "A re-examination of the material considered by Clark to contain graptolites of Trenton age allows no positive conclusions to be drawn. Markings suggestive of highly sheared graptolites occur on the rock samples from all localities but it is impossible to be sure that they are in fact graptolites. A specimen from locality 12F1 contains a dendroid marking resembling Dictyonema sp. In my opinion there is no evidence to suggest an age for these specimens."

If the markings are non-biogenic, they are useless in dating the St. Francis Group (they occur in the lower calcareous portion of the St. Francis that is stratigraphically equivalent to the Waits River Formation). If they are the remains of graptoloid graptolites, the rocks are at least as old as New Scotland (lower third of the Lower Devonian), for such graptolites have not been found in the post-New Scotland Lower Devonian of the Appalachian region.

The invalidation of the Ordovician date assigned to the St, Francis provided incentive for mapping the rocks later to be considered as belonging to the Gaspé - Connecticut River synclinorium. In Maine, Albee (1961, p. 51-54) showed that the Lower Devonian Seboomook Formation passed beneath the asymetrical Frontenac syncline of Quebec. Marleau (1958, 1959) stated that the Seboomook (Compton) slates emerged on the northwest side of the syncline, where they occupy a substantial area in Quebec. Duquette (1959, 1961) found that the basal conglomerate of the Upper Silurian Lake Aylmer Group overlies Weedon schists near Weedon and that a similar conglomerate occurs at the base of the St. Francis Group. The conglomerate can be traced around the outcrop of Weedon schist, which suggests that the calcareous and argillaceous formations of Silurian or Devonian age are facies of about the same age.

There are several possibilities for correlating the essentially unfossiliferous Waits River limestone (Fig. 1). Doll et al. (1961) assign the entire Waits River limestone to the Lower Devonian. On the basis of lithology, there is a strong possibility that the bulk of the Waits River (the punky-weathering portion) is of Lower Devonian age by analogy to the Lower Devonian Cape Bon Ami and Grande Grève formations. However, it seems equally likely that the basal portions of the Waits River may include disconformable, lenticular masses of Ludlow age beneath the Devonian limestones. It seems unlikely that the great thickness of Ludlow age Sargent Bay limestone in the Lake Memphremagog region should be absent only a few miles to the southeast, and such basal portions of the Waits River as the Ayers Cliff Member may be of the same stratigraphical level as the Sargent Bay limestone (Fig. 1, Interpretation B).

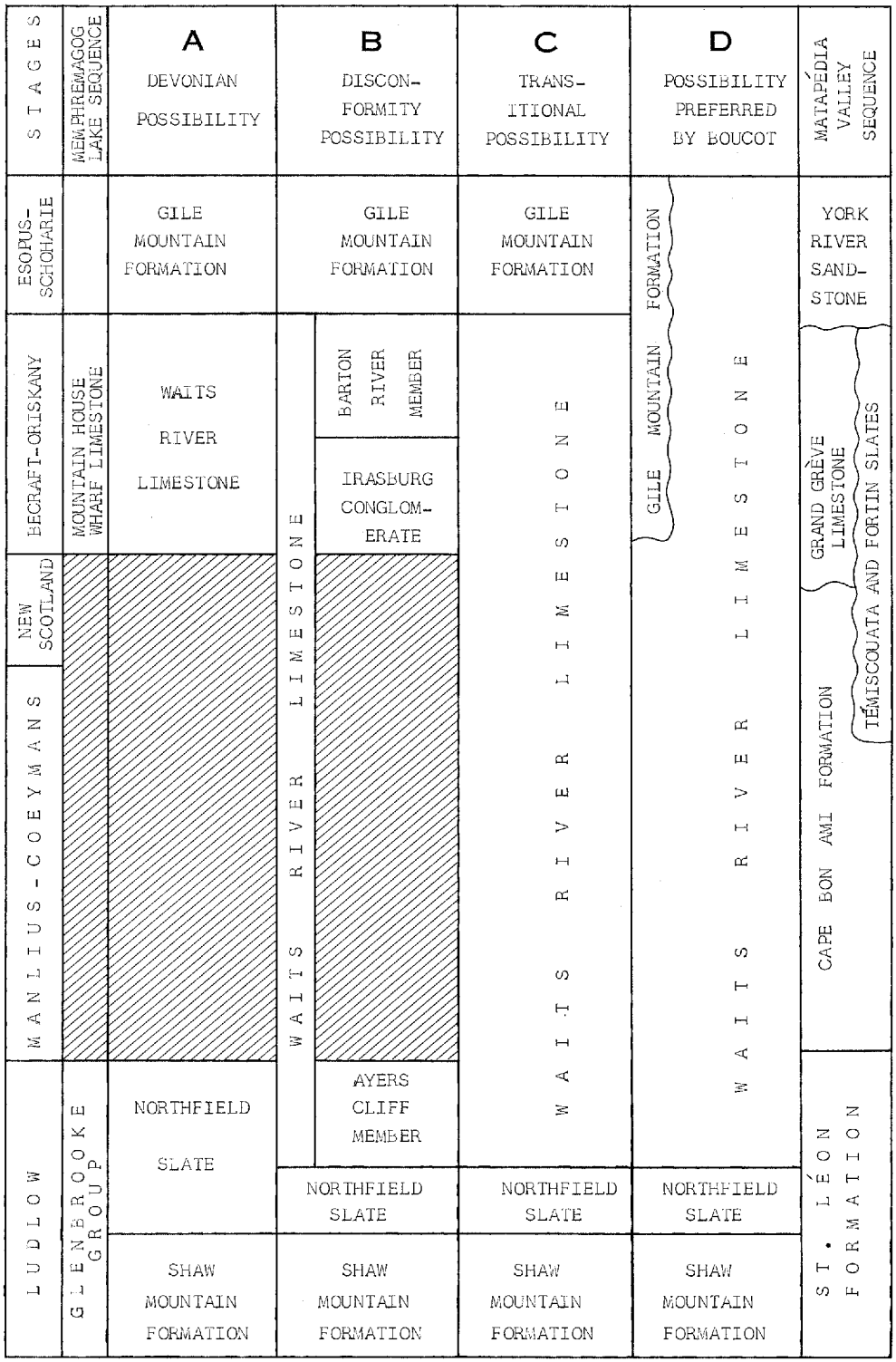


Figure 1 - POSSIBILITIES FOR CORRELATING THE WAITS RIVER LIMESTONE

Doll (1951) redescribed the Irasburg conglomerate, which occurs between the Ayers Cliff and Barton River members of the Waits River Formation, in such a way that it can be interpreted as the basal conglomerate of the Barton River lying disconformably upon the Ayers Cliff. The thinning and eventual disappearance of the Ayers Cliff beneath the Barton River in southern Vermont (Doll et al., 1961) can easily be explained in this manner. The disappearance of the Waits River Formation (the "predominantly calcareous" Siluro-Devonian of Map 1607A) to the northeast at about the latitude of Dudswell can be best explained as a result of a lateral change of facies of the Lower Devonian part of the Waits River into the Gile Mountain (=upper St. Francis Group) in the same manner that the limestones of the Grande Grève and Cape Bon Ami disappear southwest of the Matapédia valley, giving way to the Fortin-Témiscouata slates. Southwest of Matapédia valley there is adequate paleontologic control to indicate that only beds of Lower Devonian age are concerned in this change. The punky weathering Waits River rock types are lacking northeast of Dudswell until they reappear in the region between Lake Témiscouata and Matapédia river.

## AGE AND CORRELATION OF THE FOSSILIFEROUS SILURO-DEVONIAN FORMATIONS IN THE EASTERN TOWNSHIPS

Since Logan's time, considerable information has been accumulated on the paleontology and detailed zonation of Silurian and Lower Devonian fossils, and it is now possible to zone with reasonable confidence most of the fossiliferous Silurian and Devonian rocks of the Eastern Townships. The zonable rocks can be assigned to one or the other of two units: an early Middle Devonian unit of Onondaga (Eifel) age that includes the calcareous fossiliferous rocks at St-Georges, Morisset and Quai Mountain House (Wharf), and an Upper Silurian unit of Ludlow* and Pridoli age that includes the fossiliferous rocks at Marbleton, Dudswell, Petit-Lac (Lambton lake), Cranbourne, and Lake Memphremagog. The rocks of Ludlow and Pridoli age are correlatives of the Hardwood Mountain Formation (Boucot, 1961, p.181) of nearby northern Maine. At Little Big Wood pond, the Hardwood Mountain Formation contains a Pridoli age fauna very similar to that found near Marbleton, Dudswell, Cranbourne, and Petit-Lac. The Fitch Formation (Billings and Cleaves, 1934, p. 415) of northern New Hampshire is also of Ludlow age and contains an invertebrate fauna (including the critical brachiopod Kirkidium) similar to that found near Lake Memphremagog. Near

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*The Ludlow-Pridoli is probably a correlative of the Salina Group of New York. The use of New York terminology for the Silurian rocks of the northern Appalachians is less satisfactory than the international standards.

Albany, Vermont, the Shaw Mountain Formation has yielded fossils that can be of Ludlow and Pridoli age, although they could be as old as Upper Llandovery ($C_3$ or younger) or as young as Lower Gedinnian. The exact position of the Lower St. Francis (the southern Quebec equivalent of the Waits River, Northfield, and Shaw Mountain formations) adjacent to the international boundary, is still unresolved. If the material originally assigned by Clark (1934, p. 12) to the Ordovician is actually graptolitic, it is probable that the containing beds are no younger than New Scotland age because graptoloid graptolites have not yet been found in beds of post-New Scotland age in the Appalachians. The Ludlow-Pridoli equivalents near Memphremagog and in the Marbleton-Dudswell, Cranbourne, and Petit-Lac areas have recently been assigned largely to the Lower Devonian. The Middle Devonian assignment of the beds near Lake Memphremagog is chiefly attributed to Ells (1896, p. 8 J), who noted the occurrence of Taonurus in the slates and shales. Taonurus in 1896 was thought to indicate a Lower Devonian age because of its abundance in eastern New York in the Lower Devonian Esopus grits, but it is now known to have a very extended stratigraphic range within much of the Paleozoic and to be of little value for purposes of interregional correlation. Ells (1896, p. 8 J) was also influenced in favor of a Lower Devonian age for the Memphremagog rocks by the occurrence in the fault remnant at Quai Mountain House of a Devonian-type invertebrate fauna. The present mapping of the rocks in the Lake Memphremagog syncline shows conclusively that fossils of Ludlow age (Kirkidium) occur in the youngest beds of the syncline, eliminating a Devonian assignment regardless of the Devonian age of the rocks in the fault remnant at Quai Mountain House. Clark (1942, p. 15) concluded, chiefly on the basis of a number of generically misidentified brachiopods, that the Silurian rocks in the Dudswell, Marbleton, Petit-Lac, and Cranbourne areas were of Helderberg (Lower Devonian) age. The most critical brachiopods for purposes of correlating the Marbleton, Dudswell, and Petit-Lac occurrences are Eccentricosta and Protathyris (see Appendix B of this paper for reassignment of Clark's brachiopods).

The position of the calcareous rocks at St-Georges and Morisset within the Devonian has until recently been a vexing question. Clark (1923, p. 221) correlated them with the Middle Devonian of interior North America (Dundee limestone, Columbus limestone, etc.) because at Morisset they contained the index fossil Brevispirifer lucasensis. There can be no disagreement with Clark's determination of Brevispirifer in the fauna from St-Georges; calcareous rocks of Middle Devonian (Eifel) age in the Témiscouata-Touladi region at the base of slates similar to those at St-Georges contain spiriferids similar (if not identical) to those assigned by Clark to Brevispirifer lucasensis (Boucot and Johnson, 1967).

PLATE I

A

B

KIRKIDIUM sp.

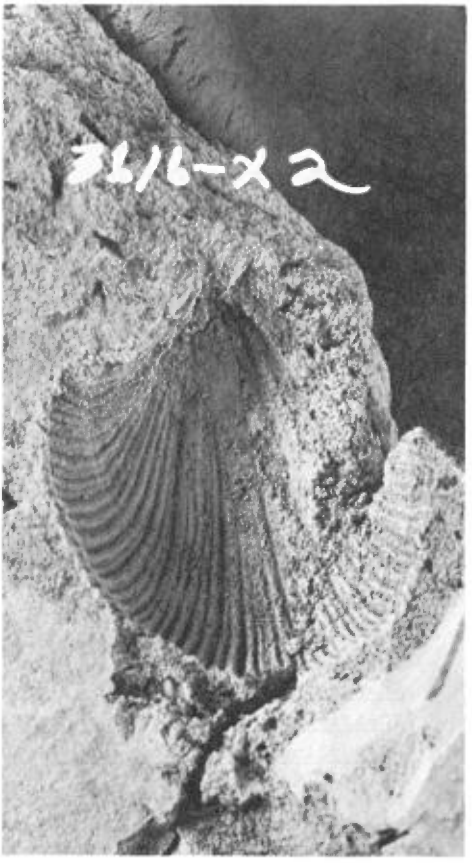
Cross-sections of deformed pedicle valve (xl) showing spondylium. This specimen is coarsely costellate. Other specimens show that the characters of the brachial valve are those of Kirkidium.

Sargent Bay limestone

Geological Survey of Canada Locality No. 11285. Collected by J.W. Ambrose (Cooke; Appendix A, item 14)

PLATE II


A




B

RESSERELLA sp.

Limestone conglomerate of Lake Aylmer shale (U.S.G.S. locality SD-3616).

IIa (x2) Impression of exterior of brachial valve (U.S.N.M. No. 126112B).

IIb (x2) Impression of exterior of pedicle valve (U.S.N.M. No. 126112A).

Oliver[1] concluded that the corals from the Famine are probably of Schoharie age, but their occurrence with a brachiopod and conodont fauna concluded to be of Eifel age suggests a Middle Devonian (Onondaga) age. Corals of Becraft-Oriskany age are little known or described in North America. Therefore it is concluded on the basis of their similar stratigraphic position and faunas that the beds at St-Georges and Morisset are also of Middle Devonian age. Assignment of the beds at St-Georges and Morisset to the Middle Devonian is in harmony with evidence elsewhere in the Northern Appalachians, which suggests that throughout that region marine sedimentation terminated before the end of the Middle Devonian.

Beds of Schoharie (= Zone B), Esopus, Becraft-Oriskany, New Scotland, Manlius-Coeymans, Llandovery, and Wenlock ages have not yet been recognized in the region southwest from St-Georges to the international boundary. Perhaps such beds were not deposited in the Eastern Townships, but until more extensive fossil collections have been made and studied such a conclusion is premature. However, the widespread occurrence of Ludlow and Pridoli age beds in the northern Appalachians from Lake Memphremagog and northern New Hampshire on the southwest to Nova Scotia and Gaspé on the northeast suggests that Ludlow and Pridoli times may have been the periods of most widespread marine sedimentation during the Silurian.

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[1] USGS 5828-SD; Famine limestone, St-Georges, Quebec, on Chaudière river. Coll. A.J. Boucot. The following corals have been identified:

| | |
|---|---|
| Favosites sp. | *Heliophyllum sp. cf. H. halli |
| *Syringopora sp. | *H. sp. cf. H. halli proliferum |
| Thamnopora sp. | Heterophrentis? sp. |
| Acanthophyllum sp. | phaulactoid coral |
| "Cystiphyllum" sp. cf. C. conifollis | Siphonophrentis? sp. |
| *Disphyllum (Cylindrophyllum?) sp. | *common in collection |

The listed genera indicate a Lower or Middle Devonian age. Most of them range as low as the Helderberg stage, but I know of no pre-Bois Blanc (=Schoharie) Heliophyllum, and I would argue strongly for a post-Oriskany age on this basis.

The Famine corals differ from the New York Onondaga and Hamilton corals in important respects. The Disphyllum is quite different, although disphyllids are common in New York. The differences may be due to facies or this may be taken to suggest that the Famine is pre-Edgecliff (Onondaga) in age.

My list is quite compatible with earlier Famine lists, which may mean that this and earlier collections are representative, although small. Clark's descriptions fit my specimens 100%, although he used different names. It is surprising that no previous list caught the excellent Heliophyllum. Billing's H.oneidaense may be Acrophyllum oneidaense not recognized in this collection. A. oneidaense is easily recognizable and a characteristic Schoharie (Bois Blanc, Zone B) species.

In conclusion, a Schoharie to Hamilton range is indicated by the corals, with Schoharie seeming to be most likely.

## CONCLUSIONS

A critical consideration of the Siluro-Devonian faunas from localities east and southeast of the Sutton axis and south of Morisset Station in Quebec shows that all the well-dated fossils are either of Ludlow and Pridoli or of early Middle Devonian age. No locality has yet been found where the stratigraphic relationships between these two groups of rocks can be determined. The problem of determining whether the Silurian and Devonian rocks are separated by a major disconformity or belong to one gradational sequence is, therefore, unsolved. The mapping near Lake Memphremagog has shown that the Glenbrooke Group was deposited on an irregular surface that was not deeply submerged. Other groups in the region to the north show the same structural relationship. The limestone of the Lake Aylmer Group at Marbleton, Dudswell, and Petit-Lac, and the limestones at Cranbourne contain fossils indicating that they are of Pridoli age, and that the Sargent Bay limestone is of Ludlow age.

It is our belief that the fossiliferous Siluro-Devonian carbonate rocks date the extensive sedimentation that occurred in a belt lying east or southeast of them. A group of formations including the upper St. Francis, St. Juste, Seboomook, Compton, Témiscouata, Gile Mountain, and Fortin is largely or altogether Devonian. The "upper" part of the Waits River Formation is probably Devonian, but a "lower" part may be of Silurian age. However, until more fossils are discovered the precise correlation of the strata in this synclinorium must remain in doubt.

## APPENDIX A

## FOSSIL LOCALITIES OF THE LAKE MEMPHREMAGOG AREA

### Glenbrooke Formation

1. Glenbrooke creek

Ells, 1896, p. 8j

*Spirophyton* (*Taonurus*) *cauda-galli*, Van.
*Psilophyton* sp.
*Buthotrephis* sp.

2. Glenbrooke creek

Ells, 1896, p. 156j

*Spirophyton cauda-galli* Vanuxem

3. Glenbrooke creek

Cooke, 1950, p. 67-68

*Dalmanites lunatus* Lambert
*Dalmanites* sp. ind.
*Calymene* sp. ind.
*Bronteus pompilius* Billings
*Ceratocephala* cf. *C. geniata* Warder
*Chonetes* sp. ind.
*Coelidium* sp. ind.
Operculum of gastropod, like that referred to *Oriostoma* by Kindle
*Orthoceratites* indeterminable

("A little higher in the section")

*Encrinurus*
*Orthoceratites*

("On the other limb of the syncline")

Rhynchonelloid, possibly a *Wilsonia*
*Atrypa nodostriata* Hall
like *Leptaena rhomboidalis*
*Favosites gothlandicus* Lamarck

4. Glenbrooke creek

Whittington, 1961 (in this report, p. 7)

*Dalmanites* cf. *lunatus* Lambert, 1904
*Calymene* sp.
*Cheirurus* sp.
*Ceratocephala* sp.

5. Ronde island
Ells, 1896, p. 154j
*Stromatopora* sp.
*Heliolites* sp. very imperfectly shown
*Favosites* sp. ind.

*Probably Sargent Bay limestone (Possibly Glenbrooke Formation)*

6. Capt. Gully's point. Stanstead twp. R.I, lot 15
Ells, 1896, p. 154j
Stromatoporoid (Undeterm.)
*Favosites gothlandicus* Lamarck
*Favosites* resembling *F. helderbergiae* Hall

7. Magog twp. R. XVI, lot 1
Cooke, 1950, p. 70
cf. *Heliophyllum* sp.
*Favosites* cf. *limitaris* Rominger
*Favosites* sp. very fine

*Sargent Bay limestone*

8. Belmere point
Boucot, 1961 (in this report)
*Delthyris*? sp.

9. Georgeville. Stanstead twp. Rs. I and II, lots 25 and 26
Ells, 1896, p. 154j
*Halysites catenularia* Linn.
*Favosites gothlandicus* Lamarck
*Favosites*, sp., cf. *F. favosus* Goldfuss
*Zaphrentis* sp.
Frag. of crinoidal columns

10. Knowlton Landing. Potton twp. R. X, lots 27 and 28
Ells, 1896, p. 254j
*Psilophyton* sp.
*Favosites gothlandicus* Lamarck
*Polypora* or monticuloporoid
*Rhynchonella* sp. type *R. wilsoni* Sowerby

11. Knowlton Landing
Boucot, 1961 (in this report)
GSC 43779:
*Rhynchospira*?

12. MacPherson brook

Boucot, 1961 (in this report)

*Gypidula*? sp.
*Atrypa* "*reticularis*"

13. Sargent bay. East shore, about 100 feet east of the head of the point shown on the map

Boucot, 1961 (in this report)

*Coelospira*? sp.

14. Belmere Farm. Stanstead twp. R. I, lot 18

Cooke, 1950, p. 69

*Stromatopora* sp.
*Conchidium* sp. (=Kirkidium)
Pelecypod

15. Stanstead twp. R. I, lot 23

Cooke, 1950, p. 70

*Favosites* cf. *F. basalticus* Goldfuss

*Mountain House Wharf limestone*

16. Mountain House

Logan, 1863, p. 436

*Zaphrentis*

17. Mountain House

Ells, 1896, p. 9j

*Syringopora hisingeri* Billings
*Favosites basaltica* Goldfuss
*Diphyphyllum stramineum* Billings
*Zaphrentis gigantea* Le Sueur
(*Atrypa reticularis*)

18. Mountain House

Ells, 1896, p. 157j

*Stromatopora concentrica* Goldfuss
*Favosites gothlandicus* Lamarck
*Favosites basalticus* Goldfuss
*Favosites polymorpha* Goldfuss
*Zaphrentis* sp. ind.
*Heliophyllum* sp. ind.
*Diphyphyllum arundinaceum* Billings
*Syringopora hisingeri* Billings
Crinoidal fragments

19. Mountain House

Harvie, 1914, p. 214

Crinoid stems
Favosites cf. basaltica
Favosites sp.
Zaphrentis sp.
Spirifer cf. arrectus
Actinopteria ?
Panenka .... ?
Proetus .... ?

20. Mountain House. Potton twp. R. IX (sic: probably should be R. X),lot 11

Cooke, 1950, p. 68

Zaphrentis sp. A
Z. sp. B
Cyathophyllum sp.
Favosites cf. helderbergiae Hall
F. cf. basalticus Goldfuss
F. sp.
Cladopora sp.
Diphyphyllum sp.
Stropheodonta sp.
Atrypa spinosa Hall
Spirifer cf. arenosus Conrad
S. sp. distorted; cf, S. montrealensis Williams
cf. Panenka sp.
Conocardium cuneus (Conrad)
Several unidentifiable pelecypods
Holopea sp.
Dalmanites sp.
Homalonotus sp.

21. Mountain House

Cooke, 1950, p. 69

Streptelasma sp.
Zaphrentis sp. A
Heliophyllum sp.
Favosites cf. basalticus Goldfuss
F. sp. A
Atrypa spinosa Hall
cf. Panenka
Conocardium cuneus (Conrad)

22. Mountain House

Cooke, 1950, p. 70

Favosites favosus

23. Mountain House

Oliver, 1961 (in this report, pp. 9-10)

NYSM 3554:

Thamnopora sp. ( or ramose Favosites?)
Favosites spp.
Heliophyllum? sp.

GSC 38148:

Thamnopora sp.
Favosites sp.
Heliophyllum? sp.
Siphonophrentis sp. (possibly Zaphrentis incondita Billings, 1874)

GSC 38149:

Thamnopora? sp.
Favosites sp.
Heliophyllum ? sp.

GSC 38165:

Favosites sp.
Stereolasma? sp. (possibly Zaphrentis cortica Billings, 1874)

GSC 1650:

Favosites? sp.
Siphonophrentis? sp.

24. Quai Mountain House

Boucot, 1961 (in this report)

GSC 1651:

Arrectiform spirifer; could be "S" duodenarius

GSC 38148:

Large form with ribs in sulcus; could be Fimbrispirifer or Costispirifer
Rhynchonellid, camarotoechiform
Atrypa "reticularis"
Large rhynchonellid

GSC 38165:

Atrypa "reticularis"

NY Museum 3554:

Atrypa "reticularis"
Arrectiform spiriferoid

Collection of 5/7/61 (retained by Boucot).
Potton twp. R.X, lot 11. On the small brook, within 100 feet each side of an old dam, about 150 yards from the lake shore:

Rhipidomellid
Stropheodontid
Orthotetacid

## APPENDIX B

## SILURIAN AND DEVONIAN FAUNAS

## ADJACENT TO THE LAKE MEMPHREMAGOG AREA

These faunas have been re-examined by Boucot. His comments, identified by the initials AJB, are given in parentheses.

Cranbourne

Tolman, 1936, p. 15

- Leptaena rhomboidalis Wilckens
- Strophonella sp. nov. (=Amphistrophia cf. funiculata - AJB)
- Uncinulus (U. vellicatus) sp. nov. (U. abruptus)
- Rensselaeria subglobosa Weller (=deformed Atrypa reticularis - AJB)
- Atrypa reticularis Linné
- Spirifer sp. nov. (S. tribuarius) (=Howellella sp. - AJB)
- Poleumita (Pleurotomaria) princessa Billings
- Euomphalus disjunctus Hall
- Trematonotus profundis Hall
- Spyroceras sp. nov.
- Poterioceras sp. nov.
- Proetus phocion Billings
- Dalmanites sp.
- Phacops sp.
- Calymene sp.

Cranbourne

Clark, 1942, p. 22

- Halysites catenularia Linné
- Leptaena rhomboidalis Wilckens
- Strophonella parva sp. nov. (=Amphistrophia cf. funiculata - AJB)
- Uncinulus tolmani sp. nov.
- Rensselaeria cf. subglobosa Weller(=deformed Atrypa reticularis - AJB)
- R. delicatula sp. nov. (=deformed Atrypa reticularis - AJB)
- Atrypa reticularis Linné
- Spirifer orientalis sp. nov. (-Howellella sp. - AJB)
- Poleumita (Pleurotomaria) princessa Billings
- Euomphalus disjunctus Hall
- Trematonotus profundus Hall
- Spyroceras sp.
- Poterioceras cranbournensis sp. nov.
- Proetus phocion Billings
- Dalmanites sp.

Phacops sp.
Calymene browni sp. nov.
Calymene sp.
Kloedenia sp.
Kloedenella sp.
Aparchites sp.

Dudswell
Logan, 1849, p. 55
Cyathophyllum
Porites
Favosites
F. gothlandica

Dudswell
Logan, 1863, p. 433
Favosites gothlandica
F. cervicornis
F. polymorpha
Halysites catenularia
Heliolites murchisonia
Syringopora compacta
Diphyphyllum like D. arundinaceum
Zaphrentis
Heliophyllum
Stromatopora concentrica
Platyostoma
Sulcatina sp. (AJB)

Dudswell
Laverdière, 1936, p. 37
Stromatopora
Favosites
Heliolites
Diphyphyllum
Halysites catenularia
Camarotoechia litchfieldensis Schuchert (=Rhynchospira sp. - AJB)
Meristella belloides Clark (ms) (=Protathyris sp. - AJB)
Eccentricosta jerseyensis (AJB)

Petit-Lac (Lambton twp. R. V. and VI, L. 17-18)
Clark, 1937 (Cooke's Mem. 211, p. 51)
Zaphrentis sp.
Amplexus sp.
Favosites sp. 2 or 3 species
Heliolites sp.

Crinoids
Strophonella geniculata Hall
S. punctulifera Conrad (=unidentified stropheodontid - AJB)
Gypidula galeata Hall
Camarotoechia litchfieldensis Schuchert
Atrypa reticularis Linné
Atrypina imbricata Hall (=Coelospira cf. saffordi - AJB)

Petit-Lac
Clark, 1942, p. 20
Zaphrentis sp.
Amplexus sp.
Favosites spp.
Heliolites sp.
Crinoids
Resserella cf. elegantula (AJB)
Schizophoria multistriata Hall (=Dalejina sp. - AJB)
Leptaena rhomboidalis Wilckens
Stropheodonta varistriata Hall
S. (Leptostrophia) tardifi var. lambtonensis nov.
(=Eccentricosta jerseyensis -AJB)
Strophonella geniculata Hall
S. punctulifera Conrad (=unidentified stropheodontid - AJB)
Anoplia sp. (unidentifiable fragment - AJB)
Gypidula galeata Hall
Uncinulus cf. nucleolata Hall
Camarotoechia litchfieldensis Schuchert
Atrypina imbricata Hall (=Coelospira cf. saffordi - AJB)
Atrypa reticularis Linné
Calymene sp.
Calymene browni sp. nov.

Morisset (Watford twp.)
Boucot, 1961
Cyrtina sp.
Brevispirifer sp.
Atrypa "reticularis"

North Stoke
Ells, 1896, p. 153j
Favosites gothlandicus Lamarck
F. cf. F. helderbergiae Hall
Syringopora sp. ind.
Zaphrentis sp.
Crinoidal fragments
..... like Atrypa reticularis

Obscure cast of Spirifera cf. S. niagarensis
Straparollus sp.

Famine river

Logan, 1849, p. 55
Favosites gothlandica
Cyathophyllum cespitosum
Atrypa affinis

Famine river

Logan, 1863, p. 428
Favosites gothlandica
F. basaltica
Syringopora hisingeri
Diphyphyllum arundinaceum
Zaphrentis
Heliophyllum oneidaense
Orthis striatula
Strophomena rhomboidalis
Chonetes
Productus
Spirifera duodenaria
S. gregaria
S. acuminata
Atrypa reticularis
Cyrtia like C. rostrata (=Cyrtina cf. C. rostrata - AJB)

Famine river

Ells, 1888, p. 10-11
Favosites gothlandicus Lamarck
F. sp. ind.
Syringopora hisingeri Billings
Diphyphyllum
Cyathopyllum (?) sp.
Heliophyllum sp. indt.
Crinoid fragments
Orthis sp. indet.
Strophomena rhomboidalis Wilckens
Strophodonta 2 sp.
Products (?)
Spirifera duodenaria Hall var. of n. sp.
Spirifera gregari Hall
Spirifera sp. indt.
Atrypa reticularis Linné
Leptocoelia flabellites Conrad
Paracyclas sp.
Pterinea textilis Hall var.

Proetus crassimarginatus ? Hall
Phacops sp. indt.
Favosites basaltica Goldfuss
Diphyphyllum arundinaceum Billings
Zaphrentis sp. indt.
Heliophyllum oneidaense Billings
Orthis seriatula Hall
Productus small form
Spirifera acuminata Hall
Cyrtia like C. rostrata

Famine river

MacKay, 1921, p. 32

Favosites basaltica
F. cf. limitaris
Alveolites sp.
Diphyphyllum arundinaceum
Syringopora hisingeri
Cyathophyllum ?
Fenestella sp. indt.
Stropheodonta
Productella
Athyris spiriferoides
Chonetes cf. arcuata
Atrypa reticularis
Atrypa spinosa
Spirifera gregaria
Spirifera duodenaria
Camarotoechia
Orthothetes pandora
Meristalla cf. nasuta
Actinopteria cf. boydii
Paracyclas cf. lirata
Macrocheilus cf. macrostomus
Orthoceras

Famine river

Clark, 1923, p. 217

Favosites basalticus Goldfuss
Diphyphyllum arundinaceum Billings
Cyathophyllum sp.
Cystiphyllum vesiculosum
Zaphrentis (Rafinesque and Clefford sensu strictu)
Amplexus cf. hamiltoniae Hall
Syringopora tabulata (Milne-Edwards-Haime)

Stromatopora Goldfuss (emnd. Nicholson)
Stropheodonta sp.
Atrypa reticularis Linné
Spirifer lucasensis Stauffer
Igoceras cf. conicum Hall
Igoceras cf. plicatum Conrad

Famine river

Oliver, 1961 (in this report p. 22)

Favosites sp.
Syringopora sp.
Thamnopora sp.
Acanthophyllum sp.
"Cystiphyllum" sp. cf. C. conifollis
Disphyllum (Cylindrophyllum?) sp.
Heliophyllum sp. cf. H. halli
H. sp. cf. H. halli proliferum
Heterophrentis? sp.
Phaulactoid coral
Siphonophrentis? sp.

St-Gérard (Weedon twp. R. VII, L. 26)

Clark, 1937 (Cooke's Mem. 211, p. 51)

Favosites sp. prob. F. helderbergiae
Crinoids

Stratford twp. (R. II, L. 28)

Burton, 1931, p. 120

Somewhat like F. cervicornis de Blainville probably a new species

Stratford twp. (R. II-S, L. 28)

Clark, 1937 (Cooke's Mem. 211, p. 51)

Favosites sp.

Weedon twp. (R. VIII, L. 22)

Burton, 1931, p. 188

Favosites prob. helderbergiae
Favosites sp.
Streptelasma sp. or Zaphrentis sp.
Meristella bella Hall (=Protathyris sp. - AJB)
Conocardium sp. n.
Orthoceras sp.
Beyrichia sp.

Kloedenia sp.
K. manliensis Weller
K. cf. turgida U and B
Leperditia sp.
Pachydomella sp.

Weedon twp. (R. VII, L. 22)

Clark, 1942, p. 19

Streptelasma sp. or Zaphrentis sp.
Favosites spp. one of them is probably F. helderbergiae Hall
Halysites sp. probably H. catenularia Linné
Stromatocerium sp.
Leptaena rhomboidalis Wilckens
Meristella belloides sp. nov. (= Protathyris sp. - AJB)
Conocardium sp.
Loxonema sp.
Diaphorostoma sp.
Orthoceras sp.
Ceratocephala sp.
Beyrichia sp.
Kloedenia sp.
K. manliensis Weller
Pachydomella sp.

Albany, Vermont

Boucot, March 28, 1960

Howellella sp.

Little Big Wood Pond, Maine

Boucot, 1961

Eccentricosta jerseyensis (AJB)
Halysites sp.
Protathyris sp.

## APPENDIX C

## LOCATION OF ADDITIONAL FOSSIL LOCALITIES REPORTED FROM THE LAKE MEMPRHREMAGOG AREA

1. Castle brook: Lot 5, range XV, Magog twp. The fossil beds lie about 300 feet below the road crossing the creek in range XV. Graptolites are found across a width of 150 feet or more of strata. (Cooke, 1950, p. 45)

2. Lot 7, range XV, Magog twp. About 150 yards south of the fork of the road along the west side of the lake. (Ells, 1887, p. 16j)

3. Austin bay. On the eastern shore of Austin bay, 1,000 feet north of Gibraltar point. (Drapeau)

4. About 2 miles south of Oliver and 1/2 mile east of the Magog-Georgeville road*. (Cooke, 1950, p. 70)

5. Approximately 1 mile north of Knowlton Landing on the west shore of Sargent bay. (Drapeau)

6. Glenbrooke creek. At the little flat where the sugar camp is. (Clark, 1936, p. 33)

7. Knowlton Landing. Along the shore, south of Knowlton Landing.* (Clark, 1936, p. 33)

8. Lot 24, range I, Stanstead twp. Plotted from Ells' map No. 571 (1896).*

9. MacPherson brook. 700 to 900 feet downstream from the Magog-Georgeville road. (Drapeau)

10. MacPherson brook. 300 feet downstream from the Magog-Georgeville road. (Drapeau)

11. MacPherson brook. 50 to 250 feet downstream from the Magog-Georgeville road. (Drapeau)

12. South shore of MacPherson bay. Along the shore, 300 feet west of the head of the small point. (Drapeau)

13. Lots 19 and 20, range II, Stanstead twp., in a cutting on the main road, about 100 yards north of the entrance to the grounds and the residence of the late Sir Hugh Allan. (Ells, 1887, p. 16j)

14. Lot 15, range I, Stanstead twp. Plotted from Ells' map No. 571 (1896).*

15. Quai Mountain House. Along the northwestern shore of the small bay. (Drapeau)

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* The asterisk indicates that the localities so designated cannot be accurately fixed.

## ADDENDUM

## LUDLOW-PRIDOLI AND MIDDLE DEVONIAN (EIFEL) AGE ROCKS OF THE EASTERN TOWNSHIPS

Since submitting this paper in 1963 for publication several significant advances in our knowledge of Siluro-Devonian paleontology and correlation have permitted the recognition of both Pridoli (post-Ludlow pre-Gedinne) and Eifel age fossiliferous rocks in the Eastern Townships. Preliminary announcement of the Eifel age rocks was made by Boucot and Johnson (1967); the information about the Pridoli age beds has not been previously published.

The most significant change in the Memphremagog area is the change in age assignment of the Mountain House Wharf Limestone from "Lower Devonian" to early Middle Devonian (Eifel). The Gile Mountain Formation (Figure 1) should be raised in age into the Eifel with the possibility that it is entirely of Eifel age and that the underlying Waits River Limestone encompasses Esopus and Schoharie time, as well as Becraft through Oriskany, and Ludlow through New Scotland time.

It is important to note that the genus Amphistrophia, which occurs at Cranbourne, is unknown below strata of Wenlock age; that Eccentricosta, which occurs at Dudswell and Petit-Lac (Lambton Lake), as well as in Maine, is known only from strata of Pridoli age; and that Coelospira, known from Petit-Lac, is restricted to Ludlow and younger beds. Kirkidium, known from the Sargent Bay limestone, is known in the Appalachians only from strata of Ludlow age.

The fauna of the Famine and Touladi limestones is currently being restudied; some preliminary comments have been made by Boucot and Johnson (1967). The conodonts of the Famine (Uyeno, written communication, 1966) are of Middle Devonian age, and the brachiopods can best be interpreted as of Middle Devonian age (provinciality prevents direct ties with faunas known elsewhere in the Appalachians), and the corals are considered by Oliver to fit very well with an Onondaga, i.e. Eifel age assignment. The conodonts of the Touladi are considered (Klapper, written communication, 1967) to be of Eifel age; the brachiopods are similar in part to those of the Famine and are in part provincial, whereas the brachiopods of the overlying Temiscouata Slate can be considered to be of Middle Devonian age. Inspection by Boucot in 1967 of the Famine - Saint-Juste contact shows that it is gradational and the Saint-Juste must be considered to be of Middle Devonian age, at least in those areas close to St-Georges.

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