RG 128(A)

SQUATEC - CABANO AREA, RIMOUSKI, RIVIERE-DU-LOUP AND TEMISCOUATA COUNTIES

QUEBEC DEPARTMENT OF NATURAL RESOURCES
Honorable Paul-E. Allard, Minister

MINES BRANCH

GEOLOGICAL REPORT 128

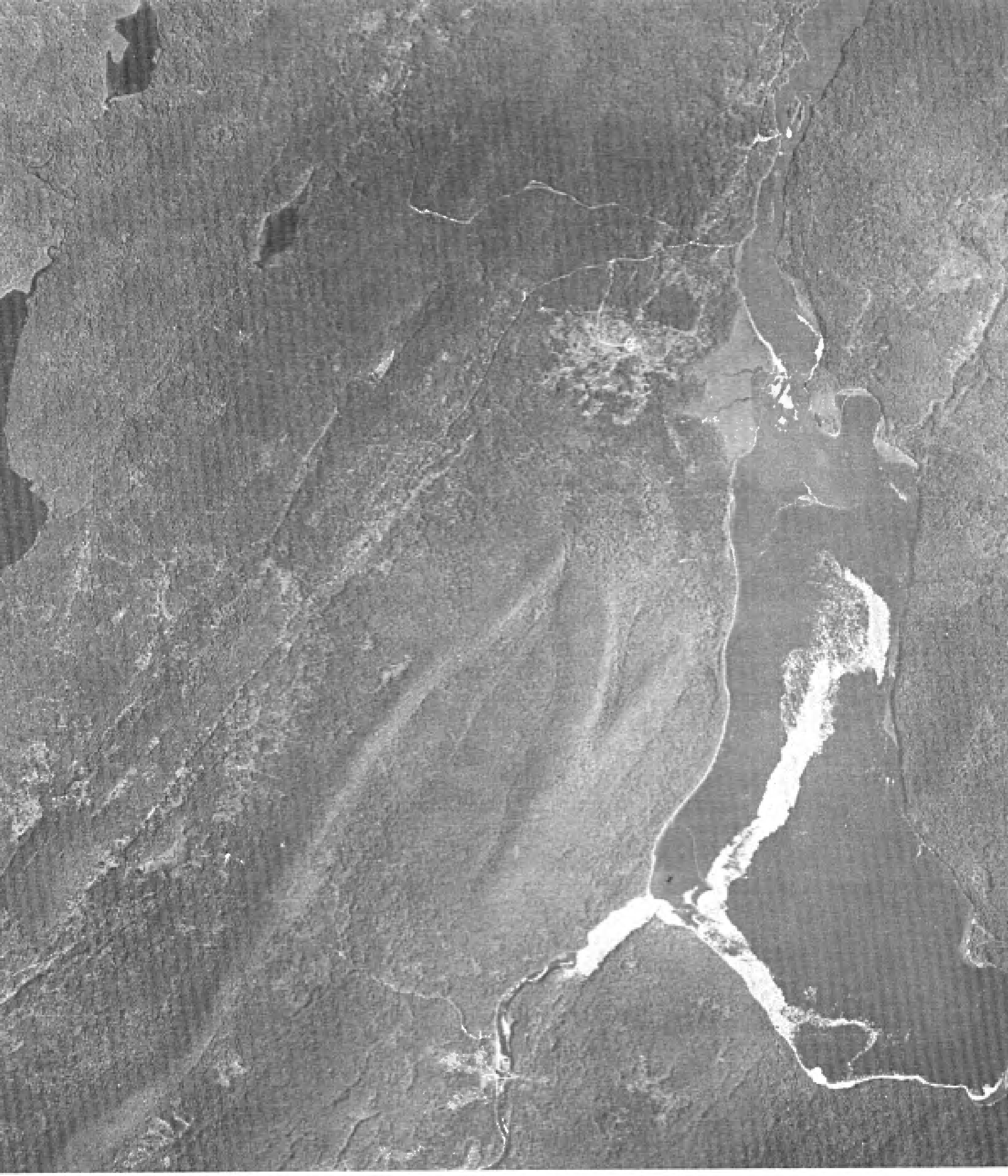
SQUATEC-CABANO AREA

Rimouski, Rivière-du-Loup and Témiscouata Counties

by
P.J. LESPÉRANCE and H.R. GREINER

QUEBEC
1969

GEOLOGICAL EXPLORATION SERVICE



Frontispiece — Aerial view of folded basal Cabano conglomerate.

TABLE OF CONTENTS

ILLUSTRATIONS

Figure

Tables

Plates

Editor's Note

The brachiopods from the Touladi Formation have been recently reappraised by Professor A.J. Boucot of the California Institute of Technology. Dr. Boucot finds that the Touladi and Famine Formations (of the Eastern Townships) are Middle Devonian. This has far-reaching effects for our maps. A thrust fault is necessitated by the Middle Devonian age of the Touladi Formation, which lies between the Lower Devonian Témiscouata and Upper Silurian Mont Wissick Formations. Such a thrust fault, dipping east, would separate the Témiscouata and Mont Wissick Formations where they are in contact, and separate the Touladi and Témiscouata where in turn they are in contact. The Mont Wissick - Touladi contact is still best explained as an erosional unconformity.

"Recently (October 1967) G. Klapper has directly confirmed the Eifelian (Middle Devonian) age of the Touladi Formation by the identification of a conodont fauna of such an age from fossil locality G-28."

SQUATEC-CABANO AREA

Rimouski, Rivière-du-Loup and Témiscouata Counties

by

P.J. Lespérance* and H.R. Greiner**

INTRODUCTION

General Statement

The Squatec-Cabano area was geologically mapped during the summers of 1957, 1958 and 1959 as part of a mapping program carried out by the Department along the Quebec-Maine border since 1952 (Marleau, Gorman, Béland, Greiner, Lespérance). In 1957, Greiner, with Lespérance as his chief assistant, mapped the Cabano West area, and in 1958-59 Lespérance mapped the Squatec West and East areas. This report was written by Lespérance.

The total area is approximately 725 square miles in extent, and includes the whole of the Squatec, part of the Wild Goose, and the Cabano West sheets of the National Topographic Series. It is bounded by latitudes 47°45' and 48°00' and by longitudes 69°00' and 68°15'30", except in the western sector where the southern boundary descends to latitude 47°30'. Part of the eastern boundary of the area (longitude 68°15'30") is also the Quebec – New Brunswick boundary. The following townships are included in the area: the whole of Asselin (Rimouski) and Robitaille (Témiscouata); some undivided land and parts of Ango, Bédard and Biencourt (Rimouski); parts of Auclair, Cabano, Packington and Rouillard (Témiscouata); parts of Bégon, Raudot, and Hocquart (Rivière-du-Loup); and part of Madawaska (Lac Témiscouata) seigniory (Témiscouata).

* Département de Géologie, Université de Montréal; writer of the report.
** Department of Geology, University of New Brunswick.

The area includes the boundary between Silurian and Devonian strata to the east, and older rocks to the west. The older rocks (Quebec Group) are well exposed and their structure is anticlinal. This fold is apparently continuous with the Sutton axis to the southwest. The Silurian strata are fossiliferous and very thick, perhaps the thickest Silurian in Quebec, and their marked differences in lithology make the definition of formations easy. The Lower Silurian strata in the area and the surrounding region is the oldest Silurian in the Northern Appalachians (i.e., from New York to Gaspé). The stratigraphy of the Devonian strata is very obscure.

Means of Access

The area is easily reached by a number of roads. An asphalt road runs from Trois-Pistoles on the shore of the St. Lawrence to La Société and Sainte-Rita within the map-area. Route 2 joins the southwestern part of the area to Rivière-du-Loup. Cabano lies on Route 2, and is an important shipping point for the Canadian National Railways. The road trending south through Lejeune joins Route 2 at Sainte-Rose-du-Dégelis. Interconnected range roads west and north of the area lead to the St. Lawrence. The old Témiscouata (Portage) road, which ran in part along Témiscouata lake, is at present unrecognizable. The rivers can be used for canoe travel only in early spring, when the water is deeper.

Methods of Work

Aerial photographs taken by The Royal Canadian Air Force in 1948 furnished the basic information about the area. From these the Topographical Survey in Ottawa prepared a topographic map at a scale of one-half mile to the inch. This map served as base map, and the aerial photographs were used for location purposes. Compass-and-pace surveys of various new roads were added to the base map.

The area was mapped geologically by running cross-strike traverses approximately every half mile. All the roads were traversed on foot, and lakeshores and rivers were covered by canoe or on foot. Outcrops are commonly abundant.

The section along Sutherland brook was tape-measured. Stratigraphic successions were drawn from data collected during routine mapping. Discontinuous areas of outcrop were generalized into sections from angle of dip of the bedding, pace-and-compass measurements, and trigonometric or descriptive geometry.

The Silurian and Devonian strata in this report are more fully treated in Lespérance's Ph. D. thesis (1960), which also presents much stratigraphic, polished section, and thin-section data here only summarized.

A. Lacoste, C. Thibault, and R. Hardy in 1957; J. Blanchet, O.J. Frenkel, D. Labelle, R. Nincheri, and J. Vézina in 1958; and E. Gratton, C. Hubert, R. Obrochta, and J.-G. Tremblay in 1959 performed capably their functions as assistants.

Acknowledgments

The cooperation of the Fraser Companies, by facilitating access to their private lumber roads, is gratefully acknowledged.

A.J. Boucot of the Massachussets Institute of Technology (now of California Institute of Technology) identified all the brachiopods of the area, and the stratigraphy is based largely on his data. Wm. A. Oliver, Jr., of the United States National Museum identified the corals (Oliver, 1962).

Geologists of the Quebec Department of Natural Resources and of McGill University provided many stimulating discussions on problems of the area, and their help is gratefully acknowledged.

Previous Work

The first publication of data from the Squatec area is in Logan's (1850) Report of Progress, in which he described the ribbon limestones on the shores of Témiscouata lake. Later (1863) he classed these limestones as Upper Silurian (Silurian in the modern sense), and Lower Silurian (Quebec Group). The strata at Mont Wissick (Indian for Beaver Cabin, Logan, 1849-50, p. 55) and at Pointe Noire (Black Point) could be seen to continue into the Squatec area (1850, p. 56; 1863, p. 420 *et seq*.).

Bailey and McInnes (1889, pp. 26-36) travelled the Boibouscache (north of the Squatec area), the Saint-Jean, and the Touladi rivers. They described the "Sillery" (Quebec Group) in the northwestern part of the area, but did not find any Silurian in place, although fossiliferous boulders were seen. They also described the strata near Pain-de-Sucre hill ("Squatec Peak").

The most recent work in the Squatec area was done by Laverdière and Morin (1941), on a traverse from Trois-Pistoles to Squatec. They drew attention to the northwestern dips in unit 1G of this report, and to the universal southeastward dips from Trois-Pistoles to Saint-Michel-du-Squatec (Squatteck). Their work in the Sauvagesse Lake area showed Silurian nodular limestones and siltstones, in addition to slates, limestones and conglomerates which they correlated with the Quebec Group Matapédia Formation. They postulated a fault in Range I, and part of Range II of Robitaille township (in the general vicinity of Sauvagesse lake). This fault was part of a fault zone, with a downthrown south side, which extended to the Matapédia valley (Laverdière and Morin, 1941, p. 254).

Work done in the Cabano area outlined, in part, the same strata to the south. The Témiscouata (Portage) road and Témiscouata lake have been described many times. Works by Logan (1850, 1863) and by Bailey and McInnes (1889, 1893) are particularly important. Gregory (1900) described the strata at Pointe aux Trembles with the help of thin-sections. Kindle (1914) described the columnar jointed limestones at Mont Wissick. McGerrigle (1934) covered the Cabano area, in addition to territory to the west, north and south of it. The present mapping under Greiner in the Cabano area showed for the first time the synclinal nature of the Squatec-Cabano fold, the presence of Lower Devonian (Touladi) limestones, and the occurrence of Silurian quartzites in the La Résurrection area.

DESCRIPTION OF THE AREA

Settlement and Resources

The greater part of Madawaska (Lac Témiscouata) seigniory and Asselin and Ango townships, and the undivided land northeast of the upper part of Touladi river that flows into Biencourt lake are wood reserves for the Fraser Companies. These are crisscrossed by private lumber roads. The main lumber mill is at Cabano, but most of the wood cut is pulpwood which is floated down to Edmondston and Madawaska in New Brunswick and Maine for processing. Balsam fir, poplar, and maple are the mainstays of the wood industry.

The remainder of the area is settled, although in places sporadically. Clearing of land for settlement continues. The efforts of most of the settlers are directed toward milk production, with additional winter logging. Game is plentiful; deer, hare, partridge, and beaver are particularly abundant. Fish are rare in certain lakes, owing partly to floating logs.

The main centers are Saint-Michel-du-Squatec (Squatteck), Lac-des-Aigles (St-Isidore), Biencourt, Cabano, Notre-Dame-du-Lac, and Saint-Louis-du-Ha! Ha!

Topography

The height of the ridges in the Témiscouata region is controlled by the rock types underlying them. Within the pre-Silurian formations most of the ridges are underlain by quartzite and sandstone. The ridge passing through Sainte-Rita and the hills in the southwest corner of the Squatec West area are good examples.

Within the Silurian and Devonian formations, conglomerates, quartzites, sandstones and limestones are resistant to erosion.

Hills of pre-Silurian rocks are wide and rise gently from the surrounding countryside, because the quartzite and sandstone units are thick and contain minor interbedded slates and siltstones. In general, the Silurian formations form narrow and sharp hills, a reflection of thin and erosion-resistant rocks (Plates I, II). The Squatec-Cabano synclinal ridge (Plate III-A) rises sharply about 300 feet above the surrounding contryside. Limestones on the edge of the syncline are responsible for the high ground. The succession of Silurian formations in the Squatec East area is an alternation of weak beds and of beds resistant to erosion. The contorted slates and impure carbonates of the Témiscouata Formation underlie an area of high altitude, composed of irregular hills.

The upper end of Témiscouata lake, Aigles lake, Saint-Jean lake, and the eastern end of Sept lakes (Les Sept Lacs) lie in broad, linear lowlands. Biencourt lake, and the Squatec lakes (Second Squatec lake, Premier Squatec (Spider) lake, Pain-de-Sucre lake) lie in narrow, deep valleys that are U-shaped in cross-section and are probably due to glacial gouging, particularly in view of the undoubted glacial scouring of Témiscouata lake (Bailey, 1889, pp. 401-402). Saint-Jean lake and Sept lakes may be fault-controlled, although they are transverse to the structure and parallel to glacial movement, as are the other lakes mentioned above.

Mont Wissick, across the lake from Cabano, rises some 600 feet above lake-level. Its slopes are steep, especially on the northwest side.

Preglacial soils have not been found in the Squatec area. Glacial striae, particularly abundant on the rocks of the Quebec Group and Témiscouata Formation, all trend southeast-northwest. The striae show undoubted movement in two directions:

- movement to the southeast, also proved by scattered Precambrian gneiss boulders;
- movement to the northwest, also shown by index boulders west of their outcrop area, such as Silurian Mont Wissick fossiliferous limestone on Range V, Raudot township, and Silurian Cabano conglomerate near Saint-Louis-du-Ha! Ha! Both types of boulders indicate a transport of approximately 2 miles.

Striae showing northwest movement are known at two localities: northeast of Sainte-Rita, and south of Notre-Dame-du-Lac.

The surface of the area is adjusted to the lithology, and projected profiles show no persistent erosion surface; thus no peneplain is recognized.

Drainage

The point at which the divides between the Bay of Fundy, Bay of Chaleurs, and St. Lawrence watersheds meet is a few miles to the east of the northeast corner of the Squatec area. The waters in the Témiscouata region drain for the most part through Témiscouata lake, and thence to the Bay of Fundy. Only the northwestern third of the Squatec West area drains northwest of the St. Lawrence.

The Squatec chain of lakes flows northwestward to Squatec, thence south to Témiscouata lake, and finally southeast to the Bay of Fundy. This forms a fish hook pattern suggesting capture. On the other hand, little water from the south drains north into the Squatec lakes, and water from the junction of the three divides drains due south to the Squatec lakes.

The streams within the Squatec-Cabano syncline are centripetal, and discharge through a single channel, namely, Sutherland brook. The drainage in a small area, underlain by limestone and dolomite, approximately 1½ miles north of Croche lake, in the above syncline, is internal, and is presumably developing a karst topography. No streams are found in this small area, but joints at least 20 feet deep and up to 18 inches wide occur.

The streams within the Silurian formations in the Squatec East area are adjusted to the structure.

GENERAL GEOLOGY

General Statement

The Quebec Group includes Cambrian (?) and Ordovician assemblages. The Cambrian (?) forms the core of a major anticline, whose crest is near the boundary between the Cabano area and the Squatec West area. This assemblage may be Cambrian on the basis of Obolella (Botsfordia) pretiosa Billings reportedly found by Bailey and McInnes (1893) near the shore of Témiscouata lake in the Cabano area.

The Cambrian(?) assemblage is characterized by its greater structural complexity and metamorphism. Practically no top determinations could be made within this assemblage, bedding is in many places obscure, and the oldest rock-units are schistose. The assemblage is most highly metamorphosed at the crest of the anticline, where red slates have been reduced to reddish gray phyllites or phyllitic slates. Red slates in the Cambrian (?) occur only locally south of Route 2 (Cabano area), near La Résurrection. Ribbon limestones are also restricted to this assemblage.

The Ordovician assemblage includes part of unit 1E, and units 1F and 1G. The Ordovician age of the greater part of 1F is established by the occurrence of crinoid stems in a limestone cobble in the underlying conglomerate of unit 1E, northeast of La Société.

The structure in the Quebec Group east of the Témiscouata-Petit Biencourt Lakes fault is unknown, and only a lithologic (not a stratigraphic) correlation is implied between units 1C, 1D, and 1F east and west of the fault. The strata east of the fault are believed to be Ordovician.

The Ordovician assemblage is characterized by good bedding (including crossbedding and graded bedding), abundant red slates in unit 1F, lower grade metamorphism than the Cambrian(?), and an apparently simple structure. All the top determinations in unit 1F are to the east. Unit 1G is folded over the continuation of the anticline in the Cambrian (?).

The stratigraphy within the Quebec Group is not clear throughout. The Cambrian (?) succession appears to be anticlinal and to plunge northward, thus the oldest unit is 1A, followed by 1B, and 1C. 1D is found within 1C, and is here termed a unit although it should properly be called a member of 1C. As 1G overlies 1C on the fold axis, it should be older than 1F, but tops in 1F indicate that 1G is younger than 1F. Strata of unit 1E have a restricted distribution, and they should properly be called lentils of other units.

The Silurian-Devonian strata of the area rest on strata of the Quebec Group, but the actual contact has not been seen. They occupy two parts of the area separated by a prong of Quebec Group.

The northwestern part of the area is Upper Silurian and can be divided into two sequences: a homocline of eastward-dipping strata on the northwest, and a syncline on the southeast. The eastward-dipping homocline is bounded by faults. The syncline, here named the Squatec-Cabano syncline, is a long, narrow, shallowly plunging fold. In both sequences the strata are thick.

The other, southeastern, area of post-Ordovician includes Lower Silurian to Lower Devonian strata. These beds dip steeply eastward, and form the limb of this area of the "Gaspé-Connecticut River synclinorium" (Cady, 1960, pp. 535-536; for the naming of this, see Marleau, 1958). The Lower Silurian Cabano Formation is overlain by the Pointe aux Trembles and Lac Raymond formations. The two last-named formations are facies of one another.

Between Lower Silurian strata and the Mont Wissick Formation is a sandstone unit, correlated with the Robitaille Formation. The Upper

Silurian formations change laterally northeasterly, and finally disappear in the northeast corner of the area. A suite of rocks composed of fine-grained clastics is here correlated with the Upper Silurian strata farther southwest.

The Lower Devonian Témiscouata Formation overlies the middle (Lac Croche) Mont Wissick Formation in the Squatec area, although immediately to the south in the Cabano area the Témiscouata Formation is underlain by the Lower Devonian Touladi Formation. The limestones in turn overlie Silurian strata of different ages.

Cambrian (?)

Quebec Group

Unit 1A

The rocks of unit 1A are predominantly quartzites, with minor sandstones and siltstones, and rare phyllites and conglomerates. These rock types grade into one another, and their color ranges from deep to light green, although a few beds are grayish green. The color and formational contact with the overlying unit 1B are commonly sharp.

The quartzites are poorly sorted and locally grade into fine-pebble (½ inch or less) conglomerates. The conglomerates are a few inches to a few feet thick. The quartzites have an average grain size slightly in excess of medium sand size. Bedding in the quartzites (Plate IV-A) is evident only when quartzites are in contact with finer- or coarser-grained rocks.

The quartzites have thin dark zones every ¼ to ½ inch. These zones weather into depressions and they form conspicuous, in part crinkled, parallel patterns on outcrops (Plate IV-A). They contain scattered micaceous minerals (as seen with the hand lens), are not parallel to the bedding, and are cleaved. The zones represent incipient gneissosity of the quartzites. They are less abundant in the more quartzose rock types, and they are believed to represent a fracture or shear cleavage, on evidence from data gathered from unit 1G. The sandstones and quartzites are in thick beds, many apparently being 100 feet or more.

The sandstones of unit 1A are finer grained, more clayey, and more cleaved than the quartzites. Some sandstone outcrops are gneissose, and others have multiple parallel cleavage planes, without micaceous minerals.

Strikes and dips from these cleaved or gneissose zones do not show any simple relation, and apparently both are much crumpled.

Table of Formations

		Age of Formation	Character
		Pleistocene and Recent	Boulders, gravels, sands, silts, and varved clays.
		Devonian ?	Kersantite dikes.
LOWER DEVONIAN		Témiscouata Formation	Gray impure dolomitic limestones, impure limy dolomites, slates, siltstones; minor sandstones. Rare andesites and quartzites.
LOWER DEVONIAN		Touladi Formation	Gray clastic limestones.
UPPER SILURIAN	LOWER LUDLOW	Unnamed formation north-east of Biencourt (Horton) river	Gray slate, minor light gray fine-grained sandstone and siltstone.
UPPER SILURIAN	LOWER LUDLOW	Lac Croche Member	Gray limestones; minor varicolored dolomites and sandstones.
UPPER SILURIAN	LOWER LUDLOW	Mont Wissick Formation	Gray siltstones, minor very fine-grained sandstones, concretionary siltstones, and nodular limestones; rare crystal tuffs and volcanic sandstones.
UPPER SILURIAN	LOWER LUDLOW	La Résurrection Formation	Green to gray volcanic sandstone and siltstone.
UPPER SILURIAN	LOWER LUDLOW	Robitaille Formation	(a) Red siltstones and sandstones; minor green siltstones and sandstones; minor varicolored quartzites and sandstones; minor gray limestone; rare dolomite.
UPPER SILURIAN	LOWER LUDLOW	Asselin Formation	(b) Gray and light gray limy sandstones, quartzites, and volcanic sandstones; rare limestones.
		Silurian Post-Lower Silurian	? Green andesites Quartz diorite and diorite.
LOWER SILURIAN	UPPER LLANDOVERY	Pointe aux Trembles Formation	(a) Gray, green, and red volcanic conglomerate, conglomeratic sandstone, and volcanic sandstone; rare latites, andesites, and lithic tuffs.
LOWER SILURIAN	UPPER LLANDOVERY	Lac Raymond Formation	(b) Gray mudstone; minor gray to light gray slate, siltstone, and sandstone; rare coarse-grained sandstones.
LOWER SILURIAN	LOWER LLANDOVERY	Cabano Formation	Gray to light gray, very fine-grained conglomerate, sandstone, siltstone, mudstone, in places greenish, and slate.
		Post-Quebec Group	Serpentinite
ORDOVICIAN	QUEBEC GROUP	1G	Gray impure sandstone
ORDOVICIAN	QUEBEC GROUP	1F	Gray and green quartzites, siltstones, and slates; red slates.
CAMBRO(?)-ORDOVICIAN	QUEBEC GROUP	1E	Limestone conglomerate; gray siltstone and slate; limy sandstone; gray quartzite.
CAMBRIAN (?)	QUEBEC GROUP	1D	Gray phyllitic slate and ribbon limestone.
CAMBRIAN (?)	QUEBEC GROUP	1C	Gray phyllitic slates and siltstones; rare greenish slate.
CAMBRIAN (?)	QUEBEC GROUP	1B	Gray impure sandstone; gray quartzite, phyllitic slates and siltstones.
CAMBRIAN (?)	QUEBEC GROUP	1A	Green quartzites and impure sandstones; minor green siltstones.

Moreover, in some outcrops, this cleavage can be seen to range from horizontal to vertical.

The siltstones have a slaty cleavage, which is in many places contorted, and rare bedding shows that they are laminated and crumpled. Rare green phyllites are found with the siltstones. A little deep reddish gray phyllite is also present; these are redder on the weathered than on the fresh surface, and range from laminated to thinly bedded, with minor white laminae of siltstone. Such deep reddish gray phyllites have been explained as reduced slates elsewhere in Quebec.

Quartz and chlorite veins are abundant throughout the unit and obscure both bedding and rock types.

The following table summarizes the thin-section data on the coarser grained rocks of this unit:-

	X	X	XX
Field Name	Quartzite %	Sandstone or Quartzite %	Sandstone %
Quartz	54	64	57
Perthite	0.5	0.5	tr
Plagioclase	2.5	5	2
Muscovite	9	2	in cleavages
Pyroxenes	0.5	tr	0.3
Chlorite	4		in cleavages
Sphene	2.5		0.7
Sandstone clasts	1.5		3
Matrix: quartz	18	22	15
chlorite	6.5	4.5	12
sericite	1		10
Carbonates	0.5	1.5	secondary
Average grain sizes (excluding matrix)	0.6	0.3	0.2
Laboratory term	graywacke	graywacke	graywacke

X: average of two sections
XX: average of three sections

Thus, the main differences between quartzites and sandstones are the grain size and the amount of micaceous minerals, although both rock types have typical graywacke textures. Some thin-sections are schistose, with strain shadows developed on quartz clasts, and others are not. The texture of schistose sections includes both parallel micaceous minerals and parallel elongated quartz clasts (i.e., typical semischist textures). The cleavage or gneissosity zones are zones in which there is a greater abundance of chlorite and muscovite. These zones are commonly 2 to 3 mm. wide where they can be recognized; elsewhere they are absent or the whole slide is schistose. The grains are commonly interpenetrated and the number of contacts between grains is high (i.e., they have a highly condensed texture).

The phyllites in thin-section are schistose and are composed predominently of muscovite, with minor chlorite. One thin-section shows porphyroblasts of chlorite 0.2 mm. and less in diameter. Siltstones, with the addition of quartz silt, have much the same composition.

Unit 1B

Gray to white quartzites, gray sandstones, siltstones, and phyllitic slates are found within this unit in about equal abundance. Quartzites, in beds 2-3 feet thick, and slates are abundant west of the anticlinal axis; east of the axis, slates are rare and many quartzite beds are as thick as 100 feet.

The slates are for the most part phyllitic and, in places, owing to shearing and crumpling, the beds are phyllites. The phyllitic slates are laminated with siltstones. Here and there the fine-grained clastics are exclusively laminated siltstones. Grayish white or white, thin laminae of siltstone are commonly present with slates or other siltstones, but these laminae form a minor part of each outcrop.

The bedding of the quartzites and sandstones is commonly difficult to see, and is found only where different lithologies are in contact. A few beds up to 3 feet thick of fine-grained conglomerate are interbedded with quartzites and sandstones.

The sandstones are massive, impure, poorly sorted, and commonly cleaved. The grain size ranges from fine to coarse, and the average is medium; when a sample is broken, the surface is spotted with broken coarser sand grains. Locally the sandstones have been sheared, and are schistose. The cleavage is not as well developed, is somewhat coarser, and is not so striking as in the sandstones of unit 1A; on the other hand, cleavage within the quartzites has not been seen.

The quartzites are gray to white, the white probably being the result of subaerial leaching. They are commonly medium grained, and range from well to poorly sorted.

The average mode of two arenites in this section is the following:-

		%	
	Quartz	63	
	Orthoclase	1	
	Perthite	1	
	Plagioclase	9	
	Muscovite	8	_ _ _ _ _ _ _ (in matrix?)
	Pyroxenes	tr	
	Sphene	1	
	Carbonaceous matter (?)	2	
	Tourmaline, zircon	tr	
Matrix:	Quartz silt	15	
	Chlorite	2	
	Muscovite	(see above)	

Average grain size = 0.35 mm.

Laboratory term = graywacke

The clasts are oriented in one section, and in both sections the muscovite is subparallel. It is not clear if the muscovite has been introduced or if it is part of the matrix reorganized. Although the grains are interpenetrated, the over-all texture is that of coarser sand grains floating in a matrix of silt and micaceous minerals (a typical graywacke texture, although rock fragments are absent).

Quartz veins within this unit are more numerous near the axis of the anticline, and diminish and finally disappear in places away from the anticline. The separation between unit 1B and 1C is based upon the disappearance of the sandstones and quartzites, which appear to plunge underneath 1C.

Unit 1C

Slates and siltstones form more than 90% of this unit. The slaty rocks range from phyllites to slates; phyllitic slates are more abundant west of Témiscouata lake, whereas slates are more abundant east of Touladi river. Collectively, unit 1C will be described as slates.

The slates are interlaminated with siltstones, although bedding thicknesses are locally thicker. The slates are commonly gray, varying from dark to light. A number of laminae weather greenish, and still others have a grayish green fresh surface.

The siltstones are commonly gray, although a few are grayish white or greenish. Some siltstone laminae or thin beds are better sorted than most, and these have a siliceous luster. Rare siltstones are limy, and others are dolomitic (Plate IV-B).

A thin-section of interlaminated phyllitic slate and siltstone shows a phyllitic lamina to be composed of muscovite with minor chlorite, and a siltstone lamina to be composed predominantly of quartz silt with minor chlorite. Laminae intermediate in composition also occur.

The other rock types found within this unit are generally in beds a few inches thick, although there are rare beds as thick as 2 or 3 feet. Very fine- to fine-grained, and rare medium-grained, light gray to gray, in places calcareous, sandstones occur. Their bedding is variable, and is commonly thin. However, abundant thickly bedded sandstones are found east of Second Squatec lake within the southwestern part of Range VII, Biencourt township. A thin-section from medium-grained sandstone shows 79% quartz, 10% epidotized feldspar, 10% matrix (predominantly chloritic clay) and minor zircon and calcite. The rock is a protoquartzite. Medium-grained, well-sorted quartzite, two outcrops of oölitic limestone, and isolated thin beds of pure and dolomitic limestone also occur. The well-bedded, and in part crossbedded, quartzite under the Saint-Mathias church in Cabano is atypical and has been found nowhere else. Less than a dozen outcrops east of Touladi river contain chert. The chert is in individual beds 1 inch to 2 inches thick, interbedded with laminated to thinly bedded slates and siltstones. A few outcrops are also entirely composed of dark gray to green, massive chert. The most readily accessible outcrop of chert is along the Range VI-VII road, Biencourt township, at its northern end.

The northernmost outcrop on the east shore of Témiscouata lake is a fault breccia and is composed of various fragments of limy rocks, whose long axes range from 3 inches to 2 feet. These fragments are in a schistose phyllite matrix, which forms approximately two-thirds of the outcrop. The schistosity ranges from N.20°W. with a 60°W. dip, to N.28°E. with a 78°W. dip. The fragments are subangular, and are commonly cut by quartz or calcite veins which do not cut the matrix. The fragments are not Silurian, and agree in composition with Quebec Group strata in the area. Limy rock types (limy sandstones, quartzites, limestones, and limestone conglomerates), however, are more abundant than a random sampling of the area would show.

The slates and siltstones of this unit are also sheared and/or contorted in many outcrops. Such a zone of shearing can be followed along Touladi river (within unit 1D), and to the north. This zone contains fragments up to 10 feet surrounded by schistose zones, although in most places lenticles a few inches long are found in a "phyllite" matrix. The contortions have no apparent regular geometry east of Touladi river, whereas, west of Témiscouata lake, they are regular in form, plunge gently northward, and more properly are termed crenulations (Plate IV-B).

Cleavage that cuts the bedding is found here and there, but most of the cleavage parallels the bedding.

Unit 1D

Unit 1D is composed of alternating, thin phyllitic slates (which range from phyllites to slates) and limestones. The limestone beds are distinctive of this unit. They range from approximately 1 inch to thin laminae, from light to dark gray, and are finely crystalline and more or less argillaceous. Locally the limestone beds are very silty. The intervening phyllitic slates are gray and range from thin laminae to a few inches thick. Weathered surfaces appear ribboned.

In thin-sections, the limestone beds are structureless calcilutite, with a quartz silt content of 0-40%. They may or may not be argillaceous, as the recognition of clay in such finely divided material is difficult; however, they are probably argillaceous, in view of the incipient clayey stylolites or cleavages present in the slides. The dull, light gray weathered surface of the limestone beds is typical of the calcilutites (this is also found in the Silurian formations).

The limestone content is variable from outcrop to outcrop within this unit. The outcrops along Ashberish river and Témiscouata lake have a high limestone content, and elsewhere limestone is less abundant. Limestones are not cleaved, whereas phyllitic slate beds are more or less distinctly cleaved, depending on their thickness.

Cambrian(?) and Ordovician

Quebec Group

Unit 1E

The distinguishing rock of unit 1E is limestone conglomerate. This unit is not associated with unit 1D, and is found within units 1C, 1F, and 1G. The two types of conglomerate distinguished are treated separately below. One type is interbedded within slates and siltstones, and its beds are thin, whereas the second is not associated with fine-grained clastics, and its beds are thick. The second type crops out at three horizons: one northeast of La Société, one 3 miles east-southeast, and east-northeast of La Société. The best exposed horizon is northeast of La Société on lot 25, Range VII, Bégon township; southeastward from that point, the succession is estimated to be:

0-8' : Sandstones, coarse grained, limy, with a calcite cement content up to 20%. The sand grains are well rounded and spheric. The beds range from 4 to 12 inches thick. A few black slate clasts up to one inch, and a few pyrite pods are also present.

8-23' : Covered.

23-43' : Limestone conglomerate, average pebble size ½ inch, although boulders of 2 feet are present. The conglomerate clasts form 50-60% of the rock (Plate V-A). The matrix is coarse, well-rounded, spheric quartz sand, cemented by calcite. Approximately three-quarters of the conglomerate clasts are finely crystalline, light gray weathering limestone. In one of these clasts crinoid stems were present. The remainder of the pebbles are predominantly limy sandstones, with minor light gray, clastic limestones.

From above the section, along strike to the southwest, and along the road, the limestone conglomerate has a maximum thickness of 3 feet. This is succeeded to the northwest by a few feet of poorly exposed fine-grained conglomerate, high in black siltstone clasts, and thick, massive, gray quartzites. The quartzites range from fine to medium grained, and carry scattered pebbles of limestone, slate, and siltstone. No slates or siltstones are found in contact with the conglomerates and quartzites. Thin-sections from the quartzite, and from the sandstone of the columnar section,have the following modes:-

Field Name	Quartzite	Limy Sandstone
	%	%
Quartz	82	60
Feldspar	1	1
Carbonaceous material	5	
Calcilutite pellets	1	30 (some grumous)
Authigenic quartz	2	
Secondary calcite	10	(replacing hydrocarbons)
Calcite matrix		10 recrystallized: i.e. 1-2 mm.
Average grain size	0.5 mm.	0.4 mm.
Sorting	Good	Excellent
Packing	2	Floating contacts per grain

The second type of limestone conglomerate is found in the remainder of the exposures of 1E. This conglomerate is interbedded within gray laminated slates and siltstones, and is in beds commonly less than 3 feet thick, although there are beds up to 5 feet thick. The outcrops of this type of conglomerate are poor and small. Here and there, thin limestone beds, of similar composition as the clasts of the conglomerates, are associated with the conglomerates. These limestones are abundant along Saint-Jean river, near Aigles lake, where they are thick and in part ribboned.

The conglomerates commonly have very little matrix, and are almost exclusively composed of finely crystalline, laminated to massive, light gray limestone clasts. The clasts are commonly subangular, lath-shaped, and up to 3 inches long, although the average size is ½-1 inch. These conglomerates are very local, and commonly cannot be followed along strike.

The limestone conglomerates in thin-sections are composed predominantly of calcilutite clasts, with minor silty calcilutite, calcisiltite, and grumous (aggregate) clasts. The matrix forms 15-40%, and is composed exclusively of calcite, or a mixture of quartz silt, fine pellets, clay and calcite.

The localized occurrence of the last-described conglomerates, their thinness, low sphericity, and poor rounding would indicate a mode of origin closely tied to underwater slumping, erosion, and deposition (i.e., an intraformational type of conglomerate). The origin of the first-described type, on the other hand, is not so obvious; the well-sorted matrix indicates wave sorting, whereas the stratigraphic position of the lentils within 1F suggests the same mode of origin as for 1F (i.e., presumed turbidites, see below).

Ordovician

Quebec Group

Unit 1F

Unit 1F consists of small-pebble conglomerates, quartzites, sandstones, siltstones, and slates. The northwest corner of the area is dominated by two wide linear ridges underlain predominantly by quartzite (Range VII, Bégon township, and between Ranges III and IX, Raudot township). The unit east of the Témiscouata - Petit Biencourt Lakes fault does not have the ridges of quartzite, and its rock types are interbedded and in discontinuous outcrops.

The most abundant rock types are quartzites, slates, and siltstones. The quartzites range from green to gray, and, although the thickness of the beds cannot generally be recognized, beds as thin as 2 feet and successions as thick as 300 feet occur. Gray and green quartzites are interbedded with no apparent local concentration of a certain color. Many of the beds are conglomeratic, and thus the sorting is locally very poor, although elsewhere the sorting may be good. Locally quartzites grade into sandstones.

The quartzites range in size from medium sand to small-pebble conglomerate. The conglomerate beds are 2-3 feet thick, and commonly have graded bedding (Plate V-B). Channel fillings composed of conglomerate and cut in the underlying quartzites are also common. Crossbedding is rare. Many of the quartzites are cut by quartz veins and many of the veins are subparallel; the coarser trunk veins show the subparallelism, and the branching veins, which thin to nothing, fan out. The following table presents the thin-section data on these quartzites:-

Field Name	Quartzite (Average of 8) %	Variation %
Quartz	74	62-86
Orthoclase	1	1-2
Microcline	1	0-3
Perthite	2	0-5
Plagioclase	8	1-23
Muscovite	1	0-3
Pyroxenes	tr	0-tr
Sphene	tr	0-tr
Chlorite clasts	1	0-1
Opaques	1	0-3 Hydrocarbons and ores
Lava clasts	1	0-3
Authigenic quartz	1	0-2
Zircon, tourmaline, rutile	tr	tr
Matrix: quartz silt	1	0-5
chlorite	2	0-15
chloritic clay	7	0-15
Secondary carbonates	1	0-2
Laboratory term	subgraywacke	graywacke to arkose

The thin-sections are from rocks that have an average grain size from medium sand to small pebble conglomerate. Lava clasts were found in one thin-section. Muscovite is partly primary (clastic), and partly secondary (illitic). Some of the clasts are second-cycle sand grains.

Gray, massive, medium-grained, well-sorted quartzites are particularly abundant northeast of Bédard lake. In thin-section these quartzites are composed almost exclusively of quartz. The quartzites of unit 1F adjacent to unit 1G have a poorly developed cleavage parallel to the bedding. Elsewhere, these quartzites are not cleaved.

Slates and siltstones are interbedded (Plate VI-A). The thickest beds of slates are green or red, and range up to 3 feet thick, although this is very rare. The gray slates range from light to dark gray and are graphitic in places. They grade into green, and intermediate colors, such as olive, are abundant. Red slates commonly have thin zones of color transition.

The gray slates and siltstone have a cleavage which is for the greater part parallel to the bedding. On the other hand, green and red slates have a cleavage which cuts the bedding, is poorly developed, and coarse.

Siltstones are found in laminae to beds 2 inches thick. The beds may be themselves laminated, or crossbedded. The siltstones range from grayish white to dark gray, gray to green and, less commonly, to reddish. The red is in many places due to groundwater deposition. Some light-colored siltstones are better sorted, others are light colored because of their high carbonate content (calcite and/or dolomite).

Sandstones are rare, and may be associated with quartzites, or in thin beds within slates, or as isolated outcrops. They range from green to gray and are commonly fine grained. Locally they are limy, and may be light gray and very limy. A few limestone beds up to 3 feet thick are associated with limy sandstones northeast of Saint-Jean lake.

Slates and poorly sorted siltstones in thin-section are mixtures of quartz, illite (locally brownish), and chlorite, whereas other slides are mixtures of clay, chlorite, and quartz. The quartz content ranges from 20% in slate to 75% in siltstone. In one thin-section, a few dark brown, isotropic laminae have an over-all texture of volcanic glass; these are probably tuffs.

Thin-sections of sandstones show that the plagioclase content ranges up to 25%, and the lime content to 25% also (as with limy siltstones). In one siltstone slide, a lamina composed of 40% calcite spar, 50% calcilutite pellets, and 10% quartz silt was seen.

The average of three better-sorted siltstones is shown in the following table:-

Field Name	Quartz Siltstone %
Quartz	79
Microcline	tr
Perthite	tr
Plagioclase	1
Brown mica	3
Muscovite	1
Clay galls	3
Tourmaline, zircon, sphene	tr
Ores	1
Matrix: chloritic clay	13
Average grain size	0.033 mm.

The brown mica is in scattered euhedra (illite?) 0.07 mm. long by 0.007 mm. wide that are pleochroic and turbid. They are secondary, having grown during metamorphism.

Graded bedding and channel structures in quartzites and conglomerates are commonly explained as due to turbidity flows. The abundance of perthite in the thin-sections suggests a source in Precambrian rocks. Both the possible turbidity origin and Precambrian source indicate that the coarse clastics of unit 1F were deposited in a deep, wide basin, whose edge was rimmed by Precambrian rocks.

Unit 1G

A gray, impure, cleaved sandstone is the characteristic and most abundant rock unit 1G. Freshly broken sandstone shows a sprinkling of broken sand grains imbedded in sand, silt, and clay. The silt and clay content is everywhere high, and commonly the average grain size is fine sand. The bedding of the sandstones is not commonly seen, although locally beds 2 or 3 feet thick can be recognized. Black slate chips up to 2 inches are found in some outcrops and may form up to 10% of the rock. The following data gives the mineralogic composition of these sandstones, as determined in thin-sections:-

	Average of 11 Sections %	Variation
Quartz	49	32-65
Orthoclase	1	0-1
Microcline	1	0-1
Perthite	1	0-1
Plagioclase	3	1-5
Muscovite	1	0-2
Chlorite clasts	1	0-2
Opaques	1	0-2
Slate (?) clasts	2	0-8
Lava clasts	5	1-12
Felsite or siltstone clasts	8	3-15
Siltstones and slate clasts	9	5-15
Zircon, tourmaline, rutile	tr	
Matrix: chloritic clay	13	8-20
quartz silt	2	0-10
Schistose zones (cleavages)	2	0-15 (illite and chlorite)
Secondary carbonates	5	0-15
Average grain size	0.27	0.1-0.5 mm.
Laboratory name	graywacke	

A few calcilutite pellets, biotite, and serpentine clasts were also noticed in thin-section. The slate (?) clasts range from opaque to dark brown, and their texture suggests tuffs in some slides, slates in others. In hand specimen, these clasts are very thin, black, and have been referred to above as slate chips. The texture of the thin-sections ranges from normal clastic (with roundish quartz grains, and a non-schistose matrix) to highly schistose, with oval quartz grains, strain shadows, and a schistose matrix. The sorting ranges from very poor to fair, and the packing ranges from not touching (floating in the matrix) to three contacts per grain. The high content of volcanic clasts is unusual in Quebec Group sandstones.

Slates commonly do not crop out with sandstones, although locally gray massive slates and siltstones are found in beds up to 3 feet thick. In only a few outcrops are the slates and siltstones laminated or crossbedded. Interbedded slates, siltstones, and sandstones are well exposed on Range B, Hocquart township. Three outcrops of red slates were found in this unit. Laminated dolomitic siltstones, and gray slates and siltstones (without sandstones) crop out along the road immediately northwest of Sauvagesse lake (within Robitaille township). Oölitic limestone and limy siltstone crop out on lot 37, Range VIII, Raudot township. This outcrop is very near limestone conglomerate of unit 1E.

The rocks of unit 1F are cut by two regional cleavages. One cleavage is slaty and cuts slates and siltstones. It is present in all slates, is evenly spaced, and is locally parallel to the bedding. The second cleavage is found within the sandstones and is commonly spaced at approximately one inch; its planes are subparallel as they join and separate in many places (Plates VI-B and VII-A). As seen under the microscope, the cleavage is a schistose muscovite zone a fraction of a millimeter thick. The sandstones are also locally sheared, parallel to the direction of cleavage.

The cleavage cutting the sandstones may or may not be parallel to the bedding. This is probably a shear cleavage, and the movement producing the cleavage was probably translated into flow in the less competent beds and so formed the slaty cleavage; thus, the two cleavages would not affect each other.

The poor bedding and the poor sorting of the rocks of unit 1G are probably the result of deposition in deep water (i.e., below wave base).

Regional Correlation of the Quebec Group

The anticlinal structure in the Quebec Group is apparently continuous with the Sutton anticline farther southwest (Béland, 1962; Gorman. unpublished data, Quebec Dept. Nat. Res.). Rock types adjacent and along the axis of this anticline in Quebec are essentially the same. Thus unit 1A is similar to the Caldwell Group, 1B and 1C to the Rosaire Group, and 1F (northwest of the anticlinal axis) to the Armagh Group. Unit

1D, on the other hand, is very similar to the strata of the Matapédia Formation as exposed in the Matapédia valley and to the northeast. Whereas the comparisons above are valid on a lithologic basis, no age correlation is implied.

Approximately 17 miles northeast of Aigles lake, Lajoie (1960) found Trenton-Utica graptolites in black slates of the "Quebec Group" similar to strata of unit 1C (east of the Témiscouata - Petit Biencourt Lakes fault).

Lower Silurian

Cabano Formation

Name

McGerrigle (1934) suggested the term "Cabano Group". In recent stratigraphic nomenclature, this is equivalent to "Cabano Formation". All of McGerrigle's stratigraphic units were named groups, but are considered formations here. As the Cabano Formation changes much along strike, the various strata which grade into each other laterally could be termed members. This, however, would be cumbersome, as typical sections could not be designated, although outcrops on the shores of Témiscouata lake are the best exposures.

Age

Fossils found in the upper 400 or 500 feet of the Cabano Formation in the Cabano area indicate a lower Llandovery age, and have been identified by A.J. Boucot as given in Table 1*:-

Bailey and McInnes (1889, p. 33) reported a Diplograptus sp. in the splintery shales near the falls along Touladi river, between Témiscouata and Touladi lakes. An intense search at this locality by Lespérance failed to reveal any graptolite fragments.

* Fossils collected in 1957 come from the Cabano area, and bear no date prefix as do later collections; collections with the prefix G were collected by Greiner, and those with L by Lespérance. Fossils collected in 1958 have the prefix 58-. Those collected by O.J. Frenkel use the prefix 58-F; those by Lespérance 58-. Fossil collections during 1958 are restricted to the Squatec West area. Fossil collections in 1959 come from the Squatec East area, the area between Témiscouata and Touladi lakes, and from the town of Cabano. C. Hubert's collections begin with the prefix 59-H, and Lespérance with 59-.

Table 1

Fossils of the Cabano Formation

Fossils	G-34	G-72A	G-82 (bouldet)	59-605	59-181
Resserella sp.	X				
Fardenia sp.	X				
Eostropheodonta sp.	X	X			
Leptaena rhomboidalis	X			X	
Leangella sp.	X		X	X	
Plectodonta sp.	X		X	X	
"*Stegerhyncus*" sp.		X			
Stegerhyncus? sp.	X		X		
Dolerorthis sp.			X		
Dolerorthis? sp.		X			
Glassia? sp.			X		
unidentified atrypaceans cf. *Coelospira* or	X				
Plectatrypa				X	
dolerorthid?				X	
two unidentified dalmanellids			X	X	
gastropods				X	X
pelecypods				X	X
trilobite			X	X	
corals				X	

Thickness

At Pointe Brûlée (Burnt Point), on Témiscouata lake, 415 feet of conglomerate and sandstone have been measured by the writers, out of a probable thickness of 1,750 feet of conglomerate and sandstone indicated by angular boulders on the shore. To the southeast of Pointe Brûlée, there are now no exposures, but Logan (1863, p. 422) reported that soft slates cropped out there. The lake level then was much lower because there were no dams. Thickness measurements are most reliable on the southwestern shore of Touladi lake, where enough top determinations can be made to establish the structure as a simple homocline. The lower conglomerate member, probably 1,900 feet thick, and succeeding strata 6,500 feet thick, make up a total thickness of 8,400 feet for the Cabano.

In the Squatec East area, the lower coarse conglomerate unit is absent, and data on the bedding are meager. The minimum thickness of strata present southwest of Pain-de-Sucre lake, determined by simple graphic construction, is 3,000 feet; the maximum is 7,000 feet. In both cases the reasonable assumption of no folding was made. Between Biencourt and Biencourt (Horton) lake, a number of bedding determinations can be made.

The southeast-trending road leading to the south end of Boucle (Loop) road traverses the area in which measurements are the most reliable. Southwestward, the width of outcrop thins, and northeastward the width of outcrop widens considerably. North of Biencourt lake folds account for the width of outcrop, at least in part. To the southwest, either changes in dip or depositional thinning account for the narrower width of outcrop.

Stratigraphy and Petrography

To illustrate the changes along strike and to describe the formation fully, various cross-sections, progressing from southwest to northeast, are described below from areas of abundant outcrops.

Pointe Brûlée (Burnt Point) Section (See detailed section in Appendix)

The lower conglomerate unit of the Cabano Formation is well exposed at Pointe Brûlée. North of Pointe Brûlée, it forms a prominent hill, and near Touladi lake it is folded into a giant drag-fold (Frontispiece). The sandstones in the unit are gray, medium to coarse grained, in many places pebbly or cobbly (Plate XII), and poorly cemented. The conglomerate is gray and composed of pebbles and cobbles. The sandstones and conglomerates are thick to very thick bedded, and only locally medium bedded. They "weather readily to a rotten brown rubble and fresh samples are difficult to obtain except at road and railway cuts "(Gorman, 1957, p. 6). The sandstones and the matrices of the conglomerates are generally slightly limy (probably due to limestone sand grains) and are schistose to non-schistose mixtures of quartz, slate, and siltstone chips. The schistosity is obvious only in the coarse sand-grade mixtures, and is evidently due in great part to parallel or subparallel slate and siltstone chips.

The lenticularity of the sandstone and conglomerate beds is best seen at Pointe Brûlée, and the pebbly or cobbly nature of some of the sandstones is also well shown. In the upper part of the section, a black shale (unit 17) is apparently interbedded with the sandstones and the conglomerates. Crossbedding is present in a single bed (unit 16), but graded bedding is abundant. Cut-and-fill structures, which would be expected in a near-shore deposit, are absent. The only features which disturb the bedding planes are narrow "channels" of an amplitude or depth of a few feet. No tops could be determined from these symmetrical channels, for the interareas are also symmetrical. Lateral variation within the strata at Pointe Brûlée is also noteworthy, both conglomerates and sandstones pinching out and interchanging along strike. The lower part of the Pointe Brûlée section contains more limestone pebbles and cobbles than the upper part.

The frequency of the pebbles and cobbles found at Pointe Brûlée is difficult to express mathematically for two pebbles exactly alike are rare, and minor differences in color, grain size, bedding, and lime content are universal. By far the most abundant types are gray and light gray, medium-grained, limy quartzites. Light gray and whitish, fine-grained quartzites follow. Next in abundance are limestones, _ some probably clastic, others dove weathering and relatively pure, and some sandy, or dolomitic. Locally, limestone clasts are more abundant than the quartzite types. Very fine-grained, light gray or light green, well sorted sandstones or siltstones, some with high contents of calcite or dolomite, are everywhere conspicuous. Some of the very fine-grained sandstones are buff weathering, as are many of the limestones. Rarer fragments include: green impure sandstones, green quartzites, micaceous quartzites, black or green slates, and laminated siltstone and slate. All the rock types enumerated above can be either laminated or massive. The above description of the fragments in the conglomerate is essentially the same as that of Logan (1863, p. 421).

All the rock types mentioned above can be compared and matched with Quebec Group outcrops in the area, although the limestones and the limy and dolomitic rock types are more abundant than a random sampling of the Quebec Group in the Témiscouata region would show.

The only fossils found in any part of the conglomerate come from a limestone cobble at Pointe Brûlée (unit 16). The fossils were trilobite fragments suggestive of Late Cambrian to Middle Ordovician age, and another fragment resembling Schizambon sp., a Lower Ordovician brachiopod (identified by A.R. Palmer; R.B. Neuman, personal communication, February 1959).

A thin-section from the sandstone of unit 4 at Pointe Brûlée has the following mode:

Quartz	50%
Rock fragments:	
siltstones	30%
slates or phyllites	15%
lava clasts	tr.
Chlorite clasts	tr.
Clay	5% (?)

Grain size
range 0.1-1.5 mm.
average 0.4 mm.

Packing: 4 or 5 contacts per grain

Grain boundaries: eaten and interpenetrated.

Typically, the siltstone fragments have 10-20% clay, and the quartz silt is 0.02 mm. The clay is brown, slightly pleochroic and turbid, and has a birefringence up to 0.025 (second order green-blue). The clay(?) and slates or phyllites are very similar and their separation is very difficult. The rock in thin-section is non-schistose, argillaceous(?), semi-lithic arenite.

A thin-section from conglomerate along the railroad, immediately south of Pointe Brûlée, has the following mode:

Quartz	20%
Rock fragments	
siltstones, in part limy	25%
slates or phyllites	20%
calcilutite and silty calcisiltite	20%
Schistose zones	5%
Calcite	10% (replacement)

The rock in hand specimen does not appear schistose, but in the thin-section a schistosity is apparent, crossing the preferential direction of the slate or phyllite clasts at an angle of about 30°. These schistose zones cut the schistosity in the phyllite or slate grains. In parts of the section, the zones are as wide as 0.05 mm., and curve and twist around grains. The grain boundaries are generally eaten, or are rounded or subrounded. Disregarding the micaceous minerals, the smallest grains recognized are 0.2 mm. A sandstone from the same locality has the following mode:

Quartz	40%
Rock fragments	
siltstones	29% (1/3 are limy)
limestones	1%
volcanic clasts	tr.
Calcite	less than 1%
Plagioclase	less than 1%
Schistose zones	30%

The grain boundaries are as in the conglomerate. The sand grains range between 0.1 and 1.2 mm. in diameter, and average 0.4 mm.

The clay, slate, phyllite, and schistose zones of the above three rocks are indistinguishable mineralogically. Textural criteria must be used, and only where shearing is not parallel to primary bedding schistosity can rock fragments be separated from clay. In the thin-sections, clay, slate, or schistose zones are brown, turbid, and somewhat pleochroic. Under high power, they are seen to be schistose and composed of interlayered crystals less than one micron (0.001 mm.) thick. In most sections, one-third to one-half of these are chlorite crystals. The birefringence on the whole attains interference colors up to high second order. In some of the sandstones to be described below, quartz silt occurs in the schistose masses. Minute differences between these masses, such as color, quartz content, and their size, favor the view that they are individual slate or phyllite sand grains which have been sheared.

The optical properties of part of the schistose masses suggest biotite. Certain facts, however, indicate that biotite cannot be present:- These masses have not grown under metamorphism, for they are turbid, and irregular in size and in form. Muscovite, which grows in the center of the schistose zones, is the last-formed mineral. This indicates that the temperature could not have attained the biotite zone of metamorphism. Biotite in such low-grade metamorphic rocks should be accompanied by epidotization of the plagioclase feldspars, and granulation of the sand grains. Neither epidotization nor granulation is anywhere present. Thus, the mineral in the schistose zones, clays, and slates or phyllites, in addition to chlorite, is probably a hydromuscovite, i.e., an illite.

In thin-section, the slate chips are crystallized and extinguish en masse, and could be called phyllites. However, they are referred to as slates because of their appearance in hand specimen.

Regional Distribution in the Cabano Area - The shale interbedded with the conglomerates at Pointe Brûlée has already been mentioned. Two and one half miles south of La Résurrection, along the range road, thinly bedded to laminated, medium- to coarse-grained sandstone and dark gray shale crop out. On the road on the northwest limb of the anticline, west of Touladi lake, shale is interbedded with conglomerate. Although great variation exists within individual beds of the lower conglomerate, there is everywhere shale, conglomerate, and sandstone. There is no trace of the lower conglomerate immediately north and east of Touladi lake, nor where the formation crosses Cabano river, southwest of Pointe Brûlée.

A conglomerate lens south of Témiscouata lake, or northwest of Saint-Eusèbe, ranges from a feather edge (the result of pre-Témiscouata erosion) to 2,500 feet thick. The composition of this lens appears to be identical to the lower conglomerate unit, except for the absence of shales in the former. Near Témiscouata lake, the stratigraphic thickness between the two conglomerates may be as much as 1,000 feet, but is probably less.

La Résurrection - Saint-Eusèbe Section

The strata exposed between La Résurrection and Saint-Eusèbe are mainly massive gray mudstones, weathering green. Many beds are green-gray, but much of the green may be due to weathering. Local siltstone laminae and thin beds are present. At the southeastern end of the outcrops the strata are better bedded than usual, and there are a few laminated, thin beds of very fine-grained, impure, light gray sandstone, in part crossbedded and in part graded. The mudstones associated with these sandstones are thinly bedded. Here, also, pebbly mudstone, with fragments ½ inch to 8 inches (average 2 inches), crops out. Most of the pebbles are gray quartzite, and the rest are similar to the matrix. The pebbles form an average of 2% of the pebbly mudstone, although a few beds have 40% pebbles.

The irregular cleavage in the mudstones does not cut the quartzite pebbles, but cuts the mudstone pebbles. The bedding is highly contorted, and the few tops available are inconsistent. A number of small folds, many with amplitudes of a few feet, were seen. How much of the folding is due to slump overfolding is unknown, but similar irregular dips have also been found in outcrops without pebbly mudstones. The bedding contortions appear so general in this unit, however, that it is probably in great part tectonic. The pebbly mudstones crop out over a horizontal distance of nearly 175 feet, out of a total of 700 horizontal feet of exposed strata.

A thin-section of the mudstone has the following mode:

Quartz	35%	
Biotite	2%	(detrital)
Muscovite	2%	(detrital)
Clay	59%	
Calcite	2%	(as blebs and thin veins)

The quartz silt particles have eaten borders, and range between 0.01 and 0.1 mm. in diameter, with an average of 0.03 mm. The rock is cleaved every 0.02 mm. or so, and the cleavages are less than one micron across. The clay is a mixture of chlorite and illite, which extinguishes as a whole.

Immediately southwest of Témiscouata lake, up section from the conglomerate lens northwest of Saint-Eusèbe, mudstones, similar to those on the road between Saint-Eusèbe and La Résurrection, crop out. Here, however, water-rounded volcanic material is admixed with some of the mudstones. This volcanic material weathers white, is felsitic, and ranges in size from sand to fine cobbles. Fossil locality G34 is a 2-foot, gray, sandy shale outcrop containing pebbles up to ½ inch in diameter of gray, well-rounded felsite.

Témiscouata-Touladi Lakes Section

Between Témiscouata lake and Touladi lake, sandstone and dark gray shale in a 3,000-foot interval above the lower conglomerate unit are poorly exposed in a number of outcrops. The sandstones range from fine to very coarse grained, and all have a high content of slate and siltstone chips; some have a bedding schistosity. Their color ranges from light to dark gray, depending on the content of slate and siltstone chips. The coarse-grained types are either thickly bedded or massive, and crop out unassociated with any other rock types. The bedding in the fine- and medium-grained types ranges from very thick to very thin. The thinly bedded types have shale or siltstone interbeds. A few sandstone beds at the falls on Touladi river are crossbedded; some are torrentially bedded. Many of the thin beds are laminated. The shales are in thin beds, or are interlaminated with siltstones, which form a minor part of this 3,000-foot interval. At the dam on the Touladi, the shales appear to be locally mudcracked; here, also, a 6-foot bed of pebble conglomerate forms a single outcrop.

A thin-section of the laminated sandstone at the dam shows that half the rock is composed of quartz, in grains with eaten borders or angular corners and an average diameter of 0.08 mm. Perhaps a quarter of the quartz is of silt size; the non-quartzose part of the rock is classed as slate clasts, but some of the "slate" is probably clay. The rock is perhaps a very fine-grained, semi-lithic arenite. The laminae are concentrations of highly schistose clay, which contains some muscovite. Scattered detrital muscovite also occurs throughout the rock. A thick lamina of shale adjoining sandstone has 25% quartz (0.03 mm. diameter), and the remainder is illite and chlorite. The over-all texture of the sandstone is schistose, but not enough so to warrant the designation of semischist.

The upper 3,500 feet of the 8,400 feet of the Cabano Formation is very well exposed on the southwest shore of Touladi lake, and on the road nearby. This area and that at Pointe Brûlée furnish the best sections in the Témiscouata region. A columnar section cannot be given because only 25-30% of the total thickness is exposed; this is characterized by laminated to thinly bedded siltstones and very fine-grained sandstones. The siltstones, which account for more than 75% of the exposed section, may be well sorted, and limy or dolomitic or both. Most siltstones weather green. The sandstones are light gray to gray, and may be limy or dolomitic. All the rock types in beds 1 inch to 4 inches thick are laminated, and some are crossbedded or graded. Rare beds of medium- or coarse-grained sandstone occur, some with abundant slate chips. Fossil locality 59-605, on the lake shore, is in a gray, massive siltstone, in part contorted, which has quartzite fragments 2-8 inches in diameter; these fragments form less than 1% of the rock.

A thin-section from a gray, green-weathering, poorly laminated rock has the following mode:

Quartz	78%
Plagioclase	less than 1%
Biotite	1%
Muscovite	1%
Chlorite	less than 1%
Dolomite	15% (partly in 0.04 mm. rhombs)
Illite and chlorite	5%

Grain size:
range; 0.02-0.12 mm.
average; 0.04 mm.

Grain boundaries; eaten.

The illite and chlorite are absent locally, and may have been introduced by metamorphism. The rock is a micaceous, dolomitic siltstone.

Southern Part of Squatec Area Section

The Cabano Formation in the Squatec East area varies laterally, but somewhat less so than in the Cabano area. Whereas the conglomerates in the Cabano area are typically cobble size, the conglomerate lens southwest of Pain-de-Sucre lake is typically a highly weathered, massive, very fine pebble to granule conglomerate. The average grain size in some outcrops is 2 mm., in others more, and in most is ¼ inch (the granule-pebble limit is 0.15 inches). In places this conglomerate has 5% coarse pebbles, and a pronounced schistosity. Typically, it is composed of clasts of medium sand to pebble size, and has a high content of slate and siltstone chips. Here, as elsewhere, the chip content is very difficult to estimate because of its tabular nature, but in general half of the rock appears to be so composed (locally 85% or more). Slate and siltstone chips are, as elsewhere, dark gray, but some are light green, green or gray.

A thin-section from a conglomerate bed has the following mode:

Quartz	10%
Rock fragments	
siltstones, some limy	49%
slate	10%
limestone	1%
Schistose zones	20%
Calcite	10% (secondary)

The quartz particles range between 0.1 and 0.8 mm. in diamater, and have an average size of 0.3 mm. The rock fragments are elliptical and average 2.0 by 0.5 mm. The schistose cleavages are 0.5 to 1.5 mm. apart and are 0.25 mm. thick or smaller. The schistose zones are composed of pleochroic brownish illite, chlorite, and quartz silt which forms 25% of the zones. The rock is a lithic rudite (conglomerate), with semischist texture (Plate VII-B) and schistose cleavage.

Above the conglomerate lens, fossils were found at two localities (59-H187, and 59-181) in sandy or conglomeratic siltstone or mudstone. The sand and conglomerate grains range up to pebble size, form less than 5% of the rock, and are water-sorted, volcanic felsitic material. Rare thin beds of sandstone are also present. A thin-section from such a sandstone bed shows that approximately half of the rock is composed of lava fragments, and approximately one-third of secondary calcite.

Other rock types exposed stratigraphically above the conglomerate lens are similar to the non-limy types immediately northeast of Pain-de-Sucre lake.

Middle Part of the Squatec Area Section

For 3½ miles northeast of Pain-de-Sucre lake, the rock types exposed are gray, locally dark gray, massive slates and siltstones; limy gray siltstones; limy sandstones; and very rare lithic sandstones. Locally, the siltstones and slates weather greenish.

The massive slates and siltstones form almost exclusively the northern 2 miles of this stretch of outcrop. Slate is probably the most abundant rock type, but three outcrops of medium- to coarse-grained schistose sandstone, of the lithic arenite type, occur near the northeast end of the northeast-trending road in this area.

Equivalent beds to the southwest are composed of gray slates, gray siltstones, and gray to light gray limy siltstones, all of which are massive. In addition to the above, there are minor gray to light gray very fine-grained, limy sandstones, which are laminated to thinly bedded. Locally the slates and siltstones may be poorly laminated. A thin-section of the sandstone shows:-

Quartz	50%	
Plagioclase	1%	
Micas	2%	(mostly muscovite)
Chlorite clasts	1%	
Siltstone clasts	1%	
"Clay"	20%	(mixture of chlorite and illite)
Calcite	27%	(cement, in part recrystallized)

The average size of the quartz is roughly between silt and sand. The clay is schistose, and the schistose cleavages are found only where there is clay, and form an angle of about 30° with the bedding. The clay is restricted to the schistose cleavages, which perhaps resulted from embryonic metamorphic differentiation, or from having been introduced by metamorphic processes. This section suggests the interesting possibility that some of the illite and chlorite mixtures have been introduced during metamorphism, and supports the view that the Cabano sandstones are well sorted.

Northern Half of the Squatec Area

Northeastward from the above described rocks, the Cabano Formation is a mixture of slate, siltstone, sandstone, and conglomerate. The relative abundance between each rock type varies from traverse to traverse, but no definite trend in distribution is apparent.

The conglomerates show minor variation. The most abundant type is a gray granule or very small-pebble conglomerate, very similar to the conglomerate southwest of Pain-de-Sucre lake. A second type of conglomerate, found in only four outcrops, is also a granule or very small-pebble conglomerate, and differs from the preceding in its content of quartz. This conglomerate is characterized by its quartzitic texture, a content of 50-75% quartz or quartzite, and its light gray color. The only coarse conglomerate found in the Squatec area is on the nose of the small anticline northeast of Biencourt lake. Here 12-inch boulders are found in some beds, and other beds contain clasts which average ½ inch to 3 inches. The bigger clasts are quartzite; the smaller pieces are siltstone and slate. The matrix is sand size and forms 20-60% of the rock. A stratigraphic thickness of about 35 feet is probably present. The various types of conglomerate probably do not form more than 2% of the total thickness of the Cabano Formation in the northern half of the Squatec area. The remaining part of the section is composed of about equal parts of sandstone, slate, and siltstone.

The slates and siltstones are massive, gray, and locally dark gray. Rarely, they are laminated or limy. They rarely crop out with sandstones, and are particularly abundant on the road immediately southwest of Biencourt lake. A few outcrops of slate have a phyllitic sheen.

Many of the sandstones are conglomeratic, and many grade completely into conglomerates. Their color ranges from medium to dark gray, depending on the content of quartz and limestone. Coarse, very coarse, and conglomeratic sandstones are less common than medium and fine sandstones. The coarse-grained types are generally massive but many of the fine- and medium-grained types are laminated and, in at least two outcrops, cross-bedded. In the few places where bedding can be seen in these sandstones they are thickly bedded. The sandstones may be schistose or non-schistose. The schistosity is probably in great part a primary bedding schistosity, and is usually better developed in the coarse-grained sizes and in those rocks with the higher contents of slate and siltstone chips. In hand specimens, no micaceous minerals can be seen, whereas in thin-sections schistose zones can be recognized. Because these are zones, the term schistose cleavage is used. Cleavage planes are spaced every 1/8-1/10 inch in many places. In a number of localities, the cleavage is parallel to the slate and siltstone chips, and, in one or two places, aligned elliptical pods of siltstone in sandstone are the result of shearing. This would tend to diminish the importance of primary bedding schistosity, and a number of thin-sections show that the secondary schistosity makes an angle of about 30° with the bedding.

Slate chips are more abundant in hand specimens of these sandstones than siltstone chips. The content of detrital slate and siltstone fragments is variable, and extremely difficult to estimate. The slate and siltstone fragments form more than one-third, and in many places two-thirds, of the rock. Quartz rarely forms more than a third of the rock.

In the field, all the sandstones were described as impure, with high contents of clay, but shearing does not permit the sure recognition of clay in thin-section.

Outcrops of sandstone are particularly abundant 3 miles southwest of Biencourt lake. North of Biencourt lake, a few fine-grained sandstone beds are apparently entirely composed of slate and siltstone chips, and a few siltstone outcrops are laminated.

Approximately 1 mile north-northwest, and 2½ miles north-northeast of the Biencourt fire tower, there is a total of four red or red-gray outcrops. The western two outcrops are medium-grained sandstone to granule conglomerate, of which perhaps 50 stratigraphic feet are exposed. The eastern outcrops are thinly bedded, fine-grained sandstone, of which 12 stratigraphic feet are exposed.

The average of five thin-sections of sandstone is:-

Quartz	26%
Plagioclase	tr
Rock fragments	
siltstones, some limy	29%
slates	30%
limestones, some silty	8%
Schistose cleavages	2%
Calcite	5%

The schistose cleavage of a conglomeratic sandstone could not be separated from the slate chips. The calcite may be a cement, or secondary, or reorganized limestone grains. Its distribution suggests it is a cement. The slates and schistose cleavages are mixtures of illite and chlorite, with minor quartz silt. The over-all texture is semischist, and appears to preclude any detrital clay matrix. The schistose cleavages cut the schistosity of the slate chips in a number of places. The rocks are limy, quartzose, lithic arenites, partly conglomeratic.

The lutites in the Cabano area are shales, whereas in the Squatec area they are slates. Both Logan (1863) and Gorman (1957) described the lutites as slates, but the metamorphism does not seem to be high enough to justify this name. The conclusion can be drawn, therefore, that metamorphism increases northeastward. However, there is no evidence in the Témiscouata region for a northeastward increase in metamorphism, except from these lutites. This suggests that the cause of the apparent increase of metamorphism is to be sought within the formation itself. No important mineralogic variation has been found along strike, and the only variable which appears to have an effect is bedding. The lutites in the Cabano area are interbedded within conglomerates and sandstones, whereas in the Squatec area they are massive, and presumably in very thick beds. Perhaps the interbedded lutites were protected by the conglomerates and sandstones during folding, whereas the massive lutites were deformed plastically. Confirmation of the above may lie in the plastically (?) deformed mudstones on the road between Saint-Eusèbe and La Résurrection, where no competent beds protected the mudstones. The above hypothesis does not agree with the structural theory of drag folding, which postulates that incompetent beds are more highly deformed where found between competent beds.

Slaty cleavage has affected the various rock types of the Cabano Formation differently. The slates and siltstones are well cleaved. The sandstones are also cleaved, probably because of their high content of slate and siltstone chips. Much data has been presented previously to show that movement has taken place along these cleavages, and such movement has produced shearing and semischist textures in some sandstones (Plate VII-B). The data presented also showed that this shearing was in many places at an angle of approximately 30° to a primary bedding schistosity formed by sedimentation.

Pointe aux Trembles and Lac Raymond Formations

Name

The Pointe aux Trembles and Lac Raymond formations are here defined for the first time. They grade laterally into each other near Raymond lake. There are mappable lenses of the Pointe aux Trembles Formation in the Lac Raymond Formation, and there can be little doubt that the formations are facies of one another; they are treated together here for this reason.

The Pointe aux Trembles Formation is composed of volcanic conglomerates and sandstones, and the Lac Raymond Formation of mudstones, with minor slates, siltstones, and sandstones. The type section for the Pointe aux Trembles Formation is at Pointe aux Trembles, and the type area for the Lac Raymond Formation is along the lumber roads southwest of Raymond lake. The lenses of the Pointe aux Trembles Formation that can be seen in the type area of the Lac Raymond are exactly the same as the Pointe aux Trembles farther southwest.

The following fossils (except for those of locality L-83), and particularly the known range of <u>Stricklandia lens progressa</u>, indicate to Boucot the C_1 - C_2 level of the Upper Llandovery. However, <u>Atrypa reticularis</u> from the basal Pointe aux Trembles (L-83) cannot be any older than C_3. In addition, data from J. Lajoie to the north of our area indicate that C_1 - C_6 strata (Upper Llandovery) interfinger with the Lac Raymond - Pointe aux Trembles, in addition to being overlain by Wenlockian strata (immediately younger than C_6). Consequently, the age of the Pointe aux Trembles is C_3 - C_6 near Lake Témiscouata, and in the northern part of our area the age of the Pointe aux Trembles - Lac Raymond combined is C_1 - C_6 of the Upper Llandovery, _ our fossil localities from the middle of the formations representing only the oldest Upper Llandovery.

Age

Fossils identified by Boucot are as follows:-

Table 2

Fossils of the Pointe aux Trembles and Lac Raymond Formations

Fossils	G-80	G-96	59-373M	59-378	39-397	59-H-419	59-457	59-521	L-83
Eridorthis sp. (P)	X								
Eostropheodonta sp. (P)	X								
Stegerhyncus? sp. (P)	X	X							
Chonetes sp. (P)	X								
Resserella? sp. (P)	X								X
Dolerorthis? sp. (P)	X								
Eocoelia quebecensis (P) (L)			X	X	X		X	X	
Stricklandia lens progressa (L)				X					
Stricklandia? sp. (P)									X
Glassia? sp. (L)				X					
Atrypa reticularis (P)									X
Atrypa? sp. (L)									
Leperditia sp. (L)				X					
coral (L)				X					
gastropods (L)				X					
fragments (L)						X			

P: Fossils from the Pointe aux Trembles Formation

L: Fossils from the Lac Raymond Formation

Thickness

In the Squatec East area, the Pointe aux Trembles thickens northeasterly. Outcrops are scarce southwest of Pain-de-Sucre lake, but nevertheless a minimum thickness of 1,500 feet can be postulated. Between Raymond lake and Pain-de-Sucre lake, the two formations combined are 3,200 feet thick although there are variations in angle of dip and width of outcrop along strike. Individually, both formations range from zero to 3,200 feet. Northeast of Raymond lake, where there is an apparent change of strike of the formation, there is not enough data to give the thickness.

Stratigraphy and Petrography

Pointe aux Trembles Formation

The Pointe aux Trembles Formation is composed of an intimate mixture of volcanic sandstones, conglomeratic sandstones, rare lava flows and even rarer tuffs. There are complete gradations from sandstones to conglomerates. The color of the rocks ranges from gray to green, and in places is dark gray. Red rocks are abundant southwest of Pain-de-Sucre lake, and rare northeast of it. Particles ranging in size from granules to boulders are found in the conglomerates and conglomeratic sandstones, but the two extremes in size are rare; cobbles and pebbles are much more abundant. The common size of the clasts in the conglomerates is between 1 inch and 8 inches. All the clasts are rounded, and many are quite spheric. From Pain-de-Sucre lake southwestward a number of cobbles, varying in abundance from outcrop to outcrop, have internal concentric bands of hematite. The number of these bands is variable between one and four. The bands are usually less than ½ inch thick, and are believed to be formed by partial weathering of the pebbles before sedimentation.

The material composing the formation is exclusively volcanic detritus, which has been slightly reworked by the sea. Conglomerates are the most abundant rock followed by conglomeratic sandstones and sandstones. Bedding in the conglomerates is rare and ranges between thin and thick. Crossbedding was seen in two outcrops, one of which is in unit 1 of the section in the island in front of Pain-de-Sucre peak (see below), and the second at the mouth of Touladi river. At the second locality, a graded bed was also present 6 inches from the crossbedded stratum. As a whole, however, the Pointe aux Trembles Formation is massive.

The type section of the Pointe aux Trembles Formation is along the railroad tracks, where its base is placed at the lowermost exposed unit. The measurements are from pace-and-compass data, combined with graphic constructions. In descending order the section is:

	Thickness of unit	Cumulative thickness
7. Volcanic conglomerate and sandstone. The conglomerate fragments are, on the average, cobble size. The matrices of the conglomerates are a mixture of coarse sand to granules, or even to pebbles. The sandstones are generally coarse grained, and range from red to green; they form approximately 2% of the unit. The bedding strikes N.33°E. and dips 85° east	112'	112'
6. Sandstones, volcanic	11'	123'
Covered	42'	165'

	Thickness of unit	Cumulative thickness
5. Volcanic sandstone and conglomerate. Both rock types range from red to green. The sandstones are fine to medium grained, and have minor red laminae as in unit 3. The conglomerates become progressively more common upward; in the lower half of the unit they form approximately 2% of the exposure.	75'	240'
4. Volcanic conglomerate and very fine-grained, volcanic sandstones. A thin-section from one sandstone shows ores (5%), chloritic clay (10%), plagioclase feldspar (15%), and felsitic volcanic fragments (70%). The bedding strikes N.40°E. and dips 60° east.	30'	270'
3. Volcanic sandstone, — dark red to dark green or grayish green, medium to coarse grained. Local laminae or thin beds of dark red, dense, jasper-like material are probably volcanic siltstones. At the top of this unit is a 2-foot bed of dense, dark greenish gray, fine lithic tuff (as revealed in thin-section) which breaks with a pronounced conchoidal fracture	30'	300'
Covered	500'	800'
2. Volcanic sandstone, — dark gray to greenish gray, coarse grained, well sorted, massive; a few thin beds of slate in the upper half of the unit. In thin-section, the dark gray sandstone is a coarse-grained, well-sorted, feldspathic, chloritic, volcanic arenite, with 5% plagioclase feldspar, 15% chlorite as replacement and cement, and 80% miscellaneous hyalo-ophitic, subangular, lava, grains	125'	925'
1. Sandstone, — light gray, well sorted, coarse grained, massive. The sandstone probably has a quartz content as high as 75%	75'	1,000'

Unit 1 does not contain sedimentary rock particles typical of the Cabano, is highly quartzose, and is probably volcanic-bearing. It appears to be a transition zone between the Cabano and the Pointe aux Trembles formations, and has prompted Gregory (1900) to say that the Cabano grades into the Pointe aux Trembles. Although no sedimentary rock particles are present in unit 1, the quartz content is more typical of the Cabano than of the Pointe aux Trembles. Nowhere else in the Témiscouata region have any strata been recognized as transitional between these two formations; furthermore, no quartzose rock type has been found elsewhere at the base of the Pointe aux Trembles Formation.

The strata exposed in front of Pain-de-Sucre peak (Plate I) on the little island in the middle of Pain-de-Sucre lake are particularly instructive. The section on this island is given below, in descending order, and is considered typical of the whole formation. The thicknesses are estimated. The rocks are massive except where otherwise noted:-

		Thickness	
5.	Sandstone and volcanic conglomerate, – greenish gray, ranging from fine to coarse (medium is the most common). Conglomerate fragments range between 1/8 inch to 4 inches. The average pebble content is 1-2%, although locally it is 15%. A thin-section of medium-grained sandstone is composed of 1% "augite" grains, 10% clear chlorite cement (not a matrix), and 89% volcanic fragments averaging 0.4 mm., most of which are felsitic or felty masses. The rock is a well-sorted chlorite-cemented volcanic arenite	25'	25'
4.	Volcanic conglomerate. As unit 5, but conglomerate fragments average 2 inches and form 40% of the rock	5'	30'
3.	Sandstone and volcanic conglomerate, as unit 5 ...	5'	35'
2.	Volcanic conglomerate. In the lower 8 feet of the unit conglomerate fragments form 40-60% of the rock, whereas in the remainder they form 80%. There is a complete gradation from sand to boulders 15 by 10 inches. The average size of clast is 6 by 4 inches. The matrix ranges from clay(?) to granules, has an average size of coarse sand and is composed of green grains with minor red ones. The over-all color of the matrix is green-gray. Approximately 2/3 of the cobbles have paper-thin to 1/4-inch concentric bands of hematite, and are either green or dark red lavas. Most of these lavas are probably andesites, and a thin-section from a dark red cobble is a hyalo-ophitic andesite. These lavas show in hand specimen some greenish minerals tentatively identified as chlorite and augite. A second important group of cobbles are those which are obviously porphyritic, with crystals of feldspar up to 1/8 inch, forming up to 40% of the lava. Both red and green types are porphyritic. A few cobbles of layered volcanics or tuffs were also noticed	35'	70'
1.	Volcanic sandstone, – thin bedded to laminated (crossbedded in one place), greenish gray, generally medium grained. In one place there are two 1- by 18-inch lenticles of dark red, dense, jasper-like material (probably silt size clastics, judging from a thin-section of similar material from Touladi river). The bedding strikes N.30°E. and dips 55°E., and the top is to the east	10'	80'

The sandstones and the matrices of the conglomerates have similar average grain sizes, and range from fine- to very coarse-grained sand. All the fossils found in the Pointe aux Trembles Formation were in the matrices of volcanic conglomerates.

The sandstones are for the most part dense, and many were termed tuffaceous in the field on the basis of visible lath-shaped rock or mineral fragments. However, thin-section studies did not confirm the tuffaceous nature of the rocks, and the laths are probably porphyritic cleaved feldspars. A number of sandstones, apparently in the upper half of the formation, are not dense and weather to a crumbly mass. In these sandstones, the sand grains are much easier to distinguish, and they can all be identified as volcanic fragments.

In thin-sections, no difference has been noticed between the matrices of conglomerates, conglomeratic sandstones, and sandstones; consequently, they will be treated together below.

The average composition of ten thin-sections is:-

	Average %	Variation %
Quartz and chert	tr	0-1
Plagioclase	8	0-26
"Augite"	1	0-3
Ores	tr	0-5
Lava fragments	78	50-97
Clay		
chlorite	1	0-10
red	2	0-20
Cements		
chlorite	4	2-15
chalcedony	2	3-6
Calcite	tr	0-1 (secondary)
Chlorite	2	0-14 (secondary)
Epidote	tr	0-4 (secondary)

Roundness : angular to rounded
Packing : floating to five contacts per grain

The chloritic clay is turbid, but the chlorites formed by alteration and cementation are clear and more coarsely crystalline. The distinction between chlorite that cements and chlorite that replaces is in places tenuous. The "augite" and the plagioclase are probably fragments from reworked lava flows. The lava fragments are mostly hyalo-ophitic, and brownish. Staining of two thin-sections revealed all the lava fragments to be latites. In general, the clastic texture is difficult to recognize but where there is a high content of cement and/or where the lava fragments are dark brown, the clastic texture is evident. The chalcedony cement is typically the first deposited, adjoining the sand grains. The remaining void space is filled with clear green chlorite. One crumbly weathering sandstone has 20% cement, and the other has none and has pressolved zones (Thomson, 1959). According to Thomson, pressolved zones are pressure induced solution zones between grains in an arenite, and can be thought of as microstylolites one grain wide. Clays have a catalytic action on this solution, according to Thomson, and the only section which has clay in the above volcanic arenites also possesses these pressolved zones. The rocks are chalcedony- and chlorite-cemented, feldspathic, volcanic arenites.

A thin-section from a dense, greenish gray bed at Pointe aux Trembles shows that one-third of the rock is plagioclase feldspar in 0.05 to 0.1 mm. grains, which are very angular and have sharp borders. The remainder of the slide is "felsite", with very rare higher birefringent spots, and is probably a greenish, devitrified, tuffaceous dust. The rock is termed a vitric tuff, although no vitric texture is present. Even under the hand lens no grains can be seen. Similar fine tuffs occur west of Little Auclair (Little Eau Claire) lake, in a gray 1-inch bed interstratified with latite, as the matrix of an 18-foot-thick gray conglomerate bed on the south shore of Pain-de-Sucre lake, and as a 1-inch gray bed approximately 3/4 mile southwest of Pain-de-Sucre lake.

A thin-section of lithic tuff from the Pointe aux Trembles lens within the Lac Raymond Formation approximately 2½ miles southwest of Raymond lake has the following mineralogic composition:-

Lava fragments	70%
Groundmass	
plagioclase	6%
chlorite	15%
ores	1%
Chlorite	2% (secondary)

Grain size:

Range : 0.4-6.0 mm.
Average : 1.1 mm.

Roundness : very angular

Sphericity: very low

Grain boundaries : sharp

Packing : unpacked

Most of the rock fragments have hyalo-ophitic textures, although some have trachytic textures. In hand specimen, the rock is dark green and a few irregular red fragments can be seen. Possibly 10 feet of tuff are discontinuously exposed here. This tuff is interbedded with fine-grained sandstones and granule conglomerates, all of which are mixtures of red and gray volcanic fragments, which weather dense in part and crumbly in part. The lowermost 5 stratigraphic feet exposed contain up to 50% quartz.

Gregory (1900) has reported biotite and olivine from the rocks at Pointe aux Trembles. Neither of these two minerals have been seen by the writers in the Pointe aux Trembles Formation.

A total of five thin (1-5 feet) lava flows have been found, in addition to a large area of flows of Auclair (Eau Claire) lake. West of Claire lake, about 200 feet of deep red latites (one gray outcrop was found) have minor amounts of a dark mineral and abundant feldspar laths. Elsewhere, the latites are commonly light gray and felsitic. Flows near Raymond lake are dark gray, porphvritic, massive andesites.

The conglomerate clasts in the Pointe aux Trembles Formation show a slight variation in composition along strike. In the Cabano area the fragments are practically all dark. In the Squatec area, dark fragments gradually decrease in importance and are replaced by light gray and gray ones. Along with this change of color, the minerals that can be identified under the hand lens also show a slight variation. Dark minerals (augite and chlorite) are absent in the northern outcrops of the Pointe aux Trembles Formation, i.e., the lavas become more felsitic. The red pebbles and cobbles show this change particularly well. In the northern half of the Squatec area, a few sedimentary and igneous or metamorphic pebbles and cobbles are found.

There is little difference between thin-sections of the flows in the Pointe aux Trembles Formation and the conglomerate clasts. The latites are commonly composed of 40% porphyritic sodic andesine, with 5% augitic clinopyroxene, and 55% groundmass. The groundmass is composed of approximately equal amounts of potash feldspar in blebs 10 microns in diameter, plagioclase microlites, and diffuse felsitic minerals. Chalcedony and chlorite amygdules are locally present. A typical thin-section contains:-

Chalcedony	6%	(in amygdules)
Plagioclase, An_{28}	35%	(phenocrysts)
Clinopyroxene - augite	3%	(2V of 49^{o})
Chlorite	4%	(in amygdules)
Epidote	1%	
Zircon	tr	
Groundmass		
plagioclase, An_{28}	15%	(microlites)
potash feldspar	17%	(0.01 mm.)
felsite	10%	
ores	10%	

The thin-section has a felty texture and is an amygdular and porphyritic latite.

The andesites, on the other hand, have a plagioclase that is commonly more calcic, chlorite is abundant, and potash feldspar is absent. A rough estimate of the abundance of the types of clasts in the formation is 4:1 in favor of latites. The andesite clasts are coarse grained, and have not been found as sand clasts. A few pebbles, foreign to the Témiscouata region, of saussuritized gabbro and albite granite have also been found near Raymond lake.

Lac Raymond Formation

The Lac Raymond Formation crops out discontinuously both north and south of the upper part of Touladi river that flows into Biencourt lake. In both these areas the formation is composed of mudstone, with minor interbeds of different rock types. The interbeds are so thin or so local that no generalized stratigraphic succession can be drawn.

The mudstone is gray to dark gray, green to greenish gray weathering, dense, poorly cleaved, and massive. The greenish weathering is characteristic of the formation. Typically the mudstone is smooth to the touch and hard to the knife blade. The cleavages in the Lac Raymond mudstone are planar and cause the outcrop to break typically into pencil-shaped fragments; this is possibly a fracture cleavage.

The Lac Raymond mudstone may have irregular greenish pods on the fresh surface. In places, it is poorly laminated or very thinly bedded. The laminae are colored various shades of gray but have diffuse contacts. No bedding fissility is present, such as is typical of the lutites of the Quebec Group. Light gray to dark gray laminae and thin beds of siltstone are present locally; elsewhere such layers are fine-grained, impure or well-sorted sandstones. Rare, white weathering, very thin, medium-grained beds are crystal tuffs. Isolated outcrops of the Lac Raymond Formation are light gray, gray or green non-fissile slates (smooth to the touch and soft to the knife blade). A light gray slate in one locality yielded perfect specimens of Stricklandia lens progressa (59-378).

Three thin-sections of the main rock types in the formation show:-

Field Name	Slate %	Siltstone %	Mudstone %
Quartz	20	65	
Plagioclase	1	3	
Biotite, muscovite	1	3	1
Chlorite blebs	2		
Lava fragments	36	10	
Chloritic clay	40	15	30-70
Cleavage every	0.02mm. (poor)	0.005 mm.	uncleaved
Grain size			
range (mm.)	0.01-0.05	0.02-0.1	?-0.06
average (mm.)	0.02	0.04	0.015
Grain boundaries	eaten	eaten	eaten
Bedding	massive	poorly laminated	laminated

The cleavages are sinuous. In the mudstone, silt and clay, and quartz and lava fragments were difficult to distinguish. The mudstone has rounded to spheric clay galls up to 2 mm., which form 15% of the slide. These blebs are of the same composition as the surrounding matrix, and are probably intraformational slump structures.

A thin-section from a very thinly bedded dark gray fine-grained sandstone has the following mode:-

Quartz	35%
"Augite", chlorite, biotite ..	2%
Plagioclase	10%
Lava fragments	45%
Opaque and chloritic clay	7%
Authigenic quartz	2%

Grain size
range : 0.05-0.85 mm.
average : 0.2 mm.

Packing : 4 contacts per grain

The grain boundaries are rounded or, where eaten and interpenetrating, are angular. The brownish lava fragments are trachytic, felty, felsitic, and spherulitic or hyalo-ophitic. The rock is an impure, feldspathic, semi-volcanic arenite.

A thin-section from a very thin bed of crystal tuff (interlayered with tuffaceous siltstone, tuffaceous slate, and siltstone), in which there are rounded and spherical blebs of siltstone, shows that the tuff is composed of kaolinized plagioclase feldspar fragments which are irregular in shape and very angular. In the tuff itself, the feldspar grains range in size from 0.1-2.0 mm., and have an average size of 0.4 mm. The feldspar is calcic andesine (An_{47}). The groundmass forms a fifth of the tuff, and is a mixture of ores, chlorite, and chloritic clay.

Less than 5% of the formation is medium-grained sandstone and conglomeratic sandstone. These sandstones are in beds 1 foot to 3 feet thick, and are a mixture of quartz, lava fragments and, rarely, dark gray siltstone chips. Many of the coarser sand size mixtures have a quartzitic texture. The maximum dimension attained by conglomerate fragments is pebble-size, and these form less than 20% of the rock. In most outcrops, quartz forms more than one-third of the whole. The color of these beds generally ranges from light to dark gray, but locally they are light green. These sandstone and conglomerate beds are isolated but dispersed throughout the whole formation. Such a sandstone, containing Coelospira sp. (59-373M), has the following mode in thin-section:-

Quartz	50%
Plagioclase	1%
"Augite"	1%
Lava clasts	41%
Chlorite cement (?)	2%
Calcite	5%

Grain size
range : 0.1-3.0 mm.
average : 0.3 mm.; in addition 10% varies between 0.8 and 3.0 mm.

Sorting : medium
Roundness : rounded
Packing : six contacts per grain

Most of the lava fragments have either felty or hyalo-ophitic textures.

Outcrops along Gros (Big) brook show that sandstones are quite abundant locally; here slates, siltstones, and sandstones each form approximately a third of the strata. The rocks are mostly gray and weather green, as elsewhere. The slates are in various thicknesses. The siltstones range from light gray to gray; most are limy to some degree. These strata are in places contorted and sheared. Part of the contortions are possibly slump structures, but the presence of definite tectonic shearing makes the recognition of this structure difficult. Medium-grained, limy beds are very rare. Nowhere else have sandstones and siltstones been found to form such an important part of the section in the Lac Raymond Formation.

The above descriptions show that quartz is present in the Lac Raymond Formation and absent from the Pointe aux Trembles. The sandstones of the former are semivolcanic arenites, whereas the sandstones of the latter are volcanic arenites.

The bedding, coarseness of the material, and irregular distribution of the Lower Silurian formations suggest that deposition of these strata was in deep basins, which were probably also local and intramontane.

Silurian

Andesites

Lavas underlie a hill trending N.25°E. on the northern nose of the Squatec-Cabano syncline. They are not in contact with any other rock type, and their position on the nose of the syncline suggests that they are pre-Robitaille in age. However, as they are lavas in both the Lower and the Upper Silurian, and as there is no Lower Silurian in the Squatec West area, the age of these lavas is not clear. Perhaps they are pre-Silurian, but the absence of lavas in pre-Silurian strata argues against such a dating.

No structural information was obtained from these andesites, but if the length of the hill (2,000 feet) is assumed to be composed of strata which have the same plunge as the Squatec-Cabano syncline, as much as 400 stratigraphic feet of lavas may be present.

The lavas are green and fine grained. In one place, however, patches of white material give a brecciated appearance to the outcrop. Two thin-sections of these lavas have the following modes:-

Name	Andesite	Volcanic breccia	
Potash feldspar	1%	35%	
Plagioclase	35%	4%	
An content	32%		
Hornblende	15%	10%	(wormy growths)
"Augite"		3%	
Clinozoisite	5%	20%	(replacing plagioclase)
Chlorite	3%	3%	(replacement and veins)
Serpentine		20%	(veins)
Felsitic glass	40%	5%	
Calcite	1%		

The lavas are predominantly andesites, although the volcanic breccia does have abundant potash feldspar.

Within the outcrop nearest the Robitaille Formation, but not in contact with the lavas, a light gray, finely crystalline, dense, pure limestone up to 6 inches thick, with less than 1% chert nodules, crops out for a few feet.

Upper Silurian

Robitaille and Asselin Formations

Name

The Robitaille Formation is defined as the Upper Silurian red siltstones and sandstones, and minor varicolored quartzites, found between the Quebec Group and the Mont Wissick Formation in the Squatec West area. Lowermost Mont Wissick strata are commonly limestone, and uppermost Robitaille strata are quartzites or red or green siltstones. The type section of the Robitaille Formation is on Lots 17 and 18, Range IV, Robitaille township, near the northern nose of the Squatec-Cabano syncline. Approximately half the formation is there exposed, and there are complementary exposures to the west of Sauvagesse lake, and on the road between Cabano and Saint-Michel-du-Squatec.

The term "Asselin" Formation is new. This formation is believed to change along strike into the Robitaille. The Asselin is restricted to the Squatec East area, within Asselin township. No type section can be suggested, and the most abundant outcrops are in the bush. The formation shows considerable variation in lithology along strike, making the designation of a type area or sections even more difficult.

Age

Fossils identified by Boucot from the Robitaille Formation, and correlated with Lower Ludlow, are:-

Table 3

Fossils of the Robitaille Formation

Fossils	58-230	58-643	58-651
Hyattidina? sp. (has conjunct hinge plates)	X	X	
Howellella sp.	X		
Atrypa reticularis	X		
Salopina sp.	X		
Unidentified dalmanellid			X

A loose angular boulder in a stream cutting the Asselin Formation yielded the following fossils, identified by Boucot (this boulder is similar to outcrops of the Asselin Formation on the sides of the stream):

Porpites? porpita (Collection 59-267)
Pentamerus? sp.
Atrypa "reticularis"

If the identification of Porpites is correct, this fauna is of Upper Llandovery age.

In addition to the above fossils, Oliver reports a ramose favositoid coral.

Thickness

The Robitaille Formation is 1,400 feet thick in the Squatec West area. In the Cabano area, underlying the Squatec-Cabano syncline, it is also 1,400 feet thick. Near La Résurrection, 1,400 feet of these rocks are probably also present, although data are scant. Near Touladi lake, the Robitaille ranges from a few feet to 700 feet thick.

The "few feet" is owing to pre-Témiscouata Formation erosion. From Touladi lake to Pain-de-Sucre lake, outcrops are rare, and the Asselin and Robitaille formations combined are interpreted to range between 700 and 1,300 feet in thickness. The 1,300-foot thickness is the thickness of the Asselin Formation.

Stratigraphy and Petrography

Robitaille Formation

The base of the type section of the Robitaille Formation is a few hundred feet to the west of the Squatec-Cabano road, and the section extends from there southeastward. Outcrops are numerous but discontinuous. The section in descending order is as follows (from pace-and-compass data combined with graphic measurements):-

	Thickness	
Mont Wissick nodular limestone, perhaps sheared.		
Concealed	175'	175'
7. Siltstone,– red, massive, sandy; rare, impure, fine-grained sandstone beds. A single bedding plane seen strikes N.10°E. and dips 42° east	270'	445'
Concealed	25'	470'
6. Siltstone, green	25'	495'
5. Quartzite,–light gray to dark gray, fine to medium grained, very thinly bedded, crossbedded. Bedding N.21°E., dip 77° west, top to the east	5'	500'
4. Siltstone,–gray, poorly fossiliferous but with local one-inch coquina beds	40'	540'
3. Limestone,–gray, fossiliferous, finely crystalline; laminated to beds of 2 feet; in places silty or sandy. This limestone is slightly cleaved locally, and carries (particularly in the upper 3 feet) numerous broken brachiopods. The weathered surface is light gray. The bedding strikes N.32°E., and the dip ranges from 70° to vertical	65'	605'
Concealed. The center of the Squatec-Cabano road is at 1,150 stratigraphic feet	685'	1,290'
2. Siltstone,–red, sandy, mostly massive	15'	1,305'
1. Sandstone,–gray, fine grained, impure, massive, cleaved; a few feet of red sandstone at the top. This unit is weathered	20'	1,325'
Concealed,–perhaps 75 stratigraphic feet to the base	75'	1,400'

Units 3 and 4 contain fossiliferous localities 58-230F. A thin-section of this limestone shows quartz sand (5%) averaging 0.07 mm. in diameter, brachiopod fragments (10%), calcite spar (25%), which is a cement, and calcisiltite pellets (60%) averaging 0.5 mm. in diameter. Many pellets contain quartz grains. Numerous pellets show plastic compaction, although many others are separated by a sparry cement 0.02 mm. thick. The rock is a sandy grumous limestone. The presence of broken brachiopods and the quartz content indicate a near shore, shallow water, agitated environment of deposition.

The uppermost 100 feet of the Robitaille Formation are not constant along strike. At Anse (The Cove) on Témiscouata lake, and on the eastern limit of the Squatec-Cabano syncline near fossil locality 58-F279, concretionary dolomites and red and green siltstones are found.

Also found at Anse are thin white beds and laminae of volcanic siltstones and crystal tuffs, which are composed of chert, illite, and albite. Much shearing has occurred at Anse, and this is seen also in thin-sections. Elsewhere, quartzites and volcanic sandstones are present, particularly in the La Résurrection area and along the road to Croche (Crooked) lake.

The middle part of the Robitaille section is characterized by the absence of quartzites (only the quartzite at the type section is known), and by the presence of red siltstones and sandstones, minor green siltstones and mudstones, limestones, and rare dolomite beds. Volcanic, water-sorted grains can at places be recognized in these strata, but are commonly not evident.

Red siltstones form perhaps one-half of this part of the formation, and red sandstones, one-quarter. The red siltstones are typically sandy, massive, and impure, and the sandstones are much the same except that their average grain size is fine. North of Saint-Jean river, the siltstones and sandstones are locally in thin beds, and the sandstone may be well sorted. Two such better sorted beds show in thin-section:-

Quartz and chert	72%	65%
Orthoclase and plagioclase	1%	3%
Mica		1%
Rock fragments		
volcanic	7%	2%
slate chips	4%	16%
Clay (chlorite and illite?)	6%	14%
Authigenic quartz	10%	

Grain size			
range	:	0.06-0.35 mm.	
average	:	0.2	most laminae are 0.06 mm. some are 0.03 or 0.1 mm.
Packing	:	2	1 contact per grain

The clay is red or greenish. The volcanic grains are felty, felsitic, or hyalo-ophitic. The sandstones are typical subgraywacke types.

Red beds appear to crop out much more readily in the bush than in green beds, which are known almost altogether from stream sections.

Limestone outcrops are ubiquitous, and seem to occur at the stratigraphic horizon assigned to them in the type section. Bush outcrops of limestone are commonly massive. Some of these outcrops are cleaved, others have abundant corals (north of Saint-Jean river), all are light gray weathering. Thin-bedded limestone is known only from Sutherland brook. Very rare, light green or greenish gray, commonly laminated, dolomite beds are found at approximately the middle of the Robitaille Formation. The laminated beds of dolomite have also laminae of dark green shale or mudstone, reminiscent of the laminated dolomite at Anse.

The lowermost 350 feet of the formation are well-exposed conglomerates, quartzites, and sandstones. Continuous sections through the 350 feet are unknown and the basal rock types do not appear to be everywhere the same. The 350-limit is the uppermost stratigraphic horizon of these quartzites and sandstones west of Sauvagesse lake. In general, this zone can be divided into two sequences, each about 175 feet thick. The lower is characterized by salt-and-pepper weathering sandstones and quartzites, whereas the upper is characterized by crossbedded quartzites and conglomerates.

The best exposures of the upper 175 feet are near La Résurrection and due west of Sauvagesse lake. The section at the latter locality complements the type section and is given below in descending order (it was measured by the pace-and-compass method, and the lowest exposed unit is on the range road):-

	Covered.		
6.	Siltstones, – red, impure, sandy	5'	5'
	Covered	175'	180'
5.	Sandstone,– dark red, impure, fine grained	5'	185'
4.	Covered. As unit 2	35'	220'
3.	Quartzite,– dark red to gray coarse to medium grained, crossbedded and laminated. The lowermost 8 feet are conglomeratic quartzites, with 5% pebbles. The quartzites become progressively finer grained up-section	20'	240'
2.	Covered. 50 feet farther along strike, crossbedded quartzites are found, similar to those of unit 3	50'	290'

1. Conglomerate. The average size of the clasts is pebble-size, but clasts up to 3 inches occur. Some beds have 40% pebbles, others only 2 or 3%. The matrix of the conglomerates is very coarse sand and granules of quartz. The conglomerate clasts are mostly felsite (green with some gray) and abundant gray quartzite	8'	298'
Covered. Probable thickness missing to the base of the formation is	177'	475'

There is a complete gradation from conglomerates, through quartzites, through sandstones, into the red sandy siltstones which form the bulk of the upper two-thirds of the Robitaille Formation.

(The following description of the upper half of the lower 350 feet of the Robitaille Formation is general and does not apply to a particular section.)

The conglomerates form a minor part of the 175 feet, and quartzites are more abundant than sandstones. The colors of the conglomerates are, in order of abundance: light gray, red, white, and dark green. The quartzites range from dark red to white, although there are light gray, light green to green, and even yellow, quartzites.

The conglomerates range from pebble to granule size and the clasts are, in order of abundance: quartzite, quartz, felsite lava fragments, and red jasper-like clasts which are probably volcanic siltstones. Felsite clasts are rare, although locally they may be abundant particularly in the Sauvagesse Lake area. Jasper-like clasts form less than 1% of some individual outcrops. Conglomeratic quartzites are also present locally, and many are granule-bearing.

The quartzites in the upper sequence are commonly medium or coarse grained. A few outcrops in the La Résurrection area show two sets of thin red and white layers, which cut each other. One set is bedding, but the second set is probably due to ground water solution and oxidation. The sandstones are typically well sorted, crossbedded, and fine-grained, although locally they are impure.

The conglomerates are thickly bedded, or massive. The quartzite and sandstone beds are 1 foot to 3 feet thick, but these beds are themselves laminated very thinly, and crossbedded or torrentially bedded. Two thin-sections from this upper 175-foot sequence show:-

Field Name		Fine-grained quartzite	Impure, fine-grained sandstone
Quartz		89%	60%
Orthoclase		0.5%	less than 1%
Plagioclase, An 0		2.5%	
Untwinned plagioclase ...			16%
Volcanic clasts	less than	1%	1%
Calcite clasts			8%
Clay		6%	15% (red)
Authigenic quartz	less than	1%	
Grain size			
average		0.3 mm.	
80% is			0.3 mm.
20% is			0.02 mm.
Roundness		?	subangular
Packing	5 contacts/grain		unpacked
Name	orthoquartzite		graywacke (?)

In the lower part of the 175-foot sequence, the lowermost strata are dark gray, impure, massive sandstones, which crop out best along the Squatec-Cabano road, west of Anna lake, and along the road 2 miles north-northeast of La Résurrection. Locally these sandstones are light gray, laminated, thinly bedded, or well sorted. Rare, coarse-grained, impure sandstone beds are also found, and these may show feldspar or volcanic sand fragments. The grain size of the sandstones increases up-section, and the uppermost strata known are dark gray and black, medium-grained, massive quartzites, which occur on the northern nose of the Squatec-Cabano syncline. The quartzites are associated with sandstones locally, and the uppermost quartzites exposed nearby are red, in part conglomeratic (fine pebbles), or laminated. A total thickness of 35 feet of these quartzites was seen. The quartzites and sandstones are "salt-and-pepper" weathering, with spheric, brown iron oxide blebs 1/8 inch and smaller in diameter. The origin of the blebs is not clear.

At certain localities, a few thin beds of medium-grained, well sorted, light bluish green, "salt-and-pepper" weathering quartzites are associated with the dark gray sandstones, or appear to replace them. Also, a minor part (perhaps less than 25 feet thick) of the lowermost 175 feet of the Robitaille Formation is composed of red impure siltstones and sandstones. These red beds have been found at and near the type section and to the southwest. The red siltstones and sandstones underlie for the most part the dark gray quartzites. Three thin-sections of the basal dark gray sandstones contain:-

Quartz	95%	64%	35%
Orthoclase		1%	
Plagioclase	1%	5%	40%
Volcanic clasts	1%	23%	
Clay	3%	3%	22%
Apatite, tourmaline	tr		
Organic matter (?)		3%	
Zircon	less than	1%	
Ores, chlorite clasts			3%
Grain boundaries	interpenetrated	interpenetrated	sharp
Average grain size	0.25	0.1	0.4 mm.
Packing (contacts/grain)	5	3	1
Name	Orthoquartzite	Subgraywacke	Feldspathic graywacke

Where the grain boundaries can be distinguished, they range from subrounded to rounded.

The following section was measured by pace-and-compass methods, due west and north of west of the serpentinite intrusion, on the east limb of the Squatec-Cabano syncline:-

		Thickness	
	Concealed.		
3.	Quartzites,—fine to coarse grained, laminated to thickly bedded and crossbedded, in places massive. The color ranges from dark red to reddish white, and many beds are light greenish gray, light olive-green, or light gray. Well sorted. Approximately one-third of this unit crops out	275'	275'
	Concealed	5'	280'
2.	Sandstone,—dark gray, impure, medium grained.	15'	295'
	Concealed	60'	355'
1.	Sandstone,—dark gray, massive, fine grained .	5'	360'
	Concealed.		

Unit 1 is 300 feet due west of the serpentinite outcrop. Units 1 and 2 are assigned to the basal 175 feet of the formation. The rocks of unit 3 are typical orthoquartzites in thin-section. The above section is noteworthy in that conglomerates are absent, the quartzites are thicker than usual, and no "salt-and-pepper" weathering was seen, although the rocks are otherwise similar to other basal types.

The characteristic basal rock types are not exposed north of Saint-Jean river, and the lowermost exposed stratum there (in the ditch along the range road) is a dark gray, argillaceous, slightly silty limestone. This limestone has numerous ostracods (fossil locality 58-650).

The strata along Sauvagesse brook do not fall readily into the above divisions of the Robitaille Formation. The lowermost exposed units are red siltstone, and they are followed by quartzites and granule conglomerates, some of which are light bluish green and "salt-and-pepper" weathering.

Transition between the Robitaille and Asselin Formations

Strata found between the Pointe aux Trembles and the Mont Wissick formations in the Cabano area and in the Squatec East area are dissimilar. The strata to the northeast (Squatec East) are mostly sandstones, and have a high content of volcanic clasts, whereas the strata to the southwest are predominantly red siltstones. An outcrop a few miles southeast of Pain-de-Sucre lake is red conglomeratic sandstone and gray crossbedded quartzite, whereas a group of outcrops 2 miles southwest is composed of volcanic sandstones and volcanic granule conglomerates. These two groups of outcrops are assigned respectively to the Robitaille and the Asselin formations. The facies boundary between these two formations is arbitrarily drawn between these groups of outcrop. The main points of dissimilarity between the Asselin and the Robitaille formations are:- a) the absence of red beds in the Asselin, b) the predominant silt size in the Robitaille, and c) the greater abundance of water-sorted, volcanic material in the Asselin.

Asselin Formation

The Asselin Formation crops out poorly. Near Auclair lake it has a high content of lime in the form of cement for the arenites and as limestone beds. The high solubility of calcite cement under surficial weathering, and the consequent disintegration of the arenites, is probably the reason why the Asselin Formation is found in valley bottoms. The few outcrops on valley sides have a silica cement in the basal part of the formation, and a lime and silica cement in the upper part. The outcrops near the upper part of Touladi river that flows into Biencourt lake have no lime, but break typically into loose angular blocks. These two areas of outcrop are treated separately below.

A- Area southwest of the upper part of Touladi river that flows into Biencourt lake.

I- Upper 300 feet

The upper 300 feet of the Asselin Formation southwest of the upper part of the Touladi river that flows into Biencourt lake are composed of impure siltstones and sandstones. These strata can be separated from the Mont Wissick Formation by their lack of fossils and calcite. On eastern Boucle road the lower part of this 300 feet is interbedded with the underlying strata.

The sandstones and siltstones are massive, impure, and range from gray to dark gray, with local laminae of light gray sandstone. The sandstones are commonly fine grained, and only rarely are light green or greenish gray medium-grained beds present. The impure sandstones appear to grade into the siltstones, making the recognition of very fine-grained impure sandstone beds difficult. Three thin-sections of these sandstones have the following mineralogic composition (mode):-

Color	light green	greenish gray	gray
Quartz	35%	67%	32%
Plagioclase	1%	2%	1%
Biotite	0.25%		1%
Muscovite	0.75%	1%	
Chlorite clasts	1%	1%	1%
"Augite"	tr		tr
Volcanic	52%	10%	45%
Clay	10%	20%	20%
Grain size			
range:	0.08-0.75	0.02-1.4	0.02-0.2 mm.
average:	0.15	0.3	0.08 mm.
Grain boundaries	slightly eaten	eaten	eaten
Packing	not touching	0 to 4	not touching
Name	Semi-volcanic arenite	Graywacke	Volcanic graywacke

II-Lower 1,000 feet

No complete section of the lower 1,000 feet is known, and persistent stratigraphic horizons appear to be absent. The best exposures are in the bush, near the southeastern end of Boucle road.

The lowermost 1,000 feet are sandstones which range from green to gray, and locally are light colored. The grains are a mixture of fine sand to rare 1-inch conglomerate clasts. Some of the sandstones are better sorted. The average grain size ranges from coarse sand to granules, although locally medium- or fine-grained sandstones are present, particularly in the upper 300 feet. Many beds are conglomeratic, with abundant granules. The clasts in these are quartz and water-worn volcanic fragments. The volcanic fragments are exclusively felsites which are commonly light gray, although dark gray, light green, and red ones are also found. Bluish gray quartzites form a few outcrops, and their color is due to a chert cement (as determined in thin-section). Some beds are composed entirely of felsite fragments, and others entirely of quartz; there is a complete gradation between the two.

The bedding in the sandstones is commonly indistinct, although some have thin beds, crossbeds, or laminae, which are particularly abundant within and immediately below the upper 300 feet of the formation.

Four thin-sections of these sandstones show the variation in volcanic fragments:-

		(average of 2)	
Quartz	85%	50.5%	2%
Plagioclase	less than 1%	6%	8%
Microcline		tr	
Biotite		less than 1%	
Clinopyroxene	tr	tr	
Chlorite clasts	tr	tr	
Zircon	tr	tr	
Volcanic clasts	5%	32.5%	76%
Clay	8%	2.5%	
Chlorite cement		2.5%	2%
Chert cement		0.5%	10%
Chert or quartz veinlets	1%		
Secondary calcite		4%	
Grain size			
range :	0.1-3.5	0.05-1.8	0.2-3.5 mm.
average :	1.0	one 0.15 one 0.8	1.0
% conglomerate clasts :	15		10
Grain boundaries :	interpenetrated	eaten to sharp	sharp
Roundness :	rounded where seen	rounded	rounded to subangular
Name	<u>Protoquartzite</u>	<u>Semi-volcanic arenite</u>	<u>Volcanic arenite</u>

Most volcanic grains are felsitic, although trachytic or hyalo-ophitic grains are also found. Most of the volcanic grains are brownish.

B- <u>Auclair Lake area</u>

The upper 300 feet of siltstone and sandstone found farther northeast are absent from the Auclair Lake area, and the total 1,300 feet appears to be predominantly composed of limy sandstones and granule conglomerates. Whereas near the upper part of Touladi river that flows into Biencourt lake the sandstones are not limy, some of the rocks in the Auclair Lake area have a lime content up to 25%. The lime content is generally high (10-15%), the bedding is commonly thin, crossbedding is rare, and the rocks are commonly light gray, although gray and green beds are found. The clasts of the rocks have the same composition and same size range as the sandstones farther northeast, although medium- and coarse-grained beds are perhaps more abundant in the Auclair Lake area. Collectively, the rocks are limy volcanic sandstones, conglomerates, and limy sandstones and conglomerates. Two small outcrops of gray, finely crystalline limestone, and another two small outcrops of laminated, limy and dolomitic, very fine-grained sandstone were noted. A few other beds near the base of the formation are dolomitic.

La Résurrection Formation

A sequence about 2,000 feet thick, overlying the Robitaille Formation near La Résurrection and consisting of a monotonous succession of green to gray, massive, volcanic sandstones and siltstones, with some 100 feet of orthoquartzite at the top, is here named the La Résurrection Formation.

Age

No fossils were found in this formation but, as it overlies the Lower Robitaille (Lower Ludlow), and as it has some volcanic deposits in common with the Lower Mont Wissick south of Touladi lake, it is probable that the La Résurrection is Lower Ludlow.

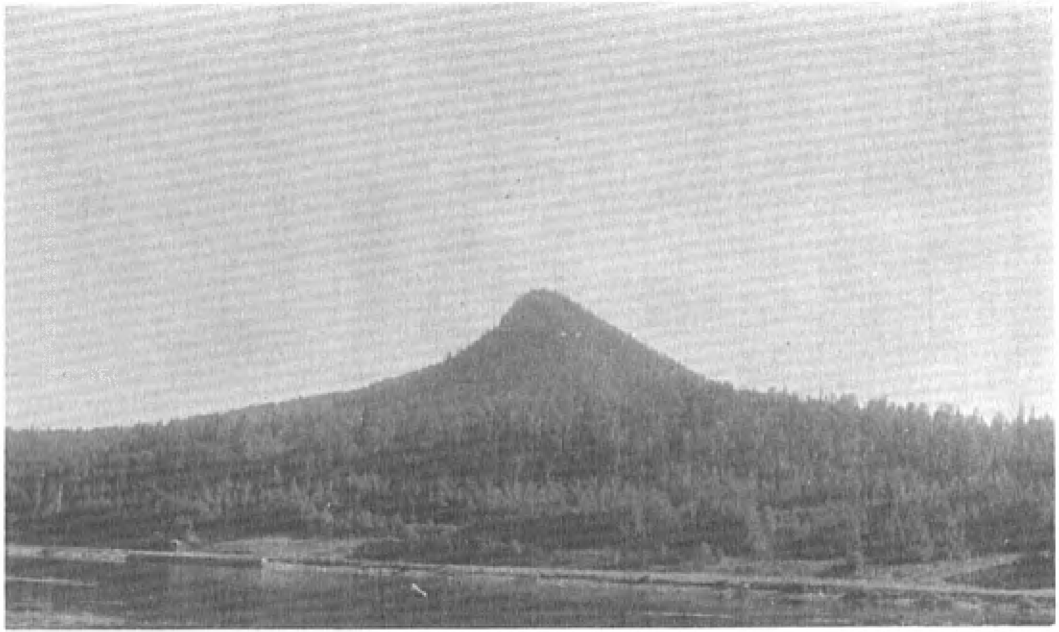
Petrography

Sandstone, the most abundant rock type, is commonly fine grained but ranges from very fine to coarse. It appears "dirty" because it contains white-weathering volcanic fragments. Bedding, which is rare, is most evident where siltstone or the occasional green to gray slate is present.

Three thin-sections of these sandstones have the following modes:

Color	gray	greenish gray	green-gray
Quartz	5%	40%	25%
Microcline			tr.
Plagioclase		3%	3%
Biotite	1%	tr.	tr.
Muscovite	tr.		tr.
"Augite"		tr.	
Chlorite clasts	1%	2%	1%
Ores		5%	
Zircon, apatite	tr.		
Zircon, tourmaline			tr.
Rock fragments			
volcanic	85%	37%	25%
siltstone		2%	34%
slate	3%	3%	1%
Clay	5%		10%
Chlorite cement		8%	
Chalcedony cement			tr.

Plate I

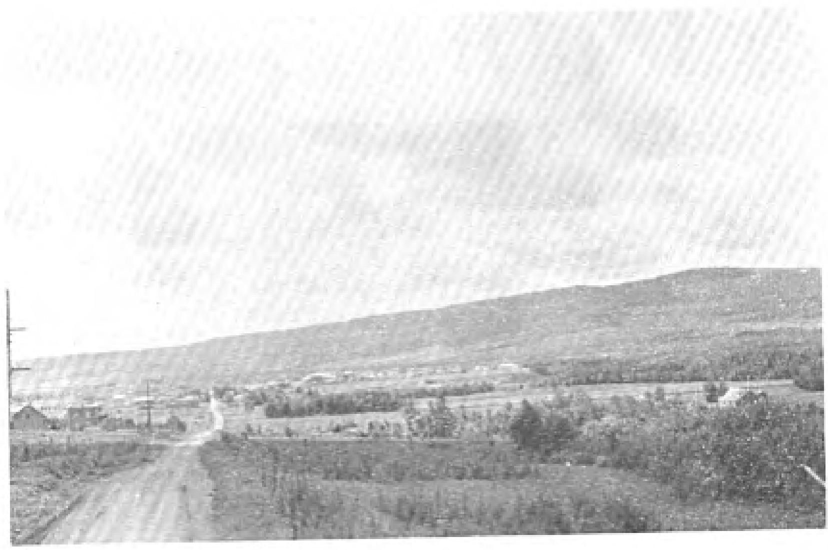


Pain-de-Sucre (Squatec) peak. The asymmetric peak is due to the Pointe aux Trembles strata dipping to the right of the photograph. Pain-de-Sucre lake in foreground.

Erosion-weak and erosion-resistant Silurian strata in the Squatec East area. Looking south from the Biencourt fire tower. Auclair lake in left background.

Plate II

Plate III



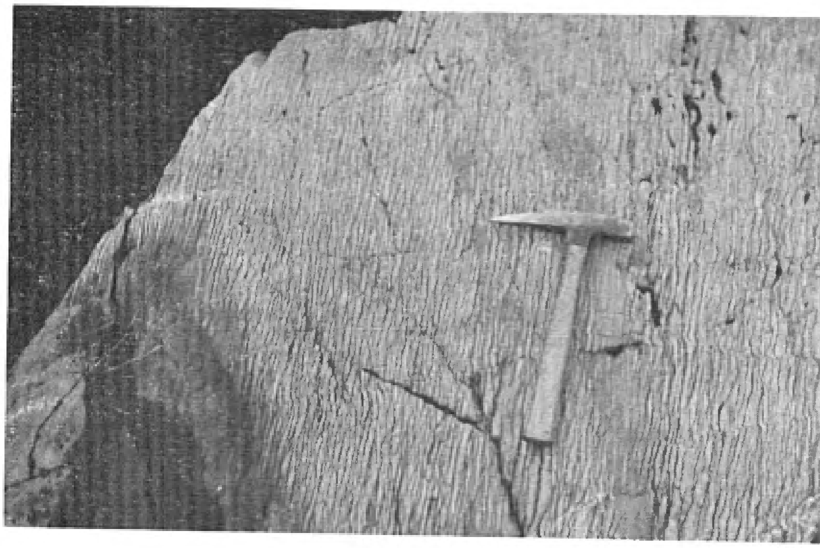
A — Highest point of the Squatec-Cabano syncline, with the village of Saint-Michel-de-Squatec to the left of the photo. Touladi river in valley. Looking southwest.

B — Sept Lakes, showing subdued topography near the water divide. Looking east-southeast.

Plate IV

BEDDING

CLEAVAGE



A — Cleaved quartzite of unit 1A, on Sload lake. Note crinkled cleavage (parallel to hammer handle), and bedding (dark zones) cut by this cleavage.

B — Interbedded slates, dolomitic siltstones, and siltstone of unit 1C, showing the crenulation and the shallow northward plunge of the axial lines of these crenulations. (Lot 40, Range A Lac Témiscouata, Madawaska Seigniory).

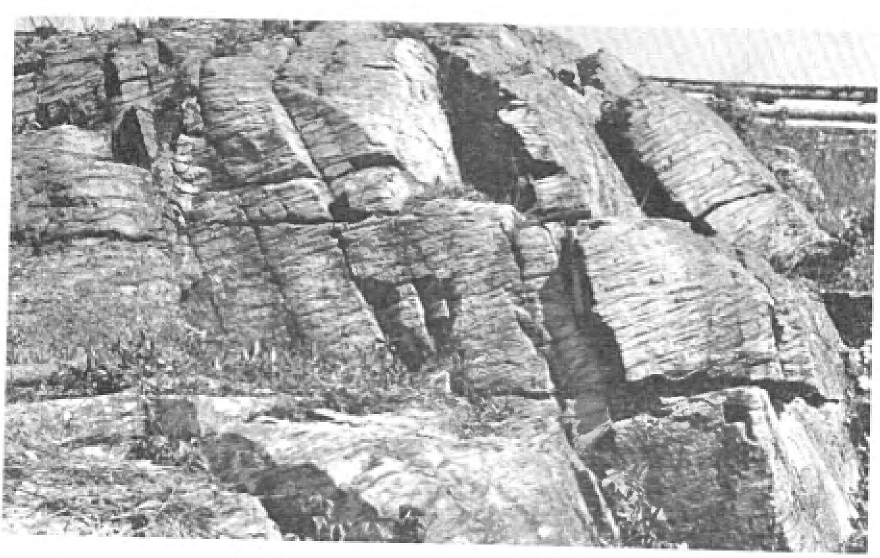
Plate V

A — Limestone conglomerate of unit 1E, northeast of La Société. View of a bedding plane. (Lot 25, Range VIII, Bégon township).

B — Graded bedding and partly exposed channel structure in a very fine-grained conglomerate of unit 1F, underlain by quartzite. Notice quartz veins. (Lot 33, Range III, Raudot township).

Plate VI

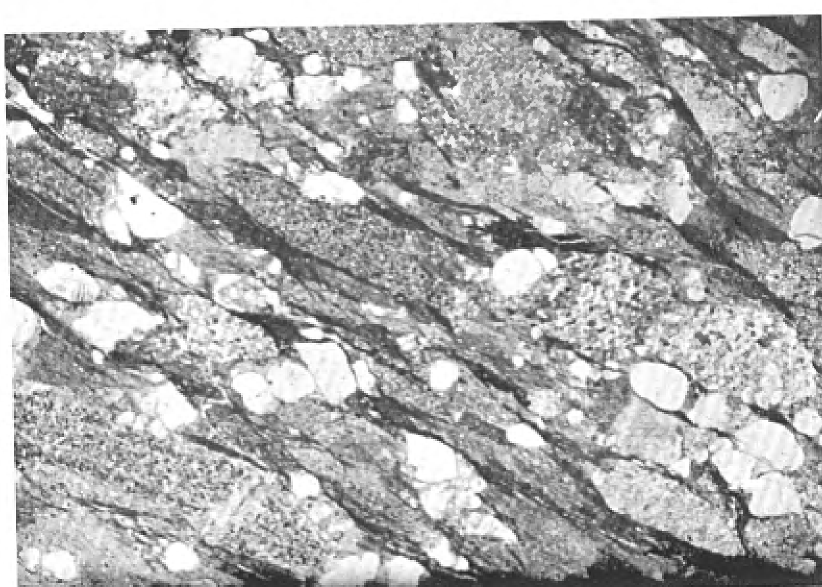
A — Interbedded slates and siltstones of unit 1F. The siltstones stand in relief. Hammer handle parallel to cleavage. (Lot 33, Range IV, Raudot township).



B — Cleaved, massive sandstone of unit 1G. (Lot 45, Range V, Raudot township).

Plate VII

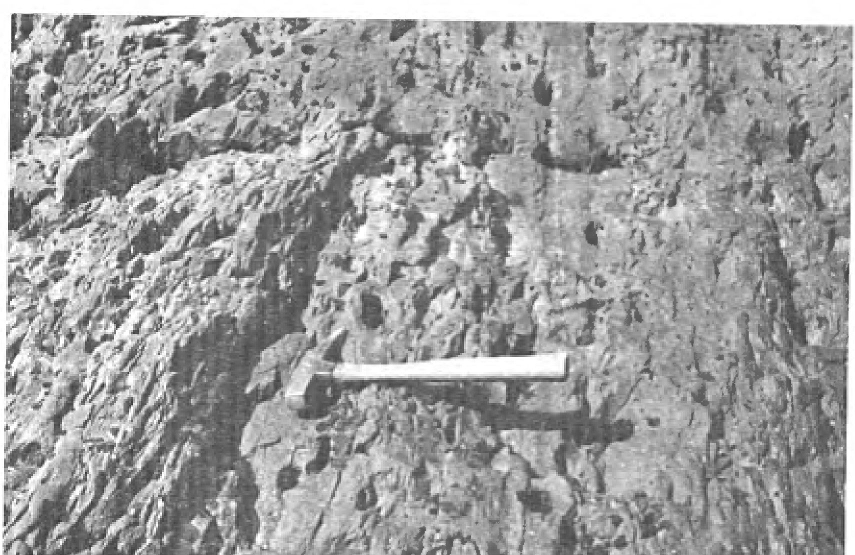
A — Detail of Plate V-B.



B — Photomicrograph of the semischist texture in a sandstone of the Cabano Formation. Notice abundance of siltstone clasts (Diameters magnified approximately 15 times; plain light).

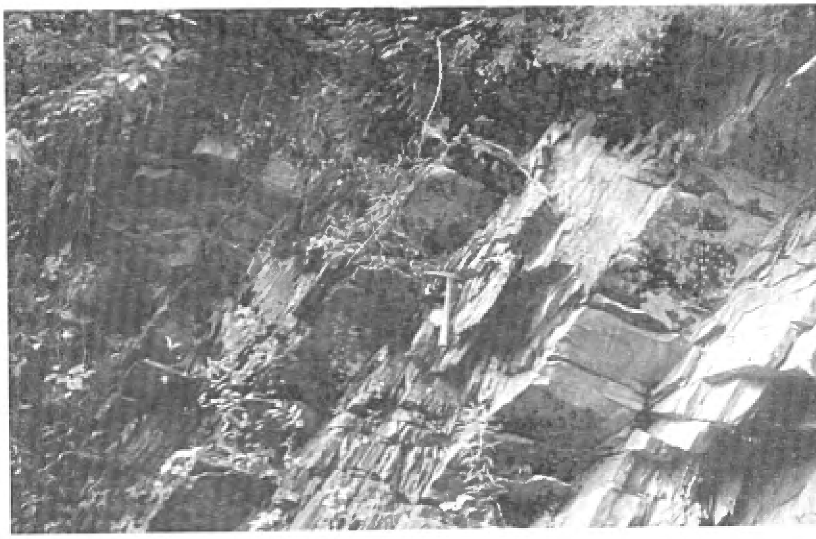
Plate VIII

A — Massive and cleaved siltstone of the lower Mont Wissick, unit 36, Sutherland brook.

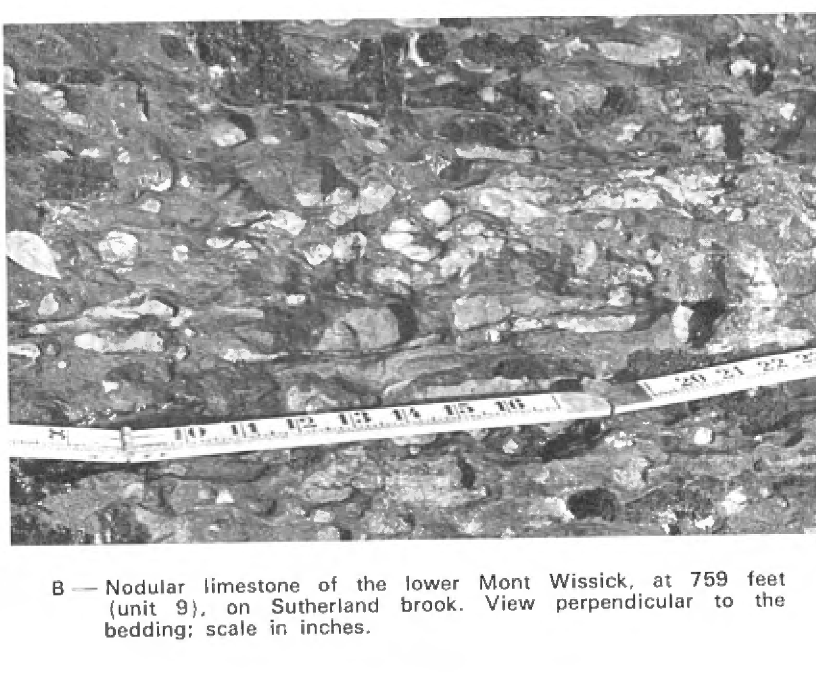


B — Concretionary siltstone of the lower Mont Wissick, unit 33, Sutherland brook.

Plate IX

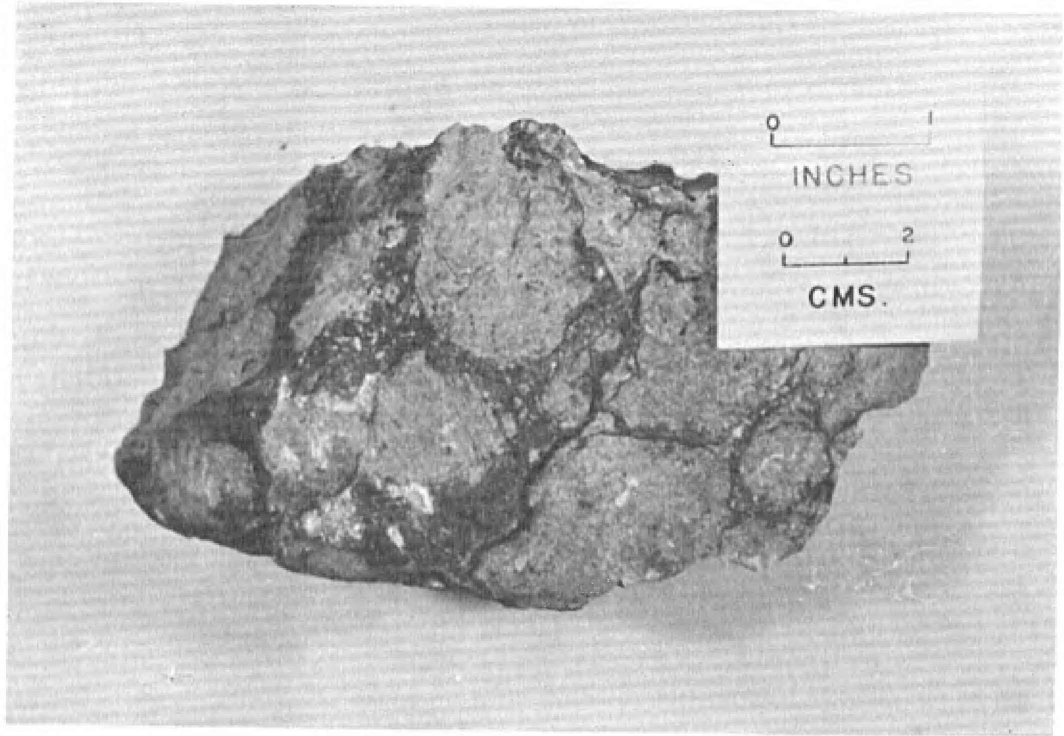


A — Sandstone and siltstone of the lower Mont Wissick, unit 31, Sutherland brook. Note the two joint systems, cleavage, and bedding.



B — Nodular limestone of the lower Mont Wissick, at 759 feet (unit 9), on Sutherland brook. View perpendicular to the bedding; scale in inches.

Plate X



Nodular limestone, view parallel to the bedding. Dark areas are limy, very fine-grained sandstone. The concretions are very finely crystalline limestone, with 25% organic clasts up to 2 mm. Sample from Lac Croche Member of the Mont Wissick Formation, Squatec East area.

Plate XI

A — Nodular limestone of the lower Mont Wissick, west of Sauvagesse lake. The concretions are silty limestone, and the remainder is yellow-brown silt and clay. View perpendicular to the bedding. (Lot 17, Range II, Robitaille township).

B — View parallel to the bedding of a Mont Wissick biostromal limestone, with abundant stromatoporoids, apparently in growth position. (Lot 16, Range II, Robitaille township).

Plate XII

Railroad cut in basal Cabaño conglomerate 1½ miles southeast of Cabano. Tops to right (east).

Grain size			
range :	0.05-0.5	0.02-2.8	0.1-0.6 mm.
average :	0.1	0.5	0.3 mm.
Grain boundaries:	interpenetrated and eaten	interpenetrated and eaten	interpenetrated
Name	Volcanic arenite	Semi-volcanic arenite	Semi-lithic arenite

The uppermost 100 feet of the formation are quartzites, which range from medium-grained (sand) to granule conglomerates. Granule conglomerates are rare, and coarse-grained sand-size quartzites are by far the most common. These quartzites range from light gray to red, and rare beds are light green. They are crossbedded in part, and generally thinly bedded or laminated. Only two outcrops of these quartzites are known, in contact with a fault to the east.

Mont Wissick Formation and Lac Croche Member

Name

Bailey and McInnes (1889, p. 35) first used the term "Mt. Wissick beds", and later McGerrigle (1934) used "Mt. Wissick group". No type section was designated by these writers, but it appears evident that Mont Wissick was the type area. However, this is a relatively poor type area, and Sutherland brook is suggested as an additional reference section.

Logan (1863) and Kindle (1914) in reference to the hill itself used "Mount Wissick", the French edition of McGerrigle's report used "mont Wissic", and the preliminary report on the Squatec West area (Lespérance, 1959) used "Mont Wissick" in the text, "Mount Wissick formation" and "formation du Mont Wissick" on the enclosed map. In order to standardize the spelling for stratigraphic use, "Mont Wissick" is suggested.

The Lac Croche Member is here defined as the middle part of the Mont Wissick Formation, and its type area is Croche lake in the Squatec-Cabano syncline. No type section can be suggested, but the best outcrops are on the shore of Croche lake and the brook discharging from the lake.

Age

Fossils identified by Boucot, are the following, the age being Lower Ludlow:-

Table 4

Fossils of the Mont Wissick Formation

	G-53	G-59	L-61	G-64	G-65	G-66;G-173	G-67	L-86	G-94	58-1	58-23	58-38	58-41A	58-41B	58-42A	58-54	58-56	58-77	58-126A	58-137	58-233	58-279	58-303	58-315	58-332	58-334	58-338	58-339B	58-392	58-402	58-423	58-613	58-615A	58-635	59-H22	59-112	59-151	59-153	59-211	59-H507	59-625	59-627	59-H628	59-645	59-646
Atrypa reticularis	X		X	X	X		X				X	X				X					X	X									X	X				X									
A. "r." -C-														X																													X		
Chonetes sp.																																												X	
"C." sp.		X	X	X						X		X		X	X				X							X					X														
"C." jerseyensis (C)																																					X								
"C." aff. j. (C)																																									X				
Sphaerirhynchia sp.		X								X		X		X	X	X						X								X															
"S." sp. (C)																																											X		
Shaleria ? sp.		X												X																															
Protathyris sp. -C-			X												X									X	X	X	X	X														X			
P. ? sp. -C-										X							X									X			X					X											
Howellella sp. -C-			X	X	X									X																											X			X	
H. ? sp. -C-										X									X							X						X													
Camarotoechia ? sp.				X																																									
"C." sp. -C-																																							X			X			
Strophonella cf. funiculata					X									X																															
Hyattidina? sp.						X												X																											
Leptostrophia sp.							X																																						
Conchidium cf. knighti									X				X																																
C. ? sp., not C.k. but has bifurcating ribs																																								X					
Resserella sp.											X									X																									
R. ? sp.																X																	X												
Cyrtia sp.											X																																		
Gypidula or Sieberella sp.											X											X																							
S. sp. (C)																																							X				X		
Leptaena rhomboidalis														X																															
Mesopholidostrophia sp.														X																															
Merista ? sp.															X																														
Dolerorthis ? sp. -C-															X				X																		X								
D. aff. D. rustica (C)																																							X				X		
Isorthis sp.																							X																						
I. ? sp.																				X													X												
Mesodouvillina sp. (C)																																									X				
M. ? sp. -C-																																					X							X	
Delthyris sp. (C)																																											X		
Meristina ? sp. (C)																																											X		
Salopina sp.														X																															
Oriostoma sp.														X																															
O. ? sp.	X																																												
Platyceras sp.								X																																					
Euomphalopterus sp. (C)																										X																			
Leperditia sp. -C-																										X		X														X			
Calymene sp.																				X																									
unidentified dalmanellid																																				X									
unidentified strophomenoid								X																																					
unidentified spiriferoid																																								X					
orthotetacid (C)																																					X								
pterinoid (C)																																									X				
rhynconellid (C)																																					X								
trilobites																																					X		X		X		X		
Fragments																																			X										
Halysites																						X																X							X

(C) : Restricted to the Lac Croche Member

-C- : Found both in the Lac Croche Member and the remainder of the Mont Wissick Formation

Corals from the Squatec East area, identified by Oliver, are the following:-

Table 5

Fossil Corals of the Mont Wissick Formation

Fossil	58-F1	58-23	58-41A	58-41B	58-F52	58-F54	58-F233	58-F279	58-F300	58-318	58-335	58-392	58-615A	58-675	58-724
Favosites helderbergiae praecedens			X	X	X										
F. sp. aff. F. h. p. -C-	X		X	X					X		X				
F. sp. cf F. hisingeri	X				X										X
F. sp. cf. F. occidentalis -C-					X							X			
F. sp. cf. F. favosus			X												
F. sp. 6 (ramose)					X										
F. sp. 6 ?							X								
F. sp.			X		X		X		X					X	
F. ? sp.													X		
Paleofavosites sp.	X		X							X					
P. sp. 5		X	X	X	X									X	
P. sp. 5?								X							
Halysites sp. -C-							X		X						
H. sp. cf. H. nitida								X							
Cystihalysites amplitubulata														X	
C. ? sp.													X		
Clavidictyon ? sp.						X									
Phaulactis quebecensis			X		X									X	
P. ? sp.									X						
Tryplasma nordica			X		X				X					X	
T. ? sp.										X					
Alveolites sp.									X						
Cladopora sp. 1 -C-			X	X	X				X	X				X	
Syringopora sp. 1			X		X										
S. ? sp. (C)											X				
Clathrodictyon sp.			X												
"Cyathophyllum" sp. 1					X										
"C". sp. 2					X										
Heliolites 2 sp.													X		
Plasmopora petaliformis														X	
Ferrostromatopora sp.					X										
Holmophyllum sp.					X										
Entelophyllum sp.					X										
Columnaria ? coralliferum (C)										X					
cyathophylloid horn coral	X		X			X									
ramose favositoid coral	X														
phaceloid ? rugose coral					X		X								
horn coral					X		X		X						
auloporoid coral				X					X						
cerioid rugose coral					X										
stromatoporoid coral -C-					X					X					
Girvanella sp. -C- (x)		Found here and there													
Hedstromia sp. (x)		Found at The Cove													

(x) : identified by the writer

(C) : restricted to the Lac Croche Member

-C- : occurring both in the Lac Croche Member and the remainder of the Mont Wissick Formation.

Collections 58-41A, 58-41B, and 58-F-52 are on strike with one another.

The above fauna would seem to indicate a Niagaran or Cayugan age, when compared with the Bay of Chaleurs faunas, or a Late (in the American sense) Silurian age,when compared with the Cobleskill, Keyser, or Decker Ferry formations.

Thickness

The thickness of the Mont Wissick Formation in the Squatec-Cabano syncline is 4,700 feet, of which the upper 1,200 feet belong to the Lac Croche Member. The uppermost strata in the Squatec-Cabano syncline (unit 9 of the Lac Croche Member) may be thicker than here interpreted. The thickness of unit 9 must be estimated from meager structural information, in an area of low dips (on the axis of the syncline) and with relief of 400 feet. It is possible that unit 9 is 300 feet thicker than the 700 feet here assigned to it. The sequence of Mont Wissick strata to the east of Sauvagesse lake has a possible thickness of 6,000 feet, if the sequence is homoclinal. The structural improbability of an isoclinal syncline east of Sauvagesse lake makes it reasonable to assume that this sequence is homoclinal. If such is the case, 1,300 feet of strata overlie the Lac Croche Member. On the basis of few outcrops, the Lac Croche Member appears to be 1,200 feet thick here also, and a further, upper, 1,300 feet is known only from the homocline east of Sauvagesse lake.

In the Squatec East area, the Lac Croche Member is also 1,200 feet thick, but it thins toward the northeast to a feather edge, owing to pre-Témiscouata erosion. The lower part of the Mont Wissick Formation is 1,500 feet thick in the southwest corner of the Squatec East area, but thickens northeastward to 2,700 feet between Pain-de-Sucre lake and Auclair lake, and thins to 800 feet near the upper part of Touladi river that flows into Biencourt lake. The thinning near the upper part of Touladi river that flows into Biencourt lake is partly due to pre-Témiscouata erosion. The boundaries of the lower Mont Wissick have been drawn to exclude rock types typical of underlying or overlying formations.

The Mont Wissick Formation southwest of Touladi lake contains tuffs and volcanic conglomerates and sandstones which can be mapped as volcanic lenses. This volcanic material indicates near shore deposition. Near shore deposition and pre-Témiscouata Formation erosion are responsible for the variation in thickness of the formation. The Mont Wissick Formation thins to a feather edge at its southwestern end owing to erosion, attains 1,200 feet, decreases to 800 feet in a tuff-bearing area, and thickens finally to 2,700 feet.

Stratigraphy and Petrography

Upper Mont Wissick

The uppermost 100 feet of the upper Mont Wissick are exposed near the Témiscouata – Petit Biencourt Lakes fault, near fossil locality 58-137. The uppermost strata exposed are light gray to dark gray, thickly bedded, fine- to medium-grained quartzites about 35 feet thick. Fifty stratigraphic feet west of the quartzites, a few feet of massive red siltstone crop out.

The remainder of the upper Mont Wissick is composed mostly of gray, green weathering, massive, limy siltstones. Rarely are the siltstones laminated or not limy. A few beds of gray, dolomitic, very fine-grained, laminated to thinly bedded sandstone are found, particularly in the middle part of the upper Mont Wissick.

Lac Croche Member (middle Mont Wissick)

The following is a generalized section of the Lac Croche Member, in the Squatec-Cabano syncline. The measurements have been obtained graphically and from pace-and-compass data. The separation into units is made easy by the existence of distinctive rock types which can be found on adjacent traverses. The section is in descending order:-

	Thickness	
9. Limestone, nodular limestone, and sandstone. The limestones are gray, and range from pure to silty and/or argillaceous. Most of the outcrops are nodular and massive, although rare nodular limestones may be laminated; the remainder of the limestones are massive to laminated. The limestones range from finely crystalline to (rarely) coarsely crystalline (clastic?) and all appear to be slightly dolomitized. Rare gray, thinly bedded to laminated, very fine-grained, dolomitic sandstones crop out near the base of this unit	700'	700'
8. Dolomite, dolomitic sandstone, dolomitic limestone, and limestone. The dolomites form the major part of this unit, and are red, yellow, light green, light gray, dense, finely crystalline, pure to sandy, poorly bedded to poorly laminated. The red is local, and is probably surficial. Dolomitic sandstone and dolomitic limestone, very thinly bedded and laminated, grade into the dolomites. The dolomites are interbedded with coarsely crystalline, pure, gray, massive limestones. Stylolites are abundant ..	50'	750'

		Thickness	
7.	Sandstone and dolomite. Massive to laminated, light gray, medium-grained, dolomitic sandstone forms the base of this unit. Massive sandy dolomites overlie the sandstones, and the dolomites are light bluish gray, weathering violet, or are very light gray and weather red	50'	800'
6.	Sandstone, red-violet, medium grained, very dolomitic, massive	50'	850'
5.	Sandstone, light gray, fine to coarse grained, dolomitic, locally limy, in beds up to 2 feet	35'	885'
4.	Limestone and nodular limestone. The limestones are gray, argillaceous to silty, finely crystalline, laminated to thinly bedded. The nodular type is the more abundant	25'	910'
3.	Limestone, sandstone, and dolomite. Gray and light gray, poorly bedded, stylolitic, dense, pure, commonly biostromal, coarsely crystalline limestones form the lower part of this unit. A few beds of pure or limy, light gray, dense dolomite crop out within these limestones. The limestones appear to grade upward into gray, coarse-grained, poorly bedded and massive clastic limestones, and, in turn, the clastic limestones grade upward into fine- to coarse-grained sandstones. The sandstones are generally massive, although crossbedding has been found. Some of the sandstones are limy, others are very limy or dolomitic. The color of the sandstones ranges from gray to light gray, and yellow brown. Biostromal limestone is the more abundant rock type in this unit ...	150'	1,060'
2.	Limestone, nodular limestone, sandstone, and siltstone. Poorly laminated to massive, argillaceous to pure, finely crystalline gray limestone and nodular limestone. A few thin beds of gray, limy, laminated, very fine-grained sandstone and siltstone	40'	1,100'
1.	Sandstone, light gray, fine to coarse grained, dolomitic, in beds of 1-2 feet	100'	1,200'

From the northern end of the bay at the north end of Croche lake, where limestone analyses F310 (see below) are based, the various rock types are best exposed as follows:-

a) unit 8: 4,200 feet north-northeast

b) unit 6: 4,500 feet south-southwest, along the brook

c) unit 5: 4,100 feet north, along the brook

d) unit 3: upper sandstones: 8,200 feet north-northeast; middle clastic limestones: 10,700 feet north-northeast;

lower biostromal limestones: 7,500 feet north-northeast

e) unit 2: 7,700 feet northeast

f) unit 1: 11,100 feet southwest

Unit 9 is best exposed between the two arms of Croche lake, unit 7 at the southwest end of the lake, and unit 4 on the lake itself, at the outcrop from which limestone analysis 315 was taken.

Thus, the Lac Croche Member is characterized by light gray, fine- to coarse-grained, dolomitic sandstones, varicolored dolomites, and clastic limestones, in addition to a great thickness of gray limestones, some of which are laminated, thinly bedded, or nodular. Light gray limestones with a high content of sparry calcite is partly recrystallized fossil material, most of which is coralline. Some specimens are wholly composed of fossils and unit 3 has a large content of these biostromal limestones.

Five partial chemical analyses have been made of gray limestones cropping out on the shore of Croche lake, as follows:-

Sample	F310-A %	F310-B %	315 %	318 %	321 %
FeO	0.03	0.03	0.31	1.01	0.26
Fe_2O_3	0.48	0.30	0.53	0.71	0.62
SiO_2	3.17	3.50	10.83	25.97	10.66
CaO	51.00	52.16	45.41	29.62	46.20
MgO	2.08	1.00	2.06	5.94	1.54
Al_2O_3	0.34	0.24	2.07	4.84	1.76
CO_2	42.68	42.43	37.81	28.45	37.08
Unit	9	9	4	9	9
Rock name (field)	coralline limestone	coralline limestone	laminated limestone	nodular limestone	nodular limestone

The nodular limestones of the Lac Croche Member will be described with the nodular limestones of the Mont Wissick Formation.

Two thin-sections from analyzed limestones, and a third from a crinoidal limestone of unit 2 contain:-

Sample	F310A %	315 %	unit 2 %	
Quartz	1	8	2	
Muscovite	tr	1		
Rock fragments				
corals	60			
calcite	15	7	30	(most with calcilutite rims)
pellets		73	50	
Clay	1	2		
Calcilutite	19		13	(matrix)
Calcite spar		7		(authigenic, i.e., cement)
Dolomite	3	2		
Chert	1		5	

Size of

corals	:	3 mm.
calcite	:	1.0-0.02 mm.
pellets	:	0.05-0.1 mm.

The dolomite (euhedral and finely crystalline) is along thin veinlets, which can be seen in hand specimen. Because clay is concentrated along the veinlets they are probably incipient stylolites. The calcite "rock fragments" are single crystals and, as they have calcilutite rims, they are true broken rock fragments. The thin-section of unit 2 also includes calcite spar, as cement and fragments could not be separated (calcilutite rims are not everywhere present). Chert replaces the "calcite" of unit 2, and also replaces the corals of F310A. The pellets are very well sorted as to size, and where no spar (cement) separates them, they are included under "calcilutite". Both "pellets" and "calcilutite" may contain clay, which is very difficult to estimate in thin-section. The quartz of the two analyzed samples is silt, but it is very fine-grained sand in unit 2. The size of the pellets and the quartz content is variable from lamina to lamina in 315. F310A is a biostromal limestone, with a calcilutite matrix, and 315 is a current-sorted, pellet limestone. Both limestones are slightly dolomitized. The limestone of unit 2 is a pellet limestone.

Numerous other polished- and thin-sections have been cut from the rocks of the Lac Croche Member, and for a detailed description of these data, the reader is referred to Lespérance's thesis. The results of these investigations have been incorporated in the above generalized section.

The Lac Croche Member in the homocline east of Sauvagesse lake crops out poorly. These outcrops are composed of limestone similar to unit 9, siltstone, and fine-grained gray sandstone beds, similar to the upper Mont Wissick. Limestones are less abundant than clastic rocks. A conglomeratic, gray, fine-grained sandstone, at the southwest end of the outcrop of the Lac Croche Member, is a calcareous semi-volcanic arenite, as determined in thin-section.

No continuous section of the Lac Croche Member is known in the Squatec East area. The member is here composed of nodular limestones, clastic limestones, biostromal limestones, gray, dense, finely crystalline limestones, sandstones, siltstones, and concretionary siltstones. All the rock types are massive, although, rarely, they may be laminated or thinly bedded. The limestones range from gray to light gray, and the siltstones and sandstones are gray. No rock type is restricted to a particular stratigraphic horizon. The manner of outcrop of the rock types suggests that many lithologic units are 2-3 feet thick.

Approximately one-quarter of the Lac Croche Member is composed of siltstones and sandstones. The sandstones range from massive to laminated, are limy, locally dolomitic, and are very fine grained. Two outcrops of coarse-grained, very limy, volcanic sandstones were found near the base of the member. These sandstones are composed predominantly of felsite fragments, with minor quartz, and much (one-third?) calcite. The siltstones range from limy to very limy, are massive, and many contain abundant crinoidal or coralline material. Concretionary siltstones are rare, but fossil collection 59-151 comes from concretions (of pellet(?) limestone) in a concretionary siltstone. It is possible that the fossils served as nuclei for the concretions.

The other three-quarters of the Lac Croche Member is equally divided between nodular limestones and other limestones. The nodular limestones (Plate X) are gray, silty, argillaceous, and massive. The other limestones are gray to light gray, commonly massive and pure. This second group of limestone is largely correlative (lithologically) with unit 3 of the Lac Croche Member in the Squatec-Cabano syncline, although the sandstones of unit 3 are absent. Three main types can be recognized:-

a) clastic limestones, commonly coarse grained;
b) very finely to finely crystalline, dense limestones, in part argillaceous;
c) biostromal limestones, pure.

The clastic limestones are restricted to the southern half of the area of outcrop of the Lac Croche Member, and types b) and c) are much more common in the northern half of the area of outcrop. The two types interfinger approximately one mile northeast of Squatec river. The biostromal limestones grade into type b), and are particularly well exposed one mile northeast of Squatec river. These mainly light gray biostromal limestones are locally composed wholly of organic material. The organic material is mostly coralline, although a few brachiopods have been found. Types a), b), and c) are here interpreted to grade laterally into one another (lithofacies of one another).

The weathered surfaces of the biostromal limestones and the gray, dense, finely crystalline limestones are typically light gray. These surfaces are cut locally by thin (less than 1/10 inch) veinlets, which are planes of dissolution, i.e., incipient stylolites. Two thin-sections from very finely crystalline dense limestones show:-

Quartz silt	2%	
Muscovite	tr	
Fossils (mostly brachiopods)	5%	
Clay	13%	
Calcilutite	78%	
Calcite	100%	(0.1 - 0.2 mm.)
Dolomite	2%	(secondary)

The dolomite is in irregular blebs 0.02 to 0.03 mm. in diameter. The area between calcilutite crystals is gray and opaque, and is probably clay. Clay and silt are concentrated locally along dissolution veinlets. The other thin-section is recrystallized.

Lower Mont Wissick

The following section was measured along Sutherland brook, and is the most complete section known in the Mont Wissick Formation. (Sutherland brook is on the western limb of the Squatec-Cabano syncline).

The section starts on the southwestern shore of a small lake at the head of Sutherland brook. All the rock types are gray, except where otherwise noted. The section was tape-measured, and is in descending order.

The siltstones and sandstones are more or less limy and dolomitic. The better sorted siltstone beds are light gray, whereas the impure beds are dark gray. The laminae in the siltstones and sandstones are commonly faint and difficult to see. Pods are circular to subcircular concentrations of limestone (formed both of calcite and fossils). These pods are concretionary, are commonly flattened parallel to the bedding, and form 10-70% of the rock locally. Weathering of the pods produces a pitted surface. Some of the pits are very much elongated, to a ratio of 5 to 1:-

		Thickness	
41.	Siltstone, impure	7'	7'
	Concealed	2'3"	9'3"
40.	Siltstone, impure	2'3"	11'6"
39.	Limestone, very impure	5'	16'6"
38.	Sandstone, very fine grained	2'6"	19'
	Concealed	11'	30'
37.	Siltstone, well sorted	21'	51'
36.	(Plate VIII-A) Siltstone, limy to very limy, dolomitic, massive. A thin-section study shows that this rock is limy (2%), micaceous (5%), dolomitic (18%) siltstone. In fresh rock a cleavage is spaced every 3", and branches every 3-6'. The cleavage strikes N.24°E., and dips 55° east	35'6"	86'6"
35.	Siltstone, as unit 36, but laminated to medium bedded	26'6"	113'
34.	Siltstone, predominantly impure, less so locally	69'6"	182'6"

		Thickness	
33.	(Plate VIII-B) Siltstone,—concretionary, pitted, limy, massive to medium bedded. The pits average 40% of the rock, but may form 20-70%. The pits are aligned parallel to the bedding, and have an average diameter of 2"; they are underlain by silty limestone dissolved out (probably concretionary)	20'6"	203'
32.	Siltstone,—well sorted, dolomitic, in laminated medium beds, with rare cross-bedding	7'6"	210'6"
31.	(Plate IX-A) Sandstone and siltstone. The siltstone forms approximately 15% of the unit; cleaved; in beds up to 12" thick, with an average of 8"; impure. The sandstone is very fine grained; in beds from 10-28", with an average of 18"; limy and dolomitic. Rare thick beds of sandstone may be laminated. The sandstone is broken by two joint systems, one striking N.78°E., with a dip of 75° east, and the other striking N.37°W., with a dip of 35° west	28'	238'6"
30.	Sandstone,—very fine grained, jointed; siltstone,—well sorted, forming 40% of the unit in the upper 33 feet, and 80% of the unit in the lower 15 feet. _Halysites_ sp. is found locally	49'	287'6"
29.	Siltstone,—coralliferous	30'	317'6"
28.	Siltstone,—concretionary (pitted as a result)	31'6"	349'
27.	Siltstone,—slightly concretionary	13'	362'
	Concealed	9'	371'
26.	Siltstone,—slightly concretionary	12'	383'
25.	Siltstone,—concretionary	27'6"	410'6"
24.	Siltstone, and minor clastic limestone ...	1'6"	412'
23.	Sandstone,—very fine grained	7'	419'
22.	Siltstone. Locally 2% of the outcrop may be pitted; thus the rock is in part concretionary	98'6"	517'6"
21.	Siltstone,—in part concretionary	6'	523'6"
20.	Sandstone,—very fine grained	7'	530'6"
19.	Siltstone,—concretionary and non-concretionary; very rare impure limestone	38'	568'6"
	Concealed. 603' is at the top of a continuous series of falls	34'6"	603'
18.	Sandstone,—very fine grained	11'6"	614'6"
17.	Sandstone,—concretionary; minor siltstone	33'6"	648'
16.	Sandstone,—volcanic, limy, predominantly coarse grained, but in part fine grained	11'6"	659'6"

		Thickness	
15.	Sandstone,—very fine grained, and minor siltstone	42'	701'6"
14.	Siltstone,—concretionary, with very minor siltstone and impure limestone	2'6"	704'
13.	Siltstone,—in part coralliferous	17'	721'
	Concealed	4'	725'
12.	Limestone,—silty, argillaceous, pitted owing to dissolved corals	3'	728'
	Concealed	1'	729'
11.	Siltstone	9'	738'
10.	Siltstone,—concretionary, with very minor siltstone	18'	756'
9.	(Plate IX-B) Limestone,—nodular. As a whole the rock can be described as silty argillaceous limestone. In detail, it is very silty argillaceous limestone surrounding patches of purer limestone, which weather as pits. The purer limestone is light gray weathering; the remainder weathers dark gray, is schistose, curves around patches of the purer material, and locally may be very limy siltstone. The pods of purer limestone are finely crystalline, have small amounts of coralline and crinoidal material and range in size between ½" and 2", with an average size of ¾". The bedding is poor, and thin. Pods form 60% of the weathered surface	3'6"	759'6"
8.	Limestone,—nodular (?), in 4" beds	10'6"	770'
7.	Siltstone,—impure, coralline	4'	774'
6.	Limestone,—nodular, impure; siltstone,—concretionary; and limestone,—silty; all three rock types grade into one another .	19'	793'
5.	Limestone,—nodular, with notable schistose veinlet networks surrounding the concretions (pods). Pods form 40-90% of the rock. The limestone is medium bedded	25'	818'
4.	Siltstone,—concretionary	10'	828'
	Concealed	36'	864'
3.	Limestone,—nodular, very thinly bedded ..	7'6"	871'6"
	Concealed	2'	873'6"
2.	Limestone,—nodular	5'	878'6"
1.	Sandstone,—medium grained, finely bedded	6'6"	885'
	Concealed. Probable thickness to base of the Mont Wissick Formation (seen on the road immediately adjacent)	30'	915'

Total measured Mont Wissick:- 785'3".

The lower Mont Wissick is composed predominantly of siltstones and sandstones, with minor limestones most of which are nodular. The siltstones are the more abundant, may be crossbedded, and they range from very limy to limy, non-dolomitic to dolomitic, well sorted to very impure, and massive to laminated. The sandstones are generally very fine grained. The siltstones and sandstones can be separated with confidence only with the petrographic microscope. The siltstones and sandstones are rarely as well bedded as Plate IX-A indicates, and are more commonly massive and cleaved as shown in Plate VIII-A. The rock typical of the lower Mont Wissick is thus light gray, laminated, limy and dolomitic, fine-grained, and clastic.

The averages of two sandstones, and four siltstones in thin-sections are:-

	Sandstones %	Siltstones %	
Quartz	64.5	50	
Orthoclase	tr	tr	
Plagioclase	0.5	tr	
Muscovite	tr	tr	
Biotite	3	7	
Chlorite clasts	tr	tr	
Rock fragments			
volcanic clasts	1		(felsites)
calcite	tr	2	(most are bioclastic)
Clay	10.5	17	
Dolomite	16	10	(mostly euhedral)
Calcite	8.5	14	
Average sizes			
calcite :	0.04	0.05 mm.	
dolomite :	0.04	0.03 mm.	
silicates :	0.06	0.375 mm.	
biocalcite:		0.5 mm.	

The upper half of the lower Mont Wissick, in the Squatec-Cabano syncline, is exclusively composed of siltstones and sandstones, as described above. Within the lower half, however, there are rare beds 2-3 feet thick of gray clastic limestone, and dark gray, crinoidal, very limy siltstone, which resembles impure limestone in the field.

Plate VIII-B is typical of concretionary siltstone outcrops. A sample of concretionary siltstone was cut and polished. The contact between the concretion and the surrounding siltstone is sharp. The concretion itself is finely crystalline limestone, with 15% bioclastic material. There is no bioclastic material in the surrounding siltstone, and the bioclastic material appears to have served as concretionary centers (nuclei). The average mode of two thin-sections from concretions in concretionary siltstones is (one of these concretions comes from the concretionary siltstone east of Sauvagesse lake):-

	%	
Quartz	18	
Microcline	tr	
Plagioclase	1	
Muscovite	1	
Rock fragments		
fossils	2	(calcite)
volcanic clasts	2.5	
pellets	5	
calcite	17	(not bioclastic)
Clay	10	
Dolomite	tr	("matrix")
Calcite	43	("matrix")
Oölites	1	(calcite)

Units 5-10 (inclusive) of the Sutherland Brook section were sampled every foot, and insoluble residues were prepared. The residues were examined under the binocular microscope and an estimate of the amount of calcite dissolved was made. A few samples were weighed, and this permitted a factor to be applied to estimates of the calcite dissolved. The field designations were found to be correct.

The residues were in general very porous, and showed numerous fossil molds, particularly of crinoid stems. Pin-point type porosity within silt is particularly abundant. A number of fossil fragments were silicified (by white chert), and some showed beekite structure. Chert replacement and beekite structure are particularly abundant in rock with much silt, which presumably furnished the silica. Silicified fossils are notably abundant at 814 feet, within unit 5.

Lowermost strata The lowermost exposed strata of the Mont Wissick Formation are commonly limestones, but the type of limestone is not constant.

At Anse, the lowermost 175 feet are predominantly laminated limestones, much of which are columnar-jointed. The succeeding 225 feet are concretionary siltstones and nodular limestones.

This columnar-jointed limestone is well known (Logan, 1863; Kindle, 1914). Kindle was impressed by the concentrations of silt and clay between the columns, and thought they were due to infilling by mud in mudcracks in limestone. A specimen was broken and polished, and the laminae are shown to be broken by planes, and locally infilled by muddy material. Two jointed columns fused together were also cut and polished. In this specimen, the laminae were not broken, and in addition the planes of separation of the columns pinched out in the rock without meeting; this can also be seen on unpolished specimens. Along these planes the rock was weathered. The concentration of mud along them is thinner than in true mudcracked strata, and is probably due to ground-water leaching of the impure limestone. A thin-section of the limestone shows that the rock is composed of quartz silt (5%), clay (25%) (much of which appears concentrated in "pods" or concretions), and the remainder acicular calcite. The acicular calcite crystals are 0.03 by 0.01 mm., and their longest axes make angles of 70°-90° to the laminae. The calcite crystals grew under pressure. The columns themselves, in outcrop, make an angle of 76° with the bedding, at least in the lower part of the unit. In view of the acicular crystals of calcite, and the failure of some columnar-jointed blocks to be mudcracked, the writer suggests that some of the columnar joints are the result of tectonic processes. Some of the joints probably spread upward or downward through uncracked limestone from previous lines of weakness (mudcracked joints), when the rock was brittle, and the stress recrystallized the impure mud. The 76° inclination of the columns to the bedding cannot be explained by sedimentation processes, and is probably tectonic in origin. For further descriptions of this feature, see Kindle (1914).

Along Sutherland brook, the lowermost 3 feet of the Mont Wissick Formation are laminated limestone, and the succeeding 175 feet are predominantly nodular limestones (Plate IX-B).

On the other side of the syncline, on the road to Croche lake, the contact between the Robitaille and Mont Wissick formations is not clear in view of the abundance of sandstones and quartzites, and the contact has been drawn above the lowermost light gray quartzite. Upsection from this quartzite, concretionary siltstones, nodular limestones, a few feet of volcanic sandstones, and one foot of trachyte crop out. The upper and lower contacts of the trachyte are vague, and the fresh color is green. A thin-section of sheared trachyte showed the following:-

	%	
Quartz	2	
Chert and chalcedony	10	(spheric blebs 0.2-0.8 mm. in diameter)
Plagioclase	1	
Potash feldspar	35	
Muscovite	15	(veinlets)
Chlorite	10	(veinlets)
Felsite	27	

Farther to the north, at fossil locality 58-F279 along the road on the east limb of the syncline, the following section overlies Robitaille strata:-

		Thickness	
	Concealed.		
4.	Limestone,—argillaceous, gray, poorly laminated, with abundant brachiopods and corals (58-F279)	40'	40'
3.	Limestone,—nodular	20'	60'

		Thickness	
2.	Limestone,—gray, thinly bedded, contorted	10'	70'
1.	Limestone,—argillaceous, well laminated, columnar jointed	30'	100'
	Concealed	10'	110'
	Robitaille mudstone		

Thus the lowermost exposed sections are dissimilar, although predominantly laminated or nodular limestones.

The greater part of the strata in the homocline immediately east of Sauvagesse lake are siltstones and very fine-grained sandstones, as described above. There are, however, a number of outcrops which do not appear to have correlatives elsewhere, and in general they indicate a more shallow environment of deposition than outcrops in the Squatec-Cabano syncline. In the southwestern part of the homocline three quartzite outcrops (predominantly medium grained) and a red sandstone outcrop were found. Concretionary siltstones, and biostromal and nodular limestones (Plates XI-A and XI-B) are abundant immediately east of Sauvagesse lake, particularly from 1,700 to 2,200 above the base of the formation. Two outcrops of volcanic sandstone, with abundant perlites, were also found (these are shown on the map).

A thin-section of volcanic sandstone shows that the rock is very coarse-grained volcanic arenite, with 5% serpentine cement, 12% calcite (cementing and replacing grains) and the remainder is volcanic clasts (1% trachytic, 7% hyalo-ophitic, and the remainder felsitic). Approximately half of the felsite clasts have a perlitic texture. A thin-section from the second outcrop is much the same, although it contains only 1% serpentine cement, no calcite, 1% quartz, and trace amounts of feldspar grains. The feldspar microlites in the clasts are An_{30}.

A number of limestone beds also crop out within the lower 400 feet of the formation in this area. A thin-section from one bed shows that the rock is a calcilutite, with 2% bioclastic(?) calcite, and 3% fine sand quartz. The mineral content is not constant in each lamina, and some laminae show 15% calcite spar between pellets, which are uniformly 0.05 mm. in diameter. The limestone is thus grumous, and those laminae not showing this texture are probably due to fusion of the pellets. This limestone, like other limestones showing grumous textures, weathers light gray, and is laminated. The laminae and the weathered surface are apparently typical of grumous and high pellet limestones.

The fault-bounded block of Mont Wissick strata west of Petit Biencourt lake is almost wholly composed of limestones, and is thus probably representative of the lower part of the Mont Wissick Formation. Mont Wissick strata west of Bédard lake, on the other hand, are practically wholly siltstones.

The lower Mont Wissick Formation is composed of very fine-grained sandstones, siltstones, and limestones in the Squatec East area. These three rock types are perhaps equally abundant and are similar to strata found in the Squatec-Cabano syncline. Concretionary siltstones are rare. No continuous section is exposed. No rock type is restricted to a particular stratigraphic horizon, but all are found at various positions in the sequence.

Three or four outcrops of coarse-grained volcanic sandstone, ranging from limy to non-limy, were also found. In the vicinity of Auclair lake, there are also a few beds of light gray limestone, similar to rock types found in the Lac Croche Member. Strata exposed on the east shore of Auclair lake show beautiful dolomitization, nowhere else seen in the Témiscouata region. The dolomitization has proceeded along anastomosing veins 0.1 to 5.0 mm. wide, which form approximately 10% of the surface of the outcrop; it has affected the nodular limestones, the light gray limestones, and the rare biostromal limestones. Elsewhere in the Squatec East area, dolomitization is not as evident.

South of Touladi lake, in the Cabano area, the Mont Wissick strata contain lenses of volcanic material. An upper volcanic lens, 325 feet thick, is predominantly composed of water-sorted felsite clasts. Rocks formed by these clasts range in size from siltstones to granule conglomerates. Some of these beds are black; others gray, green, or red. Many are very limy. Down-section from these strata vitric tuffs, 75 feet thick, crop out and are best seen along the northern stream discharging into Touladi river. This stream runs on a right lateral fault (see Figure 1).

The Mont Wissick underlying the Touladi Formation in one area, and underlying the upper volcanic lens in a second area, is thin-bedded, gray, more or less silty and argillaceous dolomite. Only a few feet of dolomites were seen at both localities.

Nodular Limestones of the Mont Wissick Formation

The nodular limestones of the Mont Wissick Formation are found at every stratigraphic level, except in the upper Mont Wissick beds. The nodular limestones are massive, silty, and argillaceous, and calcite is concentrated in ellipsoidal or nodular masses. These limestones, when viewed perpendicular to the bedding, have the typical ellipsoidal shapes of concretions (Plates IX-B, XI-A), but when viewed parallel to the bedding have shapes irregular in size and round (Plate X). Single outcrops rarely show both dimensions well. Gradation from nodular limestones to concretionary siltstones is well displayed along Sutherland brook.

The concretions are surrounded by clay and silt masses which are more or less limy. Some of these masses are limestone, and a few others are very fine-grained, limy sandstone. Where the lime content is low, the masses are schistose (Plate XI-A) and where the lime content is high they are non-schistose (Plate X). The width of these masses is variable, as the nodular limestones grade into the concretionary siltstones, but a width of ¼ inch is common in the purer nodular limestones.

In a number of polished sections of nodular limestones the masses of clay and silt are continuous in three dimensions. The areas where clay and silt are concentrated are more permeable zones in the nodular limestones, and as such are pathways for surficial alteration. Surficial alteration has been found in almost every polished section examined, and the clay and silt masses are brownish. The fossils in the masses are fresh, and stand out locally on the weathered surface. Because of the surficial alteration, the contact between the concretions and the clay and silt masses is commonly vague. On the weathered surfaces of the nodular limestones, and in the few sections where no alteration is present, the contact between the concretions and the remainder of the rock is sharp (Plates IX-B, and XI-A).

The concretions are gray, finely crystalline limestone ranging from pure to argillaceous and/or silty. Fossil fragments are ubiquitous in these concretions, and fossils, particularly corals, may make up a high proportion of some. The size of the concretions ranges from ½ inch to 4 inches in diameter; the most common diameter is 1 inch to 2 inches.

Two analyzed nodular limestones from the Lac Croche Member, at Croche lake (see analyses above), can be separated in thin-section into two parts: limestone, and impure masses. The average composition of these two parts are:-

	limestone concretions %	impure masses %	
Quartz	4	15	
Rock fragments			
organic	30	5	(calcite)
calcite	12	30	
pellets	5		
Clay	12	15	
Calcilutite and calcisiltite ..	44		("matrix")
Dolomite		35	(secondary)

Average sizes
quartz : 0.04 mm.
pellets : 0.1 mm.
Range of calcite grains: 2.5-?

The "calcite" rock fragments are not obviously bioclastic fragments. In both thin-sections, the dolomitization followed the concentrations of clay and silt. The dolomite is euhedral, and averages 0.05 mm. in diameter.

Concretions can be syngenetic or epigenetic (Weeks,1957, p.99). Syngenetic concretions are found today in marine Recent clays along the coasts of Greenland and northern Canada. Epigenetic concretions are those in which the bedding goes through the concretion, and this criterion is perhaps the only definite one that distinguishes epigenetic and syngenetic concretions (Lombard, 1956, p. 342). Epigenetic concretions are found in the Robitaille Formation at Anse. Concretions in the Mont Wissick Formation are in massive beds, and it cannot be demonstrated that these are epigenetic or syngenetic.

The siltstones and very fine-grained sandstones of the Upper Silurian formations are cleaved, but the other rock types are not. The cleavage in these rocks is not well developed, and is sinuous. It is probably both slaty and flow cleavage, in which the parallel arrangement of minerals is poor owing to the coarseness of the components, and their low content of micaceous minerals.

The good bedding, crossbedding, local good sorting, and fineness of the Upper Silurian strata suggest that the lowermost deposits of the Asselin and Robitaille formations are the result of a transgressing sea. A gap in the fossil record is present between Lower and Upper Silurian (the upper two-thirds of the Llandovery and the Wenlock are missing), and it is probable that this gap represents a time of retreat of the sea. Overlying the basal strata, the rocks are fine grained, and it is probable that the basin was shallow and above wave base. A few determinations of current direction from crossbedding data suggest that the anticline in the Quebec Group was above the sea in Late Silurian time.

Unnamed Formation

Name

The strata between the Lac Raymond and Témiscouata formations northeast and southwest of the upper part of Touladi river that flows into Biencourt lake are dissimilar. Southwest of the river these strata are the Mont Wissick and Asselin formations. The strata northeast of the river are separated as a new, unnamed formation, and are composed of slates, with minor siltstones. Further mapping north and east of the Témiscouata region may reveal a satisfactory type section from which the name of the formation could be taken, but such sections are lacking in the area mapped to date. The best exposures are those along the road to Echos lake.

Age

Fossils identified by Boucot, and determined as Upper Llandovery to Ludlow in age, are:-

Table 6

Fossils of the "Unnamed" Formation

Fossils	59-344	59-503
Leangella sp.	X	
Cyrtia sp.	X	
Skenidioides sp.	X	
Dicaelosia sp.	X	
Atrypa "*reticularis*"	X	
Resserella sp.	X	
Plectodonta sp.	X	
Chilidiopsis sp.	X	
Protomegastrophia sp.	X	
Leptaena "*rhomboidalis*"	X	
trilobites	X	
corals	X	
unidentified fragments		X

The unnamed formation is here interpreted as Late Silurian on the basis of lateral continuity with the Asselin and Mont Wissick formations.

Thickness

Structural information within the unnamed formation is very scant and largely meaningless in view of the predominantly slaty nature of the beds. A thickness similar to the Upper Silurian strata southwest of the upper part of Touladi river that flows into Biencourt lake is here suggested, i.e., 2,000 to 2,500 feet. It is probable that this thickness has been reduced by pre-Témiscouata Formation erosion.

Stratigraphy and Petrography

The rock types of the unnamed formation are, in order of abundance: slate, siltstone, sandstone, and limestone. These rocks are interbedded, and no stratigraphic section can be given. Slate and siltstone combined probably form three-quarters of the formation.

Five limestone outcrops within this unnamed formation have been found, all southwest of the Echos Lake road. Two outcrops are pebble and granule limestone conglomerates. The remaining three are finely crystalline, and range from pure to argillaceous and/or silty, and from cleaved to uncleaved. The limestone beds are 1 foot to 5 feet thick.

The other rock types are either massive or in beds up to 2 inches. The sandstones are predominantly in laminated, crossbedded or torrentially bedded thin beds, which range from limy to very limy. The sandstones are very fine or fine grained and range from gray to light gray, although very rare medium-grained beds with felsite or slate clasts, and dark gray non-limy ones are found. Laminated, light gray, very limy, very fine-grained sandstone beds are typical of this formation. The sandstones are more common in the southwestern area of outcrop.

The slates and siltstones are massive to thinly bedded or laminated. They range from gray to dark gray, and are generally non-limy. Fossil locality 59-344 is in a very limy siltstone bed, but such beds are rare. These slates and siltstones can be separated from the Témiscouata Formation rock types in that the Témiscouata "slates" are laminated, limy and dolomitic.

A thin-section of laminated dark gray slate, with a very fine-grained sandstone lamina, shows the following modes:-

Lamina	slate %	sandstone %	
Quartz	25	55	
Muscovite clasts	less than 1		
Muscovite	4		(in cleavages)
Felsite clasts		5	
Calcite		40	(matrix)
Illite and chlorite	70		(clay)

The work of Lajoie (1961) and Béland (MSS.) indicates that the Témiscouata Formation passes to the northeast of the present area into the Lower Devonian York River and Grande Grève formations. Also, these authors show that the Lower Devonian is limited to the northwest by a fault that Lajoie (1961) extends up to the edge of our area. However, no indication of this fault was found in our area.

Moreover, Lajoie (1961) did not recognize in the Lac Prime area (adjoining Squatec) the rocks of our "unnamed formation". He attributed to this fact several changes in the stratigraphy of the sector of the upper part of Touladi river that flows into Biencourt lake (Lajoie,1961, 1963). Nevertheless we prefer, after careful examination, to maintain this unit as mapped. In view of its limited extent, we do not believe it should be given a formal name. It would seem that a rapid change of facies takes place here. Detailed mapping perhaps would resolve the problem.

Lower Devonian

Touladi Formation

Name

The Touladi Formation includes Lower Devonian strata differing from the Témiscouata Formation. It is best exposed in the Touladi Lake area, although no type section can be suggested. It is composed predominantly of fossiliferous, probably clastic limestones.

Age

Fossils identified by Boucot, and determined as Becraft to Oriskany in age, are given in Table 7:-

Thickness

The maximum thickness of the Touladi is 350 feet, only one-half or less of which crop out. The irregular distribution of the formation is due in part to pre-Témiscouata Formation erosion.

Stratigraphy (1) and Petrography

The Touladi Formation is composed of limestones, sandstones, and conglomerates. Three areas, or lenses, of the formation are found. Within each lens the strata are somewhat different, but the typical rock type, found in all three lenses, is a dark gray, slightly silty, argillaceous, massive limestone. Practically every outcrop is abundantly fossiliferous.

I - Touladi Lake Area

The uppermost strata, known from two outcrops only and aggregating 6 feet thick, are fine-grained, slightly to very limy, massive sandstones.

---

(1): The accompanying sketch-map (Figure 1) shows the variation in thickness of the formations in the Touladi Lake area, and the distribution of the Touladi Formation.

Table 7

Fossils of the Touladi Formation

	G-22	G-28	G-43A	G-79	G-82	L-93	G-103	G-105	59-629	59-632	59-638A	59-638B	59-647
Atrypa reticularis	X	X		X		X	X						
A. "*r.*"									X	X		x	X
Gypidula or *Sieberella* sp.							X					X	
G. or *S.* (ribbed sp.)								X					
G. or *S.* (smooth species unlike those in the Mont Wissick)	X												
Athyris sp.									X				
A. ? sp.	X	X	X				X						
"*Chonetes*" sp.		X	X										
Pholidops sp.		X	X										
Rhipidomelloides sp.		X	X										
Brevispirifer sp.		X		X	X	X	X	X	X	X	X	X	X
"*Spirifer*" *bischofi*												X	
Isorthis ? sp.			X										
Barrandella ? sp.							X						
Cryptonella sp.							X		X				
Stropheodonta sp.												X	
Camarotoechia ? sp.										X			
leptostrophid												X	
stropheodontid		X											
strophonellid							X						
unidentified brachiopods										X	X		
coral							X						X
trilobite									X				

Localities G-102, G-105, and 59-632 are on strike with one another.

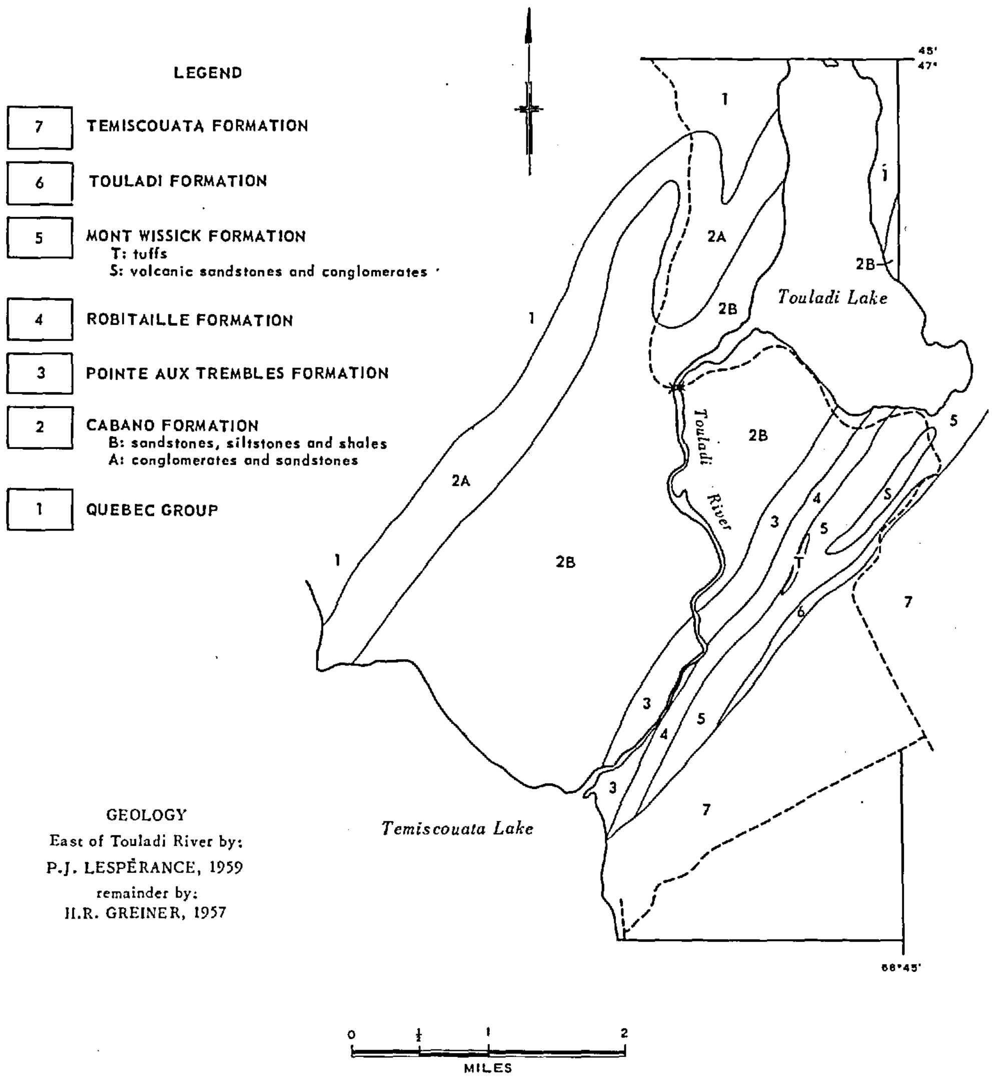


Figure 1

GEOLOGY OF THE TOULADI LAKE AREA

D.N.R.Q. 1965 B-851

Within the lower half of the formation the following section was measured in a washed-out lumber road, due south of fossil locality 59-630; the section is from pace-and-compass data, and is in descending order:-

		Thickness	
	Concealed.		
6.	Limestone,—argillaceous, gray, finely crystalline, crinoidal, poorly exposed ..	3'	3'
5.	Sandstone (2/3 of the unit) and limestone; beds 6" - 12" thick. The sandstones are gray, limy to very limy, and in part brachiopod-bearing. They are predominantly fine grained, although some are medium grained. The limestones range from gray to light gray, and are fetid. The gray limestones are argillaceous, finely crystalline, and brown weathering. The light gray limestones are medium crystalline and carry abundant broken corals, crinoids, and brachiopods	12'	15'
	Concealed	3'	18'
4.	Sandstone,—gray, fine grained, massive limy	3'	21'
	Concealed	2'	23'
3.	Limestone in 2-inch beds with rare gray siltstone laminae. The limestone is gray, finely crystalline, fetid, argillaceous, and has abundant corals and small brachiopods	3'	26'
2.	Sandstone, gray to light gray, fine grained, very limy. Traces of siltstone laminae. The bedding strikes N.50°E. and dips 70° southeast	3'	29'
1.	Siltstone, and limestone. The siltstone is weathered and partly laminated. The limestone is very coralline and forms the lower 3 inches of the unit	2'	31'
	Concealed.		

Approximately 50 stratigraphic feet below the above section, there are approximately 7 stratigraphic feet of fine- to medium-grained, limy to very limy, light gray to gray sandstones which are abundantly fossiliferous (collection 59-629).

The lower part of the formation is composed of massive dark gray, brown weathering, fetid limestones which range from argillaceous to very sandy, and from finely to medium crystalline. Fossil collections include G103, G105, 59-638B, and 59-632. The limestones are at least 40 feet thick, and probably are all clastic limestones. Two thin-sections of these limestones have the following modes:-

	%	%	
Quartz	1	25	
Plagioclase		5	
Chlorite clasts		tr	
Felsite clasts		5	
Limestone clasts		50	(with calcilutite rims)
Organic calcite clasts ..	45	15	(no calcilutite rims)
Calcite matrix	50		
Average sizes			
silicates :	0.04	0.01 mm.	
organic calcite clasts :	0.5	mm.	
matrix :	0.05	mm.	
limestone clasts		0.1 mm.	
Texture	clastic	in part recrystallized	

One limestone is silty and probably bioclastic, and the second is partly recrystallized, clastic, and very sandy.

II - Remainder of the Area

The most easily accessible outcrop of the Touladi Formation is in the fields approximately 2½ miles southwest of Pointe aux Trembles. This outcrop shows approximately 35 stratigraphic feet of dark gray, slightly silty, argillaceous, finely crystalline limestone. The lower 20 feet are massive and unfossiliferous, and the upper 15 feet are in fossiliferous beds 1 inch to 2 inches thick, separated by laminae of gray fossiliferous siltstone (fossil locality G28)

Northwest of Saint-Eusèbe the strata are predominantly coralline and sandy limestones. In the lower part of the formation, however, are 10 feet of pebble conglomerate, with clasts of 1½ inches average diameter, but ranging from the size of sand to boulders 12 inches across. The conglomerate clasts form 50-75% of the conglomerate, and are predominantly light gray or light green-gray, non-limy or limy, fine-grained, well rounded sandstones. The matrix of the conglomerate is medium-grained, limy sand.

McGerrigle (1934) reported the above lens, but did not mention the conglomerates and sandy strata. Both McGerrigle and Girard (1937, 1938a, 1938b) discuss high calcium limestones which crop out in the southern Témiscouata area, and which are presumably equivalent to the Touladi Formation. According to Gorman (1957), a limestone quarry near Rivière Bleue is in dark to light gray limestone in massive beds up to 5 feet thick. This quarry exposes 175 stratigraphic feet of limestone. The limestone is finely crystalline, dense, in beds 2-12 inches thick in the lowermost 50 feet of strata, and in beds 18 inches thick in the remainder of the quarry. The lower contact of the limestone is gradational to slate, but carbonaceous films and calcite veins occur throughout the quarry.

The fossils indicate a period of erosion between the Mont Wissick and Touladi formations. This erosion break is also indicated by local slightly angular unconformities (see Structural Geology). The strata of the Touladi Formation were deposited during the Lower Devonian transgression which followed the period of erosion.

The lateral variation of the Touladi Formation, combined with the clastic nature of the limestones, suggests a shallow water environment. As the strata contain abundant fossils, many of which are broken, a turbulent and shallow water environment is indicated. The lenticular nature of the Touladi Formation is in part due to pre-Témiscouata Formation erosion, but probably also in part due to the paleotopography of the transgressed surface. The abrupt disappearance of the formation near Touladi lake, where in one area Mont Wissick strata are on strike with Touladi strata, suggests a local basin boundary.

Témiscouata Formation

Name

McGerrigle (1934) suggested the term "Témiscouata group", but did not detail a type section. Consequently it is here suggested that road cuts along Highway 2, from approximately 1 mile northwest of Notre-Dame-du-Lac to approximately 2½ miles southeast, i.e., to the border of the Cabano West area, be taken as a type section.

The best exposures in the Squatec East area are found along Sauts and Dionne brooks.

Age

Fossils identified, and assigned to the Oriskany, by Boucot are as follows:-

Table 8

Fossils of the Témiscouata Formation

	59-350	59-542	59-90
Athyris ? sp.	X		
Chonetes ? sp.	X		
Leptocoelia cf. *L. flabellites*	X		
"*Spirifer*" n. sp.	X		
Cyrtina sp.	X		
Leptaena "*rhomboidalis*"	X		
Globithyris cf. *G. callida* aff. "*Spirifer*" *bischofi*	X		
Pleurodictyum ? sp.		X	
Tropidodiscus sp.	X		
Platyceras sp.	X		
favositid	X		
pelecypods	X		
unidentified dalmanellids	X		
unidentified Devonian type spiriferoid		X	
worm tracks			X

Thickness

The Témiscouata Formation is a plicated, plastically folded suite of rocks in which thickness estimates are hazardous. Numerous folds only a few feet wide render the problem even more difficult; nevertheless the following line of reasoning is suggested.-

The average of the lineation measurements (intersection of bedding and cleavage) in the Squatec area is 17° north. This compares favorably with the low plunge (11°) of the Squatec-Cabano syncline. If the same type of folding is assumed in the Témiscouata Formation as in the Upper Silurian, i.e., large, open, shallowly plunging folds, with an amplitude of approximately 4 miles from outer limbs, on which the strata are plicated, then a minimum of 6,100 feet of strata (as in the Squatec-Cabano syncline) are present. This 6,100 feet accounts for one fold, but as one synclinal limb is at least 10,000 feet thick (i.e., the Silurian formations in the Suqatec East area), then a minimum thickness of 10,000 feet can be postulated for the Témiscouata Formation. The Silurian formations in the Squatec East area plunge very shallowly, if at all, and no shallowing of the dip is present in the uppermost formations, thus the minimum thickness may be raised confidently to 12,000 feet. This subject is treated more fully under Structural Geology.

Duquette (1959) has mapped (upper) Saint Francis Group strata in the Weedon district. These strata are presumably correlative with the Témiscouata Formation. Duquette has shown that the beds are in a succession of symmetrical anticlines and synclines. These folds have an average distance of 160 feet from crest to crest, over a distance of less than 2,500 feet. Duquette's findings do not support the presence of large folds in the Témiscouata Formation as postulated above, unless the closely spaced fold axes are a feature of the plicated limbs of the larger folds here suggested. Such large folds are present in the Devonian strata of Gaspé to the northeast.

Stratigraphy and Petrography

The Témiscouata Formation can be separated into three parts: a) a local lower basal facies composed of quartzites or lavas, b) a local sandstone facies, and c) a mud-carbonate facies which forms the greater part of the formation.

c) Mud-carbonate facies

This facies is composed of gray, strongly cleaved slates that contain clay, silt, calcite, and dolomite. It weathers quickly to a brown silty mass, and outcrops are commonly poor and small. Because the carbonate component offers little resistance to weathering, these rocks alter to soil very easily. Collectively they may be called slates, on the basis of their cleavage. They range from non-limy to very limy, and locally they appear to be siltstone. Siltstones are identified more commonly in bush outcrops than in fresh road cuts or stream sections, because the carbonates are leached and the remainder has a higher proportion of silt than normal. The slates are only well exposed in road cuts and stream sections, where the contortion of the strata can be recognized, whereas bush outcrops generally appear massive.

The best outcrops of slates show that they are laminated to thinly bedded, and that the most common bedding thickness is approximately 1 inch. No bedding fissility is found between laminae beds, and the most conspicuous feature is cleavage. Minor slip folds and shears are present locally. The thin bedding is universal, and rare thin beds are dark gray or light gray. Dark gray beds and laminae are commonly more clayey, whereas light gray beds are better sorted, with high contents of carbonate, silt, or sand. The light gray beds become progressively thicker, coarser, and more abundant in the northern part of the Squatec East area, where some of the beds are crossbedded. Fine-grained sandstones are rare. The cleavage in the slate is planar, and very well developed; it is probable that much, if not all, of this cleavage is due to flow.

Thin-sections of two non-limy slates have the following modes (one sample is from an outcrop 3 miles east of Lejeune, and the second one from an outcrop east of Ango lake):-

	%	%	
Quartz	50	50	
Plagioclase	1		
Biotite	1		
Muscovite clasts	10	1	
Muscovite		9	(metamorphic, i.e., in cleavages)
Chlorite clasts	1	•	
Clay	39	40	(chloritic)
Average grain size	0.04 mm.	0.03 mm.	
Quartz-content range from lamina to lamina	30-70	massive	
Grain boundaries	eaten	eaten	
Cleavage every	0.1 mm.	0.01-0.06 mm.	

On the basis of their cleavage these rocks are slates, but on the basis of their content they are siltstones.

Three thin-sections from rocks identified in the field as limy slates and siltstones have the following modes:-

	a)	b)	c)
	%	%	%
Quartz	20	15	20
Plagioclase	tr	1	tr
Metamorphic muscovite	1	1	1
Muscovite clasts	1	1	1
Chlorite clasts	tr		
Volcanic clasts		tr	
Clay	25	15	15
Dolomite matrix	33	20	38
Calcite matrix	21	50	25
Zircon	tr	tr	
Average sizes			
quartz :	0.05	0.05	0.04 mm.
dolomite :	0.015	0.03	dololutite mm.
calcite :	calcilutite	calcilutite	calcilutite
Cleavage zones every	0.01-0.1	0.02-0.06	0.01-0.05 mm.

Clay is found both in the cleavage zones and mixed with the matrix, and is commonly opaque. The metamorphic muscovite clasts are approximately twice the size of muscovite growing in the cleavage zones. The dolomite ranges from anhedral to euhedral. Sample a) (above) is from an outcrop near the village of Lejeune, b) is from Sauts brook, and c) is from an outcrop along Route 2. In order to verify the thin-section modes, ten grams of sample b) were weighed, dissolved in concentrated hydrochloric acid, washed, dried, and reweighed; as 65% of the sample was dissolved, the rock is truly a carbonate. On the basis of the ratios found in the thin-sections, sample a) is a silty, limy, very argillaceous dolomite; b) is a silty, argillaceous, dolomitic limestone; and c) is an argillaceous, silty, very limy dolomite.

A thin-section from Sauts brook shows the laminae in thin-section, and the following modes:-

Name	Dolomitic limestone %	Sandy siltstone %	Dolomitic siltstone %
Quartz	10	55	60
Plagioclase			tr
Volcanic clasts	tr		
Clay	8		
Dolomite matrix	17	30	40
Calcite	65	15	
Average sizes			
quartz :	0.04 mm.		
dolomite :	0.04 mm.		
calcite :	calcilutite		

The sandy siltstone laminae have up to 10% very fine-grained sand. The dolomite is in euhedra scattered throughout the slide. The dolomitic limestone is dark gray in hand specimen, whereas the siltstone laminae are very light gray.

From the above thin-section modes it can be seen that the Témiscouata "slates" range from true slates or siltstones, to impure dolomites or limestones. Limy siltstones, limy slates, impure limy dolomites, and impure dolomitic limestones cannot be separated in hand specimen.

The Témiscouata Formation is found on the higher ground. As limestones are erosion resistant in the Témiscouata region, this suggests that limestones and/or dolomites are the most abundant rock types of the Témiscouata Formation.

Some outcrops of slates are riddled by white calcite veins up to ¼-inch thick. The rocks of the Témiscouata Formation are also in part sheared, although locally a number of primary features can be recognized. In addition to bedding and crossbedding, a few outcrops show penecontemporaneous slump structures in the northern part of the Squatec East area.

b) Sandstone facies

Beds of massive, gray, limy, fine-grained sandstone, ranging from 1 inch to a few feet thick, crop out in the northern part of the Squatec East area. Thirty feet of predominantly medium-grained sandstone, in beds 1 inch to 18 inches thick, occur in one outcrop. One bed carried an abundant fauna (59-350), and miscellaneous conglomerate clasts of slate. Sandstones are particularly abundant along Dionne brook, on the eastern edge of the map-area, and in the area immediately to the north.

Irregular areas in the Cabano map-area are predominantly gray, impure, and fine- to very fine-grained sandstones. These sandstones also have interbedded slates, and are typically massive.

Three sandstones in thin-section show the following modes:-

	Cabano %	Squatec %	Squatec %
Quartz	76	35	35
Plagioclase	1	10	2
Biotite	1		
Metamorphic muscovite	1		
Muscovite clasts	1		1
Chlorite clasts	1		1
Rock fragments			
siltstone and slate clasts	3	17	
felsite clasts	2	3	20
felsite or siltstone clasts		15	
Clay-chloritic	14	5	15
Authigenic quartz			2
Calcite	1	15	24 (secondary)
Dolomite			1 (secondary)
Zircon	tr		
Average grain size:	0.08	0.25	0.2 mm.

a) Basal facies

Basal rock types of the Témiscouata Formation are not everywhere the same. A few inches of dark gray chert crop out northeast of the upper part of Touladi river that flows into Biencourt lake. West of Auclair lake a few outcrops of green slates and siltstones are found. Lavas approximately 60 feet thick crop out southwest of Squatec river and overlie 8 feet of medium-grained quartzites. The lavas are gray, green and red, partly sheared, and partly replaced by irregular masses of calcite up to ½ inch in diameter. The calcite is locally brown, colorless, or red. The lavas and quartzite are underlain by a few feet of finely crystalline, light gray, sheared limestone.

A thin-section from a 10-foot-wide band of sheared lavas shows a trace amount of potash feldspar, 2% chert, 5% serpentine, 10% muscovite, 15% calcite, and the remainder felsitic fragments. The chert, serpentine, and muscovite are found within shears in the thin-section. Four other thin-sections of these lavas can be separated into two groups: one highly altered, the second less so. The averages of two thin-sections from each group are:-

	%	%	
Plagioclase	59	30	
An content	45	43	
Epidote	3	6	(in plagioclase)
Chlorite	22	34	
Ores	13	14	
Calcite	2	16	(secondary)
Chert	1		(secondary)

The chlorite is in part secondary, and is found both as "phenocrysts" and in the groundmass. The texture of the four thin-sections is intersertal and slightly porphyritic. All four rocks represented are andesites.

Southwest of the andesites (still within the Squatec East area), more quartzite is found, ranging from fine to coarse grained. The quartzites are individually less than 10 feet thick in outcrop.

In the Cabano area, near the base of the formation, quartzites again crop out, ranging from 2-25 feet thick. These quartzites are fine to coarse grained, very thickly bedded and massive, and light brown, although light gray is probably their fresh color. They show stylolites locally, which are probably pressolved zones (Thomson, 1959). The quartzites are interbedded with slates. A thin-section from the Squatec East area, and one from the lens northwest of Saint-Eusèbe have the following modes:-

Area	Squatec %	Cabano %
Quartz	96	88
Plagioclase		tr
Biotite	tr	
Muscovite	tr	
Rock fragments		
felsite clasts	1	
slate clasts		1
siltstone clasts ..	1	
Clay-chloritic	1	1
Authigenic quartz	2	10
Grain size		
range :	0.1-1.5	0.1-1.2 mm.
average :	0.4	0.3 mm.
Roundness	rounded	rounded
Packing	4-5	3 contacts per grain
Name	Orthoquartzite	Orthoquartzite

Pleistocene and Recent

The unconsolidated deposits of the Témiscouata region are related in one way or another to the Pleistocene glacial periods. They include boulders, moraines, kames, eskers, and various clays, sands, and gravels. Water-sorted deposits are widely distributed and thick, and are found to an altitude of at least 600 feet near Squatec, and 750 feet near Biencourt lake.

Erratic boulders are in places abundant, particularly southwest of Témiscouata lake, and most are of local origin. In a number of places, as in the western part of the Squatec West area, many boulders are more than 10 feet in diameter.

Within the Squatec West and Cabano areas, outcrops are abundant, and in general unconsolidated material is rare except in the lowlands. In the Squatec East and part of the Wild Goose map-areas, the area underlain by the Témiscouata Formation has few outcrops, and most of the ground is covered by pebble gravels. Here, two eskers up to 20 feet high trend southeast for 1½ and 2½ miles, respectively. Another esker trends southeasterly about 4 miles south of Notre-Dame-du-Lac.

Lee (1953, 1955) has described the terminal moraines in the Edmundston area. It is probable that the ground moraine in the Témiscouata region belongs to the same glacial advance as the end glacial deposits in the Edmundston area.

At Grand Falls, till from the last ice sheet dammed the St. John river (de Jongue 1951; Lee 1953). Following this, water accumulated behind the dam, to form glacial lake Madawaska (de Jongue, 1951). Wood buried in the sediments of this lake has yielded an age of 8,200 years (Lee, 1953) in the Grand Falls area. The radiocarbon date strongly suggests that the last glacial advance, which formed glacial lake Madawaska, was Mankato (Valders) age.

Glacial lake Madawaska was drained when the lowering of level at Grand Falls (the inland limit of marine waters) induced the cutting of a gorge 200 feet deep there (de Jongue, 1951, p. 49). De Jongue did not believe that glacial lake Madawaska extended beyond the divide at Sept lakes (Les Sept Lacs). The writer has observed eastward-dipping gravels at the dam on Trois-Pistoles river, between Saint-Clément and Saint-Jean-de-Dieu, and believes that glacial lake Madawaska extended farther northwestward than suggested by de Jongue.

In the Témiscouata region, glacial lake Madawaska produced spectacular beach terraces at the mouth of Cabano river, along the river itself to the west of Cabano, along Ashberish river, and the Touladi river up to Biencourt lake. De Jongue measured the elevations of beach ridges along Témiscouata lake, the highest of which is at the base of the church at Cabano at an elevation of 606 feet. Other lower beaches have also been reported by de Jongue at Notre-Dame-du-Lac station, at elevations up to 581 feet.

Sauvagesse lake has two raised beaches on its western shore at elevations of 13 and 33 feet above the present lake level. Pebble and cobble gravels in the Ashberish and Touladi valleys, not reported by de Jongue, are as thick as 75 feet, and overlie varved clays.

De Jongue found varved clays only between Grand Falls and Edmundston. Varved clays were found by the writer on the shore of Lake Témiscouata at its northern end, and in the Ashberish, lower Saint-Jean (in Robitaille township), Aigles, upper part of Touladi, and Squatec valleys. The clays are laminated, with fine silt, in laminae up to ¾ inch. The clays lower in the exposures are purer, and silt content increases upward, to where the clays finally grade into sand. Sand overlying the whole section is well exposed along Saint-Jean and Aigles rivers. The varved clays were sampled at two localities, as follows:-

- Locality 772, Ashberish River valley:

  Approximately 20 feet of clays are exposed along the road. The lower 10 feet are slightly weathered and were sampled.

- Locality 739, northern end of Témiscouata lake:

  Approximately 6 feet of clays are exposed along the shore and were sampled. These clays are varved and highly plastic.

- Analyses:

  Both samples passed completely through a 325-mesh screen (very fine silt is the coarsest particle that will go through this mesh).

	No. 739 %	No. 772 %
SiO_2	55.33	68.63
Fe_2O_3	8.74	6.60
Al_2O_3	19.77	10.77
MgO	3.37	2.32

The high percentage of iron in the above analyses would seem to preclude any use of these clays apart from brick-making.

A poorly defined small kame terrace was found on lot 17, Range IV, Raudot township. A gravel pit in the kame exposes beds of fine gravels with high dips; these are best explained as ice contact features. The irregular trending hills southwest of Saint-Eusèbe in the valley of Cabano river, between the river and the steep rise marking the western limit of the Témiscouata Formation, are best explained as landslides from the east, i.e., from the steep rise. The Squatec-Cabano syncline, which forms the highest strip of land within the western half of the Squatec area, is devoid of any appreciable thickness of soil or unconsolidated deposits, except for a few boulders. This strip of land does not appear to be fit for agricultural purposes. The discharge of Round lake into Témiscouata lake is presently forming a delta, which can be seen on aerial photographs. A 1-inch peat bed was found within the gravels in a pit, approximately 35 feet above the valley bottom, ½ mile southeast of Biencourt. The peat is underlain by 8 inches of soil and overlain by gravel.

INTRUSIVE ROCKS

Post-Quebec Group

Serpentinite

A serpentinite intrusion is found on the eastern limb of the Squatec-Cabano syncline, within the Cabano area near its boundary with the Squatec West area. Six individual outcrops are known, defining a band parallel to the strike of the adjoining syncline. The intrusion can be no larger than 75 by 200 feet. Two outcrops of brecciated slates of the Quebec Group occur 125 and 150 feet northwest of the intrusion, and a third outcrop of light green Quebec Group slates is found 25 feet southeast of the intrusion.

The serpentinite intrusion is cut locally by chlorite veins, and also by asbestos veins up to 1/10 inch wide. The asbestos has been silicified, at least in part. The asbestos veins nowhere form more than 2% of the rock. The serpentinite is dark green-black, and locally has black grains. A thin-section of serpentinite with black grains shows that the rock is composed entirely of antigorite serpentine, and the black grains are 4.0 mm. "phenocrysts" of antigorite (i.e., bastite), which form approximately one-third of the section. The thin-section also shows 5% calcite, and 10% ores, with a minor amount of chlorite in a thin vein. No relict textures of previous minerals could be seen in the thin-section.

Post-Lower Silurian

Diorite

A small body of diorite, trending with the surrounding strata, intrudes the Cabano Formation southeast of Pain-de-Sucre lake. The small ridge underlain by the intrusion is approximately 125 feet wide by 175 feet long. The distance between outcrops of the Cabano Formation is 300 feet, and the intrusion may possibly be this long. The intrusion has contorted and hardened the Cabano sandstones and siltstones on the road immediately adjacent. A thin-section shows that approximately one-third of the rock is composed largely of plagioclase (An_{35}), and that the remainder is composed of calcite, chlorite, kaolinite, and epidote, with minor amounts of quartz (2%) and biotite (3%). The biotite replaces in part a bladed, opaque mineral, which forms 5% of the slide.

Quartz Diorite

A fine-grained intrusion underlies a ridge 3,500 feet long and 1,000 feet wide northeast of Pain-de-Sucre lake. The ridge is parallel to the regional strike, on the contact between Pointe aux Trembles and Asselin strata. The crystals are commonly 0.7 mm. in diameter, but "phenocrysts" up to 2 mm. occur. The texture and the elongation of the intrusion suggest that it is a sill, approximately 800 feet thick.

The average mode of two thin-sections of this intrusion is as follows:-

	%	
Quartz	12.5	
Orthoclase	15	
Plagioclase	48.5	(An content 57%)
"Augite"	11	(One 2V of 49° measured)
Chlorite	7	
Ores	6	

The plagioclase is slightly sericitized and kaolinized, and is euhedral to subeuhedral. "Augite" is anhedral. The orthoclase forms rims around the plagioclase, whereas quartz fills interstices between the crystals. Thus the order of crystallization was: plagioclase, "augite", orthoclase, and quartz. The above rocks are quartz diorites, although they are near the boundary of quartz diorites and quartz monzonites. A third thin-section of this intrusion shows extensive saussuritization.

The age of the diorite and quartz diorite is not clear. Both are definitely post-Lower Silurian and perhaps Devonian.

Devonian ?

Kersantite

Two lamprophyre (kersantite) dikes cut Quebec Group rocks in the Squatec East area. One is 2 miles south of Saint-Isidore, and the second is 4 miles north-northeast of Biencourt. One dike strikes due north, and the other strikes N.18°E.; both have vertical dips, and are about 6 feet thick. They are dark, and chlorite and abundant mica are visible in hand specimen. A thin-section has the following mineral composition (mode):-

	%	
Quartz	3	
Plagioclase (An_{28}) ..	36	(kaolinized)
Kaolinite and epidote	5	(unresolvable masses)
Biotite	20	
Chlorite	15	(replacing biotite and "augite")
Calcite	5	
Apatite	1	
"Augite"	15	

The quartz occurs interstitially and interlayered with biotite. Plagioclase, biotite, and "augite" appear both as phenocrysts and in the groundmass. The texture is lamprophyric, i.e., panidiomorphic and porphyritic.

Gorman (1957) reported two thin (2 and 3 inches) biotite lamprophyre dikes cutting the Témiscouata Formation. Probably the Squatec East lamprophyres are also post-Lower Devonian, perhaps Acadian or even related to Monteregian igneous activity.

STRUCTURAL GEOLOGY

Cleavage

The cleavage in the slates and siltstones of the Quebec Group does not form a simple structure. The incipient gneissosity of the sandstones and quartzites in units 1A and 1B appears to be crinkled and contorted, along with the bedding, whereas the gneissosity in unit 1G forms a shallowly dipping structure. The strikes of the gneissosity in unit 1G swing with the 1C-1G contact, and thus have a half-dome form. Cleavage or gneissosity domes are found locally in highly metamorphosed rocks of the Sutton - Green Mountain anticline.

The strike of the cleavage in the Upper Silurian formations in the Squatec-Cabano syncline is parallel to the strike of the fold. The strike of the cleavage of the mudstones of the Cabano Formation and the slates of the Témiscouata Formation in the Cabano area is approximately N.35°E. In the Squatec East area, the strike of the cleavage of these two formations is not parallel. The Témiscouata Formation in the Squatec East area has an average cleavage strike of N.55°E., which changes to N.22°E. in the vicinity of the upper part of Touladi river that flows into Biencourt lake. The strike of the cleavage in the slates and siltstones of the Cabano Formation also changes from north to N.35°E. (the cleavage in the Quebec Group adjacent to the Cabano Formation is parallel to the cleavage in the Cabano Formation).

The cleavage which strikes north is in areas of abundant slates and siltstones, i.e., in areas with a notable lack of competent beds. In the Témiscouata region thousands of feet of incompetent strata are interbedded within equally thick competent strata on the limb of a very large fold. The flow lines in incompetent strata of the Cabano and Témiscouata formations are represented by a slaty flow cleavage, i.e., a rock in which the components are aligned parallel, and which flowed plastically.

Faults

The Témiscouata - Petit Biencourt Lakes fault probably joins with the fault in the La Résurrection area, although it is covered by Pleistocene and Recent deposits south of Témiscouata lake. It is supposedly continuous with a "fault zone" which can be traced to the Matapédia valley (Laverdière and Morin, 1941). Work in progress by officers of the Quebec Department of Natural Resources has shown that such a fault (zone?) exists. The fault is here interpreted to continue southwest of the Témiscouata region, and also north.

The Témiscouata - Petit Biencourt Lakes fault brings Quebec Group strata in contact with the upper Mont Wissick, lower Mont Wissick, Robitaille Formation, and the La Résurrection Formation. In addition it passes within Quebec Group strata. The topographic expression of this fault east of Sauvagesse lake and north of Bédard lake is a well-marked obsequent fault-line scarp, but elsewhere the fault is not marked topographically. The fault is interpreted as a normal fault with a 65° western dip, on the basis of overturned uppermost quartzites of the upper Mont Wissick, and the schistosities of a fault breccia on the shore of Témiscouata lake (this outcrop of fault breccia is about 600 feet long, and contains miscellaneous fragments of the Quebec Group).

The fault has a minimum throw of 7,400 or 7,800 feet, depending on the interpretation adopted (see below). The latter figure is considered more likely, and has been calculated from the cross-section east of Sauvagesse lake. The throw east of Sauvagesse lake is 9,000 feet, and the heave 4,000 feet, if the hypothesis of a homoclinal sequence is accepted, and if the strata in the homocline are joined with those of the Squatec-Cabano syncline.

[Addendum Lajoie's work (1962) has demonstrated a thrust fault in the area north of the Squatec West area. This is the continuation of the Témiscouata-Petit Biencourt Lakes fault of the Squatec area. Thus, this latter fault is probably also a thrust, dipping gently east, and carrying westward the synclinal strata of Squatec-Cabano. The fault near La Résurrection (Cabano West area) is probably the continuation and possibly is also a thrust.

The strata to the west of this thrust, north of the Squatec area, are Mont Wissick equivalents and are synclinal. It is, therefore, quite possible that the Mont Wissick beds surrounding Sauvagesse lake also are synclinal, but there is no direct evidence of this.

The Lac Raymond Formation in the northeast corner of the present area is widespread, probably as the result of being on the hinge of a syncline, the existence of which was demonstrated farther north by Lajoie (1961).

Collections of corals from limestone in the Rivière Bleue quarry some miles south of the Cabano West area have been identified by L.M. Cumming (1956) and W.A. Oliver (1962), and personally reported on to the writers. These corals are Silurian in age, and the limestone is at the base of the Témiscouata Formation. The relations are uncertain, but the following possibilities are suggested: a) The base of the Témiscouata is Silurian here; b) The limestone is a fault block; c) The limestone is Mont Wissick and is a relic of pre-Devonian.]

Cross-faults bound the homocline east of Sauvagesse lake. The southern cross-fault is interpreted as a tensional branch of the Témiscouata - Petit Biencourt Lakes fault; the northern one is perhaps tensional also, but it displaces the Témiscouata - Petit Biencourt Lakes fault. Little data exist on these cross-faults, or on a third cross-fault needed to explain the outcrop pattern west of Petit Biencourt lake.

A small stream $1\frac{1}{2}$ miles southwest of Touladi lake runs on the trace of a right lateral fault, which displaces the strata 60 feet horizontally.

There is no evidence for a southeast-trending fault in Témiscouata lake (Blanchard, 1935), or a northeast-trending fault between the Cabano and Robitaille formations in the Cabano area, as postulated by Bailey and McInnes (1889), or a fault at the western boundary of the Témiscouata Formation (see below).

Folds

The major fold of the Témiscouata region is the syncline which extends from Cabano to Saint-Michel-du-Squatec, a distance of 17 miles, and here named the Squatec-Cabano syncline. It is a broad, open, symmetrical fold. The eastern limb of the syncline, particularly in its southern part, is thinner than the western limb, by an average of 2,000 feet horizontally. This thinning indicates that the axial plane of the fold dips west. The deepest section of the fold (i.e., the point of zero plunge) is between the two arms of Croche lake, and both extremities plunge approximately 11° toward this deepest section. The southern area of the fold, near or at its nose, is complicated by a number of minor folds, which have metamorphosed the strata to a somewhat higher degree than elsewhere (minor folding and shearing of some beds is apparent at Anse). The southern nose of the Squatec-Cabano syncline is difficult to place in view of the folding at Anse, but an outcrop with a northern dip in the town of Cabano suggests that the fold extends to the southern edge of the lake.

The second fold of importance is the Squatec anticline in the Quebec Group, in the western part of the area. The distribution of units 1A and 1B indicates a plunging fold, and lineation obtained from crenulations in slaty rocks (as in Plate IV-B) indicates that the plunge of the fold is an average of 10° northward.

From meager lineation data, near the boundary of the Squatec and Cabano areas, and from the distribution of the units of the Quebec Group in the Cabano area, it is probable that the crest of the anticline is in the Cabano area, or at the southernmost extremity of the Squatec area, and that the anticline plunges south farther southwest. The bedding of the strata in units 1A, 1B, and 1C does not support this fold, and probably the strata are much crinkled and contorted in detail, but the over-all structure is anticlinal.

Strata of unit 1D indicate roughly the plunge of the anticline, but they also abut against unit 1G. This suggests an unconformable relationship between units 1C, 1D, and 1G. It is more probable, however, that the difference in competence between these units is responsible for the abutment. Thus, it is suggested that units 1C and 1D flowed during incompetent folding in contact with 1G. The strikes and dips within units 1C and 1G are almost parallel to the contact between these two units, and this further suggests that no unconformable relation exists.

As pointed out above in the section on the stratigraphy of the Quebec Group, the eastward facing tops in unit 1F, to the northwest of the anticlinal axis, are difficult to interpret. Much similar data have been found by Béland (particularly 1954). A fault contact between units 1F and 1G could explain the above relations, but no evidence supports such a fault. Either the tops from graded beds are not reliable, or else the folding is so tight, and asymmetric, that a reversal of dip has occurred which has not been recognized (i.e., a syncline would exist between Sainte-Rita and the anticlinal axis). Such a syncline appears improbable with the data at hand.

The Upper Silurian strata west of the Témiscouata - Petit Biencourt Lakes fault dip eastward. Top determinations of beds are in general scarce, and the Mont Wissick strata east of Sauvagesse lake may be folded into an isoclinal syncline, or they form a homoclinal sequence. These two interpretations are shown on cross-sections CC', and C" C"'. If an isoclinal syncline is postulated, this would necessitate a very sharp bending of the Robitaille Formation above the present land surface, in order that these strata might pass underneath the adjacent syncline. The interpretation that the sequence is homoclinal, and that this homocline was the western limb of the syncline now mostly eroded away is much more plausible. Elsewhere west of the Témiscouata - Petit Biencourt Lakes fault, the strata are so thin that there is little chance that folds have gone unrecognized.

The Silurian strata east of the Squatec-Cabano syncline and Cabano river dip eastward, and form the limb of a major fold. A few folds in the Cabano Formation were found, but they are small. North of Biencourt lake an anticline and a syncline were recognized, but these are poorly known. West of Touladi lake (Cabano area) the lower conglomerate is folded into two sharp folds. The plunge of the folds is to the south, and graphic constructions indicate that the syncline plunges at 60°, and the anticline at 24°.

The structure of the Silurian and Devonian strata in the Témiscouata region are shown on the cross-sections. Folds in the Témiscouata Formation cannot be shown on the scale of the accompanying map. The extraordinary contortions within the formation, combined with the endless varieties of folds, indicate folding of a very plastic mass. The mineralogy and the bedding of part of the Quebec Group slates and the Témiscouata Formation "slates" are very similar, but the Quebec Group slates have not been deformed on a scale comparable to the Devonian slates. If the strata were plastically folded, and if this plastic nature was due to heat and pressure, the Quebec Group rocks should have behaved as the Devonian slates. This is not the case, and incongruous folding in the Quebec Group has not been proved. If heat and pressure were not responsible for the plastic nature of the slates, what was? Perhaps the muds of the Témiscouata Formation were plastic because they still contained much water. When the muds were deformed, the slates of the Quebec Group had been previously consolidated, and the temperature and pressure were not great enough to affect them further. Consequently, the type of folding may not have been of a deep-seated geosynclinal nature, but of a water-mud mixture which was probably relatively thin and near the surface. The folds were more probably large and open, like the Squatec-Cabano fold. In effect, what is here suggested is that the Acadian folding in the Témiscouata region is similar to the folding found in the Valley and Ridge Province of the central Appalachians.

Unconformities

The unconformity between Silurian strata and pre-Silurian strata is indicated in part by differences in metamorphism of the rocks, in part by differences in tectofacies, and in part by well-proved relations outside the Témiscouata region. This Taconic unconformity is a major tectonic break.

The unconformity between the Pointe aux Trembles and Robitaille formations is proved through fossil data. The absence of Lower Silurian in the Squatec West area may be owing to erosion, and not to non-deposition as here interpreted. The unconformity between Silurian and Devonian is based on fossil data, structural information, and necessity of interpretation.

The pinching out of every formation against the Témiscouata Formation can be explained in two ways. Either a fault separates the Témiscouata from older formations, or an unconformity underlies the Devonian strata. This unconformity would be Upper Ludlow, as no fossils of this age have been found in the Témiscouata region (following Boucot, however, Lajoie (1963) interprets _Eccentricosta jerseyensis_ from the Lac Croche Member as Upper Ludlow). A fault would explain particularly well the great thickness presumably missing in the Cabano area (perhaps as great as 14,000 feet). Erosion to such degree would imply a very important unconformity. In the area to the north (where mapping was in progress concurrently with the present work) Upper Silurian type strata (Saint-Léon) and lowermost Devonian (Cape Bon Ami) type strata are interbedded - although no fossils of the Upper Ludlow have been found. Also in this area, a fault apparently separates York River (Témiscouata) and older strata. Nevertheless, the writers believe that the pinching out, in the Squatec and Cabano areas, is owing to an unconformity, and the strongest argument in favor of the unconformity is the absence of fracturing and veining adjacent to the supposed major fault.

Gorman (1957) interpreted the western contact of the Témiscouata Formation as a fault. He placed this fault between the Cabano and the Témiscouata formations. At one place, Gorman found slates resting on trachytes. These trachytes may belong to the Pointe aux Trembles Formation, or to the Témiscouata Formation. If they are Pointe aux Trembles, the contact of the Témiscouata Formation is not necessarily a fault.

The "fault-line scarp" of the Témiscouata Formation is only found east of Cabano river; elsewhere the contact with Devonian formations passes indiscriminately through lowlands and hills. Furthermore, the writers have seen Mont Wissick and Touladi rocks within 50 feet of each other, and Touladi and Pointe aux Trembles rocks in contact in a pit at fossil locality G-28, southwest of Pointe aux Trembles. The deformation of the strata near these contacts is no greater than elsewhere. Thus, a regional unconformity seems to explain the pattern of outcrop here better than a fault.

The disappearance and thinning of all the Silurian formations at the contact of the Témiscouata Formation indicate an important period of erosion preceding deposition of the Témiscouata Formation. The slightly angular nature of this unconformity is indicated by the saucer-shaped pattern of outcrop of the Mont Wissick Formation in the Cabano and Squatec areas. That such a slightly angular unconformity does exist is proved by strikes and dips taken in the Touladi Lake area. The difference in strike of the Mont Wissick and Touladi formations is an average of 15°. This slightly angular unconformity is even better displayed along the stream 2 miles southwest of Touladi lake where Mont Wissick siltstones and sandstones containing *Halysites* sp. strike N.35°E., and dip 85° east, whereas 50 feet farther east, dark gray, argillaceous, fetid limestones of the Touladi Formation, strike N.50°E., and dip 50° south. Neither fracturing, nor calcite or quartz veins are present in these two outcrops.

An erosional unconformity younger than the Touladi Formation is also needed to explain the irregular pattern of this formation below the Témiscouata Formation, although part of this distribution is probably owing to primary depositional irregularity.

ECONOMIC GEOLOGY

Metallic Deposits

Sulfides have replaced two outcrops north of Sauvagesse lake. One hundred feet northwest and 300 feet southwest of the southeast corner of lot 2, Range I, Robitaille township, a well-sorted sandstone replaced predominantly by pyrite crops out. This outcrop is exposed in a gravel pit opening on the road; part of the gravel pit is under water. The sandstone is massive, grayish white to dark gray, and medium to coarse grained. Clay pods up to 2 inches in diameter in the sandstone are light gray, have various sizes and shapes, and form up to 10% of the rock. The pods, in a few places, may be altered slate or shale chips.

The sandstone replaced by sulfides is exposed for 10-20 feet along a horizontal surface, and is overlain at its sides by up to 2 feet of gossan-like, highly limonitic, reddish sand. At the northwest end of the outcrop, the pyrite is in bands up to 1 inch that strike N.17°W., and dip 25° east. At the northeast end of the outcrop, and 25 stratigraphic feet above the replaced sandstone, green impure sandstones and red siltstones crop out; both are unreplaced.

The sulfides are disseminated, are predominantly pyrite, and locally form 40% of the rock. Sheared galena is seen in a few fractures, in addition to disseminated grains. The sulfides replace Robitaille sandstones or quartzites; thus the mineralization is post-Upper Silurian in age. Three grab samples (numbers 123) were assayed, and the following metal contents were obtained:

Sample	123-A	123-B	123-C	
	%	%	%	
Copper	0.03	0.10	0.14	
Zinc	0.14	2.93	0.02	
Lead	5.35	0.00	1.15	
Silver	0.356	0.166	0.00	ounces per ton
Gold	0.00	0.00	0.00	ounces per ton

Approximately 1 mile northeast of the above occurrence, two 8-inch, coarse-grained, conglomeratic sandstone beds have a pyrite content of 3-5%. The outcrop is along a stream, 100 feet southwest and 300 feet southeast of the northwest corner of lot 50, Range II northwest, Biencourt township. Adjoining these sandstone beds, spherical pyrite nodules up to 2 inches in diameter replace gray slate and silty limestone. The pyrite weathers yellow, blue, and green. A composite sample of the sandstone and the pyrite was assayed for gold, silver, lead, zinc, and copper; none of these metals were present. The strata within which this mineralization is found are crossbedded and laminated to thinly bedded, pure, argillaceous, and/or silty limestones and slates. The sulfides replace Quebec Group rocks, and are probably related to the same period of mineralization as the preceding occurrence.

The above sulfide mineralizations occur at the intersection of the Témiscouata - Petit Biencourt Lakes fault, and a second fault which displaces it. The second fault is the northeastern boundary of the homocline east of Sauvagesse lake. The homocline is also bounded on the southwest by a cross-fault. Both areas of intersection of the cross-faults and the Témiscouata - Petit Biencourt Lakes fault are suggested as areas worthy of additional prospecting. Both intersections are in part drift covered, and geophysics and geochemistry would no doubt be useful tools for prospecting here.

Gold in quartz veins cutting the Témiscouata Formation 1½ miles southwest of Notre-Dame-du-Lac has been reported. A pit was dug here, but no development work has been done for many years.

Non-metallic Deposits

Asbestos

The serpentinite on the eastern limb of the Squatec-Cabano syncline has asbestos veins, in part silicified, which form up to 2% of the rock. This body is too small for exploitation, but other intrusions may be found. The east limb of the Squatec-Cabano syncline has few outcrops, and a diligent search for outcrops may reveal other intrusives.

Clay

Varved clays are probably present in all lowlands below 600 feet in altitude, and in the Biencourt Lake area in lowlands below 750 feet. These clays are proglacial deposits and are rich in rock flour and iron oxides but poor in clay minerals.

The thickness of the clay deposits is unknown, but within the Ashberish River valley at least 20 feet are exposed. This valley is possibly the area which is best suited for exploitation, for it contains less water than other valleys. This locality is also the nearest to the railroad at Cabano. The clays would, however, require stripping, as they are overlain by gravel up to 50 feet thick.

Gravel

All lowlands have gravel, and deposits can easily be found where needed. A number of gravel pits have been operated, or are in operation, and are indicated on the accompanying map.

Limestone

The Lac Croche Member of the Mont Wissick Formation is predominantly limestone. High calcium, dolomitic, and impure (argillaceous and/or silty) limestones are present in this member within the Squatec-Cabano syncline. Thus the Lac Croche Member in the Squatec-Cabano syncline is a possible industrial source for magnesian limestones, or dolomites, admixed with high calcium limestones. For high calcium limestones, however, the Lac Croche Member immediately northeast of Squatec river is more easily accessible, and probably has thicker sections of pure limestones than elsewhere in the Témiscouata region. The thicknesses of limestones, magnesian limestones, or impure limestones and dolomites are known imperfectly, and a drilling program would be necessary to determine this.

Five analyses (see stratigraphy of the Lac Croche Member) have been made by the Department on limestones of the member, in the Squatec-Cabano syncline. Of these five, samples F310A and B are high calcium limestones, and are suitable for the pulp industry. The limestones of unit 1D in the Quebec Group are also limestones which possibly could be used advantageously for commercial purposes.

Marl

Waddington (1950, 1953a, 1953b, 1954a, 1954b, 1954c) has visited a number of lakes in the Témiscouata region in search of marl, which is a ready source of fine-grained lime for agricultural purposes. The information is summarized below:-

Lake	Reserves (cu. yds)	$CaCO^3$ content %
1½ miles west-southwest of Saint-Eusèbe (Cabano area)	2,500	70
2 miles north-northeast of Saint-Eusèbe (Cabano area)	4,000	77
Auclair lake	80,000	92
Little Auclair lake	25,000	90
Raymond lake	2,500	95

Only those lakes which have marl have been included above. In general the marl is under only a few feet of water.

Auclair lake derives its name from the white lake bottom, composed of marl, and its shallowness which makes the water "clear". Samples from the lake bottom show that the marl is amorphous, brownish white, and contains a number of thin-shelled gastropods and pelecypods.

The distribution of the deposits indicates that the lime content of the bedrock has an important influence on their location. No marl is found in areas of Quebec Group rocks, and the biggest deposits are those surrounded by rocks of the Mont Wissick Formation.

Oil and Gas

The metamorphism of the Silurian formations was not intense enough to have completely volatized any petroleum. The Mont Wissick Formation perhaps would contain both source and reservoir rocks.

No oil or gas seeps have been seen, or reported, although the biostromal limestones of the Mont Wissick east of Sauvagesse lake and in a few other places have a distinct petroliferous odor. No favorable anticline structure for petroleum accumulation is known, however, and stratigraphic traps would seem to offer the best possibilities.

The Touladi limestones have such a strong odor that working in these rocks is unpleasant. As many, if not all, of these limestones are clastic and coralline, they would make ideal reservoir rocks. Favorable structures for oil accumulation may be present underneath the Témiscouata Formation, should the Touladi limestones be present.

REFERENCES

BAILEY, L.W. (1887) On the Silurian system of northern Maine, New Brunswick, and Quebec: Roy. Soc. Canada Trans., v. 4, pp. 35-41.

BAILEY, L.W. (1889) On the Acadian and St. Lawrence watershed: Canadian Rec. Sci., v. 3, pp. 398-413.

BAILEY, L.W. and McINNES, W. (1889) Report on explorations and surveys in portions of northern New Brunswick, and adjacent areas in Quebec and in Maine, U.S.: Geol. Surv. Canada An. Rept. 1887-1888, Rept. M, 52 p.

BAILEY, L.W. and McINNES, W. (1893) Report on portions of the province of Quebec and adjoining areas in New Brunswick and Maine relating especially to the counties of Témiscouata and Rimouski, P.Q.: Geol. Surv. Canada, An. Rept. 1890-1891, Rept. M., 28 p.

BELAND, J. (1962) Ste-Perpétue area, Kamouraska and L'Islet counties: Que. Dept. Nat. Res., G.R. 98.

BLANCHARD, R. (1935) L'Est du Canada français: Beauchemin ed., Montreal; 2 vol., 228 p.

CADY, W.M. (1960) Stratigraphic and geotectonic relationships in northern Vermont and southern Quebec: Geol. Soc. Am. Bull., v. 71, pp. 531-576.

CUMMING, L.M. (1956) Personal communication.

CUMMING, L.M. (1959) Silurian and Lower Devonian formations in the eastern part of Gaspé peninsula, Quebec: Geol. Survey Canada Mem. 304.

DE JONGUE, E.J.C. (1951) Glacial water levels in the St. John river valley: Ph.D. thesis, Clark University, Worcester, Mass.

DUQUETTE, G. (1959) Le groupe de Québec et le groupe de Gaspé près du lac Weedon: Naturaliste Canadien, v. LXXXVI, pp. 243-263.

GIRARD, H. (1937) Limestone inspection, Notre-Dame du Lac area, Témiscouata county: unp. ms., Que. Dept. Mines, no. GM-92, 6p.

GIRARD, H. (1938a) Limestone inspection, Cabano township, Témiscouata county: unp. ms., Que. Dept. Mines, no. GM-93, 3 p.

GIRARD, H. (1938b) Report on work done for limestone exploitation, range XI, Cabano township: unp. ms., Que. Dept. Mines, no. GM-890, p. 8.

GORMAN, W.A. (1957) Preliminary report on southern Témiscouata area: ms., Que. Dept. Nat. Res., p. 11.

GREGORY, H.W. (1900) Volcanic rocks from Témiscouata lake: Am. Jour. Sci., vol. 10, pp. 14-18.

KINDLE, E.M. (1914) Columnar structure in limestone: Geol. Surv. Canada, Mus. Bull. 2, Geol. Ser. 14, p. 10.

LAJOIE, J. (1961) Preliminary report on Prime Lake area (west half), Rimouski county: Que. Dept. Nat. Res., R.P. 448.

LAJOIE, J. (1962) Preliminary report on the Chénier-Bédard area, Rimouski county: Que. Dept. Nat. Res., R.P. 493.

LAJOIE, J. (1963) The Siluro-Devonian stratigraphy of the Matapédia-Témiscouata area: Doctorate thesis, McGill University, ms.

LAVERDIÈRE, J.W. and MORIN, L.G. (1941) Géologie des Appalaches canadiennes entre Rivière-du-Loup et Matane: Nat. Can., v. 68, pp. 216-260.

LEE, H.A. (1953) Two types of till and other glacial problems in the Edmundston-Grand Falls region, New Brunswick, Quebec and Maine: Ph.D. thesis, University of Chicago.

LEE, H.A. (1955) Surficial geology of Edmundston, Madawaska, and Témiscouata counties, New Brunswick and Quebec: Geol. Surv. Canada Paper 55-15.

LESPÉRANCE, P.J. (1959) Preliminary report on Squateck area (west half), Témiscouata, Rivière-du-Loup and Rimouski electoral districts: Que. Dept. Mines, P.R. 385.

LESPÉRANCE, P.J. (1960) The Silurian and Devonian rocks of the Témiscouata region, Quebec: Ph.D. thesis, McGill Univ., Montreal, 264 p.

LOGAN, W.E. (1850) Report of progress for the year 1849-1850: Geol. Surv. Canada, 72 p.

LOGAN, W.E. (1863) Geology of Canada: Geol. Surv. Canada, p. 983.

LOMBARD, A. (1956) Géologie sédimentaire, les séries marines: Masson Ed., Paris, 722 p.

MARLEAU, R.-A. (1958) Geology of the Woburn, East Megantic, and Armstrong areas, Frontenac and Beauce counties, Quebec: G.R. 131, Que. Dept. Nat. Res.

McGERRIGLE, H.W. (1934) Western Témiscouata with parts of Kamouraska and Rivière-du-Loup counties: Rep. Minister Mines, Prov. Quebec 1933, part D, pp. 93-128.

OLIVER, W.A. jr. in STUMM, E.C., and OLIVER, W.A. jr., (1962) Silurian Corals from Maine and Quebec: U.S. Geol. Surv., Prof. Pap. 430.

THOMSON, A. (1959) Pressure solution and porosity: Soc. Econ. Paleo. Mine., Spec. Pub. 7, pp. 92-110.

WADDINGTON, G.W. (1950) Marl deposits of the Province of Quebec: Que. Dept. Mines, Geol. Rept. 45, 127 p.

WADDINGTON, G.W. (1953a) Marl Inspection, Biencourt township: unp. ms., Que. Dept. Mines, no. GM-6612.

WADDINGTON, G.W. (1953b) Marl Inspection, Asselin township: unp. ms., Que. Dept. Mines, no. GM-5827.

WADDINGTON, G.W. (1954a) Marl Inspection, Madawaska seigniory: unp. ms., Que. Dept. Mines, no. GM-9294.

WADDINGTON, G.W. (1954b) Marl Inspection, Asselin township: unp. ms., Que. Dept. Mines, no. GM-3284.

WADDINGTON, G.W. (1954c) Marl Inspection, Asselin township: unp. ms., Que. Dept. Mines, no. GM-3283.

WEEKS, L.G. (1957) Origin of carbonate concretions in shales, Magdelena valley, Columbia: Geol. Soc. Am. Bull., v. 68, pp. 95-102.

Appendix

Section at Pointe Brûlée (Burnt Point)

The section begins on the southeast side of Pointe Brûlée (Burnt Point), at the end of a narrow strip of land projecting from the point. This strip of land is generally under water, and was mapped under the very low-water conditions (483 feet approximately) of September, 1957. The section was measured with a tape, is in descending order, and is taken near the water level. The dip of the strata is steeply east. All the rock types are gray and poorly cemented, and have a "dirty" appearance owing to the slate and siltstone chips present. The matrix of the conglomerate is sand.

		Thickness of unit	Cumulative thickness
18.	Conglomerate and sandstone. The average size of the cobbles is 3". The sandstones are generally cobbly. Approximately half of the unit is exposed, discontinuously, below high-water level	62'	62'
17.	Concealed. Approximately 500' to the southwest, 10' of black shale are exposed. Probably this unit is all black shale	83'	145'
16.	Sandstone and a few thin beds of pebble conglomerate. Typically the sandstone has cobbles up to 8", never forming more than 20% of the rock. Graded bedding and crossbedding (in one single bed) indicate the beds are right side up. The bedding planes are irregular, and form symmetrical "channels" from which no tops can be determined. These channels have an amplitude of 2 feet or so. The unit is well exposed along strike. At the southwest end of the outcrop, farther than the shale above, a limestone cobble contained trilobite fragments suggesting a Late Cambrian to Middle Ordovician age, and also contained a fragment resembling <u>Schizambon</u> sp., a Lower Ordovician brachiopod (identified by A.R. Palmer; R.B. Neuman, personal communication, February 1959). A black slate cobble was also noticed here	17'	162'
15.	Conglomerate and sandstone, interbedded. Sandstone forms 40% of the unit, in beds 1'-15' thick; the conglomerate is in beds 1'-10' thick. The sandstone is medium grained and conglomeratic. The conglomerate is more abundant toward the top, and is closely associated with sandstone near the bottom; pebble size is 2½". One sandstone bed 31' 6" above the base of the unit grades <u>down-dip</u> into boulder conglomerate, which rests on sandstone. This boulder conglomerate has a coarse sand and pebble matrix; a boulder tally gave 93% quartzite, and 7% limestone. Boulders in some sandstone beds arch the bedding eastward, or else the bedding stops on either side of the boulder. One sandstone bed pinches out along strike. Tabular pebbles are parallel to the bedding. This unit possibly forms a large channel, concave to the east.	66'	228'

		Thickness of unit	Cumulative thickness
14.	Conglomerate and sandstone. The sandstone (7' thick) is in beds up to 1' which pinch out along strike. As a rule beds of conglomerate are 2-3 feet thick. The average size of the conglomerate clasts is 1", although granules and 6" cobbles occur. The pebble size seems to increase upsection. The 1½" and coarser pebbles form the better sorted beds. The sandstones and granule conglomerates are more poorly sorted. At 46 feet above the base of the unit, at low-water level, a pebble count gave 55% quartzites, 25% limestones, and 20% limy sandstones. The average strike of the bedding is N.35°E. and the dip is 55° east ...	65'	293'
13.	Sandstone and conglomerate in 2-5-foot interbeds; each forms approximately half of the unit. Both the sandstone and the conglomerate beds pinch out along strike so that the section is nowhere the same. Contacts between beds are generally gradational, with tops to the east. The sandstone is medium to coarse grained, and has abundant slate and siltstone chips. Sandstone beds with single boulders up to 12" are notable. Clasts in conglomerate beds grade in size from boulders of 26" to granules. Tabular pebbles (mostly cobbles) are parallel to the bedding, and are abundant at some horizons. The upper 14' are transitional to the unit above, and are better sorted. Here sandstone and conglomerate are interbedded in units approximately 12" thick	47'	340'
	Concealed. This forms a bay and a cultivated lowland to the south	350'	690'
12.	Conglomerate and sandstone. The sandstone forms an aggregate thickness of 6', either lensing out along strike or grading into conglomerate. The average size of clasts in the conglomerate is 2", but in some beds the average size is ¾". The matrix of the conglomerate is sand and granules, and forms approximately 25% of the rock	81'	771'
11.	Sandstone, conglomeratic, with a 2' conglomerate bed. The sandstone is medium to coarse grained, and has approximately 5% pebbles. The conglomerate bed pinches out along strike	6'	777'
10.	Conglomerate. The average size of the pebbles is 1½". The unit is conspicuous because 2% of its pebbles are green-weathering quartzite	7'	784'
9.	Sandstone with some pebbles. Pebbles grading to sand indicate a top to the east. The sandstone is medium grained, well sorted (better than the underlying unit, with less argillaceous material), dark gray	4'	788'
8.	Conglomerate. Average pebble size is 2"; cobbles up to 6" are present. Approximately 1/2 of the pebbles are limestones and related rocks; these pebbles are tabular (and aligned parallel to the bedding) whereas the quartzite pebbles are more spherical. The matrix of the conglomerate forms approximately 25% of the rock. Twenty-five feet farther along strike the whole unit is sandstone.	7'	795'

		Thickness of unit	Cumulative thickness
7.	Sandstone and conglomerate interbedded. Sandstone forms the base and the top of the unit. As a rule the sandstone beds are approximately 2' thick, and form 20% of the unit. Granules grading to sand, in the upper part, indicate a top to the east. In two places the sandstone appears to form thin channels in the conglomerate, or vice versa. The average size of the conglomerate clasts is 1", although granules to boulders 10" across are present. A black slate pebble was noted. Buff-weathering pebbles (limestone, argillaceous limestone, dolomite) form approximately 1/2 of the clasts, and appear better rounded than in the underlying unit	22'6"	817'6"
6.	Conglomerate,-clasts range from 1/2" to 8", but the average size is 2". This unit differs from 5 only in the size of the conglomerate clasts	6'	823'6"
5.	Interlensed sandstone, conglomeratic sandstone, and conglomerate. The conglomerate is local, and more abundant in the lower 2 feet, where the average size of clasts is 3/4". The sandstones form 70% of the unit, and have conglomerate clasts up to 6", with an average size of 1/4-1/2". Elongated pebbles of limestone and related rocks are oriented parallel to the bedding, and form approximately 3/4 of the pebbles. Coarse, black slate (or phyllite) sand is very abundant in the sandstone	11'6"	834'
4.	Sandstone,— medium grained, poorly schistose. Micaceous or black slate particles form 1/2 of the sandstone; green slate and biotite(?) occur. The sand grains are well sorted. The matrix forms 5-10% of the rock. Thin-sections show that this rock is composed of quartz (50%), siltstone chips (30%), and slate chips (20%)	3'	837'
3.	Conglomerate and sandstone. Sandstone forms approximately 10% of the unit. It is coarse grained, somewhat weathered, and has a few granules or pebbles. The conglomerate clasts range in size from granules to 5", and form 25-75% of the rock; the average is 40%. Buff-weathering, tabular pebbles are parallel to the bedding and form approximately 1/2 of the pebbles	10'	847'
2.	Conglomerate. Conglomerate clasts range in size from granules to 12" in the same bed, although 8" is the usual maximum; the average is 1". Approximately 3/4 of the pebbles are buff-weathering limestone, which gives a pitted appearance to the weathered surface. Half of the limestone pebbles are tabular, and are parallel to the bedding. The matrix forms 30-60% of the conglomerate, and is coarse-grained sandstone. The strike of the bedding is N.35°E., and the dip is 54° east	11'	858'

	Thickness of unit	Cumulative thickness
1. Angular, very large boulders found along the shore to the northwest are conglomerates and sandstones, similar to those described above. The boulders are probably near bedrock that underlies the point extending into the lake. A pebble count in these blocks shows that gray quartzite and dark gray limestone are the most abundant fragments. In the upper 150' or so of the unit, about 10' of sandstone and conglomerate crop out. The sandstones are minor, occur in one-foot beds, are coarse grained, and have 2% light green, slate sand. The average grain size of the conglomerate is 1" in some beds, and 3" in others. The matrix is a coarse-grained sandstone, with a trace of light and dark gray slate grains, and forms approximately 20% of the conglomerate. Most of the pebbles are light gray limestone.	1,342'	2,200'

Total measured: 415'

Estimated thickness of sandstone and conglomerate: 1,750'.

ALPHABETICAL INDEX