GEOLOGY OF THE LAKE MEMPHREMAGOG SYNCLINE

by

GEORGES DRAPEAU

B.A. Universite Laval
(1954)

B.Sc.A. Universite Laval
(1959)

SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF

SCIENCE

at the

MASSACHUSETTS INSTITUTE OF

TECHNOLOGY

June, 1961

Signature of Author.
Department of Geology and Geophysics,
May 20, 1961

Certified by.. ....
Thesis Supervisor

Accepted by....
Chairman, Departmental Committee
on Graduate Students

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ABSTRACT

The Lake Memphremagog syncline is made of sedimentary post-Ordovician rocks known as the Lake Memphremagog group. This group is of Upper Silurian age, except for the exposure at Mountain House Wharf, which is Lower Devonian.

The Lake Memphremagog group is underlain by the Bolton Igneous Series, some quartzite and the Middle Ordovician Magog (Beauceville) slate. No angular unconformity is observable between the Ordovician and Silurian rocks.

This group is of the carbonate-quartzite assemblage. It is divided into three formations: the basal Peasley Pond conglomerate, the Glenbrooke slate and siltstone and the overlying Sargent Bay limestone. The Peasley Pond is a fairly pure quartz conglomerate. The Glenbrooke formation includes non-to very calcareous slate and siltstone. The Sargent Bay is greyish-blue aphanitic limestone.

The problem of the Lower Devonian limestone (Mountain House Wharf formation) outcropping at Mountain House Wharf is an unsolved problem as all the other formations are Upper Silurian.

The rocks are folded into two isoclinal synclines. Cross faults are about one mile apart. A contact fault is assumed along the eastern boundary of the eastern syncline.

Correlation with other post-Ordovician exposures in adjacent areas shows that the interpretation given by Logan a hundred years ago is essentially correct.

TABLE OF CONTENTS

INTRODUCTION

Although the geology of the Lake Memphremagog area has been studied for over a century, many of its problems are still unsettled.

The Silurian limestone surrounding part of the lake was first reported by Logan, in 1849 (p.46). In the Geology of Canada, published in 1863 (p.251), we read that: "On approaching Memphremagog Lake, a different series of rocks is met with, consisting of clay slates, followed by fossiliferous limestones. These strata, which appear to be of the Upper Silurian and Devonian ages, belong to a synclinal area, which terminates in a point at the base of the Owl's Head, a mountain on Memphremagog Lake. The west shore of this lake, from the Owl's Head, inclusive, to the province line, is however composed of strata which appear to belong to the Quebec Group.". In the following pages, Logan accurately describes what is now called the Sargent Bay limestone. He did not discriminate everywhere the Silurian from Ordovician slates of the area. But in the next decades, R.W. Ells (1887, p.12 J) did a more detailed survey of the area and was soon convinced that: "The Silurian rocks do not extend far inland on either side of Lake Memphremagog, but form a narrow margin resting on black slates and sandstones, the former of which contain graptolites of Cambro-Silurian age, and are of an entirely different character. At the foot of the Lake, the Silurian basin evidently terminates in the flat ground along the lower part of the Cherry River about two miles from the shore, the contact with Cambro-Silurian strata being visible on the road to Lake Fraser, on lot 2, R.XVI, Magog. On the west side of the lake, the contact is seen on the road at the brook crossing on lot 5, R.XV, Magog."

Ells work was published in the 1890's and if we read the latest report on the area we find the same information. This series is still called Siluro-Devonian and the different formations have never been mapped separately. In the mean time, attention has been given to the fossil localities but no sharp conclusions have been drawn from the faunas collected.

The purpose of this paper is to provide more accurate information on the post-Ordovician formations of the Lake Memphremagog area. The formations of this group were studied and mapped separately. The fossils collected during the survey were identified by Drs. Boucot, Whittington and Oliver. To complete this paleontologic investigation, Boucot restudied fossil collections previously gathered in the area and now deposited in the Geological Survey of Canada, the Geology Department of McGill University and the New-York State Museum. Finally, a review of the Silurian and Lower Devonian fossiliferous limestones of adjacent parts of the Eastern Townships, Vermont and Maine is included.

GENERAL SETTING

The area surveyed borders both sides of Lake Memphremagog, Quebec. It includes a belt of a maximum width of one mile, on the east side of the lake. On the west side, the area covered is wider, as shown on the map. The formations studied end at Fitch Bay, on the east side. No outcrops are reported south of the Brule Marsh, on the western side of the lake. To the north, the survey has been limited to latitude 45 20'N.

These Silurian rocks occur in two tightly folded synclines that parallel Lake Memphremagog. The western syncline is named the Sargent Bay and the eastern, the Lake Memphremagog. Two patches of post-Ordovician sediments outcrop outside these synclines. On the east side of the lake, limestones are exposed on the shore of the bay north of Whetstone Island. The second exposure is located at Mountain House Wharf. As this exposure is a problem in itself, it will be discussed separately.

PREVIOUS WORK

Sir William Logan, as for most of the Canadian Appalachians, was the first to visit the Lake Memphremagog syncline. He described briefly the area for the first time, in 1849. After spending many seasons in the Eastern Townships he did a synthesis of the geology of the area, in his Geology of Canada, published in 1863. It is interesting to notice how, after diverging in all directions, it has been rediscovered in the last decade that the bulk of Logan's interpretation is right. A.R.C. Selwyn succeeded Logan as chief geologist of the Canadian Geological Survey and collected more fossils from the Lake Memphremagog area. In 1885, R.W. Ells was assigned the remapping of the Eastern Townships. He mapped the area on a scale of 1 inch to 1 mile. From 1911 to 1913, Robert Harvie surveyed the Mount Orford map area that includes part of the Lake Memphremagog syncline. Harvie gathered a considerable fossil collection from the syncline. During the field season 1923, F.A. Kerr worked in the area east of Lake Memphremagog. His work has never been printed. In 1936, T.H. Clark published a short paper on the Silurian rocks of Lake Memphremagog. This was a summary of the field survey he did of the syncline. J.W. Ambrose mapped the Mansonville map area in

1941 and the Stanstead map area in 1943. Y.O. Fortier extended this survey to the Orford map area, that was printed in 1945. These three sheets are very good preliminary maps. H.C. Cooke spent the summers 1947 and 48 to re-examining the Ambrose and Fortier work. Most of his effort was devoted to finding a boundary between the Cambrian and the Ordovician of the area and to shifting the stratigraphic position of the Bolton lavas. The Quebec Department of Mines is now supporting detailed mapping in the area, north of latitude 45° 20'. Pierre St-Julien has been in charge of this survey since 1959 and already has made very interesting discoveries.

ACKNOWLEDGMENTS

It is obvious from the extent of this paper that the conclusions reached exceed the competence of the author. This thesis coordinates the geology of the Lake Memphremagog syncline, surveyed by the author, with extensive paleontologic and correlation studies made by competent persons in these fields.

The first acknwledgments go to Dr. A.J. Boucot who planned for a long time to clarify the stratigraphy of the Lake Memphremagog syncline and suggested the present thesis. Professor Boucot has supervised this work and has written the chapter on correlation.

The author acknowledges Dr. F.F. Osborne, of Laval University, for the "benevole" and constant attention he has given to this project. Dr. Osborne also supervised the field work of the author.

The Quebec Department of Mines, namely Drs. H.W. McGerrigle and J. Beland, is acknowledged for the technical assistance that made this thesis possible. The author has been provided with a field assistant, a canoe and outboard motor, airphotos and topographic maps.

Paleontology has been the most important tool to clarify the stratigraphy and the correlation. Dr. Oliver and Whittington are acknowledged for their important contribution in this field.

The friendly collaboration of P. St-Julien, working in an adjacent area, has been very helpful to the author. The field experience of St-Julien in the area helped the author to solve local problems.

The author is grateful to the Department of Geology and Geophysics of the Massachusetts Institute of Technology for giving the author the opportunity to work on this most interesting subject. It has been a pleasure to study in the ambiance of this school.

LOCATION OF THE AREA

The area studied is included between longitudes 72° 05' and 72° 20' and latitudes 45° 00' and 45° 20'. Mount Orford stands in the north-west corner of this quadrangle and Owl Head Mountain in the south-west corner. Lake Memphremagog lies in the center of this area. This lake is 1 to 2 miles wide. It is 28 miles long, extending from Magog, Quebec, beyond the international boundary, to Newport, Vermont. The city of Magog, at the outlet of the lake, is 70 miles east of Montreal and 115 miles south-west of Quebec City. The survey was restricted to the Silurian and Devonian rocks of this quadrangle. These rocks border the northern two-thirds of Lake Memphremagog. They cover an area of 60 square miles.

STRATIGRAPHY

INTRODUCTION

The term Lake Memphremagog group is proposed to designate the post-Ordovician strata of the Lake Memphremagog region. The term Glenbrooke group used by Cooke (1950, p.64) can be confused with the term Glenbrooke slate.

The Glenbrooke group consists of a carbonate, quartzite, slate assemblage, with subordinate conglomerate and tuff. The section grades from a lower non-calcareous slate, underlain in places by a quartz conglomerate, to an upper impure limestone.

The group is divided into three formations: the basal Peasley Pond conglomerate, the Glenbrooke slate and the overlying Sargent Bay limestone. The Glenbrooke formation can be subdivided in places into two members; a basal slate and an overlying calcareous siltstone. All these rocks rest unconformably on the Ordovician Magog slates and Bolton lavas. The maximum thickness of this group is approximately 7000 feet.

The Lake Memphremagog group is underlain by the Magog slates, the Bolton igneous series and some quartzite.

TABLE OF FORMATIONS

UPPER SILURIAN OR YOUNGER:

Rocks intruding the Lake Memphremagog group.

LOWER DEVONIAN:

Mountain House Wharf fm.:

Dark aphanitic limestone

UPPER SILURIAN:

Sargent Bay fm.:

Greyish-blue aphanatic limestone

Glenbrooke fm.:

Siltstone member:
non-to very calcareous silt-stone

Slate member:
non-to moderately calcareous dark grey slate

Peasley Pond fm.:

Quartz conglomerate, some sand-stone

MIDDLE ORDOVICIAN:

Magog fm::

Black, pyritic, carbonaceous slate

CAMBRIAN (?) AND ORDOVICIAN:

Bolton Igneous Series:

Itrusive and volcanic rocks

Quartzite, including some graywacke

PRE-SILURIAN QUARTZITE

A dark grey quartzite adjacent to the Lake Memphremagog group is encountered on the east side of the lake. This quartzite outcrops in two small areas; south-east of Lafrenaye Point and east of Molson Island. Few quartzite exposures have been recorded. They are nevertheless mapped separately because they are an important unit farther east. This is well shown on Ambrose's (1943) Stanstead preliminary map. On that sheet, Ambrose (1943) assigns these rocks to the "Cambrian (?) and Ordovician", in a stratigraphic position lower than the Magog slate.

BOLTON IGNEOUS SERIES

The igneous rocks in contact with the Lake Memphremagog group have been named the Bolton igneous series by Clark (1934, p.12).

These rocks have been given less attention than the Magog slates for two reasons. First, they have no direct relation with the problem studied. Second, the Magog slates have some similarity with the Glenbrooke slates and both have to be well known to make their discrimination possible. Such is not the case with these igneous rocks.

Where they have been observed, these rocks looked either ~~like~~ a greenish-grey fine grained gabbro or an aphanitic greenstone.

The age and the interrelation of these rocks has been debated. They are now known to be pre-Silurian.

MAGOG SLATES

NOMENCLATURE:

The term Magog formation was first used by H.M. Ami (1900, p.200) to identify the black carbonaceous slates that outcrop in the Lake Memphremagog basin. T.H. Clark (1934, p.11) also used the term for the same purpose. This nomenclature has been somewhat duplicated by the term "Beauceville", first used by MacKay (1921, p.12, 24) for a group of rocks, mainly slates, outcropping in the Beauceville map-area to the north-east. H.C. Cooke (1950, p.33) suggested that: "This term (Magog), therefore, has priority over the term Beauceville and should perhaps supplant it. However, as the term "Magog formation" never came into general use, and the name "Beauceville" has now been applied to the group throughout a length, along the strike, of more than 100 miles, and is used in successive reports, it seems best to avoid confusion by retaining it."

Nevertheless abundant, well preserved fossils have never been found in the typical Beauceville, while the fossil locality on Castle Brook, near Magog, is well known for its graptolites. Last summer more graptolites from the same formation have been discovered by Pierre St-Julien near East Branch Pond. These fossils have been identified by P.W. Berry and found to be of Middle Ordovician age, and belong to the same horizon as those collected on Castle Brook.

TYPE LOCALITY:

No type locality has ever been assigned for the Magog slates. Ami (1900, p.200) is very brief when he speaks of this formation.

DISTRIBUTION:

It is beyond the purpose of this paper to discuss the distribution of these rocks. However, it is obvious, from the confusion with the Beauceville slates, that the facies extends for at least one hundred miles along strike.

LITHOLOGY:

This rock is a black carbonaceous, rusty weathering, pyritic, phyllitic slate. The original bedding in most places is completely destroyed by slaty cleavage.

AGE AND FAUNA:

The Magog formation is of Middle Ordovician (Trenton) age. Abundant graptolite faunas have been collected from Castle Brook and East Branch Pond.

LAKE MEMPHREMAGOG GROUP

As already stated, this term is used to designate the post-Ordovician formations outcropping in the Lake Memphremagog region.

This group is unconformable with the underlying pre-Silurian rocks (Magog slate, Bolton igneous series, pre-Silurian quartzite). The Lake Memphremagog group consists of a carbonate-quartzite assemblage, while the Magog slates, with which it might be confused, are of the gray-wacke-shale assemblage. Despite the unconformity and the assemblage differences, in some places, where the exposures are small, it is difficult to discriminate the Glenbrooke from the Magog slates.

The thickness of the group is about 7000 feet. The Peasley Pond conglomerate does not exceed 300 feet and the other two formations have about equal thicknesses.

The Peasley Pond conglomerate marks the beginning of post-Taconic sedimentation. The Glenbrooke and Sargent Bay formations have a gradational contact.

A tuff layer about two feet thick, outcrops in the Glenbrooke formation, on Austin Bay. Even if it is not important quantitatively, it shows that there were some volcanic activity at the time the Glenbrooke was being deposited.

Because of the synclinal structure, the limestone makes ~~cores~~ surrounded by slate, which is in turn bordered by the conglomerate. As the map shows, the limestone outcrops are grouped mainly around Lake Memphremagog and in the center of the syncline crossing Sargent Bay. The eastern and western borders of the group are accurately located. The north-eastern limit is not as sharp, as the exposures are scattered because of the thick glacial gravel.

PEASLEY POND FORMATION

NOMENCLATURE:

The nomenclature of the whole group has been established by T.H. Clark (1936, p.33). He proposed the term Peasley Pond, because of the proximity of the type locality to the pond of this name. Peasley Pond is 3 miles due north of East Bolton and 3.5 miles due west of Green Point lighthouse, on Lake Memphremagog.

DISTRIBUTION:

This conglomerate borders the Sargent Bay syncline, south of Sargent Bay. It outcrops on the western limb of this syncline, north of Sargent Bay. This formation is also exposed on the border of the Lake Memphremagog syncline, in the Cherry River area. In all these cases, this formation is at the base of the section. North-east of the Benedictine Monastery this conglomerate makes the core of a small anticline, as shown on the map.

TYPE LOCALITY:

The type locality is on the north shore of Peasley Pond, localised above. At that place the best exposure observed is in front of the long lumber road linking Peasley Pond and Lac d'Argent, at its junction with the small road west of Peasley Pond. At this point, the conglomerate is adjacent to pre-Silurian volcanic rocks. The contact is 50 feet from the road and a section of about a hundred feet is exposed.

LITHOLOGY:

The Peasley Pond formation is a quartzose conglomerate. It contains subangular and subrounded mostly quartz pebbles, up to 3 cm. in diameter. The bulk of the rock is composed of quartz grains, 1 to 4 mm. in diameter. These grains are subangular, well sorted and well packed. The matrix is made of quartz altered feldspar, dark minerals and mica. The cement is siliceous. The weathered surface shows scattered rusty spots, because of the mafic minerals.

LOWER CONTACT:

The Peasley Pond formation lies on the Magog slates, except at Peasley Pond and south of Knowlton Landing, where it is in contact with pre-Silurian lavas. During the survey~~, n~~o angular unconformity has been observed between the Peasley Pond and Magog formations. At Cherry River, the contact is well exposed and the two formations have the same trend. This is the only place where the contact with the Magog slates has been directly observed. The contact is sharp and no material from the slate is found in the conglomerate. No faulting or angular unconformity are observable.

General conclusions can't be drawn from this single observation. However, nowhere in the area do the Magog slate exposures closest to the conglomerate have a trend much different from the conglomerate. These observations infer that no important folding took place between the sedimentation of the two formations.

At Peasley Pond, the contact of the conglomerate with the Bolton lavas is well exposed. The contact plane at that place is an irregularly undulating surface. The contact plane has the same general trend as the strata in the vicinity.

STRATIGRAPHIC SEQUENCE:

The Peasley Pond formation includes grits and quartzites as well as conglomerate. These latter rocks are intimately related to the conglomerate and are merely the result of slight changes in environmental conditions. In some places, the conglomerate grades into a dark grey quartzite ~~and in~~ others, it seems that grits and sandstones have been deposited without any conglomeratic phase.

THICKNESS:

At Cherry River, the Peasley Pond formation is only 10 feet thick. At Peasley Pond, it is over a hundred feet thick and over two hundred at Vale Perkins. These measurements are obtained directly from the field survey.

AGE AND FAUNA:

No fossils have ever been collected from this formation. It is problablу not much older than the overlying Glenbrooke formation as it is rather thin and conformable with this formation.

GLENBROOKE FORMATION

NOMENCLATURE:

The term Glenbrooke slate was first applied by T.H. Clark (1936, p.33). He used this term because of the good section exposed along Glenbrooke.

SUBDIVISION:

For mapping purposes, this formation has been divided into two members. The lower member is a dark grey slate non-to slightly calcareous. The other member is a non-to very calcareous siltstone. The whole section is gradational. In some places the two members cannot be differentiated. Nevertheless, over most of the area, these two members are quite distinct and help in an understanding of the structure.

TYPE LOCALITY:

The type locality is on the brook of the same name. This brook drains George Pond into Sargent Bay. It reaches the west shore of Sargent Bay 0.7 mile due north of Knowlton Landing. The section is exposed for 800 feet, 2000 feet from the mouth of the brook.

DISTRIBUTION:

The Glenbrooke formation surrounds the overlying Sargent Bay limestone. It is best exposed on the west side of the lake because of the structure of the whole group. Its westward extention is accurately located. It is not well known how far north this formation extends. More rocks of the same type have been reported by P. St-Julien a little north of the northern boundary of this map. Chances are, that the limit, as it is drawn on the map is a good approximation of the facts. On the east side of the lake this formation is not continuous and is surrounded by limestone exposures. These latter occurences are explained by the anticline developed in the area.

LITHOLOGY:

1) Lower slates Member:

It is a dark grey, well cleaved, usually non-carbonaceous, non-pyritiferous, seldom calcareous slate. In many instances, it has been possible to verify that cleavage and bedding are parallel.

2) Upper siltstone member:

This member includes 65% of the formation. It is normally a greenish-grey, moderately to very calcareous siltstone. Some exposures are massive, others are well cleaved, depending on the clay content of the rock. No specific study has been made of the cement.

LOWER CONTACT:

The Glenbrooke slate lies directly on the Peasley Pond formation. On the Cherry River section, the Peasley Pond and Glenbrooke formations grade from a conglomerate, to a quartzite, to a siltstone. Nowhere else in the area has the contact been directly observed. In many instances, the Peasley Pond and Glenbrooke exposures are only a few hundred feet apart, but they don't show any gradational features. Direct contact with Bolton lavas and Magog slates has not been observed either. From the network of exposures, it is evident, nevertheless, that the Peasley Pond and Glenbrooke formations are conformable.

STRATIGRAPHIC SEQUENCE:

An ideal section would start with a pure slate grading to a slightly calcareous and very shaly siltstone and finally to a calcareous siltstone. These conditions are partly realized at many places. In some areas, such a gradation is not apparent and the formation could not be subdivided. It is worth noticing that the members are undifferentiated where the exposures are scattered and it might mean that the mapping difficulties are more dependent on the scarcity of the outcrops than the disturbance of the rock sequence.

THICKNESS:

This section is 800 feet thick on the type Glenbrooke section. From the cross sections and structure contour map, the Glenbrooke is concluded to be over 3000 feet thick in the area north-west of Channel Bay. This last figure is questionable. The thickness of the Glenbrooke formation is accurately known in the Sargent Bay syncline and reaches a maximum of 1800 feet. It seems unlikely that the thickness of a same formation differs so much in two synclines only a couple of miles apart. Because of the large area covered by the lake, half the Lake Memphremagog syncline is under water. In addition, the exposures of the Glenbrooke formation are scattered on the east side of the lake. For these two reasons, it had to be assumed that the structure of the Lake Memphremagog syncline is simple. This might well not be the case, and folding might be responsible for such an apparent thickness.

AGE AND FAUNA:

Fossils, mainly trilobites, have been collected from the Glenbrooke formation. A complete list of the fossils reported in the literature is given in the appendix A. Some of the trilobite collections have been examined by Dr. Whittington of Harvard University, who has made the following preliminary report:

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

Dalmanites cf. *lunatus* Lambert, 1904

Calymene sp.

Cheirurus 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 of Baker Pond, Maine. Raymond compared this 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

NOMENCLATURE:

T.H. Clark (1936, p.33) gave the name Sargent Bay to the limestone exposed in the Lake Memphremagog basin.

TYPE LOCALITY:

The type locality is on Glenbrooke creek. The limestone section is adjacent, downstream, to the Glenbrooke formation. 900 feet of limestone are exposed on the brook, but the formation is only 500 feet thick, as top and bottom features outline a syncline along this section.

DISTRIBUTION:

This formation makes the cores of the Sargent Bay and Lake Memphremagog synclines, already outlined. Other limestone exposures are recorded outside the two main synclinal bodies. The limestone exposures north of Lake Memphremagog reflect small synclinal features of this area. There is no structural evidence for such an interpretation, but it is logical to assume that the stratigraphic sequence that prevails in the Sargent Bay and Lake Memphremagog synclines is the same there.

LITHOLOGY:

The Sargent Bay formation is essentially a limestone. It is a bluish-grey almost pure to moderately shaly limestone. It weathers to a lighter grey color, but its original bluish-grey color is very characteristic. It is very fine grained. The rock is resistant, massive, often well cleaved and well jointed. The bedding is almost never apparent. Where it is, it has been found to be parallel to the cleavage, but such cases are too scattered to make it a rule.

M.F. Goudge (1935, p.241) provides the following analyses for the purer type of limestone.

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, rge.XVI, Magog tp.
206	Georgeville	Abandoned quarry, lot 27, rge.II, Stanstead tp.
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.

Fossils are fairly abundant in the Sargent Bay limestone; corals in the purer limestone and brachiopods and bryozoa in the more shaly limestone. Most fossils, however, are poorly preserved, because of the severe deformation.

LOWER CONTACT:

As already noticed, the Glenbrooke and Sargent Bay formations are gradational. All the siltstones, even the most calcareous, are related to the Glenbrooke formation. The limit between a limy shale and a shaly limestone is arbitrary. Care has been taken to always give the same thing the same name. Where the slate and the limestone are adjacent, quite often, the former is not calcareous.

STRATIGRAPHIC SEQUENCE:

The limestone is more shaly at its base, but most of the sequence is homogeneous. On the east side of the lake, south of Georgeville this limestone is not as homogeneous; it is more shaly in places.

THICKNESS:

According to the cross sections and structure contour map this formation has a maximum thickness of 4000 feet in the Lake Memphremagog syncline at Merriman Shoals level. The problem of the thickness is the same as for the Glenbrooke formation. On the Sargent Bay syncline, where the stratigraphy is well outlined by numerous exposures, this formation is 1000 feet thick. This thickness is discordant with the 4000 feet assumed in the Lake Memphremagog syncline. The reasons are the same as for the Glenbrooke formation. In the other hand, the exposure of the Sargent Bay limestone on both sides of the lake for a distance of over 7 miles suggests that this formation is thicker in the Lake Memphremagog syncline.

AGE AND FAUNA:

Abundant fossils, mainly corals and brachiopods, are found in the Sargent Bay limestone. Collections have been made from many localities. All those reported in

the literature are listed in the appendix A.
The Halisytes found in the Sargent Bay limestone restrict this formation to the Silurian and the Conchidia to the Lower Ludlow (Upper Silurian).

MOUNTAIN HOUSE WHARF LIMESTONE

NOMENCLATURE:

The term Mountain House Wharf is suggested for the limestone exposed at Mountain House Wharf, at the foot of Owl Head Mountain on west shore of Lake Memphremagog.

TYPE LOCALITY:

The type locality is on the northern side of the small cove at Mountain House Wharf and along the creek flowing in this cove. About 350 feet of section are exposed at this locality.

DISTRIBUTION:

The type locality is the only place where this formation has been observed in the area. The map shows that the location of this exposure of Devonian limestone is problematic.

LITHOLOGY:

The Mountain House Wharf formation is a dark greyish-blue almost pure to modelately argillaceous limestone. This rock contains some volcanic debris at one horizon. The section exposed on the brook is more massive than the

the slightly argillaceous exposure on the lake shore. From a lithological point of view, this formation is not discriminable from the Sargent Bay limestone.

LOWER CONTACT:

The lower contact is exposed on the Lake Memphremagog shore. Where this formation ends, it is intermingled with the Magog slate. What can be seen at that place is that the contact is overturned, Whether it is faulted or not has not been established positively.

STRATIGRAPHIC SEQUENCE:

The rocks exposed on the lake shore are more argillaceous than the ones outcropping on the creek. These two exposures have the same trend. The more argillaceous one is at the base of the section.

THICKNESS:

The exposed section adds up to 300 feet. The total thickness probably does not exceed 700 feet. This last figure is based on a rough estimate of the extension of this patch of Devonian rocks.

AGE AND FAUNA:

This limestone would not be discriminable from the Sargent Bay limestone if it were not of the different faunas in the two formations.

The fauna collected at Mountain House has been studied by Dr. W.H. Oliver from the U.S. National Museum:

"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 at hand could be Zaphrentis incondita Billings, from the Grande Grevells.

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

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).

You can draw your own conclusion from the following:

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

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

3. *Heliophyllum* suggests a post-Oriskany age.

Ties to the Famine limestone turned out to be more apparent than real. A report on the Famine corals will be sent in the near future.

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

The following corals have been identified:

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.

STRUCTURE

The Lake Memphremagog group is located across the Stoke Range, which extends from Vermont to Lake St.Francis, Quebec. The rocks of this group were disturbed by the Acadian and Appalachian orogenies. They were tightly folded into two isoclinal synclines.

The Sargent Bay syncline is about 14 miles long and 1.5 mile wide at its maximum. It is threefold in places. At the northern extremity, the axis plunges 25 degrees towards the south. The southern end of this syncline is completely concealed. The Lake Memphremagog syncline is 18 miles long and between 1 and 2 miles wide, in average. Its northern axis plunges 35 degrees southward. The Sargent Bay and Lake Memphremagog axes are parallel and average about 2.5 miles apart.

Analysis of the structure is based on the assumption that the stratigraphy is uniform over all the area; that is grading from a basal conglomerate, to a slate, to a limestone.

Folds, faults, joints and cleavages of the area will be discussed separately.

FOLDS:

The Lake Memphremagog group is folded into two synclines parallel to Lake Memphremagog. As already noticed, the western syncline is named Sargent Bay and the other Lake Memphremagog. The rocks are tightly folded and bedding, where it can be seen, is vertical or near vertical.

The Lake Memphremagog syncline originates 4.6 miles north of the lake. At Cherry River, it is 6000 feet deep. At that place, the Peasley Pond conglomerate dips 86° east. At the outlet of the lake, the syncline is sagging and slightly shifting west. At Magog, the syncline is some 8000 feet deep. The west limb of this syncline is anticlinally refolded from the outlet of the lake to the level of Lords Island. This anticlinal feature is related to the faulted contact of the Glenbrooke against the Ordovician rocks. This syncline is deepest at the level of Lords Island, where it reaches a maximum depth of 11,000 feet. This syncline ends in Molson's Landing area, against the contact fault.

The Sargent Bay syncline is smaller than the Lake Memphremagog syncline. It is also shallower and more folded. It reaches a maximum depth of some 3500 feet between Millington and East Bolton. In the Sargent Bay area, the rocks are folded into three smaller synclines. The western one is well outlined on Glenbrooke and the other two, on the shore of Sargent Bay. South of Sargent Bay, the Glenbrooke group is limited to a narrow syncline that extends as far south as the Owl Head Mountain.

FAULTS:

Faults of the area are cross faults, except for the long north-south fault, along the eastern contact.

Evidence for faulting is based on offset of adjacent exposures. In all cases, air photos have been carefully examined for any indicative lineation. In some cases, these photos helped to determine the trend of the faults.

Starting from the northern end, the first fault encountered is 0.6 mile south of Cherry River Village. This fault is closely controlled by the abundance of the outcrops. The horizontal displacement is of 1300 feet.

On the east side of the lake, one mile south of Lafrenaye Bay, a block of slaty quartzite 0.7 mile across encroaches the eastern limb of the Lake Memphremagog syncline. The horizontal displacement is about 1000 feet. The vertical displacement, if any, would involve an uplift of the block.

A few hundred feet north of Peasley Pond a cross fault truncates the northern part of Sargent Bay syncline. The displacement is of the order of 2500 feet. This fault does not reach the Lake Memphremagog syncline.

South of Lake Gilbert two small left hand faults counterpart the displacement along the right hand fault north of Peasley Pond. It looks as if the volcanic rocks west of Peasley Pond and Lake Gilbert would have protected the syncline against the compression from the west.

The structure, west of Lords Island, is difficult to explain. The map shows that the traverse surveyed along this section line does not fit to well in the picture. This local anticline is separated from the rest of the area by three faults. The location of the two cross faults is approximate. The fault along the contact is better outlined by the steep topography and intrusive rocks.

The cross fault near Knowlton Landing is the most important. It cuts the Sargent Bay syncline completely and part of the Lake Memphremagog syncline, as the Glenbrooke group does not outcrop any more on the shore of the lake, south of Sargent Bay. Its displacement is evaluated to 3500 feet.

Minor cross faults are recorded at Vale Perkins and in Molson's Landing area, on east side of the lake.

The cross faults are likely the result from the uneven distribution of the forces against the synclines.

The longitudinal fault on east side of the lake is a very high angle reverse fault. The Silurian rocks are downthrown relatively to the Ordovician formations. This faulted contact is indicated by the distribution of the Lake Memphremagog group on east side of the lake. In most places, the Sargent Bay limestone is adjacent to the

Magog slates. The Glenbrooke slates outcrop from place to place, outlining the anticlinal structure developed against the fault. The displacement is probably not the same all along the fault. In addition, direct evidence of faulting is observable on Quinn Bay Brook. The rock section along this brook is quite contorted. Rock escarpments, intrusions and folding are exposed on this creek, from the road to 2000 feet downstream.

JOINTS:

The rocks, mainly the limestone, are abundantly jointed. Most joints trend roughly east-west. However they do not indicate any specific stress pattern.

CLEAVAGE:

A slaty cleavage has developed through all the rocks, but the conglomerate, of this group. It trends about 20 degrees and is almost vertical. As one might expect, it parallels the broad features of the area. This cleavage has destroyed the bedding cleavage. When the bedding could be identified, it has been found to be most of the time parallel to the slaty cleavage.

CORRELATION OF THE SILURO-DEVONIAN ROCKS OF THE MEMPHREMAGOG SYNCLINE WITH THOSE OF ADJACENT AREAS OF QUEBEC, MAINE, VERMONT AND NEW HAMPSHIRE.

Logan (1863, p.435) early recognized the Siluro-Devonian age of the rocks in the Memphremagog syncline and their equivalence in age to similar rocks in adjacent parts of the Eastern Townships and the Connecticut River Valley. He assigned the bulk of the strata now mapped as Memphremagog group, Shaw Mountain formation, Northfield slate, Waits River limestone, Gile Mountain formation, the bulk of Clark's (1934, p.11) Tomifobia slates, the bulk of Cooke's (1950, p.29) Lower and Upper St-Francis group (which is essentially a synonym of Clark's Tomifobia), McGerrigle's (1934, p.71) Compton group, the Famine limestone, Beland's (1957, p.24) St-Just group, and the fossiliferous calcareous rocks in the neighborhood of Dudswell and Marbleton, to a position equivalent to the Gaspe limestone series. Subsequent study by a number of geologists both in Canada and United States resulted in the gradual restriction of a Siluro-Devonian assigment to only those rocks in this area which contain easily datable Siluro-Devonian fossils. The great bulk of the unfossiliferous beds were then reassigned to the Ordovician. The reassignment of these rocks to the Ordovician was greatly facilitated by Clark (1934, p.12) who claimed to recognize Ordovician graptolites in his Tomifobia formation (the direct equivalent in Southern Quebec of part of the Waits River limestone plus the Northfield and Shaw Mountain formations). At Boucot's request, with Clark's cooperation, these supposed Ordovician graptolites were reexamined by Drs. L.M. Cumming[1] and D.H. McLaren[2] of the

(1) Cumming, Nov. 20, 1953:
Specimens of the Tomifobia formation from localities 9D1, 10E1, 12F1, show, on bedding surfaces, anastomosing bands of lighter coloured 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.

(2) McLaren, Nov. 19, 1953:
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 12E1 contains a dendroid marking resembling Dictyonema sp. In my opinion there is no evidence to suggest an age for these specimens.

Geological Survey of Canada, Ottawa. They both agreed that the material studied by Clark could not be proved to be of organic origin. However s possibility exists that these specimens are graptolites, but if they are graptolites it is clearly not possible to decide if they are of Ordovician or Silurian age. This reassignment of the bulk of these Siluro-, Devonian rocks to the Ordovician culminated in Cooke's (1950, p.32) paper. Cooke separated the calcareous Silurian rocks in the Marbleton-Dudswell-

Lake Aylmer region from similar rocks to the south-west by the use of a fault. MacKay (1921, p.33)had earlier done the same thing for the fossiliferous Lower Devonian rocks at St.Georges to separate them from the overlying Lower Devonian slates which he assigned to the Ordovician and correlated the fossiliferous Ordovician (the Beauceville) in the north-west. A few recent writers (Doll, 1943; Billings, 1948; Hadley, 1950; White, 1950 thesis at Harvard) had,largely on the basis of lithologic similarity, suggested a Siluro-Devonian age for these rocks, but the more commonly accepted view favored an Ordovician assignment. By 1953, both Osborne and Boucot (unpublished map showing the distribution of fossiliferous Silurian and Devonian rocks in the Northern Appalachians) had independently arrived at the conclusion that Logan's original assignment of these rocks to the Siluro-Devonian was essentially correct. Duquette (1959, p.254) showed that Cooke's fault separating the fossiliferous calcareous rocks in the Marbleton-Dudswell area from similar rocks to the south-west was no longer necessary now that the Ordovician assignment of the Tomifobia (Lower St.Francis) had been discredited. Gorman (1955, p.4) did the same thing to the north-east between the Famine limestone and the overlying Lower Devonian slates which had formerly been assigned to the Ordovician. After the completion of the studies by Duquette and Gorman, the situation was essentially back to the position in which Logan had left it one hundred years earlier.

The fossiliferous rocks of Lower Ludlow age at Dudswell, Marbleton, Lake Aylmer, Cranbourne and in the Memphremagog syncline are lithologically somewhat different from those in the "punky" weathering Waits River limestone. This consideration as well as the fact that elsewhere in the Connecticut Valley region the Waits River actually overlies grey, cyclicly banded, slates of Seeboomook-Gile Mountain-Littleton lithology inclines Thompson (1961, oral communication) to consider the Waits River limestone and its equivalents to be of Devonian rather than Silurian age. Thompson's hypothesis implies the existence of a disconformity between the calcareous fossiliferous rocks of Lower Ludlow age and the overlying presumed Lower Devonian Waits River type rock. The answer to this question regarding the Silurian-Devonian, or Silurian and Devonian age of the Waits River cannot be settled until more paleontologic and stratigraphic evidence is available. Further mapping in the area studied by Duquette might prove one way or the other whether the Waits River is a facies of the fossiliferous Lower Ludlow rocks in the Marbleton-Dudswell area or whether the Waits River overlies them disconformably.

Since Logan's day, considerable new information has accumulated regarding the paleontology and detailed zonation of Silurian and Lower Devonian fossils. By taking advantage of this new information, it is now possible to zone, with a reasonable degree of confidence most of the fossiliferous Silurian and Devonian rocks of the Eastern Townships. The zonable rocks can be divided into two units: a Lower Devonian unit comprising the calcareous fossiliferous rocks at St.Georges, Morisset and Mountain House Wharf of Becraft-Oriskany age, and an Upper Silurian unit, including the fossiliferous rocks at Marbleton, Dudswell, Lambton Lake, Cranbourne and Memphremagog, of Lower Ludlow* age. The rocks of Lower Ludlow age are

* The Ludlow 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.

correlatives of the Hardwood Mountain formation (Boucot 1961, p.181) of nearby Northern Maine. At Little Big Wood Pond, the Hardwood formation contains a fauna very similar to that found in the area of Marbleton, Dudswell, Cranbourne and Lambton Lake. The Fitch formation (Billings and Cleaves 1934, p.415) of Northern New Hampshire is also of Lower Ludlow age and contains an invertebrate fauna similar to that found in the Memphremagog syncline, including the critical genus Conchidium. Near Albany, Vermont the Shaw Mountain formation has yielded fossils*

* Boucot, May 4, 1960:
The two brachiopods (one brachial and one pedicle valve) from the Hardwick quadrangle (2 miles S. 37 W. of the center of the village of Albany, on east-facing hill slope, 0.25 mile north of the Seaver Branch of the Black River) belong to a strongly plicated form of the genus Howellella. The collection is very meagre and should be supplemented by about 200 lb. of blocks if a more definitive date is desired (Which it certainly should be in this region). Howellellids of this type have been found elsewhere in strata of Upper Llandoverian (C_3 or younger Williams QJGSL 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 I have dated as of Ludlovian age as both "Chonetes" jerseyensis and Protathyris are present in a collection made by Laverdiere, 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 the Shaw Mountain form whereas that from the Clough formation on Hetty Brook has very subdued plications. It is of interest locally to note that 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.

which, although they cannot be precisely dated, could be of Lower Ludlow age, although the only limits which can be set for them are Upper Llandovery (C_3 or younger) to Lower Gedinnian. The exact position of the Lower St.Francis (the Southern Quebec equivalent of the Waits River limestone, Northfield and Shaw Mountain formations) adjacent to the international boundaries, is still a difficult problem. If the material originally assigned by Clark

(1934, p.12) to the Ordovician is actually graptolitic, it is probable that the containing beds are of Silurian rather than Lower Devonian age since graptoloid graptolites have thus far never been found in the Lower Devonian of the Appalachians, although it must be admitted that there are a number of occurrences of Lower Devonian (Gedinnian and Siegenian) age elsewhere in the world. The Lower Ludlow equivalents in the Memphremagog group and the Marbleton-Dudswell, Cranbourne and Lambton Lake areas have in the recent past been assigned largely to the Lower Devonian. In the case of the Memphremagog syncline the Lower Devonian assignment is chiefly attributed to Ells (1896, p.8 J) who noted the occurrence of Taonurus in the slates and shales, which at that time was thought to suggest a Lower Devonian age because of its abundance in Eastern New York in the Lower Devonian Esopus grits but which now are known to have a very extended stratigraphic range whithin 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 rocks of the Memphremagog syncline by the occurrence in the fault remnant at Mountain House Wharf of a Devonian type invertebrate fauna. The present mapping of the rocks in the Memphremagog syncline, shows conclusively that fossils of Lower

Ludlow age (Conchidium) occur almost precisely on the axis of the syncline precluding a Devonian assignment regardless of the Devonian age of the rocks in the fault remnant at Mountain House Wharf. Clark (1942, p.15) concluded, chiefly on the basis of a number of generically misindentified brachiopods that the Silurian rocks in the Dudswell, Marbleton, Lambton Lake and Cranbourne areas, were of Helderberg, Lower Devonian age. Clark was also misguided by the then prevalent assignment of the Halysites bearing St.Alban formation of Gaspe to the Lower Devonian rather than the Silurian (see Cumming for the evidence which necessitated reassignment of the St. Alban to the Silurian). The most critical brachiopods for purposes of correlating the Marbleton, Dudswell and Lambton Lake occurrences are "Chonetes" jerseyensis and Protathyris (see the appendix in the rear for reassignment of Clark's misindentified Silurian brachiopods).

The position within the Devonian of the calcareous rocks at St.Georges and Morisset 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 of the presence at St.Georges of the index fossil Brevispirifer lucasensis. While there can be little disagreement with Clark's determination of Brevispirifer in the fauna from St.Georges, additional information from calcareous rocks at the base of slates similar to those at St.Georges occurring in the Temiscouata-Touladi region, alters the picture considerably regarding the lower range of <u>Brevispirifer</u>. In the Temiscouata-Touladi region spiriferids similar, if not identical to those assigned by Clark to <u>Brevispirifer</u> <u>lucasensis</u> occur in beds of Becraft-Oriskany age. 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 Becraft-Oriskany rather than Middle Devonian age. Reassignment of the beds at St.Georges and Morisset to the Lower Devonian is in harmony with evidence elsewhere in the Northern Appalachians, which suggest everywhere that marine sedimentation prior to the onset of the Acadian orogeny terminated before the end of the Lower Devonian. The previous assignment of the beds at St.Georges to the Middle Devonian was always anomalous as it necessitated that the widespread, grey, cyclicly banded slates of Becraft-Oriskany and New Scotland age (Fortin series, Temiscouata slates, Seeboomook formation, Compton group, St.Just group, Upper St.Francis, Gile Mountain formation, the bulk of the Littleton formation and Leyden argillite) in the St.Georges region ascend to a position well up in the Middle Devonian.

It is notable that so far in the area between St. Georges and the international boundary beds of Schoharie, Esopus, New Scotland, Manlius-Coeymans, Llandovery and Wenlock age have not yet been recognized. It is possible that these were time intervals in this part of the Eastern Townships of non-deposition. But until more extensive fossil collection has been made and studied such a conclusion would be premature. However, the widespread occurrence in the Appalachians from Memphremagog and Northern New Hampshire in the south-west to Nova Scotia and Gaspe in the north-east make it clear that Lower Ludlow time may have been the interval of most widespread marine sedimentation during the Silurian for the Northern Appalachians.

APPENDIX A

FAUNAS OF THE FOSSIL LOCALITIES OF THE LAKE MEMPHREMAGOG SYNCLINE

CAPT. GULLY'S POINT

ELLS, 1896, p.154j

Stromatoporoid (undeterm.)

Favosites gothlandicus Lamarck

Favosites resembling F. Helderbergiae Hall

GEORGEVILLE

ELLS, 1896, p. 154j

Halysites catenularia

Favosites Gothlandicus Lamarck

Favosites, sp., cf. F. favosus Goldfuss

Zaphrentis sp.

Frag. of crinoidal columns.

MAGOG TP. R. XVI, L. 1

COOKE, 1950, p.70

cf. Heliophyllum sp.

Favosites cf. limitaris Rominger

Favosites sp. very fine

GLENBROOKE CREEK

ELLS, 1896, p. 8j

Spirophyton (Taonurus) Cauda-galli, Van.

Psilophyton sp.

Bythotrepis sp.

GLENBROOKE CREEK

ELLS, 1896, p. 156j

Spirophyton Cauda-galli Vanuxem

GLENBROOKE CREEK

HARVIE, 1912, p. 289

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 limb of the syncline")

Rhynchonelloid, possibly a Wilsonia

Atrypa nodostriata Hall

like Leptaena rhomboidalis

Favosites gothlandicus Lamarck

KNOWLTON LANDING

ELLS, 1896, p.254j

Psilophyton sp.

Favosites gothlandicus Lamarck

Polypora or Monticuliporoid

Rhynchonella sp. type R. wilsoni Sowerby

MOUNTAIN HOUSE

LOGAN, 1863, p.436

Zaphrentis

MOUNTAIN HOUSE

ELLS, 1896, p. 9j

Syringopora hisingeri B.

Favosites basaltica Goldfuss

Diphyphyllum stramineum B.

Zaphrentis gigantea Le Sueur

(Atrypa reticularis)

MOUNTAIN HOUSE

ELLS, 1896 p.157j

Stromatopora concentrica

Favosites gothlandicus Lamarck

Favosites basalticus Goldfuss

Favosites polymorpha Goldfuss

Zaphrentis sp. ind.

Heliophyllum sp. ind.

Diphyphyllum arundinaceum Billings

Syringopora hisingeri Billings

Crinoidal fragments

MOUNTAIN HOUSE

HARVIE, 1914 p.214

Crinoid stems

Favosites cf. basaltica

Favosites sp.

Zaphrentis sp.

Spirifer cf. arrectus

Actinopteria ?

Panenca .... ?

Proteus .... ?

MOUNTAIN HOUSE (dam site)

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.

MOUNTAIN HOUSE (shore)

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)

OLIVER (lake Memphremagog)

COOKE, 1950 p.70

Favosites favosus

ROUND ISLAND

ELLS, 1896 p. 154j

Stromatopora sp.

Heliolites sp. very imperfectly shown

Favosites sp. ind.

STANSTEAD TP., R.I, L.18
(BELMERE FARM)

COOKE, 1950 p.69

Stromatopora sp.

Conchidium sp.

Pelecypod

STANSTEAD TP., R.I, L. 23

Favosites cf. F. basalticus Goldfuss

APPENDIX B

FAUNAS OF THE SILURIAN AND DEVONIAN FOSSIL LOCALITIES ADJACENT TO THE LAKE MEMPHREMAGOG SYNCLINE

These faunas have been re-examined by Dr. A.j. Boucot His comments are in parentheses and identified by (A.J.B.)

CRANBOURNE

TOLMAN 1936 p.15

Leptaena rhomboidalis Wilckens

Strophonella sp. nov.
(=Amphistrophia cf. funiculata (A.J.B.))

Uncinulus (U. vellicatus) sp. nov. (U. abruptus)

Rensselaeria subglobosa Weller
(= deformed Atrypa reticularis (A.J.B.))

Atrypa reticularis Linne

Spirifer sp. nov. (S. tribuarius)
(= Howellella sp. (A.J.B.))

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 Linne

Leptaena rhomboidalis Wilckens

Strophonella parva sp. nov.
(= Amphistrophia cf. funiculata (A.J.B.))

Uncinulus tolmani sp. nov.

Rensselaeria cf. subglobosa Weller
(= deformed Atrypa reticularis (A.J.B.))

R. delicatula sp. nov.
(= deformed Atrypa reticularis (A.J.B.))

Atrypa reticularis Linne

Spirifer orientalis sp. nov.
(= Howellella sp. (A.J.B.))

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

Parites

Favosites

F. gothlandicus

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

Trigonirhynchia sp. (A.J.B.)

DUDSWELL

LAVERDIERE, 1936 p.37

Stromatopora

Favosites

Heliolites

Diphyphyllum

Halysites catenularia

Camaratochia litchieldensis Schuchert
(= Rhynchospira sp. (A.J.B.))

Meristella belloides Clark (ms)
(= Protathyris sp. (A.J.B.))

"Chonetes" jerseyensis (A.J.B.)

LAMBTON LAKE (Lambton tp. R. V&VI, L. 17-18)

CLARK 1937 (Cooke's Mem. 211 p.51)

Zaphrentis sp.

Amplexus sp.

Favosites sp. 2 or 3 species

Heliolithes sp.

Crinoids

Strophonella geniculata Hall

S. punctulifera Conrad
(= unidentified Stropheodontid (A.J.B.))

Gypidula galeata Hall

Camarotoechia litchfieldensis Schuchert

Atrypa reticularis Linne

Atrypina imbricata Hall
(= Coelospira cf. saffordi (A.J.B.))

LAMBTON LAKE

CLARK 1942 p.20

Zaphrentis sp.

Amplexus sp.

Favosites spp.

Heliolites sp.

Crinoids

Resserella cf. elegantula (A.J.B.)

Schizophoria multistriata Hall
(= Rhipidomelloides sp. (A.J.B.))

Leptaena rhomboidalis Wilckens

Stropheodonta varistriata Hall

S. (Leptostrophia) tardifi var. lambtonensis nov.
(= "Chonetes" jerseyensis (A.J.B.))

Strophonella geniculata Hall

S. punctulifera Conrad
(= unidentified Stropheodontid (A.J.B.))

Anoplia sp. (unidentifiable fragment (A.J.B.))

Gypidula galeata Hall

Uncinulus cf. nucleolata Hall

Camarotoechia litchfieldensis Schuchert

Atrypina imbricata Hall
(= Coelospira cf. saffordi (A.J.B.))

Atrypa reticularis Linne

Calymene sp.

Calymene browni sp. nov.

MORISSET (Watford tp.)

BOUCOT 1961

Cyrtina sp.

Brevispirifer

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.

RIVIERE FAMINE

LOGAN 1849 p.55

Favosites gothlandica

Cyathophyllum cespitosum

Atrypa affinis

RIVIERE FAMINE

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 (A.J.B.))

RIVIERE FAMINE

ELLS 1888 p.9-10k

Favosites gothlandicus Lamarck

F. sp. ind.

Syringopora hisingeri Billings

Diphyphyllum

Cyathophyllum(?) sp.

Heliophyllum sp. indt.

Crinoid fragments

Orthis sp. indt.

Strophonema rhomboidalis Wilckens

Strophodonta 2 sp.

Productus (?)

Spirifera duodenaria Hall var. of n. sp.

Spirifera gregari Hall

Spirifera sp. indt.

Atrypa reticularis Linne

Leptocoelia flabellites Conrad

Paracyclas sp.

Pterinea textilis Hall var.

Proetus crassimarginatis ? Hall

Phacops sp. indt.

Favosites basaltica Goldfuss

Diphyphyllum arundinaceum Billings

Zaphrentis sp. indt.

Helyophyllum oneidaense Billings

Orthis seriatula Hall

Productus small form

Cyrtina like c. rostrata

RIVIERE FAMINE

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

Camarotechia

Orthothetes pandora

Meristella cf. nasuta

Actinopteria cf. boydii

Paracyclas cf. lirata

Macrocheilus cf. macrostomus

Orthoceras

RIVIERE FAMINE

CLARK 1923 p.217

Favosites basalticus Goldfuss

Diphyphyllum arundinaceum Billings

Cyathophyllum sp.

Cystiphyllum visiculosum

Zaphrentis (Rafinesque and Clefford sensu strictu)

Amplexus cf. hamiltoniae Hall

Syringopora tabulata (Milne-Edwards-Haine)

Stromatopora Goldfuss (emnd. Nicholson)

Stropheodonta sp.

Atrypa reticularis Linne

Spirifer lucasensis Stauffer

Igoceras cf. conicum Hall

Igoceras cf. plicatum Conrad

ST. GERARD (Weedon tp., R.VII, L. 26)

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

Favosites sp. prob. F. helderbergiae

Crinoids

STRATFORD tp. (R.II, L.28)

BURTON 1931 p.120

Somewhat like F. cervicornis de Blainville
probably a new species

STRATFORD tp. (R.II-S, L.28)

CLARK 1937 (Cooke's Mem.211 p.51)

Favosites sp.

WEEDON tp. (R. VIII, L. 22)

BURTON 1931 p.188

Favosites prob. helderbergiae

Favosites sp.

Streptelasma sp. or Zaphrentis sp.

Meristella bella Hall

(= Protathyris sp. (A.J.B.))

Conocardium sp. n.

Orthoceras sp.

Bevrichia sp.

Kloedenia sp.

K. manliensis Weller

K. cf. turgida U&B

Leperditia sp.

Pachydomella sp.

WEEDON tp. (R. VII, L.22)

CLARK 1942 p.19

Streptelasma sp. or Zaphrentis sp.

Favositis spp. one of them is probably
F. helderbergiae Hall

Halysites sp. probably H. catenularia Linne

Stromatocerium sp.

Leptaena rhomboidalis Wilckens

Meristella belloides sp. nov.
(= Protathyris sp. (A.J.B.))

Conocardium sp.

Loxonema sp.

Diaphorostoma sp.

Orthoceras sp.

Ceratocephala sp.

Beyrichia sp.

Kloedenia sp.

K. manliensis Weller

Pachydomella sp.

ALBANY, Vermont

BOUCOT 3/28/60

Howellella

LITTLE BIG WOOD POND, Maine

BOUCOT 1961

"Chonetes" jerseyensis (A.J.B.)

Halysites sp.

Protathyris sp.

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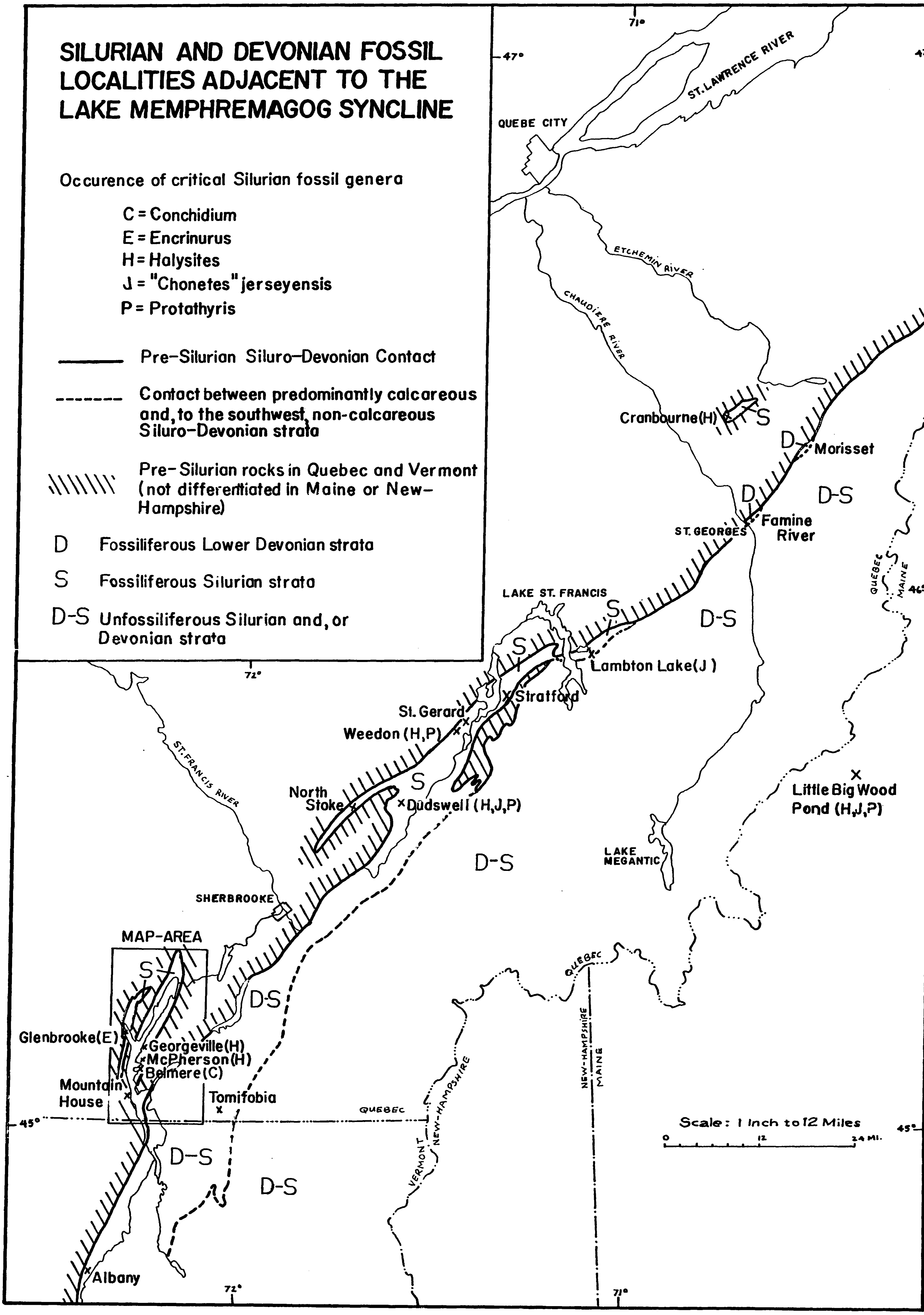
SILURIAN AND DEVONIAN FOSSIL LOCALITIES ADJACENT TO THE LAKE MEMPHREMAGOG SYNCLINE
Occurence of critical Silurian fossil genera
C = Conchidium
E = Encrinurus
H = Halysites
J = "Chonetes" jerseyensis
P = Protathyris
Pre-Silurian Siluro-Devonian Contact
Contact between predominantly calcareous and, to the southwest, non-calcareous Siluro-Devonian strata
Pre-Silurian rocks in Quebec and Vermont (not differentiated in Maine or New-Hampshire)
D Fossiliferous Lower Devonian strata
S Fossiliferous Silurian strata
D-S Unfossiliferous Silurian and, or Devonian strata
QUEBE CITY
ST. LAWRENCE RIVER
ETCHEMIN RIVER
CHAUDIERE RIVER
Cranbourne(H)
Morisset
ST. GEORGES
Famine River
LAKE ST. FRANCIS
Lambton Lake(J)
Stratford
St. Gerard
Weedon (H,P)
North Stoke
Dudswell (H,J,P)
ST. FRANCIS RIVER
LAKE MEGANTIC
Little Big Wood Pond (H,J,P)
SHERBROOKE
MAP-AREA
Glenbrooke(E)
Georgeville(H)
McPherson(H)
Belmere(C)
Mountain House
Tomifobia
Albany
QUEBEC
MAINE
VERMONT
NEW-HAMPSHIRE
Scale: 1 Inch to 12 Miles
0 12 24 MI.
47°
46°
45°
72°
71°

GEOLOGIC MAP OF THE LAKE MEMPHREMAGOG SYNCLINE

LEGEND

i	Rocks intruding the Lake Memphremagog group

LOWER DEVONIAN

Dm	MOUNTAIN HOUSE WHARF FM. Limestone

UPPER SILURIAN

Ss	SARGENT BAY FM. Limestone

GLENBROOKE FORMATION

Sg_2	SILTSTONE MEMBER (non-to very calcareous)	Sg	UNDIVIDED Slate and Siltstone
Sg_1	SLATE MEMBER		

Sp	PEASLEY POND FM. Conglomerate, some sandstone

MIDDLE ORDOVICIAN

Om	MAGOG FM. Slate

CAMBRIAN(?) AND ORDOVICIAN

€Ob	BOLTON IGNEOUS SERIES Intrusive and volcanic rocks
€Oq	QUARTZITE

SYMBOLS

Outcrop (small, area)

Geological boundary (definite, approximate)

Bedding (strike and dip)

Cleavage (strike and dip)

Fault

Fold (anticline, syncline)

SCALE

Two inches to one mile (1:31,680)

Geology by G. DRAPEAU, 1960