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PRIME AND BAIES LAKES AREA, RIMOUSKI COUNTY

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GEOLOGICAL REPORT 139

PRIME AND BAIES LAKES AREA

(Rimouski County)

by
Jean Lajoie

QUÉBEC
1971

TABLE OF CONTENTS

Page

ILLUSTRATIONS

Map

Figures

Page

Plates

Tables

PRIME AND BAIES LAKES AREA

Rimouski County

by

Jean Lajoie*

INTRODUCTION

General Statement

The Prime and Baies Lakes area covers about 400 square miles and is in the Appalachians, between Matapédia and Témiscouata lakes, some 30 miles south of Rimouski on the south shore of the Saint-Laurent. It is underlain mainly by sedimentary rocks of Ordovician and Silurian age. Devonian sedimentary rocks in the southeast corner of the area are faulted against the Silurian, but in the north-central part a band of Devonian (Cap Bon Ami) overlies the Silurian conformably. The only igneous rocks present are a few gabbroic sills and dikes involved with Silurian rocks near the southeast corner of the area.

Structurally, the rocks may be considered as pre-Taconic and post-Taconic. The former (Ordovician) is much folded, faulted, and brecciated; the beds generally are isoclinally folded and generally dip about 70°

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southeast. The post-Taconic (Siluro-Devonian) sequence overlies the pre-Taconic with angular unconformity and is generally in open folds. Both sequences trend northeast.

The main structure of the area is the Lac-des-Aigles - Trinité high (anticline?), which is a 15-mile-wide Ordovician zone bordered on both sides by Silurian.

This report is a modified version of a doctorate thesis presented at McGill University in 1963.

Access

The northern part of the area is made accessible by the Bic - Saint-Guy road, which, within the area, is maintained by The Price Company, Limited. The southern part of the area may be reached by the Rimouski-Cabano highway, from which several secondary roads branch towards the center of the area.

Most of the area is wooded, except near the settlements of Trinité-des-Monts, Esprit-Saint, and Lac-des-Aigles, the last being just south of the southern boundary.

Methods

The area was mapped on the scale of 1 inch to the half mile by pace and compass traverses spaced every 2,000 feet and by traverses along streams.

The best areas of exposures were studied in detail, and stratigraphic sections of Silurian sequences on each side of the Ordovician high (Fig.1) were constructed, corrections being made for the dip of the beds. The scale used (1 cm. = 1,000 feet) minimizes the missing portions in the sections and emphasizes the gross lithology of the formation involved.

In the northern compilation of sections (Figure 2), the most westerly section is on Sauvagesse lake in the Squatec West area; it was compiled from Lespérance's thesis (1960). For all the northern sections the datum plane is the top of the Saint-Léon Formation. Where sections did not reach this datum place, the top of the Saint-Léon had to be estimated.

The southern compilation of sections (Figure 3) extends from Horton lake (Squatec East area) to Porc-Epic lake (Prime Lake area, west half), and the datum plane is the top of the Lac Raymond Formation.

The reference lines in both compilations are not intended as "time lines" but rather as "rock lines", and they represent the most persistent lithologic horizons. The correlations made in this report are based primarily on lithology, although fossil evidence plays a major role in certain cases.

A correlation diagram (Figure 4) illustrates the relationship between the two compilations. This is not a fence diagram, since it must be noted that the southern sections have been thrust northward an unknown distance. A small gap is left on the correlation diagram between the southern and northern compilations to represent this displacement.

Acknowledgements

The writer is highly indebted to J. Béland and C.W. Stearn for discussions that produced many ideas for this report. Béland has kindly given permission to use some of his unpublished material.

A.J. Boucot of the California Institute of Technology classified all specimens of brachiopods collected by the writer in the area, and A.W. Oliver of the United States Geological Survey worked on a few of the coelenterate collections. L.V. Richard of the New York State Museum, as well as M. Copeland and L.M. Cumming of the Geological Survey of Canada, supplied information on brachiopods, ostracods, and graptolites. W.N. Berry of the University of California identified the graptolite collection from the Lac Des Baies Member of the Saint-Léon Formation.

The writer was assisted in the field in 1960 by T.R. Watts, graduate student at McMaster University, and by the junior assistants D.J. Kouri of Mt. Allison University and R. Allen of Laval Université; in 1961 by C.J. Berry, graduate in 1961 of McGill University, and by the junior assistants D.C. Carr of McGill and G. Longtin of the University of Montreal; in 1962 by A. Petryk, graduate of McGill University in 1962, and by the junior assistants L.A. Priéto of Loyola College and G. Longtin of the University of Montreal.

Previous Work

Matapédia Valley

Tables 1 and 2 give a résumé of the development of stratigraphic concepts in the Matapédia and Témiscouata valleys.

Crickmay (1932) was the first to study the Matapédia Lake Silurian rocks, which he devided into "three well-defined units" of probable Clinton age. Crickmay's formations are still used and, in descending order, they are:

Saint-Léon: argillaceous sandstones and limestone conglomerate - 2,000 feet
Sayabec: dark gray, dense limestone - 300-500 feet
Val-Brillant: white sandstones - 200 feet

TABLE I - DEVELOPMENT OF STRATIGRAPHIC CONCEPTS IN MATAPÉDIA VALLEY

TYPE				STANDARD A.J. Boucot		LOGAN, W., (1863)	ELLS, R.W., (1884)	BAILEY, L., McInnes, W. (1889)	CRICKMAY, G.W. (1930)	ALCOCK, F.J. (1935)	BURK, C. (1964)	BÉLAND, J. (1960)
DEVONIAN	LOWER DEVONIAN	COBLENZIAN	EMSIAN	LOWER DEVONIAN	Scoharie			Gaspé Limestones				
			SIEGENIAN		Esopus							
					Oriskany							
		GEDINNIAN			Bedcraft					? Cap Bon Ami Fm. ?	Cap Bon Ami Fm.	Causapscal Gp.
					New Scotland							
					Manlius							
? "SKALA"				CAYUGAN	Roundout					X	? Saint-Léon Fm.	Saint-Léon Fm.
?					Cobleskill							
SILURIAN	UPPER SILURIAN	LUDLOWVIAN	UP.		Bertie Gp.							
			MID.		Salina Gp.							
			LOW.			?	?	?				
		WENLOCKIAN		NIAGARAN	Lockport Gp.	Gaspé Sandstones	Gaspé Sandstones	Gaspé Sandstones			Sayabec Fm.	Sayabec Fm.
												Val-Brillant Fm.
	LOWER SILURIAN	LLANDOVERIAN	UPPER		Clinton Gp.				Saint-Léon Fm.	Saint-Léon Fm.	Val-Brillant	Awantjish Fm.
									Sayabec Fm.	Sayabec Fm.	Awantjish Fm.	X
									Val-Brillant Fm.	Val-Brillant Fm.	X	
			MIDDLE	LOWER SILURIAN	Medina Gp.	?	X	X	X	X		
			LOWER									
					Ordovician		Québec Gp.	Québec Gp.	Québec Gp.	Québec Gp.	Québec Gp.	Québec Gp.

F.J. Alcock (1935) gave a more detailed description of the three formations mentioned above than did Crickmay, based on Crickmay's work. He also recognized the Val-Brillant sandstone in the Notre-Dame mountains to the northwest.

C.F. Burk (1964) traced Crickmay's units eastward across northern Gaspé. His age determinations were based on a few graptolite localities. The Saint-Léon Formation, dated by Crickmay as Clinton, was raised to the Upper Wenlock and Ludlow. The Sayabec Formation was placed in the Wenlockian, and the underlying Val-Brillant and Awantjish formations were thought to be Upper Llandovery.

Stearn (1959) suggested the possibility that the upper part of the Saint-Léon Formation in the Causapscal area is Late Silurian. He places the contact between the Grande Grève and Cap Bon Ami Formations in the same area at the base on a zone of thin, light gray, silt-rich layers.

J. Béland (1960) extended the Silurian and Devonian units of Gaspé westward as far as the Sainte-Blandine and Prime Lake East map-areas. He named a green shale, which conformably underlies the Val-Brillant Formation and rests unconformably on the Québec Group, the "Awantjish Formation". Béland's correlations were based mostly on large brachiopod collections studied by A.J. Boucot. The Devonian Grande Grève and Cap Bon Ami Formations could not be separated on the basis of lithology, in certain localities of Béland's map-area. Therefore, the two units were classed together as the Causapscal Group.

Témiscouata Valley

Sir William Logan (1863) first described the stratigraphic section at Témiscouata lake. The rocks at Wissick mountain were assigned to the base of the Gaspé limestones and were thought to be Upper Silurian in age. The strata across the lake at Pointe-aux-Trembles were believed to be Middle Silurian and to overlie unconformably the Québec Group.

Fossils collected by Bailey and McInnes (1889) from rocks similar to those at Pointe-aux-Trembles denoted a Niagaran age.

McGerrigle (1934), following reconnaissance work in 1933, suggested three units near the lake: the Lower Devonian (?) Mont Wissick and the Silurian Témiscouata Groups, unconformably overlying the Ordovician Cabano "group".

The first detailed study of the Siluro-Devonian stratigraphy in the Témiscouata Lake area was made by Lespérance and Greiner (1969). From top to base, the stratigraphy by them is as follows:

TABLE 2 - DEVELOPMENT OF STRATIGRAPHIC CONCEPTS IN TÉMISCOUATA VALLEY

	TYPE			STANDARD A.J. Boucot		Logan, W. (1863)	Bailey, L.M., McInnes, W. (1889)	McGerrigle, H.W. (1934)	Laverdière, J.W. & Morin, L.G. (1941)		Lespérance 1960
DEVONIAN	LOWER	COBLENZIAN	EMSIAN	LOWER DEVONIAN							⊠
					Scoharie						
					Esopus						
			SIEGENIAN		Oriskany			?			Témiscouata Fm.
		GEDINNIAN			Bedcraft			Mont Wissick			Touladi Fm.
					New Scotl.			? ?			⊠
					Manlius	?	?				
?	"SKALIAN"			UPPER	Roundout	Gaspé Limestones	"Mont Wissick beds"		? ?		
?					Cobleskill						
SILURIAN	UPPER	LUDLOWIAN	UP.		Bertie Gp.				Saint-Léon Fm.		Mont Wissick Fm.
			MID.		Salina Gp.	? ?	?				
			LOW.								Robitaille-Asselin
		WENLOCKIAN		MIDDLE	Lockport Gp.	Coarse clastics at Pointe aux Trembles	"Pointe aux Trembles Sandstones"	Témiscouata Gp.	? ? Sayabec Fm.		⊠
	LOWER	LLANDOVERIAN	UPPER		Clinton Gp.				? ? Val-Brillant Fm.		Pointe Aux Trembles Fm.
						?			? ?		Lac Raymond Fm.
			MID.	LOWER	Medina Gp.	⊠	"Coarse clastics of Burnt Point"	⊠	⊠		⊠
							? ?				Cabano Fm.
			LOWER				⊠			⊠	⊠
					Ordovician	Québec Gp.	Québec Gp.	Cabano Gp.	Témiscouata		Québec Gp.

Lower Devonian : Témiscouata Formation
Touladi Formation

Unconformity

Upper Silurian : Mont Wissick Formation
Robitaille Formation
Asselin Formation

Lower Silurian : Pointe Aux Trembles Formation
Lac Raymond Formation
Cabano Formation

Unconformity

Cambro-Ordovician: Québec Group.

Most of the time determinations were established by Boucot from brachiopod studies.

Matapédia-Témiscouata Correlations

Apart from the broad correlations made by Logan and by Bailey and McInnes, Laverdière and Morin (1941) were the first to attempt a correlation between the Matapédia and Témiscouata valleys. They assigned limestone outcrops near Sauvagesse lake to the Sayabec Formation, the upper part of the Mont Wissick to the Saint-Léon Formation, and the lower sandstones to the Val-Brillant Formation. McGerrigle's Témiscouata "group" was thought to be equivalent to the Matapédia Group, of Ordovician age. Later studies by McGerrigle in Gaspé and a broad survey between the Témiscouata and Matapédia valleys by Béland (1960) showed that McGerrigle's Fortin Group of Gaspé and the Témiscouata Group were continuous along strike and are Lower to Middle Devonian in age.

Few studies were made on the present area prior to those of the author. Bailey and McInnes (1887-88) made one traverse, from Rimouski lake down Rimouski river.

PHYSIOGRAPHY

Topography

The topography of the area is controlled essentially by the lithology and structure of the bedrock. Two topographic divisions are evident: a dissected plateau, and, to the south, a northeast-trending ridge-and-valley division with ridges rising above the plateau.

The plateau is underlain by shales and mudstones of Cambro(?)-Ordovician age. The coarse facies so persistent along the Saint-Laurent shore are relatively rare here, but, wherever such coarse sedimentaries are intercalated with fine sediments, they make linear ridges paralleling the structure within the plateau. The plateau has a gentle slope towards the Saint-Laurent. In the northwestern part of the area the average elevation is 700 feet, but it reaches 1,000 feet in the central part. The maximum relief on the plateau is along the larger streams, such as Rimouski and Touladi rivers, where the relief between the rivers and the top of the plateau is 600 feet.

The northeast-trending ridges and valleys in the northwestern and southeastern parts of the area were formed by the differential erosion of coarse- and fine-grained Silurian rocks. Sandstones and conglomerates of various formations made ridges which rise above the average altitude of the plateau. The average relief above the altitude of the plateau is 700 feet. The maximum relief between ridge tops and the plateau is about 1,000 feet. The highest point, Longue Vue mountain, near the center of the Prime Lake area (west half), is 2,000 feet above the sea. The maximum relief within the area is about 1,600 feet, and the average is 1,000 feet.

Drainage

Most of this area is drained by Rimouski river, which crosses the map-area in a general northwest direction, at right angle to the structure, eventually to reach the Saint-Laurent. At a few localities the river turns 90° from its general course to follow faults.

The southernmost part of the Baies Lake area drains into Témiscouata lake by Touladi river, and then to St. John river and the Bay of Fundy.

Most of the larger lakes of the area are long and narrow, and are oriented northeasterly. Most of the smaller streams drain either northeast or southwest.

Glaciation

Erratics noted in the area are of local origin; no Laurentian boulders were seen. The geographic distribution of the larger erratics suggests northward, as well as southward, movements of ice.

South of Ferré and Duquesne lakes local hummocky topography suggests local moraines. Fluvioglacial deposits are locally important. Northeast from Aigles lake, between Saint-Isidore and Esprit-Saint, there are numerous deposits of stratified gravel and sand, some of which are 50 feet thick. These have been used locally for road material.

GENERAL GEOLOGY

General Statement

Ordovician

The Siluro-Devonian sequence is unconformably underlain by two separate, sharply contrasting Ordovician groups. The southeastern group (Trinité Group; or, structurally, the Lac-des-Aigles - Trinité high) is composed mainly of ribbon limestone, interbedded with thin layers of black phyllitic shale and slaty mudstone. It crops out prominently near Trinité-des-Monts, Esprit-Saint, and northwest of Lac-des-Aigles. Rare fossils indicate a Normanskill age (Middle Ordovician for part, at least, of this group). The northwestern group (Québec Group) is composed mostly of green, red, or black mudstones. The green mudstone has many interbeds of light green siliceous siltstone. No fossils were found in this group, but, if it is correctly assigned (on the basis of lithological similarities) to the Québec Group, it is probably Lower Ordovician to Cambrian in age. Structural complexity, coupled with scarcity of fossils and lack of marker horizons, makes it difficult to work out the stratigraphy of the Ordovician in this general region.

Silurian

The Lower Silurian rocks (Llandovery Series) vary in composition and age from place to place. They consists of three formations: the Cabano, the Lac Raymond, and the Awantjish. They crop out south of the Lac-des-Aigles - Trinité structural high.

The distinctive rocks of the Cabano Formation are dark gray, foliated lithic wackes. These are, in places, interbedded with lithic conglomerate, but most interbeds are dark gray mudstone and siltstone. The Cabano grades upward into dark gray siltstone, green mudstone, and arkosic wacke of the Lac Raymond Formation. A coarser clastic facies of the Lac Raymond Formation, the Lac Castor Member, consists mainly of conglomerates interbedded with arkosic wackes.

In the Prime Lake area, the Cabano Formation is overlain by green, rarely red, calcareous mudstone of the Awantjish Formation: green sandstones were found only near Longue Vue mountain, in the center of the area.

The Upper Silurian Wenlock Series here is time transgressive from east to west, and hence is restricted to the east-northeast of the Prime Lake West part of the area. It consists of Val-Brillant quartz arenite and Sayabec fossiliferous, silty, argillaceous limestone. The Val-Brillant grades upward into the Sayabec, which, in turn, grades upward into the Saint-Léon Formation.

TABLE 3 - TABLE OF FORMATIONS

ERA	PERIOD			FORMATION	DESCRIPTION
CENOZOIC	QUATERNARY				Drift, erratics, stream deposits
UNCONFORMITY					
PALEOZOIC	LOWER DEVONIAN	Esopus		York River Fm.	Greenish gray, feldspathic arenites; black siltstones
	LOWER DEVONIAN	Oriskany		York Lake Fm. (4000')	Dark gray calcareous siltstones; minor calcareous sandstones; calcarenites
	LOWER DEVONIAN	Helderberg		Cap Bon Ami Fm. (1500' - 2500')	Dark gray argillaceous limestones; calcareous siltstones and mudstones
	?	"SKALA"			
	? UPPER SILURIAN	LUDLOW		Saint-Léon Fm. (4000' - 12000'); Lac Des Baies Mm.	Greenish gray calcareous siltstones; Lithic conglomerates; sandstones; minor siltstones (Lac Des Baies Mm.); Minor sandstones
	UPPER SILURIAN	LUDLOW–WENLOCK		Sayabec Fm. (50' - 1500')	Dark gray argillaceous silty fossiliferous limestones
	UPPER SILURIAN	WENLOCK		Robitaille Fm. (1500' - 2500'); Val-Brillant Fm. (50' - 1000')	Red and green siltstones; quartz arenites, quartz conglomerates; White and pink quartz arenites
	LOWER SILURIAN	LLANDOVERY	C_6 Upper C_1	Lac Raymond Fm. (5000'); Lac Castor Mm.; Awantjish Fm. (600'-2000')	Tuffaceous sandstones and mudstones, minor chert; Lithic conglomerates and sandstones (Lac Castor Mm.); Green calcareous siltstones, green mudstones, minor fine sandstones (Awantjish Fm.)
	LOWER SILURIAN	LLANDOVERY	B_3 Middle B_1	Cabano Fm. (4000'-8000')	Gray, slaty siltstones, gray foliated lithic sandstones, lithic conglomerates
	LOWER SILURIAN	LLANDOVERY	A_4 Lower A_1		
	UNCONFORMITY				
	PRE-TACONIC	ORDOVICIAN AND(?) CAMBRIAN			A. Thin limestones; black phyllitic shale B. Green, red, and black slates, quartz arenites and limestone conglomerates

North of the structural Ordovician high, the lowermost Silurian formations also become younger from east to west. In the east, the basal Upper Silurian Formation is Wenlock (Val-Brillant). In the west (Baies Lake and Squatec map-areas), the lowermost Silurian unit, which is continuous with the Val-Brillant, is referred to as the Robitaille Formation of Wenlock to Lower Ludlow age. The Robitaille Formation is composed mostly of white and pink quartz sandstones, with interbedded red and green shales and siltstones. Previous writers placed the Mont Wissick "formation" immediately above the Robitaille.

In the Baies Lake area the Robitaille is overlain by a thin limestone unit (Sayabec Formation), which grades upwards into a thick unit composed of two facies: a greenish gray calcareous siltstone (the Saint-Léon Formation) and a lithic conglomerate interbedded with lithic wackes and siltstones (the Lac Des Baies Member). The two facies grade laterally into each other.

Devonian

The Devonian-Silurian boundary constitutes a problem in the Témiscouata-Matapédia area, as in many other North American localities. The lowermost, definitely Devonian fossils in the Matapédia valley occur above the base of the Cap Bon Ami argillaceous, silty limestone and calcareous mudstone. The Cap Bon Ami is overlain by the York Lake dark gray calcareous siltstones, gray calcareous sandstones, and calcarenites. The Grande Grève, which overlies the Cap Bon Ami in Gaspé peninsula, is not recognized here and apparently is absorbed in the York Lake "formation".

The York River Formation, the youngest Devonian unit (Esopus) in the area, overlies the York Lake and is composed of green feldspathic arenites interbedded with black siltstones.

Cambro-Ordovician

On the basis of lithology the pre-Taconic (Cambro-Ordovician) rocks of the area can be divided into the Québec Group and the Trinité Group.

Trinité Group

The Trinité Group, as defined by the author (1960), is restricted to the Lac-des-Aigles - Trinité structural high, which separates the Silurian trough into two northeasterly trending structures. The best exposed sections are on Rimouski river and Brisson brook, in the northwestern corner of the Prime Lake area (west half).

Two facies can be distinguished in the Trinité Group. One is characterized by light to medium gray, finely crystalline, "ribbon" limestone (½- to 3-inch beds). These are interbedded with greenish gray, finely laminated, slightly calcareous siltstones, and black phyllitic shales. Minor green and red slates are found north of Saint-Guy village.

The second facies consists mainly of black phyllitic shales interbedded with black slates. Many of these slates weather rusty, owing to the alteration of pyrite nodules, which are very common in this facies. Folding and faulting mask the relationship between the two facies.

Graptolites found in the black slates, and identified by L.M. Cumming of the Geological Survey of Canada, include: Climacograptus bicornis (Hall); Dicellograptus sp.; Amphigraptus sp. Lapworth, 1873; Dicranograptus sp. Hall.

Cumming noted that:

> "... the stratigraphic range of Climacograptus bicornis in North America is restricted to the Normanskill shale. Dicellograptus is common in the Middle Ordovician of North America, mainly occurring in the Normanskill shale and equivalent formations. The genus Amphigraptus is somewhat rare in the British Ordovician being found only in the Hartfell shales in graptolite zones 12 and 13. In North America it is found in the Normanskill shale, and Lapworth 1887 p. 178 records its occurrence from Griffon Cove, Gaspé (synonym Clematograptus)".
> (Quote from L.M. Cumming's report to the writer).

Thus the Trinité Group can be assigned to a Normanskill age.

Québec Group

The Québec Group is 7 miles wide between the Saint-Laurent shore and the Silurian contact. The group has been studied by the author in the Rimouski map-area and will be described in a later report. The best exposed sections are on the Saint-Laurent shore and along Rimouski and Bic rivers, and there are many exposures along roads. In general, the Québec Group is poorly exposed in fields and wooded areas.

In the present area, green and red slates of the Québec Group underlie the northwestern Silurian band. The relations of these slates, and of the Québec Group as a whole, to the Trinité Group is not known. However, at one locality, in Québec Group rocks in the Rimouski area to the north, small orthid brachiopods found by the writer suggest a Lower Ordovician age. Moreover, in general, the Québec Group elsewhere is classed as Lower Ordovician or older. Thus, the Trinité Group probably overlies the Québec Group.

The Ordovician-Silurian Unconformity

The attitude of the Ordovician rocks of the area differs greatly from that of the Silurian rocks. The Ordovician is tightly folded and is regionally metamorphosed, whereas the Silurian rocks are close to horizontal at many localities near the contact and are virtually unmetamorphosed. There is also a difference in the regional strike of the strata of the two systems: the aerial mosaic shows that the Ordovician rocks strike N.50°-60°E., whereas the Silurian rocks strike N.30°-40°E. Vertical phyllites underlie horizontal quartz arenites on the Rimouski - Saint-Guy road, 2 miles north of Saint-Guy village.

Lower Silurian

The greatest thickness of Llandovery in the area is south of the Lac-des-Aigles - Trinité Ordovician structural high, where it ranges from 5,000 to 14,000 feet. The series consists of the following units: the Cabano, Lac Raymond, Pointe aux Trembles, and Awantjish formations.

Cabano Formation

The Cabano Formation lies at the base of the Silurian system. It was first recognized in the Témiscouata valley where McGerrigle (1934) named it the Cabano "group", and assigned it to the Ordovician. Greiner (1958) found Silurian fossils in the Cabano, established it as a formation, and placed it at the base of his Silurian sequence.

The few fossils found in the Cabano were studied by A.J. Boucot, who concluded that they were Lower Llandovery in age. Since these are the only fossils found in the Cabano, the age of the formation as known elsewhere is based on this locality.

From the Cabano map-area, the Cabano Formation was traced into the Squatec area by Lespérance and into the present area by the writer. It plunges under the Wenlock Series in the eastern part of the area and in the western part, it rests with angular unconformity on Middle Ordovician rocks.

The formation is composed of conglomerate and mudstone, both generally with interbeds of sandstone. The sandstone is fine grained and black, and has a foliation caused by the high percentage of slaty mudstone fragments; it has the composition of a lithic wacke.

The conglomerate is composed mostly of pebbles, cobbles, and boulders, derived from nearly Ordovician sedimentary rocks set in a matrix of lithic wacke. In the Porc-Épic Lake section (Fig. 3), the formation is composed of conglomerate with some interbeds of lithic wackes.

The finer clastics are composed of black to dark gray siltstones or mudstones or both in ½- to 2-inch beds.

The differences between the lithological units caused problems in the classification of the formation. Gorman (1957) suggested that "Cabano conglomerate" be used for the lower conglomerate, but retained McGerrigle's term "Cabano group" for the rest of the unit. However, the conglomerate forms lenses at several horizons and is a relatively minor part of the formation. The lithic wacke is the only rock found throughout the formation, and it is the only lithology which can be traced from the Témiscouata region to the present area. Therefore, the term "Cabano formation" is used for the entire rock assemblage, including the conglomerate.

Lac Raymond Formation and Lac Castor Member

Greiner (1958) suggested the name "Pointe Aux Trembles" for a sequence of volcanic-pebble conglomerate, agglomerate, tuff, and sandstones exposed on the shore of Témiscouata lake. Lespérance carried Greiner's unit into the Squatec area, defined it, and also defined the Lac Raymond Formation as consisting of greenish gray mudstones with rare interbeds of greenish tuffaceous and conglomeratic sandstones (Lespérance and Greiner, 1969). The two formations grade into each other near Raymond lake.

The author has traced the Lac Raymond Formation into the present map-area. At Echos lake (Section H, Fig. 3), a 100-foot transition zone between the Lac Raymond and Cabano formations is exposed. The contact has been placed at the first appearance of volcanic material.

Near Castor lake (Section I, Fig. 3), the lower 2,000 feet of the Lac Raymond Formation is composed of conglomerates. This conglomerate is not present in sections H and J, and, consequently, it must intertongue with the finer sedimentaries along strike to the southwest and northeast. This large lens of conglomerate at the base of the Lac Raymond Formation is here named the Lac Castor Member.

The Lac Castor Member consists of interbedded pebble and granule conglomerates, sub-feldspathic lithic wackes, and green siltstones. The pebbles and granules are well rounded and composed mostly of green aphanitic, volcanic rocks and white quartz. The matrix is greenish gray arkosic arenite. In the map-area, the pebbles in the Lac Castor conglomerate have a somewhat different composition from those of the conglomerate at the type section of the Pointe Aux Trembles Member or Formation. Lespérance reports that, in the Pointe Aux Trembles of the Squatec and Cabano areas, the pebbles or cobbles are composed only of volcanic material. However, north of Castor lake, the conglomerate contains some fragments of quartzite and green mudstone.

Age of Formation - At Castor lake (section I, fig. 3; collection F1960f, map) fossils were found in the basal Lac Castor Member of the Lac Raymond Formation: *Plectodonta* sp., *Leangella* sp., Skenidioides n. sp., Stricklandia lens cf. progressa, Dolerorthis cf. rustica, Eostropheodonta sp., as well as other forms not yet identified. This collection from near the base of the formation is considered by A.J. Boucot to be early Upper Llandovery (C_1) age because of the presence of a smooth Stricklandia (resembling S. lens progressa), together with Eostropheodonta.

Upper Lac Raymond beds yielded Atrypa "reticularis" at Horton lake (section G, fig. 3), together with Resserella cf. elegantula, Skenidioides sp., Cyrtia sp., and Chilidiopsis sp. This fauna indicates the C_5 zone of the Upper Llandovery, or perhaps younger. The author interprets it as C_5-C_6. The upper Lac Raymond beds would thus be late Upper Llandovery, and the formation, as a whole, ranges in age from early to late Upper Llandovery.

"Unnamed Formation" of Lespérance and Greiner - Lespérance mapped certain rocks in the northeast corner of the Squatec East map-area, northeast of Horton river, as the "Unnamed Formation" mainly because poor exposure in the area prohibited assigning it an appropriate type section. The best section is along the road to Echos lake. Fossils found in this section indicate an Upper Llandovery to Ludlow age (Lespérance and Greiner, 1969). A collection made by the writer contained the following fossils, in addition to those in the Lespérance collection: Resserella cf. elegantula, and Dolerorthis cf. rustica (identified by Boucot). Both collections were dated as Upper Llandovery to Lower Ludlow age.

The author was unable to trace this formation in the present area, which adjoins the Squatec area. Upon visiting the best section of the formation, the author found that it could be subdivided into a lower and an upper assemblage. The lower assemblage is composed of black to dark gray siltstones and mudstones, intercalated with minor sandstone beds, the whole not being significantly different from the typical Lac Raymond strata exposed to the northeast. The upper assemblage is composed of slates or slaty siltstones very similar to rocks of the Témiscouata Formation.

The fossils listed by Lespérance and Greiner, and indicating a Late Llandovery to Early Ludlow age, were found in the lower assemblage of the formation. Since this lower assemblage represents the upper part of the Lac Raymond Formation, the collection is most probably of Late Llandovery age.

The author suggests that, in the rocks northeast of Horton river, in the Squatec East map-area, the lower beds belong to the Lac Raymond Formation and the upper beds to the Témiscouata Formation and that there is no need for a new formation.

Awantjish Formation

The Awantjish Formation was first described by Aubert de la Rüe (1941, p. 22) from exposures near Mount Saint-Pierre, 2½ miles east of La Rédemption, Awantjish township, in the Matapédia valley, but no formal name was suggested. Béland (1960) remapped the area studied by Aubert de La Rüe and proposed the term Awantjish Formation for the Silurian rocks underlying the Val-Brillant sandstone on the south flank of the Matapédia Lake syncline.

At the type section, the Awantjish is 100 feet thick and is composed of greenish gray shales grading upward into green, calcareous shales which, near the top, are interbedded with red siltstones. A 200-foot section exposed a few miles east of the type section overlies the pre-Taconic sequence with angular unconformity and is conformably overlain by the Val-Brillant Formation.

The writer has traced the Awantjish Formation westward into the present area (about 30 miles west of the type section), where it rests conformably on the Cabano Formation and underlies the Val-Brillant. On the shore of Porc-Epic lake, a few outcrops suggest that the contact of the Awantjish with the Val-Brillant may be transitional. At Longue Vue mountain (Porc-Epic Syncline section), the formation is 2,500 feet thick. Its composition is similar to that at the type locality, but the upper portion is sandy and thus coarser grained than at the type locality.

Age of the Formation - In the type area, close to Mount Saint-Pierre (about 6 miles west of Matapédia lake), the Awantjish Formation is very fossiliferous. The following fauna has been reported (J. Béland, personal communication, 1961): *Pentamerus oblongus*, *Cyrtia* sp., *Plectodonta transversalis*, *Atrypa* "*reticularis*", *Dolerorthis* sp., *Resserella* cf. *elegantula*, *Drummockina* sp., "*Coelospira*" *hemispherica*, *Halysites* sp., *Chilidopsis*? sp., *Isorthis*? sp. The collection is of late Upper Llandovery age.

The writer has made three large fossil collections in the Porc-Epic syncline. A collection (F60e) from about 1,000 feet above the base of the formation yielded the following fossils: *Dolerorthis* cf. *flabellites*, *Stricklandia lens* (var. indet.), *Leptaena* "*rhomboidalis*", *Resserella* cf. *elegantula*, "*Coelospira*" *hemispherica*, *Plectodonta* sp., *Isorthis*? sp. This collection is Upper Llandovery (C_3 to C_5), as evidenced by the presence of a "smooth *Stricklandia* with *Resserella* cf. *elegantula*" (Boucot, personal communication, 1961).

A collection (F60d) made about 1,700 feet above the base of the formation contained "*Coelospira hemispherica*", *Leptaena* "*rhomboidalis*", *Atrypa* "*reticularis*", *Eospirifer* sp., *Stricklandia* new sp., *Dolerorthis* cf. *flabellites*. This collection is also indicative of an Upper Llandovery (C_3 to C_5) age, as suggested by the presence of *Atrypa* "*reticularis*", a smooth *Stricklandia*, and *Eospirifer* (Boucot, ibid).

A collection (F60g) from near the top of the formation contained: *Chilidiopsis* sp., *Atrypa* "*reticularis*", *Resserella* cf. *elegantula*, *Rhipidomelloides* sp., *Dolerorthis* sp., *Leptaena* "*rhomboidalis*", *Plectodonta* sp., *Encrinurus* sp. Boucot (ibid) notes that this collection is C_3 Wenlockian in age, because of the presence of *Chilidiopsis*, *Atrypa* "*reticularis*", and *Resserella* cf. *elegantula*.

Thus, the upper half of the Awantjish Formation ranges in age from C_3 to C_5 in the Upper Llandovery. The lower half is not fossiliferous in the present area, but it probably represents the C_1-C_2 time span. Hence, the Awantjish Formation would range from C_1 to C_6 of the Upper Llandovery and is equivalent in age to the Lac Raymond Formation.

The collection at the type section, north of Mount Saint-Pierre, contains Pentamerus oblongus, Atrypa "reticularis", and Resserella cf. elegantula. These species indicate an age high in the Upper Llandovery, about C_5-C_6. Since the formation is only 100 feet thick at this locality, it is clear that the entire time span from C_1 to C_6 cannot be present, as in the thick Porc-Epic section. The whole type section is most probably C_5-C_6.

The formation has its maximum development in the Porc-Epic area. It thins both northward and northeastward and is mostly confined to the south of the Lac-des-Aigles - Trinité Ordovician structural high; north of this structure, it is absent or very thin. Thus, the Awantjish Formation appears to be transgressive from southwest to northeast.

The Awantjish Formation occupies approximately the same stratigraphic position as the Lac Raymond Formation and both formations are of the same age. It is logical to correlate the one with the other. If so, intertonguing should occur between Castor Lake and Porc-Epic sections (Fig. 3). Unfortunately the exact location of this intertonguing is not known because rocks of this age between the two sections have been removed by erosion.

Post-Llandovery Disconformity

The Wenlock Series (Val-Brillant, Robitaille, in part, and Sayabec, in part) is missing south of the Lac-des-Aigles - Trinité Ordovician high both in the present area and to the southwest, the Saint-Léon Formation (Ludlow) resting directly on the Lac Raymond Formation (Upper Llandovery). Three possible explanations can be given for this absence of the Wenlock:

1 - The formations were not deposited, but the basin remained under water;
2 - The formations were not deposited because the basin was above water;
3 - The formations were deposited but eroded prior to Ludlow sedimentation.

These three possibilities will be further discussed under "Sedimentation", but it may be pointed out here that each explanation implies the presence of a disconformity. There is no evidence of this disconformity to the east of the Prime Lake East area.

Upper Silurian

The Wenlock Series is present northwest and at the northeast end of the Lac-des-Aigles - Trinité Ordovician high. The series consists of the Val-Brillant Formation, part or all of the Sayabec, and part of the Robitaille.

Val-Brillant Formation

The Val-Brillant Formation was first described by Crickmay (1932). The type section is on the shore of Matapédia lake, 1¼ miles northwest of Val-Brillant village. Here, the 90-foot-thick section is composed of both thin- and thick-bedded, white and pink, silica-cemented, quartz sandstones. Both at the type locality and along the northern Silurian-Ordovician contact, the Val-Brillant Formation rests unconformably on the pre-Taconic Québec Group.

The Val-Brillant was recognized by Béland (1960) in the southern Sainte-Blandine West area. The writer traced the formation southwestward into the present area, where it ranges in thickness from 200 to 500 feet. In some places it rests unconformably on pre-Taconic rocks, and in others conformably on the Awantjish Formation. The Awantjish - Val-Brillant contact may be transitional; the contact of the Val-Brillant with the overlying Sayabec Formation is transitional.

Age of the Formation - The Val-Brillant is sparsely fossiliferous. Collections made in the Matapédia Lake syncline (Lajoie, 1961) included *Stricklandia gaspensis* (a Wenlock index fossil)and a new species of *Stricklandia* which suggests (Boucot, pers. comm.) the lowermost part of the formation may be high Upper Llandovery (C_6) to earliest Wenlock.

In the Prime Lake area,the Val-Brillant overlies the Awantjish, which is considered to range in age from C_1 to C_6 of the Upper Llandovery. In the Baies Lake area, the Val-Brillant intertongues with the Robitaille of Lower Ludlow age. The Val-Brillant is therefore transgressive from northeast to southwest.

Discussion of the correlation of the Val-Brillant Formation follows the description of the Sayabec and Robitaille formations.

Sayabec Formation

The Sayabec Formation was first described by Crickmay (1932), the type section being on the shore of Matapédia lake at a quarry 3 miles east of Sayabec village, where only the basal strata of the formation are exposed. The author (1961) described a more complete section at La Rédemption. The formation was traced westward by Béland (1960) and into the present area by the writer.

Plate I - Val-Brillant Formation, Sayabec area.

Plate II - Sayabec Formation: almost flat-lying limestone exposed on Rimouski river, north of Fond-des-Ormes.

Plate III - Sayabec Formation: sedimentary boudinage in limestone on Rimouski river.

Plate IV - Robitaille Formation, shore of Cossette lake.

The Sayabec Formation mainly consists of dark gray, silty, finely to coarsely crystalline limestone. It is highly fossiliferous at certain localities. At Ferré lake (Section F, Fig. 2) and Porc-Epic lake (Section J, Fig. 3), the middle part of the formation is sandy or conglomeratic, or sandy and conglomeratic.

The uppermost beds of Sayabec grades upward into the Saint-Léon. The transitional zone is 20 to 30 feet thick and is well exposed both on Rimouski river, north of Ferré lake, and on the southern limb of the Matapédia Lake syncline.

Age of the Formation - At the type section, the Sayabec is considered to be Wenlock. However, fossils in the more complete section at La Rédemption indicate a dual age. The basal part is certainly Wenlock, containing *Rhipidium* sp. and *Pentamerus oblongus*; the upper half contains *Conchidium* cf. knighti, a Lower Ludlow index fossil. W.A. Oliver Jr. has identified a number of rugose corals in the formation, and two of the genera found at La Rédemption (*Kodophyllum* and *Phaulactis*) are indicative of either Wenlock or Ludlow age.

At the Ferré Lake section, in the eastern part of the area, the writer found the following fossils (F1960a, F1960b), identified by Boucot: *Protomegastrophis* sp., *Atrypa* "*reticularis*", *Howellella* sp., *Protathyris*? sp., *Euomphalopterus* sp. *Howellella* and *Protomegastrophia* indicate an Upper Llandovery to Ludlow age.

In the western part of the area, fossils collected (F1961a) along strike with the Ferré Lake collection contained "*Eospirifer*" cf. *eudora*, *Amphistrophia* cf. *funiculata*, *Glassia?* sp. Boucot notes that *Eospirifer* cf. *eudora* is more suggestive of a Ludlow than of an older age.

In the Témiscouata region, the Sayabec Formation was not originally recognized as such, but it is represented by a thin unit at the base of the Mont Wissick Group (Lespérance and Greiner, 1969). In the western half of the area, the Sayabec is restricted to Ludlow age, since it rests conformably on a well-dated Ludlow formation, and underlies the Ludlow Saint-Léon.

In summary, therefore, the Sayabec Formation is:

a) Wenlock at the type section;
b) Wenlock to Lower Ludlow in the northern part of the present area;
c) Ludlow in the southern part of the area.

* * *

The *Ludlow series* represents the bulk of the Silurian sequence in the area. In the eastern half, it is represented by the Saint-Léon Formation, and in the western half, by the Saint-Léon, Sayabec, and Robitaille Formations.

Robitaille Formation

In the Cabano area, Greiner (1958, p. 16) described a series of clastic rocks that are exposed on a bush road running northwesterly from La Résurrection village; he named the sequence the "La Résurrection" Formation. Since only the quartzite sandstones are exposed at that locality, Greiner realized that the type section was incomplete. The upper La Résurrection Formation was described on the shore of Témiscouata lake (Greiner, 1958).

Lespérance (1960) traced the La Résurrection Formation into the Squatec area. He found a much better stratigraphic section in Robitaille township, and, as Greiner's report had not been published, he proposed that the term "La Résurrection" be replaced by "Robitaille". Since the Robitaille section is much more representative of the formation, the author will use the nomenclature proposed by Lespérance.

Lespérance and Greiner (1969) defined the Robitaille Formation as: "The Upper Silurian red siltstones and sandstones, and minor varicolored quartzites, found between the Québec Group and the Mont Wissick Formation, in the Squateck West area". In their area, the formation is 700 to 1,400 feet thick.

The Robitaille Formation is well exposed in the present area, but is restricted to the north side of the Ordovician high. It ranges from 1,900 to 2,500 feet in thickness, is underlain unconformably by the Ordovician sequence, and is overlain conformably by the Mont Wissick Group.

The Robitaille here is similar to that in the Squatec area. It consists of a series of green and red siltstones intercalated with pink and white quartz arenites and rare limestone beds. Quartzite-pebble conglomerates, exposed at various horizons, but mainly near the base and the middle of the formation, are similar to those near La Résurrection (Lespérance and Greiner, 1969).

Age and Correlation - Lespérance and Greiner (1969) report the following fossils from the Robitaille Formation (Squatec area): *Hyattidina*? sp., *Howellella* sp., *Atrypa* "*reticularis*", *Salopina* sp. The *Salopina* was considered by Boucot as evidence of Lower Ludlow age.*

Certain horizons of the basal green shale are highly fossiliferous in the present area. Collections (F1961, f, g) from near ; Cossette lake include: *Salopina* sp., *Gypidula* sp., *Sphaerirhynchia* sp., *Howellella* sp., *Rhipidomelloides* sp., "*Chonetes*" sp., *Atrypa* "*reticularis*";

* Salopina is not considered Lower Ludlow anymore. However, the Robitaille is still interpreted to be Lower Ludlow age (see Lajoie et al., 1968)

also, the following corals (identified by Oliver): Alveolites sp., Cladopora sp., Halysites sp., Favosites sp., Heliolites sp., Phaulactis sp. This fauna is also dated by Boucot as Lower Ludlow on the presence of Salopina sp.

Near Moose lake, in the center of the western half of the area, a collection (F1961, h) near the top of the formation contained: Protathyris sp., Salopina sp., Gypidula sp., "Chonetes" sp., Atrypa "reticularis". This collection is Lower Ludlow (Salopina sp.)

The Robitaille Formation is stratigraphically equivalent to the Val-Brillant Formation plus the lower part of the Sayabec Formation, and at Islet lake (Section E, Fig. 2) the two facies interfinger.

Val-Brillant white quartz arenite can be followed along the southern limb of the Islet Lake syncline. At the nose of the fold, the white Val-Brillant quartz arenites crop out underneath green and red Robitaille shales. Farther west (Sections A,B,E, Fig. 2), the basal Robitaille strata cannot be differentiated from the Val-Brillant quartz arenites. At Saint-Guy (Section B, Fig. 2), white quartz arenites crop out at many horizons near the base of the section, and the particular Val-Brillant horizon could not be distinguished.

Near the nose of the Islet Lake syncline, Sayabec limestones are interbedded with upper Robitaille red siltstones and sandstones, and 200-300 feet of Sayabec limestone overlies the upper-most red siltstones of the Robitaille Formation. The limestone can be traced into the basal Mont Wissick limestone of the Squatec West area (Lespérance and Greiner, 1969). This limestone was considered to be basal Mont Wissick "formation" (Lespérance and Greiner, 1969).

To recapitulate, the correlation of the Robitaille Formation with the Sayabec and Val-Brillant formations is well established along the southern limb of the Islet Lake syncline. The Val-Brillant and Sayabec formations are transgressive from east to west; this correlative (the Robitaille) is presumed to be transgressive in the same direction. The Robitaille Formation would than be:

1 - Lower Ludlow along the western edge of the area;
2 - Lower Ludlow, and possibly Upper Wenlock, on the nose of the Islet Lake syncline to the east.

Saint-Léon Formation

The Saint-Léon Formation was first described by Crickmay (1932). The type section (Saint-Léon-le-Grand, on Humqui river in the Matapédia valley) consists mainly of greenish gray, slightly calcareous siltstones and sandstones. Béland (1960) and the writer (1960, 1961, 1962) traced the formation westward through the Sainte-Blandine and Prime Lake East areas to the present and found it to consist mainly of greenish gray calcareous siltstones.

In the Sainte-Blandine West area, Béland (1960, p. 7) noticed: "Siltstone pebble conglomerate in beds or lenses up to 30 feet thick in a zone about 4 miles long on the north side of the Neigette syncline, near the top of the Saint-Léon formation". The writer traced this conglomerate into the present area (Fig. 2, Sections B, C, and D), where it is much thicker (6,000 feet) than to the northeast. The author proposed the term "Lac Des Baies Member" for this conglomeratic sequence.

The Lac Des Baies Member is underlain by about 4,000 feet of typical greenish gray calcareous Saint-Léon siltstone. It is also overlain by the same type of siltstone, and it grades laterally into Saint-Léon siltstones in the southwestern part of the Sainte-Blandine West map-area.

The author estimates the Saint-Léon Formation to be 12,000 feet thick at Baies lake. In most areas the formation is thinner; Béland (1960) estimated the thickness to be 7,300 feet in the Mistigougèche syncline. The Saint-Léon at Ferré lake (Section F, Fig. 2) is graphically estimated to be 3,700 feet thick.

Age of the Formation - Béland (1960) stated that graptolites found in the Saint-Léon of the Matapédia Lake syncline indicate a Ludlow age. In the present area, the formation is relatively fossiliferous. A collection (F1961c) made along the Saint-Guy road near the base of the formation contained the following fossils (identified by Boucot): *Rhipidomelloides* sp., *Atrypa* "*reticularis*", *Mesodouvillina* sp., "*Eospirifer*" *eudora*, *Leptaena* "*rhomboidalis*", *Sphaerirhynchia*, *Calymene* sp., corals. The collection is Upper Llandovery (C_3) to Ludlow, as evidenced by the presence of *Atrypa* "*reticularis*" and "*Eospirifer*" *eudora*.

A second fossil collection in the Lac Des Baies section, about 1,500 feet above the base of the formation, contained: *Salopina* sp., *Nucleospira* sp., *Amphistrophia* *funiculata*, *Rhypidomelloides* sp. *Gypidula* sp., *Strophonella* sp., *Howellella* sp., *Atrypa* "*reticularis*", *Sphaerirhychia* sp., "*Dolerorthis*" *flabellites*. The fauna was dated by the presence of *Salopina* sp. as Lower Ludlow.

A third fossil collection (F1961p), made about 3,500 feet above the base of the formation, contained: *Leptaena* "*rhomboidalis*", *Amphistrophia* cf. *funiculata*, *Mesodouvillina* sp., *Cyrtia* sp., *Strophonella euglypha*, *Lissatrypa* sp., *Meristina* sp., *Isorthis* sp., *Calymene* sp. Boucot dated this collection as of Ludlow age.

Plate V - Robitaille Formation: basal conglomerate exposed near Saint-Guy. Notice crossbedding.

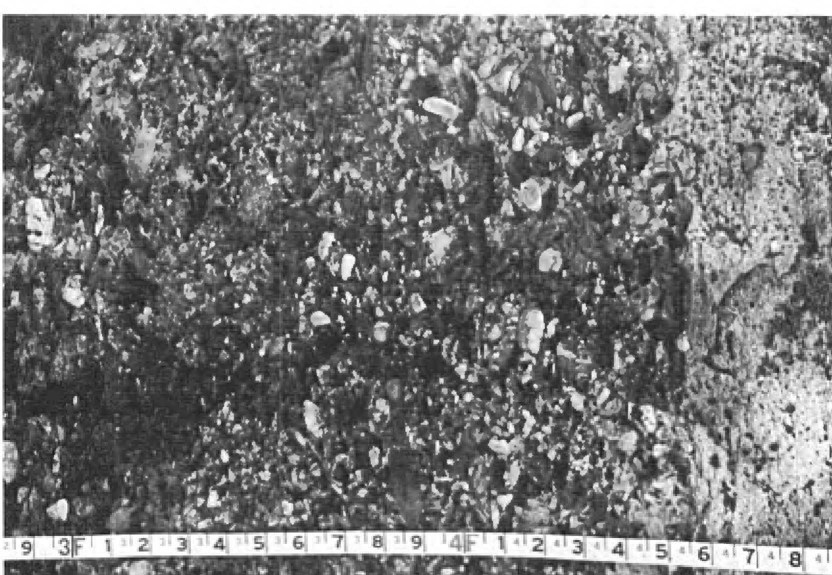

Plate VI - Saint-Léon Formation: Lac Des Baies conglomerate at type section.

Plate VII - Saint-Léon Formation: Lac Des Baies conglomerate at Baies Lake area.

Plate VIII- Saint-Léon Formation: sandstone interbedded with siltstone at Dugas Lake section.

A fourth fossil collection (F1961o) was made at the base of the Lac Des Baies Member (Section D, Fig. 2 - Dugas lake), about 4,000 feet above the base of the Saint-Léon. The fauna contained Salopina? sp.,and Prothathyris sp., among others. Neither of the genera is known below the Ludlow series in the Northern Appalachians.

Graptolite-rich beds were found by the writer south of Macpès lake (F1962, 2, see map) near the top of the Lac Des Baies Member, about 1,000 feet from the top of the Saint-Léon Formation. W.B.N. Berry found only one identifiable form in the collection: a slender Monograptus aff. longus. Monograptus longus is known in Czechoslovakia from Ludlow beds above the Monograptus nilssoni zone. This would date the upper Lac Des Baies Member as Zone 34 of the Silurian (Middle Ludlow).

The top of the Saint-Léon Formation lacks fossils and has not been dated. However, in the area there is a lithological transition from the Saint-Léon into the overlying Cap Bon Ami Formation. The upper siltstones of the Saint-Léon Formation which overlie the Monograptus aff. longus must be Upper Ludlow.

Correlation of the Saint-Léon Formation - In order to correlate the Saint-Léon Formation of the present area with its Témiscouata equivalent it is necessary to make a brief resumé of the Ludlow stratigraphy of the Squateck-Cabano area (Lespérance and Greiner 1969), where the Ludlow consists of the Robitaille and Mont Wissick Formations.

The basal 175 feet or so of the Mont Wissick Formation is commonly nodular fossiliferous limestones with some siltstone and sandstone. The basal Mont Wissick limestones are lithostratigraphic equivalents of the Sayabec limestones; they constitute a distinctive lithology between arenites (Robitaille - Val-Brillant) and siltstones (Saint-Léon).

The Mont Wissick strata overlying the basal limestones were divided by Lespérance (1960) into three members - Lower, Middle, and Upper - based upon interpretation of structure. Lespérance (1960, p. 147) states: "The sequence of Mont Wissick strata to the east of Lac Sauvagesse has a possible thickness of 6,000 feet, if the sequence is homoclinal. The structural improbability of an isoclinal syncline east of Lac Sauvagesse 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".

Lespérance assumed the presence of a homocline from his interpretation of a south-limit fault as a gravity fault. The author has mapped the northeastern extension of this fault and believes that it is a thrust. In such a case, the structure at Sauvagesse lake (Squatec West area) could be an overturned syncline, and the Lac Croche limestones could overlie the "upper" siltstone member of the Mont Wissick.

The fauna of the Lac Croche is very similar to that of the Cobleskill limestones. The former contains Eccentricosta jerseyensis, which is regarded as a Cobleskill index or youngest North American Silurian. The Lac Croche also contains Tryplasma sp., Cladopora sp., and Halysites sp. Oliver notes that some specimens of Cladopora are identical to C. rectilineata (Simpson), as described from the Decker Ferry and Lower Keyser (uppermost North American Silurian). Oliver (1962, p. 11) considers the presence of Columnaria? corralliferum (Hall) in the Lac Croche as suggestive of a relationship with the Cobleskill of eastern New York.

The Mont Wissick, therefore, consists of three different rock assemblages: an upper (Lac Croche) limestone, a middle green-gray calcareous siltstone, and a basal limestone (Sayabec). The Saint-Léon Formation is the lithologic and time equivalent of the middle siltstones. The Lac des Baies Member is apparently not present in the Squatec area.

The writer suggests that the "Mont Wissick" should be assigned "Group" status and that it includes the Sayabec Formation (lower limestones), the Saint-Léon Formation middle siltstones, and the Lac Croche Formation (formerly member).

Silurian-Devonian boundary

In the Prime and Baies Lakes area, the strata near the Silurian-Devonian boundary are unfossiliferous. Also, here, as in the Matapédia valley (Béland, personal communication), the Saint-Léon (Silurian) grades into the overlying Cap Bon Ami (Devonian) Formation. Furthermore, Boucot and Pankiwskyj (1962) have introduced the "Skala Stage" for a transitional fauna between the Silurian and the Devonian.

The base of the Cap Bon Ami Formation is not adequately dated as yet. In the area to the east, the first unmistakably Devonian fauna occurs near the top of the formation. Fossils from the northeastern end of the Islet Lake syncline, 500 feet above the base of the formation, included Spinoplasia cf. gaspensis. This is considered by Boucot (1959) to be Lower Devonian. However, this is only a qualified identification of a new genus and new species found only at one locality in the northern Appalachians.

The presence of Monograptus aff. M. longus in upper beds of the Saint-Léon Formation suggests an Upper Ludlow age for these beds. This leaves room for the "Skala" stage in the Lower Cap Bon Ami, and a possible correlation between the Lower Cap Bon Ami and the Lac Croche limestones of the Squatec area. The latter are Cobleskill, considered by Boucot (personal communication) to be "Skala".

Devonian

Devonian rocks are rare in the area, occurring only at the crest of the Islet Lake syncline and in the southeast. The Devonian section in the area and its general correlation to the west and east are summarized below:

TEMISCOUATA (Lespérance et Greiner, 1969)	PRIME and BAIES LAKES	MATAPÉDIA (Béland, 1960)	
	York River Fm.	York River Fm.	
Témiscouata Fm.	York Lake Fm.	Fortin Gp.	
Touladi Fm.		Grande Grève Fm.	
?	CAP BON AMI Fm.	CAP BON AMI Fm.	DEVONIAN / SILURIAN ("Skalian"?)

Cap Bon Ami Formation

The possibility that the basal Cap Bon Ami may be "Skalian" has been discussed above, but the bulk of the formation is definitely Devonian.

The Cap Bon Ami Formation was first described by Logan, who studied exposures in the cliffs on the north side of Forillon Peninsula, in eastern Gaspé (Logan,1863; units 3 to 6). Clarke (1908) gave the name Cap Bon Ami to these same beds. The section at the type locality is thin and, according to McGerrigle (1950), is a poor representation of the formation as exposed inland. After studying stratigraphic sections from the interior of Gaspé, McGerrigle put new boundaries to the Cap Bon Ami and traced the unit westward as far as the Matapédia valley (Gaspé Peninsula Map, McGerrigle,1953). As redefined by McGerrigle the formation consists mostly of dark gray, soft limestones and shale. The formation is overlain by the Grande Grève. Stearn (1959) traced the formation westward, to the Matapédia valley, in the Causapscal area. Béland (1960) found that the Cap Bon Ami and Grande Grève could not be separated in the Matapédia Lake area and westward because of similar lithology; he traced the Cap Bon Ami - Grande Grève unit westward as far as the present area. However, the writer has reestablished the Cap Bon Ami as a specific unit here, although it has not been recognized to the west in the Témiscouata region.

The Cap Bon Ami Formation has a uniform composition from the Matapédia valley westward. It consists of very thinly bedded (¼" - 1", rarely thicker), dark gray, buff to light brown weathering calcareous mudstone or siltstone,or both, interbedded with argillaceous limestones.

Thickness - The thickness of the Cap Bon Ami is highly variable. In Gaspé, McGerrigle (1950) estimated a thickness of 1,000 to 6,000 feet, with an average of 2,500 feet in the Causapscal area. Béland (1960) computed that the Cap Bon Ami - Grande Grève unit was 2,000 to 5,000 feet thick. In the present area, the minimum thickness is 2,000 feet.

Age - McGerrigle (1950) seems to favor an Oriskany age for the Cap Bon Ami Formation, but admits that a Helderberg age is a possibility. Cumming (1959) favors an uppermost Silurian to Oriskany age, and Boucot (personal communication) places the formation in the Helderberg.

The writer did not find fossils in the Cap Bon Ami of the present area. However, a collection made to the east near the top of the Cap Bon Ami Formation in the Mistigougèche syncline contained the following fossils (personal communication from J. Béland): Spinoplasia cf. gaspensis, Coelospira sp., "Chonetes" sp., "Schuchertella" sp., Leptostrophia sp., Leptocoelia aff. flabellites. Boucot considers the fauna to be Helderberg, the last two being certainly Devonian. The possibility that the basal strata of the Cap Bon Ami might be uppermost Silurian was discussed above. Until further data are presented, the formation may be considered to range in age from uppermost Silurian to Lower Devonian (Helderberg).

Grande Grève Formation

The Grande Grève Formation was first described by Logan (1863) and was named by Clarke (1908); both studied exposures on the Forillon peninsula in eastern Gaspé. In the original description, the formation included 900 feet of cherty limestone interbedded with "drab" limestone. McGerrigle (1950) enlarged the definition of the formation to include calcareous siltstones to siliceous limestones present in the interior of Gaspé. He also placed the lower contact of the unit at the initial appearance of hard, cherty to siliceous limestones. The chert to siliceous nature of the limestones seems to be the predominant feature that distinguishes the Grande Grève Formation. McGerrigle (1950) noted the disappearence of this feature toward the interior of the peninsula, where the formation becomes arenaceous or silty. In the Matapédia valley no chert or cherty limestones were reported by either Béland (1960) or Stearn (1959), and here it is very difficult to place the lower contact of the Grande Grève. Stearn (1959, p. 5) used thin, light gray, silt-rich layers at the base of the Grande Grève as criteria to distinguish the formation from the underlying Cap Bon Ami. Béland (1960) grouped the two formations together. West of the Matapédia valley it is impossible to use Stearn's criteria because the underlying Cap Bon Ami Formation contains many "silt-rich layers". Typical Grande Grève lithology was seen only in the central part of the Matapédia-Témiscouata region (Béland,1960), where cherty and siliceous limestones crop out at the northeastern extremity of the Islet Lake syncline, in the Sainte-Blandine East area. Boucot identified

Costispirifer arenosa and *Acrospirifer murchisoni* from collections made by Béland in these cherty limestones; these brachiopodes are indicative of an Oriskany age (personal communication from J. Béland).

York Lake Formation

The above discussion on the Grande Grève Formation has a bearing on the York Lake Formation. If the main characteristic of the Grande Grève is its chert content then there is no Grande Grève in the southern part of the present area, and its stratigraphic position is occupied by a transitional facies between Cap Bon Ami limestones and York River sandstones and siltstones. A similar facies between the Grande Grève and the York River Formations was recognized by Jones (1935), who named the sequence the York Lake "series". McGerrigle (1950) included these strata in the York River Formation but did not discard Jones' term, which he thought might later be useful in areas to the west. In the present area the writer favors the term "York Lake Formation" for the transitional rock assemblage between the Cape Bon Ami and York River Formations. The following scheme is proposed to explain the relationship between these formations.

Baies and Prime Lakes	Matapédia Valley	Gaspé
York River Fm.		York River Fm.
York Lake Fm.		York Lake Fm.
		Grande Grève Fm.
Cap Bon Ami Fm.		Cap Bon Ami Fm.

The transitional facies in this area consists dominantly of thinly bedded (1/8"-3", rarely thicker), dark gray calcareous siltstone, interbedded with calcareous feldspathic arenite and calcarenite. The amount of feldspathic arenite increases upward. The contact of the York Lake Formation with the Cap Bon Ami Formation was placed at the first appearance of calcareous feldspathic arenite; the contact with the York River Formation has been placed at the horizon where the rock assemblage contains 50% feldspathic arenite, by volume.

The unit is easily traced and comprises close to 4,500 feet of strata. Only a little of this formation is present in the area (in the southeastern corner), but it is well developed in bordering areas (Prime Lake East, Wild Goose). In the Squatec East area, Béland mapped an intertonguing of the York Lake with the Témiscouata Formation.

Age - Béland (personal communication) collected fossils from the York Lake Formation in the Wild Goose area, south of Prime Lake area. One of the collections (No. 4) yielded *Leptocoelia flabellites*, *Acrospirifer* sp., and a possible *Eodevonaria*. According to Boucot the collection is of Lower Devonian age; the last form is similar to those found in the Upper Grande Grève.

York River Formation

The York River Formation was originally described in eastern Gaspé by Logan (1863). It was traced westward mainly by McGerrigle (1953) as far as the Matapédia valley. Béland (1960) extended it towards the Témiscouata region.

The formation consists of greenish gray, white-weathering, feldspathic arenite in ½-inch to 3-foot beds, interbedded with 2-inch beds of non-calcareous siltstone. Béland (1960), to the west, estimated the thickness as between 10,000 and 14,000 feet, and found fossils indicative of a Lower Onondaga age.

Post-Lac Raymond Intrusions

In the southeastern corner of the area, igneous rocks intrude the Lac Raymond Formation. The largest body, about one square mile in area and perhaps 50 feet thick, crops out between Canard and Echos lakes. This is most probably a sill because the exposed lower contact is horizontal and concordant with the Lac Raymond strata. A second intrusion forms a northeasterly trending ridge northeast of Castor lake. Five other small bodies are exposed in the same area.

The rock has a dark green color with plagioclase phenocrysts up to 5 mm. in length. These crystals are set in a fine black crystalline groundmass.

Thin-sections show that the rock is composed mostly of large crystals (2 to 5 mm.) of plagioclase and of monoclinic pyroxenes. The plagioclase composition is An in the lower limit of labradorite; thus, the rock is probably in the gabbro clan.

SEDIMENTATION

General Statement

The sedimentation of the Silurian formations in the Prime and Baies Lakes area is treated under the following headings: megascopic description; isopach and facies map; sedimentary structures; texture; mineralogy; source; depositional environment.

Isopach and Facies Maps - Kay (1937) introduced the term "palinspastic" for a map showing a restoration of folded and faulted rocks to their original geographic positions. In constructing the facies maps, the writer wanted to indicate the depositional environment, and, since different facies have been brought together by thrusting in the area, palinspastic maps were desirable. The only formations involved in thrusting are of Wenlock and Ludlow age and palinspastic maps were not necessary for the formations of Llandovery age; however, in order to standardize the facies maps, palinspastic maps were made for all formations. The letters A to J refer to the locations of stratigraphic sections used in constructing the facies maps. The prime after a letter denotes that the section has been replaced to its presumed original position (about 3 miles southeast in every case).

Sedimentary Structures - A few Silurian formations have well-developed planar ("torrential") crossbeds. Outcrops with the highest concentrations of crossbeds were traversed at 25-foot intervals, and all the crossbeds encountered were measured.

Textural Analyses - Size distribution, roundness, and sphericity were studied for each terrigenous formation. Owing to the large number of clastic formations, only five samples were selected for size analyses from each formation. This number of samples is too small to permit any general conclusion, although the samples are representative of the formation.

Krumbein (1941) proposed a roundness scale ranging from 0.1 to 1; 0.1 being very angular and 1, well rounded. The writer found it more convenient in such a general study to use four terms to describe roundness: angular, subangular, subrounded, and rounded. In Krumbein's scale the limits would be respectively 0.1 to 0.3, 0.3 to 0.5, 0.5 to 0.8, and 0.8 to 1.

As all of the samples selected for size analyses are well indurated sandstones, thin-sections had to be used to make statistical measurements. The sizes of grains measured in thin-section do not necessarily correspond to the sizes measured by sieving. The method proposed by Friedman (1958) was used to convert thin-section values to their sieve-size equivalents.

Thin-section Studies - Two hundred thin-sections of Silurian rocks were studied. The results of these analyses are presented in tables and are briefly discussed in the text.

Cabano Formation

Megascopic Description

The Cabano Formation is composed of clastic rocks ranging laterally and vertically from boulder conglomerates to mudstones. The best exposed sections are in the eastern half of the area. An almost complete section of the formation is exposed in Rimouski river (Fig. 3, Section I). Here, the basal third of the Cabano is composed of 4- to 8-inch beds of dark gray siltstone, intercalated with 1-inch beds of fine-grained, dark gray, foliated, lithic wacke. Much of the siltstone is laminated and calcareous. The rock generally weathers black, but some thin beds weather brown or rusty. In the middle third of the section, sandstone (lithic wacke) constitutes up to 40% of the rock, the remainder being dark gray siltstone. The sandstone is coarse grained where thickly bedded (2 to 3 feet), and may be calcareous. The upper third of the formation on the Rimouski is very similar to the basal third. In a few places the beds are thick (3 feet); in one, there are pyrite nodules one inch in diameter. The uppermost 50 feet of the section is predominantly lithic wacke.

In the Rimouski River section, rare crossbeds were noted in the laminated siltstones and in the sandstones. The sandstones are in sharp contact with siltstones and rarely have graded bedding. Most of the sandstone beds are thin and massive.

A second well-exposed section of Cabano is on the NW flank of Longue Vue mountain, in the eastern half of the area (included in the Porc-Epic section, Fig. 3, Section J). At this locality the Cabano consists of interbedded lithic conglomerate and lithic wacke. The wacke is similar to that on Rimouski river. In association with the conglomerate, the lithic wacke is generally coarse to very coarse grained, with grains ranging from 1 to 2 mm. in diameter. In the conglomerates, grain size varies from bed to bed. The average size for the entire section in 64 mm. The clasts reach 200 mm. at certain localities. The larger clasts (boulders and cobbles) are concentrated in thick beds near the base of the formation. The proportions of rock fragments in the conglomerate are as follows:

60% silica cemented, quartz sandstone;
20% finely laminated, calcareous siltstone;
10% light gray limestone;
5% calcareous, quartz arenite;
5% argillaceous, silty limestone.

Lespérance (1960, p. 59) reports approximately the same proportion of rock clasts from the Cabano conglomerate at Burnt Point. The clasts are everywhere rounded (average 0.7 of Krumbein's scale). Their sphericity depends

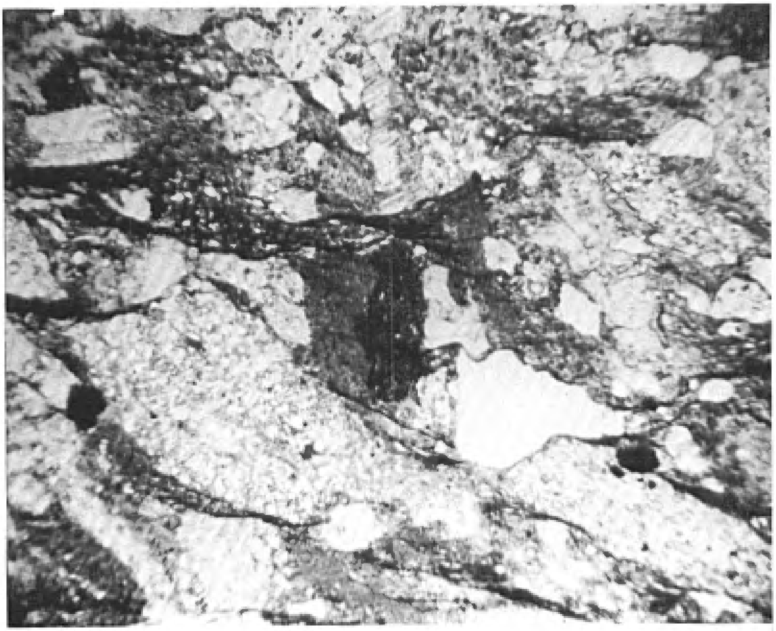

Plate IX - Cabano sandstone. Siltstone grains in a matrix of fine quartz and shale grains. x40

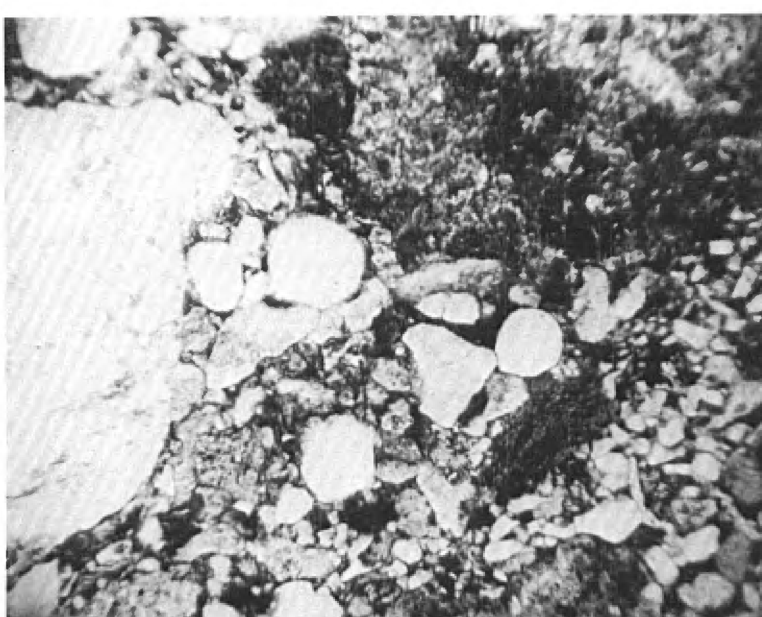

Plate X - Lac Raymond sandstone. Poor sorting, high content of matrix, angular and rounded quartz grains. x40

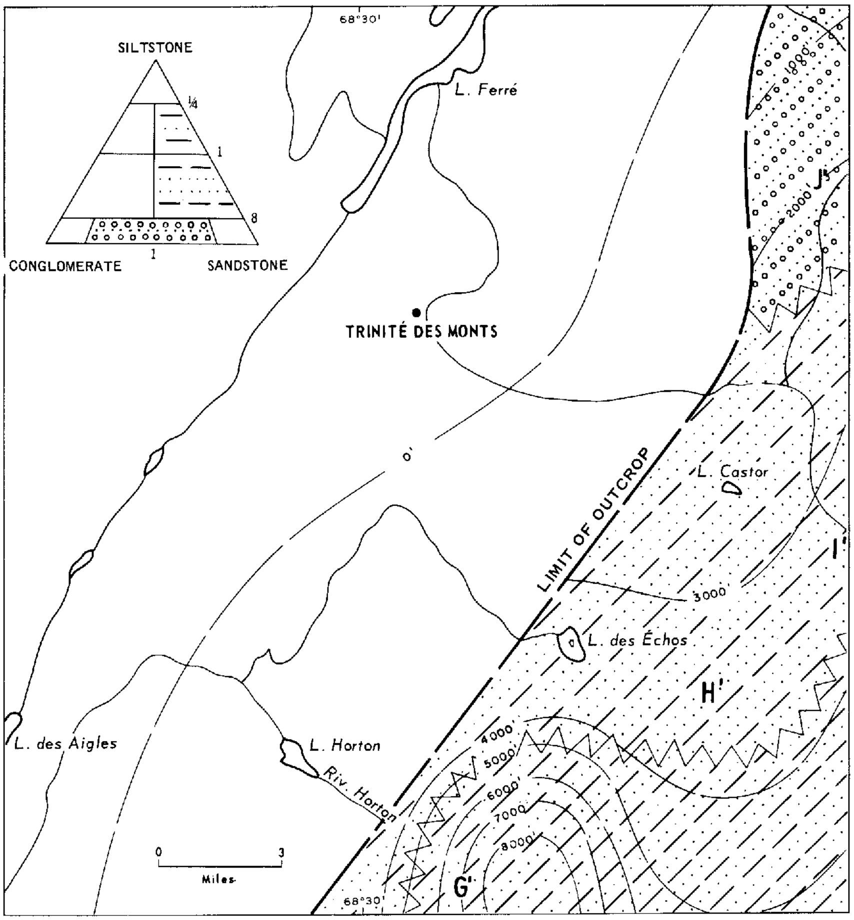

Figure 5

PALINSPASTIC ISOPACH AND FACIES MAP OF THE CABANO FORMATION

D.N.R.Q. 1969 B-913

upon their composition; usually the quartz sandstone clasts have a relatively high sphericity as opposed to the siltstone and limestone clasts, which have a sphericity of about 0.3 to 0.5.

The matrix of the lithic conglomerate is composed of lithic sandstone, similar to the sandstone of the interbeds.

The beds in the Longue Vue mountain sequence are thicker than those in the Rimouski River section. The cobble beds range from 8 to 25 feet thick, the pebble conglomerate beds generally average 3 feet thick, and the sandstone beds 1 foot. Much of the conglomerate is crossbedded, in units as thick as 10 feet in the coarsest rocks. Graded bedding, and scour and fill marks are rare.

A third well-exposed Cabano section is on Orient brook (Fig.3) near Echos lake. The only major difference between this section as exposed and the Rimouski River section is that a 100-foot conglomerate horizon occurs here at the top of the Cabano Formation. The conglomerate is in all respects similar to the Porc-Epic conglomerates.

Isopach and Facies Map

Figure 5 is a palinspastic isopach and facies map of the Cabano Formation, constructed from the columnar sections of Figure 3. These sections have been displaced 5 miles to the southeast, which approximates their displacement on the Rimouski thrust fault. The dashed lines on Figure 5 represent uncertain or interpreted thicknesses. Some of these lines are more reliable than others. It is known that the Ferré Lake and Islet Lake sections (Fig. 2, Sections F and E, respectively) do not contain any Cabano rocks, and that the Cabano is only some hundreds of feet thick at the nose of the Saint-Marcellin anticline (Béland, personal communication). Thus the "zero" isopach must lie between the Cabano outcrops and these sections. Furthermore, the dashed lines must approximately parallel the well-established 3,000-foot line.

The facies map of the Cabano includes only what is known of the formation; no interpretation is made outside the outcrop area. The facies represented on the map are a summarization of the total lithology of the formation, and show that grain size decreases from north to south. Conglomerate is almost restricted to the northeastern part of the area. Although a northwestern source is clearly indicated by the facies distribution, a southeastern source cannot be excluded because the Cabano trough was probably fed by material from all sides. Lespérance (1960, p. 57) describes a thick conglomeratic sequence at Burnt Point and states that there is a decrease in grain size from southwest to northeast across his area. Thus, there is general support for the suggestion (Lespérance, 1960, p. 81) that the Cabano was deposited in an intramontane trough.

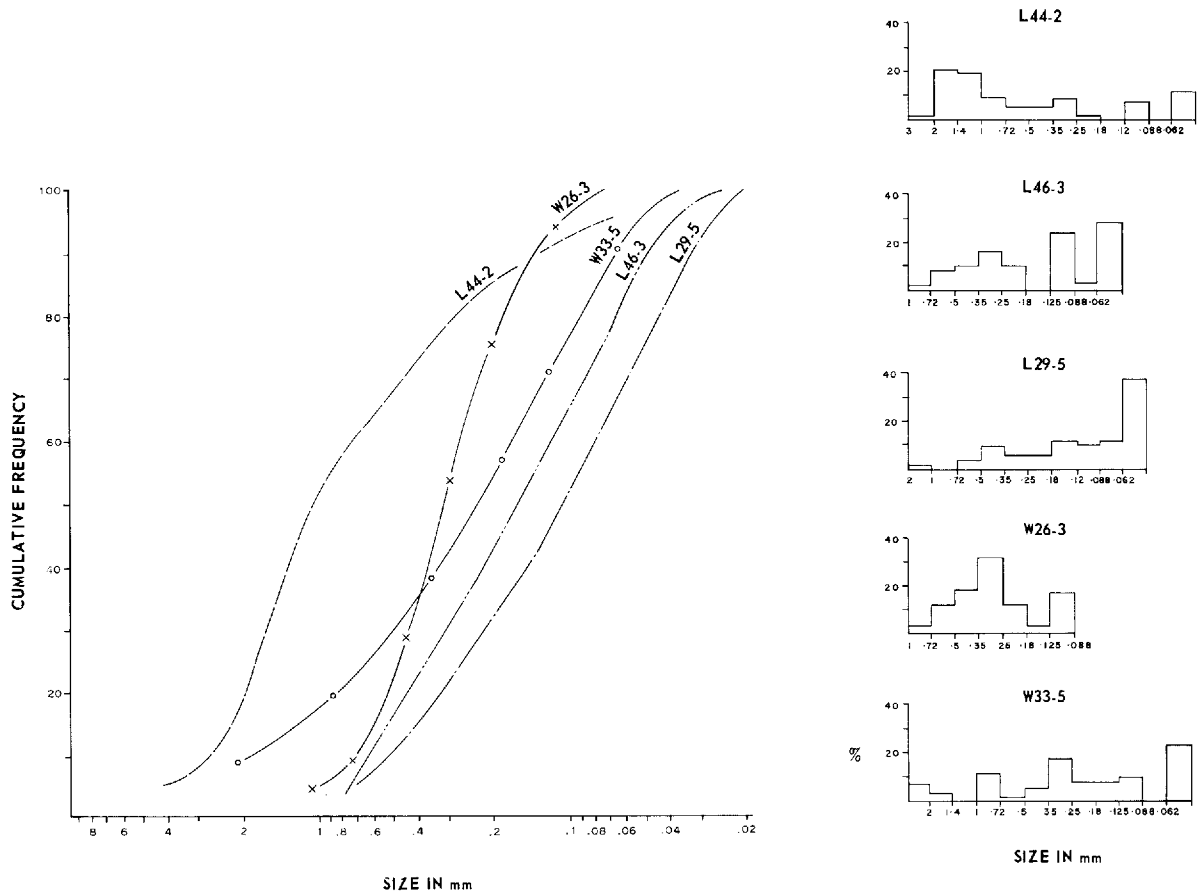

Figure 6

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Textural Analysis

The five samples from the sandy fraction of the Cabano Formation selected for statistical analysis (Table 4) come from the Echos Lake and Castor Lake sections. The samples are listed in order of increasing depth in the formation. Figure 6 gives cumulative curves and histograms of the samples.

Table 4 - Size Analysis of Cabano Sandstone

SAMPLE	$\bar{X}$ mm.	Md mm.	Q1 mm.	Q3 mm.	So	Log So	Sk
L44-2	0.9	1.2	0.3	1.9	2.5	0.4	0.4
L46-3	0.2	0.15	0.076	0.34	2.14	0.33	1.14
L29-5	0.19	0.105	0.052	0.27	2.27	0.356	1.27
W26-3	0.38	0.3	0.2	0.48	1.54	0.197	1.06
W33-5	0.46	0.25	0.12	0.68	2.45	0.388	1.30

The arithmetic mean ($\bar{X}$) ranges from 0.19 mm. (fine sand) to 0.9 mm. (coarse sand), and the average for the samples is 0.43 mm. The sorting coefficient varies from 1.54 to 2.5 and averages 2.18. A sorting of 1.3 was suggested by Folk (1951) as the limit of the mature-submature state for sandstones. The Cabano lithic wacke is thus relatively poorly sorted.

Most of the size distributions of Cabano clasts are skewed towards the fine sizes because the matrix was included in the grain counts. All the histograms show a peak in the finer fraction as they contain 15 - 30% matrix.

The Cabano sandstone grains range from subangular to subrounded; in general the larger quartz grains are well rounded and the smaller sizes (near .15 mm.) are subangular. Rock fragments range from angular to subrounded.

The sphericity of the sand grains ranges from 0.3 to 0.8 in Krumbein's (1941) scale. The mineral grains have a higher sphericity (0.6 to 0.8) than the rock fragments (0.3 to 0.7).

Textural Maturity

The Cabano sandstone is immature (Folk, 1951) owing to the fact that it generally contains more than 5% detrital clay. The quartz grains are anomalous considering that their roundness value (0.7) is characteristic of Folk's "supermature" stage. They were probably derived from pre-existing quartz sandstones.

Composition of the Cabano Sandstone and Siltstone

The compositions of twelve representative samples from the Cabano sandstone and siltstone are summarized in Table 5. This table shows that the major constituents of the Cabano sandstone are rock fragments: siltstone-slate, quartz sandstones, limestones, and volcanics. The siltstone-slate fragments are generally composed of fine angular quartz grains in a micaceous matrix (probably illite and chlorite). These fragments are elongated and usually highly rounded;

many have been deformed by compaction. In some cases it is difficult to differentiate fragments from the surrounding matrix.

Most of the quartz sandstone fragments are fine grained, recrystallized, and silica-cemented. Fine-grained, calcareous, quartz sandstone is also present, in which euhedral dolomite in places replaces the calcite cement. In both rocks, quartz grains have etched boundaries.

Detrital volcanic fragments are rare, rounded, and somewhat larger than the average grain size. They consist of very small elongated plagioclase crystals set in a matrix of anhedral quartz. The An_{35} content of one of these plagioclase crystals suggests that some of the fragments are andesitic.

Quartz is the principal detrital mineral in the Cabano Formation, and constitutes the bulk of the siltstones (85% in L14-2). In sandstones, the quartz grains are mainly subangular to subrounded; a few are rounded. Many show undulatory extinction.

Plagioclase (An_{35-40}) is the most common detrital feldspar, although a few small grains of microcline were seen. The feldspars are generally fresh, but a few grains show sericitization.

Pyrite occurs in the Cabano sandstone and siltstone as small crystals along bedding planes. Its oxidation gives a yellowish rusty stain to some beds. Rarely, ½- to 1-inch pyrite nodules are disseminated in the Castor Lake section.

The matrix of the Cabano sandstones consists of a fine powder of chlorite-muscovite-illite-quartz. Some of the micaceous minerals were probably derived from a compaction-crushing of siltstone grains.

The cement is a fine mosaic of calcite, in places dolomitic, and may compose up to 40% of the siltstones. Siliceous cement was seen in sample L46-3.

Source of the Cabano Formation

The boulders, cobbles, pebbles, and sand grains of the Cabano all have lithologic equivalents in the pre-Taconic sequence exposed northwest of the Cabano Formation, and the facies map (Fig. 5) also indicates the northwestern area as one of the possible sources for the Cabano sediments. However, at the time of the Cabano sedimentation, Ordovician rocks were also exposed to the southeast. Since the formation was deposited after the Taconic orogeny it is logical to presume that mountains surrounded the depositional site and that sediments were probably fed to this site from all sides.

Table 5

Composition of Cabano Finer Clastics

Sample	Quartz %	Feldspar %	Chert %	Dolomite %	Pyrite %	Zircon %	Siltstone %	Quartz sandstone %	Limestone fragment %	Volcanic fragment %	Matrix %	Cement %
L44-2	10	-	2	-	trace	-	15	50	-	-	18	Calcite (5)
L21-5	10	trace	2	-	-	-	30	25	-	trace	25	Calcite (8)
W32-2	15	trace	-	-	-	-	35	15	5	-	20	Calcite (10)
L14-2 beds a	85	-	-	-	-	-	-	-	-	-	-	Calcite (15)
L14-2 beds b	10	-	-	-	-	-	20	50	-	-	15	Calcite (5)
L27-4	10	-	trace	-	-	-	10	45	10	-	10	Calcite (10)
L35-1	15	trace	trace	-	-	-	20	25	10	-	20	Dolomite-Calcite (10)
L46-3	40	3	-	-	1	trace	20	10	-	-	20	Siliceous (2-3)
W26-3	52	3	trace	1	-	trace	5	10	-	2	12	Dolomite (4) Calcite (10)
L23-3	40	-	-	-	3	-	-	-	-	-	15	Calcite (42)
L27-6	10	-	trace	-	-	-	15	40	5	-	16	Calcite (12)
W33-5	10	trace	-	-	-	-	20	40	-	-	16	Calcite (12)
L11-5	10	1	-	-	9	-	10	55	5	-	15	Calcite (4)

Environment of Deposition

McGerrigle (1934) favors deposition in shallow water along a coastline of high relief for the Cabano sediments. Lespérance (1960, p. 80) concluded that the Cabano was deposited in deep water as a result of turbidity currents.

The immature nature of the sandstones suggests a limited reworking action and a nearby source area. However, it is not necessary to postulate that the Cabano was deposited in deep water. In the present area, Cabano conglomerates are local features and may be explained as river-formed deposits. At the Porc-Epic section (J, Fig. 3), the cobble deposits are crossbedded in units 10 feet thick, indicating strong currents at the site of deposition. The Rimouski River section also has many crossbedded units. As shown by the facies map, selective transport was also a characteristic feature, the coarse clastics being deposited at the edge of the basin of deposition and the finer material only being dispersed across it.

The writer suggests a rapidly sinking delta for the depositional environment of the Cabano. Turbidity currents could have been initiated by slumping on locally oversteepened slopes. Fine particles would have been deposited in relatively quiet water, away from the river mouths, but not necessarily below wave base. The immaturity of the rock assemblage is explained simply by rapid subsidence (Folk, 1951, and others).

Lac Raymond and Awantjish Formations

The Lac Raymond and Awantjish Formations have the same stratigraphic position in the Silurian sequence of the area and also have similar mineralogical compositions.They are differentiated solely on the basis of grain size.

Megascopic Description of the Lac Raymond Formation

In the present area, complete stratigraphic sections of the Lac Raymond Formation do not exist; the best exposures are at Castor and Echos lakes. At the former locality, the lower 2,000 feet of the formation has been assigned to the Lac Castor Member and consists of interbedded pebble conglomerate, granule conglomerate, sandstone, and siltstone.

The conglomerate clasts are well rounded; they range from 2 to 64 mm. in diameter, averaging 25 mm. Their sphericity ranges from disk to sphere; elongated pebbles are aligned along the bedding planes. The pebbles consist of: 60% aphanitic, green, volcanic fragments; 20% white quartz; 10% greenish gray feldspathic sandstone, weathering white; 10% light gray chert.

The matrix is composed of gray, green-weathering, arkosic sandstone.

The conglomerate beds are highly variable in thickness, each horizon being more or less composed of lenses ranging from 1 inch to 3 feet thick. The conglomerates are interbedded with tuffs, arkosic sandstones, and green siltstones. The contacts between these rock types are sharp.

The Lac Castor conglomerate grades upward into a 4,000-foot section of Lac Raymond Formation proper consisting of interbedded green mudstones and greenish gray, fine- to medium-grained arkosic sandstones. The sandstone is in beds from 1½ inches to 2 feet thick, averaging 6 to 8 inches. The mudstones are generally not calcareous or laminated, and beds range in thickness from ½ inch to 3 inches.

The Lac Raymond section at Echos lake is very similar to that at Castor lake (Fig. 3; Sections H and I, respectively), except that conglomerate is missing in the former. About 10% of the lithology in Section H is sandstone; the remainder is mostly greenish gray siltstone and green mudstone.

Megascopic Description of the Awantjish Formation

The Awantjish Formation is well exposed at Longue Vue mountain, near the center of the eastern half of the area, where most of the rock is dark greenish gray mudstone, interbedded with greenish gray siltstone and occasional reddish bed. At a few localities (as in Taché brook, south of Taché lake) the siltstone is calcareous. The beds average 4 inches thick but range from 1 inch to 6 inches. The lowermost 500 feet of the formation consists of interbedded, fine-grained, arkosic sandstones and greenish gray siltstones.

Isopach and Facies Map

Figure 7 indicates the thickness and the different facies of the Lac Raymond and the Awantjish Formations, computed from Figures 2 and 3. The sections have been displaced 5 miles to the southeast to allow for the presumed displacement along the Rimouski thrust fault. The writer has not attempted to reconstruct the depositional trough for the Lac Raymond, since only the 5,000-foot isopach can be traced with any confidence.

From Figure 7, it is apparent that grain size decreases from southwest to southeast. In the lithofacies triangular diagram, the Echos Lake section (H) coincides with the Porc-Epic section (J). Both sections have finer clastics than the sections exposed west of Horton river. The siltstone facies of the Awantjish Formation is computed from a section exposed on Taché brook, where the formation is wholly composed of siltstone and mudstone.

Textural Analysis

The samples selected for size analysis are representative of the sand fraction in the Lac Raymond and Awantjish Formations. The grain diameters of the sandstones range from 0.14 mm. to 0.74 mm. (fine to coarse sand), with an average of 0.32 mm. (medium sand).

The sorting coefficient of the samples ranges from 1.4 to 2.4, but only one sample (L30-7) has a sorting coefficient above 2; the average is 1.7. The Lac Raymond sandstone is about 1.5 times as well sorted as the Cabano sandstone, the average sorting coefficient of which is 2.2.

Table 6 - Size Analysis of Lac Raymond and Awantjish Formations

SAMPLE	$\bar{X}$ mm.	Md mm.	Q_1 mm.	Q_3 mm.	So	Log_{10} So	Sk
L30-7 LC	0.74	0.58	0.24	1.4	2.4	0.385	1
W42-10 LC	0.16	0.14	0.094	0.22	1.5	0.184	1.05
L34-5 LRY	0.42	0.4	0.24	0.64	1.6	0.22	0.94
L30-10 LRY	0.14	0.14	0.092	0.2	1.4	0.166	1
L26-Awantjish	0.15	0.14	0.1	0.2	1.4	0.149	1.05

LRY - Lac Raymond Formation
LC - Lac Castor Member

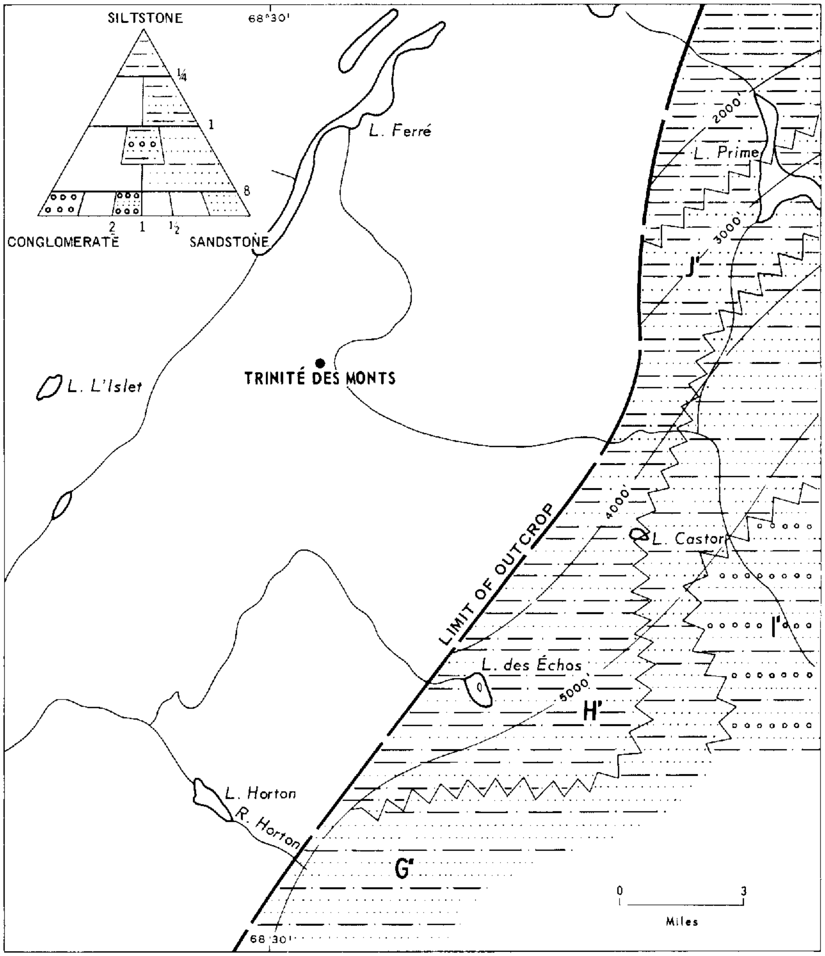

Figure 7

PALINSPASTIC ISOPACH AND FACIES MAP
OF THE LAC RAYMOND AND AWANTJISH FORMATIONS

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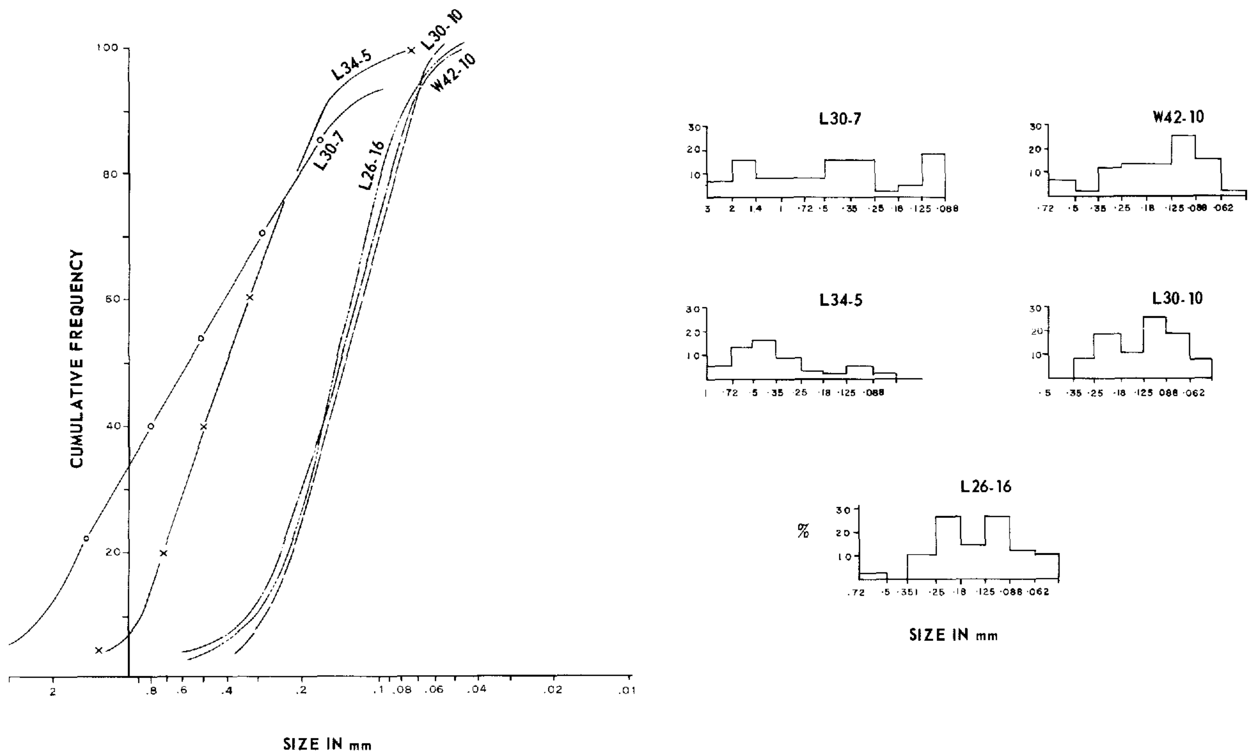

Figure 8

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Roundness of the detrital grains of the Lac Raymond and Awantjish Formations varies with the size and composition of the grains. Silt grains are angular; sand-sized quartz grains are usually subrounded to rounded; rock fragments are subrounded to subangular; feldspar grains are generally angular.

The sphericity of the sand grains reflects their composition; rock fragments range from 0.3 to 0.7 mm., and average 0.5 mm.; quartz and feldspar grains average 0.6 to 0.7 mm.

Textural Maturity

The Lac Raymond and Awantjish sandstones contain more than 5% detrital clay, and would thus be classed as "immature sandstones" (Folks,1951).

Mineralogy of the Lac Raymond Formation

Samples selected for thin-section analysis from the Lac Raymond Formation include granule conglomerates, sandstones, and siltstones taken from the Echos Lake and Castor Lake sections. Table 7 summarizes the analyses of 14 thin-sections.

Table 7 - Mineralogy of Lac Raymond Formation

Sample No.	Quartz %	Feldspar %	Chert %	Siltstone-slate %	Sand-stone %	Lime-stone %	Volcanic %	Misc. %	Matrix %	Cement %
L45-1	25	15		10			20	5	20	5
L39-2S	45	5						5		45
L30-7	10	5	10	5	5		40	7	15	3
L34-1	40	20	10					10	20	
L34-4S	40	10						10		40
L34-5	20	5	30	5	10	5	5		5	15
L30-10	30	50	3		1			1	15	
L29-14S	20	65						5		10
K16-5	35	25	5	10	10			10		5
L30-6	40	17	15		5	1	2	5	5	10
L30-8	15	5	10				40	5	15	10
L30-1	20	50	5				10	5	10	
W42-7	10	10	20				30	10	15	5
W42-10	30	30						10	30	

S = siltstone

In most exposures of the formation quartz and feldspar are the dominant minerals. The quartz grains are generally well rounded, and commonly show undulatory extinction. Plagioclase (An_{32-36}: andesine) makes up 60 - 70% of the feldspars (Table 8). The plagioclase found in the Cabano Formation are also andesine, and Lespérance (1960, p. 107) reports andesine from the Lac Raymond Formation in the Squatec area. The plagioclase grains are commonly fresh and angular, although a few are sericitized. Sample L29-14 is a tuff composed of very fine, angular plagioclase grains, with minor fine quartz grains.

Table 8

Universal Stage Analyses of Plagioclase

Sample	X'∧(010)	An Content
L45-1	15°-15° 14°-14°	An_{32} An_{32}
L30-7	18°-18°	An_{34}
L30-10	17.5°-18° 20°-20°	An_{34} An_{36}
L29-14	15°-15°	An_{32}
L30-8	18°-20° 16°-16° 17°-17°	An_{36} An_{33} An_{33}
L30-1	17°-17°	An_{33}

Chert grains are detrital; a few are rounded, but most are angular. The most common sandstone fragments are rounded quartz arenite grains; less common are fine feldspathic, sandstone fragments, mostly subangular.

Volcanic rock fragments are abundant in the granule and pebble conglomerates of the Lac Raymond. In thin-section, they have a hyalo-ophitic texture; that is, they are composed of fine, elongated plagioclase crystals in a groundmass of quartz. Lespérance (1960, p. 102) identified these volcanic fragments as "latites", implying that at least 1/3 of the total feldspar is alkaline. Universal stage analyses made on a few plagioclase crystals in the volcanic clasts identified them as andesine, but, as the groundmass of these crystals is extremely fine grained, it is difficult to establish the exact amount of alkali feldspar in them. They could be latites, trachyandesites or andesites.

"Miscellaneous" grains (Table 7) include many minor constituents of the detrital fraction of the Lac Raymond Formation, such as tuff particles, muscovite flakes, clinopyroxene and zircon grains, rare microperthite grains, and opaque materials.

The matrix of the granule and pebble conglomerates is composed mainly of sand grains similar to those in the sandstones. The matrix of the sandstones is a fine powder of quartz, muscovite, illite (micaceous clay), and chloritic material.

Most thin-sections of siltstones have a high percentage of calcite cement (dolomite is rare). However, as field evidence indicates that the siltstone is rarely calcareous, the samples studied were probably not representative. Chert cements the sand grains of many samples.

In general, the sandstones of the Lac Raymond Formation consists of arkosic arenites, arkosic wacke, subfeldspathic lithic wackes, feldspathic wackes, and lithic wackes; the most common are arkosic and subfeldspathic lithic wackes. Mineralogy and texture are both quite variable.

Mineralogy of the Awantjish Formation

The mineralogy (Table 9) of the Awantjish Formation is relatively simple. The major mineral constituent is quartz. At the Porc-Epic section (J) the sandstones are fine feldspathic wackes (L27-3, L26-1), with sub-rounded to rounded quartz grains. The silt-sized grains are angular.

Table 9 - Mineralogy of Awantjish Formation

Sample No.	Quartz %	Chert %	Feldspars %	Micas %	Misc. %	Matrix %
L27-3	40	5	10	10	5	30
L26-1	30	5	T 20	10	5	30
$L26\text{-}2_S$	40		20	15	5	20
$L24\text{-}1_S$	55		15	10	5	15
$L17\text{-}1_S$	30		20	10	10	30

S = siltstone

Feldspars (commonly plagioclase) are fine in size and angular. "Micas" in table 9 include muscovite and chloritic material. Muscovite flakes, larger than the average matrix grain size, are very common. The matrix is composed of very fine particles of micaceous minerals with up to 10% quartz grains. Miscellaneous minerals include minor epidote, clinopyroxene, tourmaline, zircon, and chalcedony. Except for the absence of rock fragments, the mineralogy of the Awantjish Formation is similar to that of the Lac Raymond.

Source

The Lac Raymond and Awantjish Formations are composed of a mixture of volcanic and sedimentary detritus. Most of the quartz grains in the Lac Raymond Formation are mature (rounded) and their association with angular and subangular grains suggests that they are at least second-cycle grains, probably derived from a preexisting sandstone. Lespérance (1960, p. 11) reports two occurrences of volcanic flows or plugs: one of andesite in the Squatec area, the other of trachyte 15 miles southwest of Pointe aux Trembles. Lespérance (1960, p. 112) considers that a single plug could not have supplied the detrital constituents for the entire Lac Raymond Formation; thus he believes that a source area lay to the southeast (east of the area of outcrop). No volcanic detritus was found in the pre-Silurian sedimentary rocks of either the present area or of the Squatec-Cabano area to the west.

The facies of the Castor Lake section (I) indicates a local source to the southeast. Since the coarser elements of a rock unit are generally found relatively nearer to the source area, it seems probable that the Lac Raymond and Awantjish sediments were derived from an area to the southeast or south. This area is covered by younger strata, but the underlying (source) rocks probably include both sedimentaries and volcanics.

Environment of Deposition

Since they contain marine fossils, the Lac Raymond and Awantjish Formations were deposited in a marine environment. The immaturity of the Lac Raymond Formation suggests that limited reworking of the sand and gravels took place. Maturity is an index of subsidence, or instability of the depositional trough. Since the Lac Raymond coarse clastics are better sorted than those of the Cabano Formation, it is logical to presume that the depositional trough was more stable in Lac Raymond time than in Cabano time. At the end of Lac Raymond time, the Silurian trough was relatively stable, as shown by the highly mature quartz sandstone unit which covers the Lac Raymond - Awantjish rocks in most of the region. The Lac Castor conglomerate crops out mostly at the base of the Lac Raymond Formation and may have been deposited under conditions similar to those for the Cabano conglomerate (suggested by Lespérance, 1960, p.110).

The Awantjish Formation is transgressive, and becomes thinner from southwest to northeast. It grades upward into the mature Val-Brillant quartz sandstone. Thus, the Awantjish probably was deposited in a shallow, quiet, but oxygenated, environment. The fine/coarse clastic ratio of the formation is very high and suggests that the associated paleotopography was relatively low.

Val-Brillant Formation

The Val-Brillant Formation is exposed in long, narrow ridges in the present area. It is a white to pink, rarely gray, quartz arenite, with silica cement. The beds are regular and range from 2 inches to 2 feet thick, although they average 6 inches. In this area, planar crossbedding is absent, and through crossbedding is present only in a few outcrops. At the type locality in the Matapédia valley, however, the formation commonly shows both types of crossbedding (Lajoie, 1961).

Textural Analysis

The Val-Brillant is generally a fine- to medium-grained, relatively well-sorted sandstone. Five representative samples from the Islet Lake (E) (C6-2), Porc-Epic Lake (J) (L25-5, L26-11), and Ferré Lake (F) (L5-4, L26-8), sections were studied in detail with respect to texture. In Table 10, which summarizes the results of the studies, the samples are listed in order of increasing depth in the formation.

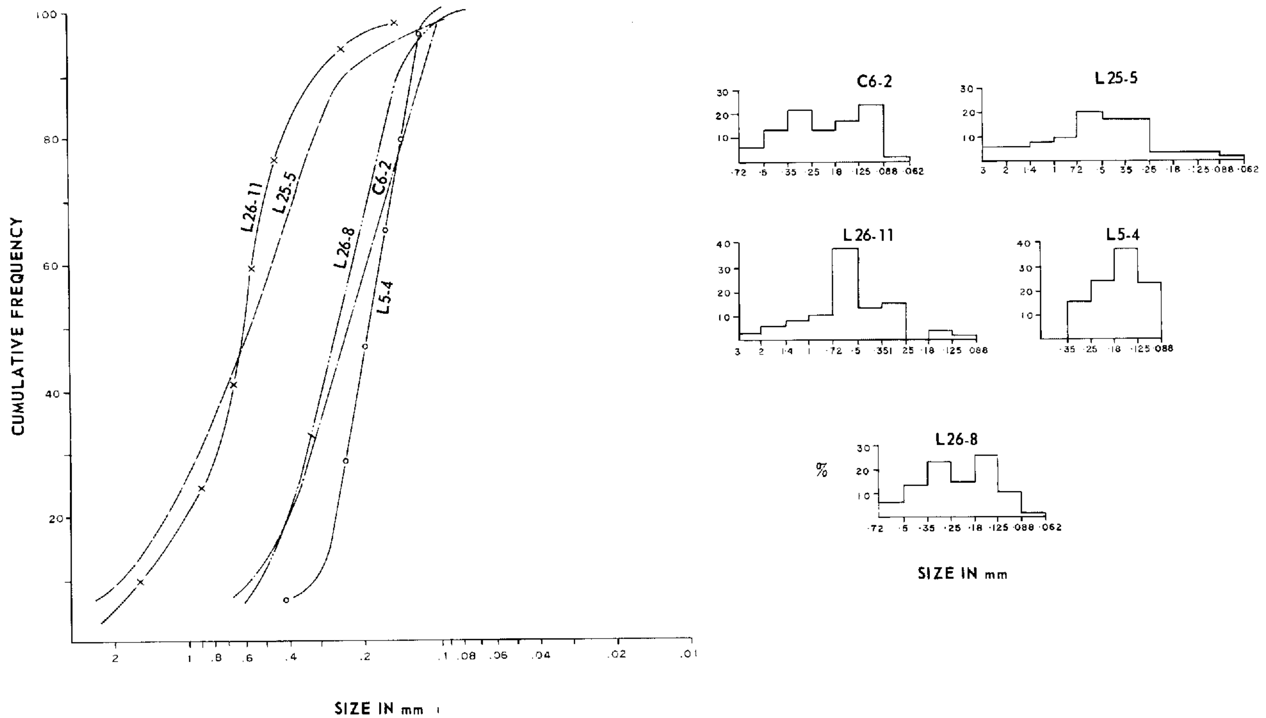
CUMULATIVE FREQUENCY
100
80
60
40
20
L26-11
L25.5
L26-8
C6-2
L5-4
2
1
.8
.6
.4
.2
.1
.08
.06
.04
.02
.01
SIZE IN mm
C6-2
L25-5
L26-11
L5-4
L26-8
%
SIZE IN mm

Figure 9

Table 10

Size Analysis of Val-Brillant Sandstone

SAMPLE	$\bar{X}$ mm.	Md mm.	Q1 mm.	Q3 mm.	So	Log So	Sk
C6-2	0.22	0.23	0.148	0.36	1.56	0.193	1.01
L25-5	0.7	0.58	0.35	1.05	1.7	0.23	1.09
L26-11	0.68	0.62	0.47	0.88	1.32	0.121	1.08
L5-4	0.17	0.19	0.15	0.25	1.29	0.111	1.09
L26-8	0.24	0.25	0.18	0.36	1.41	0.15	0.99

The arithmetic mean ranges from 0.17 mm. to 0.7 in five samples, and averages 0.4 mm. (medium sand size). The sorting coefficient ranges from 1.29 to 1.7 and averages 1.45. The formation is more poorly sorted here than in the type area, where the author (1961) found it to be 1.21.

Figure 10 summarizes roundness studies of 30 thin-sections of Val-Brillant sandstone from the area. Sphericity values from the same thin-sections range from 0.5 to 1, and average 0.7; these may be biased as only two dimensions are seen in thin-section. In hand specimens, the quartz grains seem to have a higher sphericity.

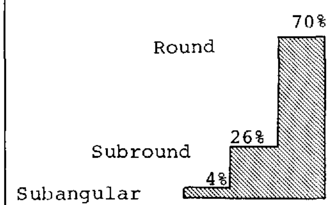

Fig.10- Val-Brillant Formation: roundness of sand grains

Mineralogy

Table 11 summarizes the mineralogy of 20 thin-sections from the Val-Brillant of the area (Is = Islet Lake section; F. = Ferré lake; P.-E. = Porc-Epic; Trans = in transition to Awantjish). Samples are listed in order of increasing depth in the formation. The upper three samples were collected at the top of the formation where it grades into the Sayabec limestones, and they contain a high percentage of calcite and dolomite. The lower two samples were taken at the base of Val-Brillant Formation. Sample C6-2 contains limestone fragments, oölites, and pellets; sample L55^{b-2} contains fragments of quartzite, andesite, chert, and micaceous siltstone.

Table 11

Mineralogy of Val-Brillant Formation

SAMPLE No.	Quartz %	Feldspars %	Rock Frag. %	Misc. %	Matrix %	Cement %
C6-2 (Is)	70	trace	5	5	0	20 (calcite)
L12-9 (F)	93		1 (chert)	trace (zircon)	0	5 (silica, minor hematite)
LL12-1 (Is)	20	1 plagio-clase	2 (quartzite)		0	77 (calcite and dolomite)
L114-1 (Is)	90		4 (chert and quartz SS)	trace (zircon)	0	5 (silica)
LL9-3 (F)	92		2 (chert)	trace	0	5 (silica)
C16-6 (F)	95		2 (chert)	trace (tourma-line)	0	2 (silica and hematite)
LL19-1 (Is)	97		(chert)		0	2 (silica)
L12-8 (F)	95		3 (chert and quartz SS)		0	2 (silica)
L26-11 (P.-E.)	90		5 (quartz SS)	trace (zircon)	0	4 (hematite and sil.)
L19-2 (P.-E)	85		3 (chert)	trace	0	10 (dolomite)
L19-1 (P.-E.)	90	trace	2 (chert	trace (zircon)	0	7 (silica and dolomite)
L26-8 (P.-E.)	80	2	8 (chert and quartz SS)		5	5 (silica)
L19-4 (P.-E.)	85		9 (chert and quartz SS)	trace (pyrite zircon)	0	5 (silica, minor dolomite)
L19-3 (P.-E.)	85	trace plagio-clase	3 (chert)	tourmaline pyrite	0	10 (dolomite)
L5-4 (F)	90		7 (chert)	1 (zircon)	0	2 (dolomite, iron oxide)
L5-3 (F)	95		3 (chert)		0	2 (silica)
L5-2 (F)	90		5 (chert)		0	5 (silica)
L12-10 (F)	90		3 (chert)		0	7 (hematite)
L55^{b-3} (Trans)	85	1 (plagio-clase	8 (chert and quartz SS)	trace (zircon)	0	2 (silica)
L55^{b-2} (Trans)	85	1 (plagio-clase	7		5	2 (silica)

SS = sandstone

The Val-Brillant sandstone is generally composed of 85 - 95% quartz, with minor amounts of plagioclase, chert, tourmaline, zircon, detrital pyrite, and fine quartz arenite fragments. The cement is silica, with, in places, calcite and/or dolomite and iron oxide.

Maturity

Mineralogically, the Val-Brillant is supermature both here and at the type-section. Texturally, it is mature (not supermature as at the type-section); average roundness is above 0.5, and the sorting coefficient averages 1.45 mm.

Source

Rounded quartz grains are believed to be of multicycle origin; the presence of detrital chert and quartzite also suggests that the sediment was derived from preexisting sedimentary rocks.

The zircon-tourmaline-microcline association is indicative of an acidic, perhaps pegmatitic, source. Thus, the ultimate source of the Val-Brillant sandstone may well have been the Precambrian Shield.

Crossbedding measurements in the Porc-Epic section give an average current direction from northwest to southeast (Fig. 12). This section is near the southern limit of the Val-Brillant sandstone, so the indicated current direction may only apply locally. The lowermost Robitaille quartz sandstone of the western half of the area, which is correlative of the Val-Brillant, carries abundant crossbedding that indicates a western to northwestern source. Crossbedding at the Val-Brillant type-section (Lajoie, 1961) suggests a northern source.

The pre-Silurian sequence north of the Val-Brillant contact contains white quartzitic sandstones ("Kamouraska"), which may have been the source of the Val-Brillant sand.

Depositional Environment

In the type area, Lajoie (1961, p. 66) concluded that the Val-Brillant was deposited in a stable, well-oxygenated, marine, near-shore environment, and the same conclusion is drawn for the present area. The degree of maturity of the sandatone indicates a stable environment. The pink to reddish color common in the formation along bedding planes and in disseminated specks through the rock results from oxidation of iron compounds. The red pigment of the iron oxide could not have been developed or preserved if the depositional environment had not been oxygenated. The regular bedding of the sandstone points to deposition in water rather than on land.

That the environment of deposition was marine is essentially established by evidences outside the present area. In the region, the Val-Brillant is conformable with marine sedimentaries both above and below, and it intertongues to the west with the Robitaille, which is definitely marine. To the east it contains marine fossils.

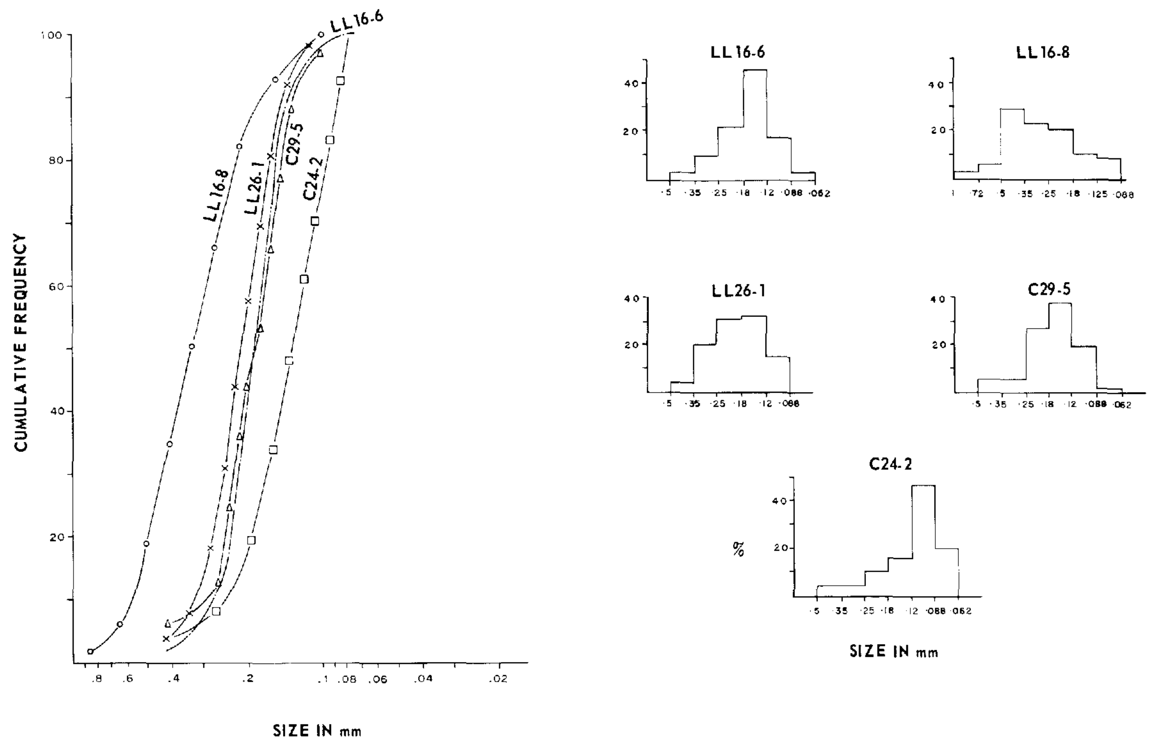

Figure 11

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Robitaille Formation

Megascopic Description

To the southwest (Lespérance and Greiner, 1969) the Robitaille consists of varicolored quartz sandstones and siltstones with local, thin limestone horizons. The base of the formation generally consists of quartz-pebble conglomerate interbedded with quartz arenite.

In the present area the Robitaille is predominantly red quartz sandstone and red siltstone. The section at Saint-Guy may be summarized, from top to base, as follows:

Red sandy siltstone in 3-inch beds	200'
Red, pink, and white, fine- to medium-grained, crossbedded quartz sandstones	400'
Red and pink quartz sandstone, interbedded with quartz-pebble conglomerate; beds 4-8 inches thick, many often crossbedded	700'
Red and green siltstones; thinly bedded with thin horizons of gray argillaceous limestone	300'
Red and white quartz sandstones interbedded with red quartz-pebble conglomerate; beds 2 feet thick	400'

The upper conglomerate is mainly composed of pebbles 10-60 mm. in diameter. The lower conglomerate consists of red and green quartz pebbles and cobbles 20 - 80 mm. in diameter, with minor felsite and siltstone fragments, in a matrix of rounded quartz grains.

The Islet Lake section consists mostly of interbedded red and green siltstones and quartz arenites. The section contains many limestone horizons, particularly near the base of the formation. The presence of the limestone beds is explained by the fact that the Robitaille and Sayabec formations intertongue about 2 miles east of the Islet Lake section.

Textural Analysis

The grain sizes in the Robitaille Formation range from cobble to fine silt. Five representative samples were collected from different sandstone horizons in the Saint-Guy section for a generalized textural analysis of the Robitaille sand fraction (Table 12). The sorting coefficient ranges from 1.22 to 1.4 mm., and averages 1.28. According to the averages, the Robitaille sands are 1.5 times better sorted than their Val-Brillant equivalent in the area. However, this average value of the Robitaille Formation is almost identical to the average sorting coefficient of the Val-Brillant of the type-section. It appears that the sorting values increase towards the northern contact of the Val-Brillant - Robitaille unit.

Table 12

Size Analysis of Robitaille Sandstones

SAMPLE	$\bar{X}$ mm.	Md mm.	Q_1 mm.	Q_3 mm.	So	Log So	Sk
LL16-6	0.17	0.19	0.155	0.23	1.22	0.086	0.99
LL16-8	0.3	0.33	0.24	0.47	1.4	0.146	1.03
LL26-1	0.2	0.21	0.17	0.26	1.23	0.09	1.01
D24-2	0.134	0.13	0.1	0.175	1.32	0.121	1.28
C29-5	0.18	0.19	0.152	0.24	1.26	0.1	1.02

The grains of the Robitaille area are rounded; pebbles and cobbles range in sphericity from 0.3 to 0.6 mm., and the sand grains average 0.7 mm.

Crossbedding - The Robitaille sandstones of Saint-Guy have strong crossbedding, all of it being planar or "torrential". The planar foresets are parallel to one another, and the crossbeds generally are 6 inches thick.

Crossbedding directions were taken at five localities, and Figure 12 shows rosette diagrams of azimuths of almost 1,000 measurements. The recorded azimuths range from 0° to 180°. The minimal direction of the rosette diagrams is taken to be the direction of the source area,or bordering land mass. Thus, the source area appears to lie to the west and northwest of the outcrops studied. The two locations studied on Cossette lake show a "grand mean" almost perpendicular to the general strike of the formation. Two localities to the southwest (Saint-Guy; fire tower lookout) have means more or less parallel to the general strike of the formation; this is assumed to be a result of littoral currents, which are responsible for the distribution of sediments along a coast line. The modes roughly perpendicular to the strike of the formation are assumed to be the result of an inflowing river which brought part of the sediments into the trough (Tanner, 1955; 1959). Thus, the major littoral current direction would be from west to east, as indicated by the strong modes in this direction. The standard deviation from the "grand mean" is high; such high deviation is generally recognized as evidence for deposition in shallow marine flats (Farkas, 1960; Pettijohn, 1962).

Isopach and Facies Map

In order to show the intertonguing of the Robitaille and Sayabec formations, both were incorporated in the facies map (Fig. 12).

At their type sections the Val-Brillant and Sayabec Formations are mostly Wenlock in age. Their lithologic equivalents in the Témiscouata Valley region are Ludlow. Therefore, these units transgress time from east to west, and the facies distribution illustrated in Figure 12 is a "physical facies distribution". In this rock assemblage the time lines rise steadily from the Matapédia valley to the Témiscouata valley. In the Prime and Baies Lakes area, and, in areas farther west, the Robitaille is either all or almost all of Ludlow age.

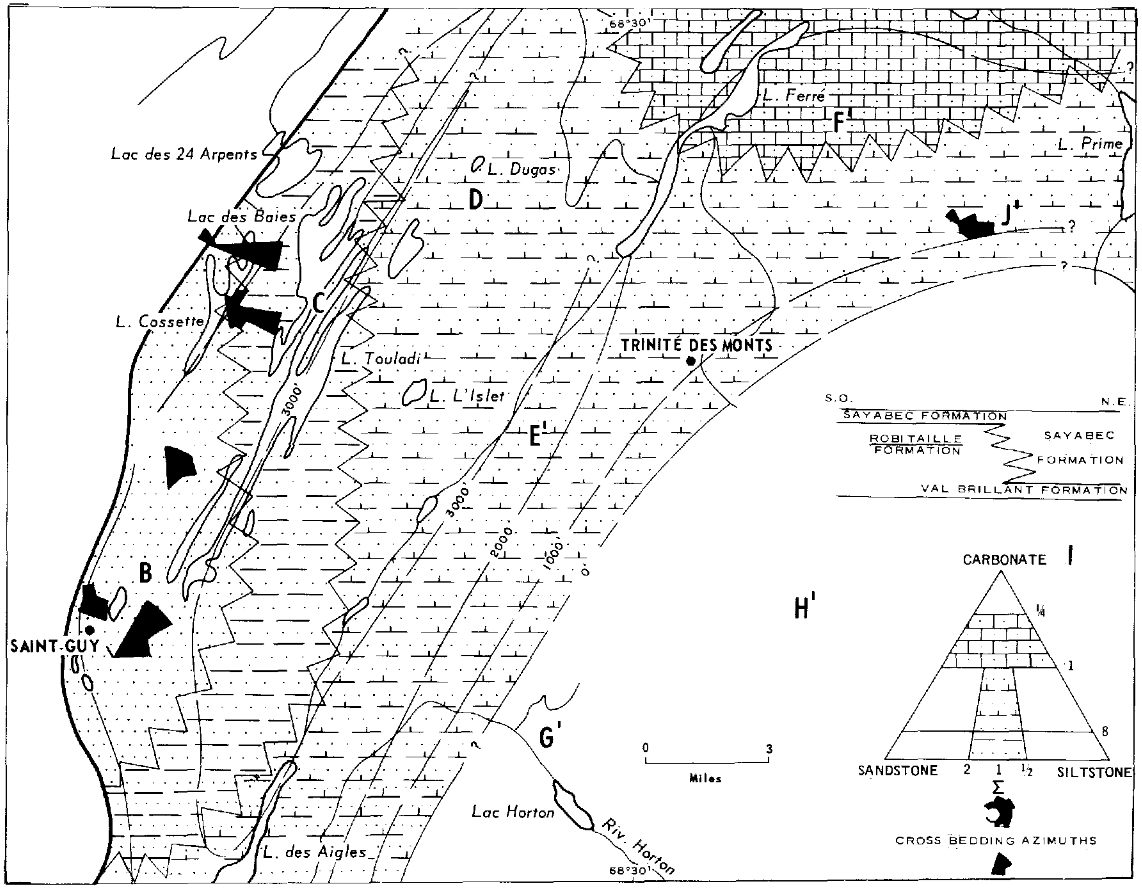

Figure 12

PALINSPASTIC ISOPACH AND FACIES MAP OF THE ROBITAILLE, SAYABEC, AND VAL BRILLANT FORMATIONS

D.N.R.Q. 1969 B-913

A general isopach map is included in Figure 12. Stratigraphic Sections G, H, and I show the Saint-Léon Formation (Ludlow) resting directly on the Lac Raymond (Llandovery); Wenlock strata and Robitaille equivalents are absent. The exact position of the zero isopach line is not known, but it has been drawn to delimit the area where Robitaille or equivalent lithologies are lacking.

The Robitaille sea seems to have transgressed from east to west across the trend of the zero isopach. This suggests that the Horton, Echos and Castor Lakes area may have been positive during Robitaille time. Such a high was suggested by Lespérance (1960, p. 140) in order to explain some features in the Squatec East area. The extent of the Prime Lake high to the south or east is not known, but it could have contributed some sediments to the Robitaille and Sayabec formations.

The grain size of the Robitaille Formation in the western half of the area steadily decreases from northwest to southeast. If present, the Prime Lake high must have been low and flat, because it does not seem to have affected the facies distribution of the Robitaille. On the other hand, the Sayabec of Sections J and F (Porc-Epic and Ferré lakes) contains sparse sandstone lenses which consist predominantly of quartz, but also contain volcanic grains similar in composition to those of the Lac Raymond. These sand lenses could have been supplied from the Prime Lake high.

Mineralogy

Table 13 summarizes the mineralogy of 15 thin-sections of the Robitaille Formation; samples are in order of increasing depth in the formation. Most samples are from gray, pink, and red sandstones, which represent the bulk of the formation. Three samples of gray and red siltstones and two samples of limestone were studied from the basal strata of the Islet Lake section.

In all sandstones, quartz averages 85% of the rock. Feldspars are minor and predominantly plagioclase. Rock fragments are chert, quartz arenite, minor hematitic siltstone, and rare volcanics. Minor mica, zircon, chloritic material, and tourmaline are present. Some sandstones have a micaceous matrix, which is everywhere less than 10% of the rock. In some samples, fine quartz grains between grains of coarser sand were counted as matrix. The cement consists of either silica (chert and quartz) or hematite; hematite colors the rock red or pink. The Robitaille sandstones are best termed quartz arenites.

Maturity

The maturity of the Robitaille Formation is difficult to assess, owing to the diversity of the formation. Mineralogically, the coarse Robitaille (sandstone and conglomerate) is mature. Texturally the sandstones are mature for the most part, although some are supermature, the amount of micaceous matrix being less than 5% and generally negligible.

Table 13 - Mineralogy of Robitaille Formation

SAMPLE No.	Quartz %	Feldspars %	Rock Fragments %	Misc. %	Matrix %	Cement %
LL11-5	75	4 (plagioclase and microcline)	2 (chert)	2 (micas)	7 (micaceous)	10 (hematite)
LL16-6	85	trace	5 (chert)		0	10 (silica and hematite)
LL16-8	90	trace (An)	5 (chert and quartz SS)	trace; (zircon)	0	4 (silica-dolomite)
LL16-7	80	2 (An)	5 (chert)	3 (chloritic material)	5	5 (silica)
LL26-1	76	1 (An and K)	10 (quartz SS;chert; hematitic siltstone)	1 (mica; zircon)	5 (micaceous)	7 (hematite)
C24-2	80	1 (An and K)	1 (chert)	3 (mica;zircon)	5 (micaceous)	10 (hematite)
C29-6	85	5 (An)		3 (tourmaline; zircon)	5 (micaceous)	2 (silica)
LL10-1	83	2 (An and K)	8 (chert and quartz SS)	trace (tourmaline; zircon;iron oxide;mica	4 (powder quartz and mica)	2 (silica)
LL30-8$_S$	30	5 (An)	5 (hematitic siltstone)	3 (micas)	55 (micaceous)	2 (hematite; silica)
LL30-10$_S$	90	2 (An and K)	2 (chert and hematitic siltstone)	trace; (tourmaline)	0	5 (hematite)
C29-5	80	5 (An and K)	4 (chert;siltstone; volcanic)	1 (chlorite; zircon)	5 (micaceous)	5 (silica)
C29-5^b_S	85	7 (An and K)	1 (chert)	4 (zircon;rutile-chlorite-muscovite		3 (dolomite)
D19-2A	82	5 (An and K)	2 (chert)	trace: (zircon)		10 (hematite and quartz)
LL9-5LS	3		40 (intraclast and skeletal LS)	50 (micrite)		7 (sparite)
LL11-7LS	3-5					95 (dolomitized sparite)

SS = sandstone S = siltstone LS = limestone

Some of the red and green siltstones contain a high proportion of micaceous material, and their quartz content is lower than that of the sandstones. The mineralogy of the siltstones is complex.

Source

The facies map (Fig. 12) and the crossbedding directions of the Robitaille Formation suggest a source northwest of the area. As noted above, a minor amount of sediments may have been derived from the southeast.

Environment of Deposition

The Robitaille is highly fossiliferous in places in the area, the fauna being that of a normal marine environment. The striking red color of parts of the formation implies a well-oxygenated environment. Sorting is very good and the coarser sizes are rounded. Cut-and-fill structures and torrential crossbedding are well developed. These facts point to a shallow water, near-chore environment of high energy.

Sayabec Formation

The classification proposed by Leighton and Pendexter (1962, p. 45) was adopted to designate the various Sayabec limestones because it presents a simple but adequate description of the limestone types. The author has added the term "intraclast" (Folk, 1959, 1962) to this classification; intraclasts are particles derived from weakly consolidated carbonate beds by penecontemporaneous (generally submarine) erosion, and are differentiated from "detrital" grains which are eroded (generally subaerially) from older consolidated rocks. For a more detailed coverage of limestone classification, the reader is referred to Folk (1959, 1962).

Megascopic Description

The Sayabec Formation is highly variable along strike in both thickness and composition, and also varies vertically. The type-section, as well as areas immediately to the west, was described earlier by the writer (1961). The formation consists predominantly of dark gray, argillaceous, silty, highly fossiliferous limestones. At La Rédemption, the Sayabec grades downward into the Val-Brillant sandstone (Lajoie, 1961). Westward from La Rédemption, the silt content of the Sayabec increases steadily. At Ferré lake (Fig. 2, Section F), the lithology of the formation, from top to base, is as follows:

	Units	Cumulative
e - Limestone with about 40% silt (in transition to the Saint-Léon Formation)..................	100'	100'
d - Silty limestone, interbedded with highly fossiliferous calcarenites, and calcilutites. By differential compaction, the silty limestones and the argillaceous dark gray calcilutites have formed pinch-and-swell structures ("sedimentary boudinage": McCrossan, 1958) very common in the formation.	600'	700'
c - Sedimentary and volcanic granule conglomerate in 5- to 10-inch beds (cemented by approximately 40% calcite in which the grains float) interbedded with calcareous quartz arenite. This horizon is about 500 feet thick, and is restricted to the Ferré Lake section. The complete Sayabec section along Rimouski river, 5 miles to the southwest, does not show any clastic fraction coarser than silt.	500'	1200'
b - Dark gray calcilutites, interbedded with calcareous siltstone, both of which show sedimentary boudinage.	200'	1400'
a - Sandy calcarenites and dolomites transitional to the Val-Brillant Formation	100'	1500'

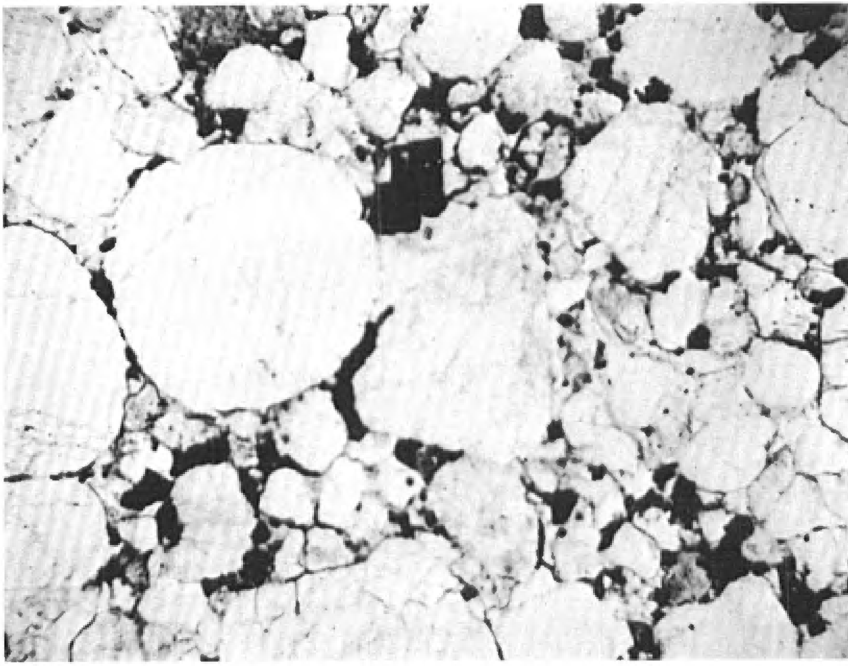

Plate XI - Photomicrograph of Val-Brillant sandstone: moderate sorting; siliceous and dolomitic cement; dolomite rhombs. x40

Plate XII - Photomicrograph of Val-Brillant sandstone: rounded and subrounded quartz grains cemented by dolomite and silica. x40

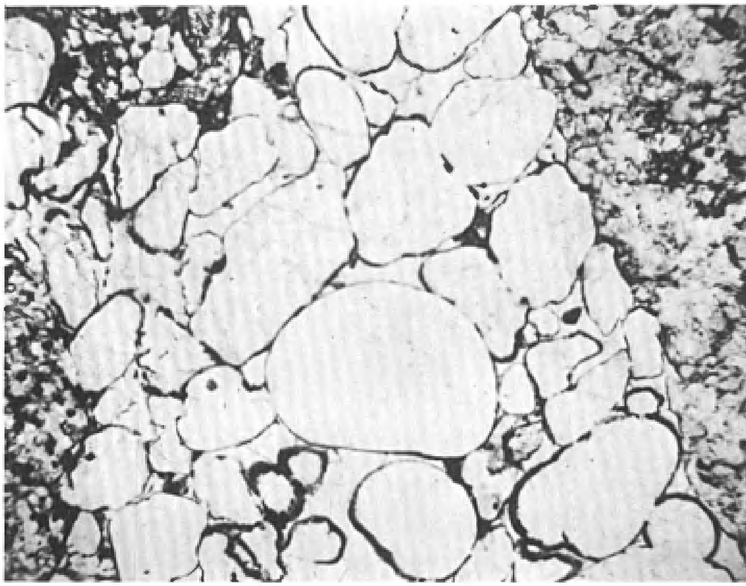

Plate XIII- Robitaille sandstone. Quartz arenite cemented by silica. The grains are coated with iron oxide. s40

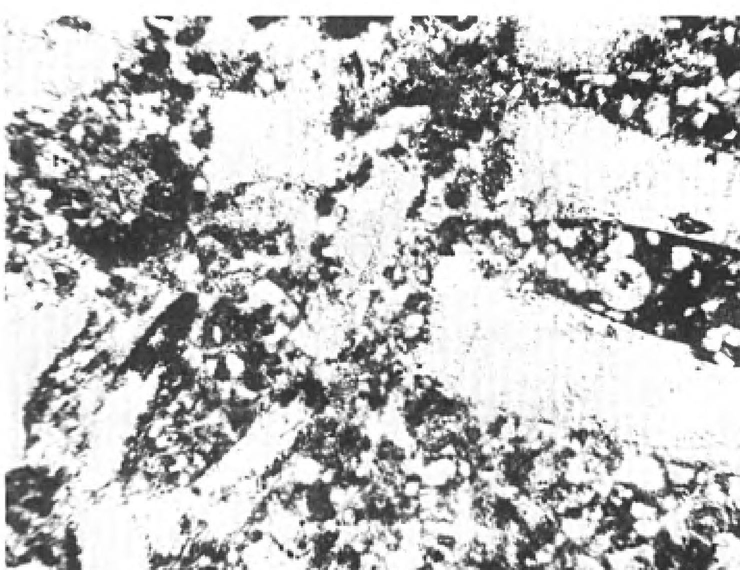

Plate XIV - Sayabec Formation: Skeletal grains, intraclasts and sparite. x40

In the Ferré Lake section, the limestone beds range in thickness from ½ inch to 6 inches. The silt layers weather buff-brown, and the more calcareous horizons, light gray.

The Sayabec exposed on Rimouski river and near Islet lake is very similar to that described above. However, the coarse clastic facies seen north of Ferré lake is absent.

The Sayabec of the Porc-Epic section is also very similar to that at Ferré lake, and includes the zone of granule conglomerate and sandstone, although in local lenses; coarse clastic material was not seen on the south limits of the Porc-Epic syncline. At the Porc-Epic section, the beds are ½ inch to 4 inches thick.

The Sayabec near Saint-Guy is 150 to 200 feet thick. Calcareous siltstone beds are relatively common and boudinaged. Beds are 1 inch to 3 inches thick.

Sedimentary Boudinage

Ellipsoidal limestone "boudins" surrounded by calcareous silt are common in the Sayabec of the area and are well shown on weathered surfaces. The silt veinlets (1/8- to 1/4-inch thick) form networks which commonly follow the bedding planes but pinch and swell around the limestone "boudins" and stand out in relief. In a few exposures silt veinlets crisscross the limestone without any pattern.

Textural Analysis

Most of the Sayabec Formation consists of various carbonate fragments cemented by micrite and sparite. Most of these fragments are of sand size and range from 1/16 to 2 mm. in diameter, the coarser sizes predominating.

The shape of the fragments depends on their nature: intraclasts are angular to rounded; skeletal debris is generally angular; and pellets are rounded. The sphericity of all grains ranges from 0.3 to 0.8 mm.; pellets generally tend to have a higher sphericity.

In many thin-sections a micritic, limy, mud matrix makes up 5 - 60% of the rock, and averages about 20%. In the other samples, the grains are cemented by sparite.

Mineralogy

Table 14 summarizes the mineralogy of 15 thin-sections; the samples are listed in order of increasing depth in the formation.

Samples LL18-12 and W17-4 were taken from the sandstone and granule conglomerate of the Porc-Epic section, slightly below the middle of the formation. LL18-12 is a volcanic arenite, with about 20% volcanic fragments, 5% chert, 10% quartz, and 10% quartzite; all grains are cemented by sparry calcite. Sample W17-4 is a chert-granule conglomerate, consisting of 30% chert, 10% quartz, 10% intraclasts, and 12% chalcedony, plagioclase, and pyrite; the granules are cemented by sparry calcite.

L5-9 and L5-11 are highly calcareous, fine-grained, quartz arenites cemented by sparry calcite and, to a lesser degree, by dolomite. L5-5 is a fragmental sandy limestone.

Most of the Sayabec is composed of intraclasts, skeletal grains, pellets, and binding material (micrite and sparite). It is difficult to distinguish intraclasts from detrital limestone grains in some samples.

The skeletal grains consist mostly of fragments of crinoid columnals, corals, stromatoporoids, brachiopods, and bryozoans.

The pellets are fine-sand sized (rarely coarser), composed of an argillaceous, calcitic mud.

Silt-size quartz grains occur in most of the thin-sections LL10-4 and L2-6; the miscellaneous grains are quartz, zircon, plagioclase, and a few pseudo-oölites.

The few dolomite rhombs present in sample L2-9 and LL9-6 replace parts of the sparry calcite cement.

Table 14

Composition of Sayabec Limestones

SAMPLE No.	Intraclasts %	Pellets %	Skeletal Grains %	Micrite %	Sparite %	Others %
L2-10	30		40		20	10 Silt
L2-9	40	5	30	20	5	
LL9-6	10		10	70		10 Silt
LL10-3	5		15	55	10	15 Silt
LL10-3[b]	15	35	20		30	
LL10-4	10	5	25	28	20	12
L2-6	20	10	30	10	20	10
LL27-2			30	50	20	
LL8-12					40	60
W17-4	10				38	52
W57-1	50		5	10	35	
L5-7	30		30		30	10 Silt
L5-9					35	65
L5-11					40	60
L5-5	10	5	20		20	45

Source

Most of the Sayabec sediment was derived in situ. Sand grains for the horizons near the base of the Sayabec were probably derived from the same source as that for the Val-Brillant and Robitaille formations.

Sand grains for the sandstone horizons slightly below the middle of the formation in the Porc-Épic and Ferré Lakes sections may have been derived from a southern (Lac Raymond) source.

Environment of Deposition

The Sayabec limestones are probably biochemical for the most part. The abundant content of marine fossils indicates that they were deposited in a normal, well-oxygenated, marine environment. The corals and stromatoporoids suggest warm, shallow waters. Calcarenites and broken crinoid columnals indicate moderate currents.

Saint-Léon Formation

The Saint-Léon Formation crops out from near the eastern limit of Gaspé peninsula to Témiscouata lake, and varies greatly in lithology and thickness from place to place.

Megascopic Description

Crickmay (1932) defined the Saint-Léon of the Matapédia valley as gray and greenish gray calcareous siltstone, with limestone conglomerate about 2,000 feet above the base of the formation.

Westward (Béland, 1960) the formation continues to be predominantly composed of greenish gray siltstone and shales, but the sandstone content increases. Béland recorded a section of sandstone on Mitis river, in the Humqui map-area; in the Sainte-Blandine area, a conglomerate composed of siltstone and quartz sandstone pebbles is interbedded with siltstone and corssbedded coarse sandstone; also, a limestone pebble-cobble conglomerate is interbedded with greenish gray calcareous siltstone near Sainte-Blandine village.

In the present area, the Saint-Léon Formation is divided into two facies: one, the main part of the formation, is similar to the Saint-Léon to the east; the other, composed of interbedded conglomerate and sandstone with minor greenish gray calcareous siltstone, is the Lac Des Baies Member. This member is exposed only north of the Lac-des-Aigles - Trinité-des-Monts high and is absent to the east (Béland, personal communication).

The most complete section of Saint-Léon in the area south of the high is at Castor lake. Here,the top of the formation is not exposed and the section consists of 2,000 feet of greenish gray, rarely red, calcareous siltstone with, in the basal beds, about 30% sandstone. In this section the beds range in thickness from ½ inch to 1 foot, and average 4 inches.

North of the Lac-des-Aigles - Trinité-des-Monts high the Saint-Léon is well exposed. At Ferré lake (Fig. 2), it is about 4,000 feet thick. The upper 1,300 feet is composed of massive, 4- to 6-foot beds of gray and greenish gray calcareous siltstone, rarely interbedded with quartz arenite and feldspathic wackes. This assemblage is underlain by the Lac Des Baies Member, which is about 1,400 feet thick and composed of pebble conglomerate in beds 5 to 24 inches thick, intercalated with 4- to 6-inch beds of quartz wacke, quartz arenite, feldspathic wacke, and, rarely, with green, calcareous siltstone. The conglomerate consists of quartz, siltstone, and rare volcanic pebbles (6-15 mm.) in a matrix of quartz sand grains, cemented by calcite (10-30%). The clasts are rarely graded. The contacts between the various lithologies are sharp. The Lac Des Baies Member at Ferré lake is underlain by nearly 1,200 feet of greenish gray calcareous siltstone, similar to the siltstone overlying it. The siltstone weathers buff and is massive.

At Baies lake, the base and top of the Saint-Léon Formation are faulted out. However, the base of the formation crops out along strike, a few miles to the southwest. The estimated thickness of Saint-Léon near Baies lake is 12,000 feet, of which the Lac Des Baies Member comprises 6,000. In the Baies Lake section, 800 feet of gray and greenish gray calcareous siltstone overlies the Lac Des Baies Member. This member may be summarized, from top to base,as follows:

	Thickness		
	Units		Cumulative
a - Lithic conglomerate (70%) interbedded with coarse to fine sandstone (30%). The conglomerate consists mainly of 5 to 20 mm. pebbles of quartz sandstone and green siltstone. Pebbles are well sorted in a given bed, rounded, oriented parallel to bedding planes. The matrix of the conglomerate is highly calcareous and mostly composed of coarse quartz grains; locally it contains large crinoid columnals and small brachiopods. Conglomerate beds are 8 to 12 inches thick; sandstone beds 2 to 6 inches, averaging 4 inches	1200'	-	1200'
b - Greenish gray calcareous siltstone in 6-inch beds, intercalated with fine- to medium-grained sandstone in 8- to 10-inch beds.	700'	-	1900'
c - Predominantly (60-70%) coarse sandstone (locally calcareous; in places crossbedded), interbedded with greenish gray calcareous siltstones (about 20%), and rare beds of small-pebble conglomerates (10%). The sandstone ranges in composition from calcaerous quartz wacke to calcareous quartz arenite and feldspathic arenite. The sand grains are generally rounded. Beds are 6 to 24 inches thick. The siltstones are in beds 3- to 10 inches thick; in places they are laminated and crossbedded	3500'	-	5400'
d - Lithic conglomerate, interbedded with coarse quartz sandstone. Pebbles consist of massive, green siltstone; green, finely laminated siltstone; coarse and medium, well-sorted, quartz sandstone; and rarely limestone. The matrix is composed largely of quartz sand grains and is calcareous (10%)	200'	-	5600'

	Thickness	
	Units	Cumulative
e - Lithic conglomerate in 8- to 12-inch beds, intercalated with gray, white weathering, 5% calcareous, medium-grained, quartz sandstone. The pebbles average 50 by 20 mm., are subrounded to rounded, and have the same composition as those in zone (d). Pebbles of low sphericity are aligned in the bedding plane. ..	100' -	5700'
f - Lithic conglomerate in 2- to 6-foot beds, intercalated with coarse, feldspathic and quartz arenites. Fragments range in size from cobbles to small pebbles and are composed of well-sorted, pink or gray or red quartz sandstone. The sand matrix carries corals, brachiopods, and crinoid columnals (some 1 inch across). A few limestone pebbles contain corals and bryozoans.	300' -	6000'

This section is underlain by some 4,000 feet of greenish gray and gray calcareous siltstone, interbedded with dark shales, in beds 4- to 10 inches thick.

From its type-section, the Lac Des Baies Member changes along strike. To the southwest, near Saint-Guy, the member is composed almost entirely of pebble and cobble conglomerates. To the northeast it intertongues with the finer facies of the formation (Fig. 2, Section D).

Textural Analysis

The detrital constituents of the Saint-Léon Formation range in size from fine silt to cobble. Five representative samples of Lac Des Baies sandstone and two large exposures of Lac Des Baies conglomerate were studied for size analysis. The results are summarized in Table 15. Figures 13 and 14 represent cumulative curves and histograms of the samples.

Table 15 - Textural Analysis of Lac Des Baies Member

SAMPLE No.	$\bar{X}$ mm.	Md mm.	Q_1 mm.	Q_3 mm.	So	Log So
15-Cgl	21	24	15	40	1.6	0.205
M-Cgl	21	20	14	36	1.6	0.205
LL35-12	0.46	0.5	0.25	0.72	1.7	0.23
LL22-5	0.71	0.75	0.14	1.8	3.55	0.55
LL22-6	0.25	0.19	0.09	0.38	2.06	0.31
LL35-8	0.53	0.38	0.17	0.9	2.44	0.38
LL44-2	0.57	0.72	0.38	1	1.63	0.21

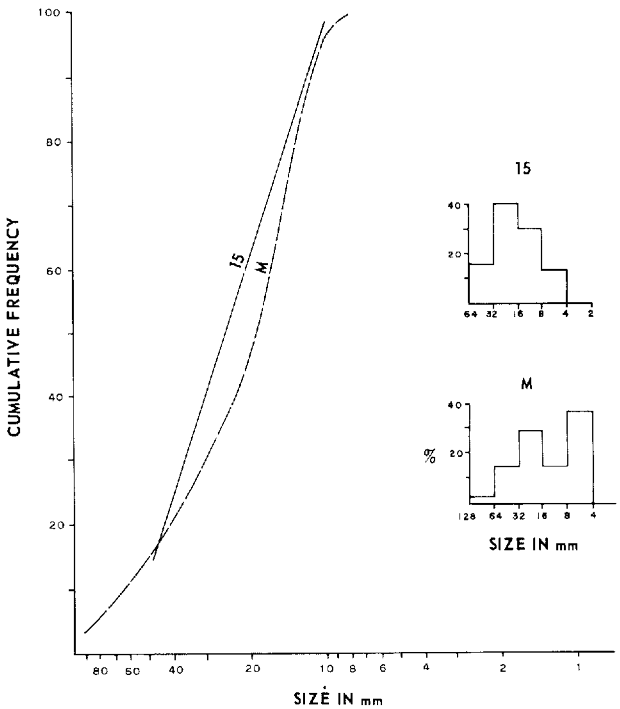

Figure 13

LAC DES BAIES CONGLOMERATE - CUMULATIVE CURVES AND HISTOGRAMS

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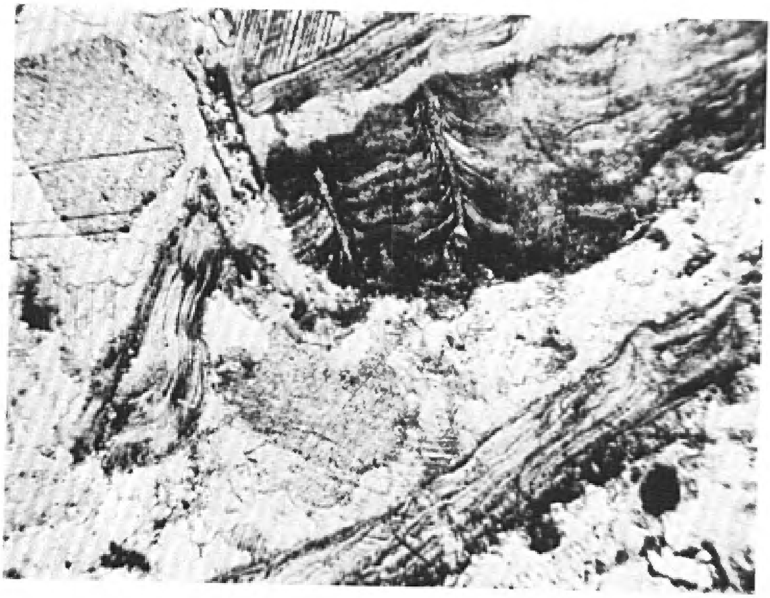

Plate XV - Sayabec limestone. Skeletal grains and micrite. x40

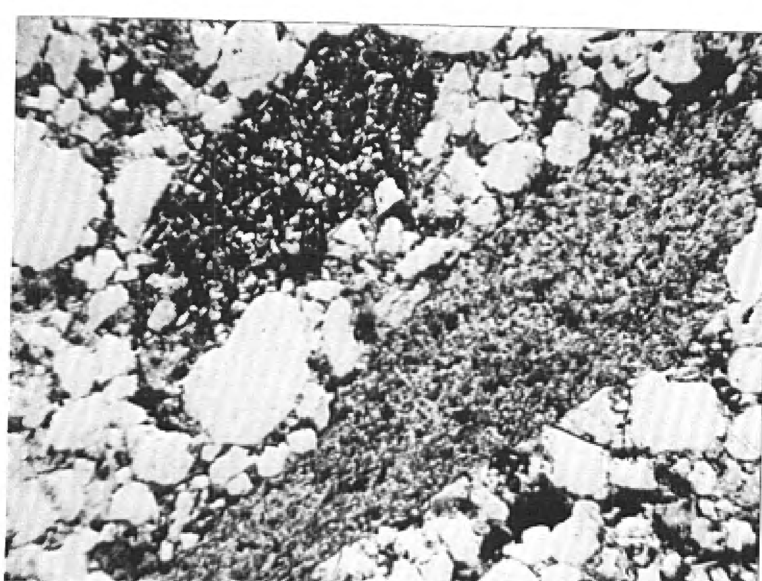

Plate XVI - Lac Des Baies granule conglomerate. Elongated siltstone grains in matrix of quartz grains. x40

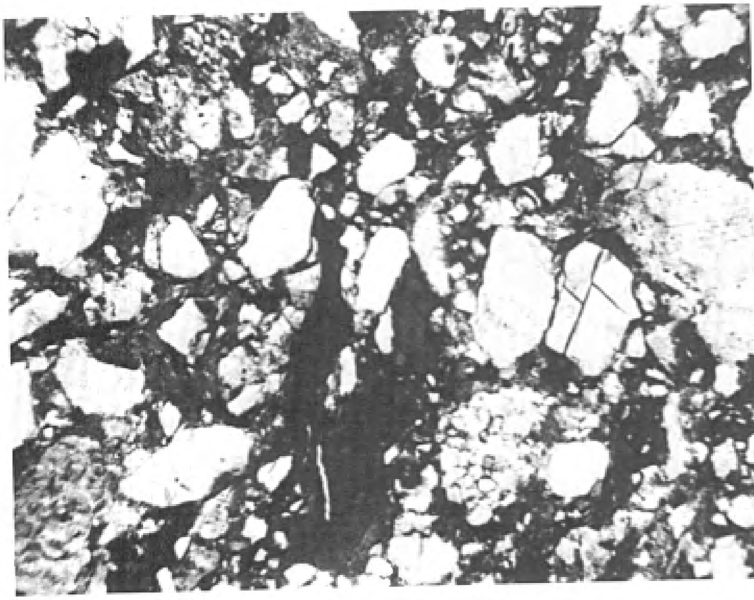

Plate XVII- Lac Des Baies sandstone. Quartz grains with clay matrix. x40

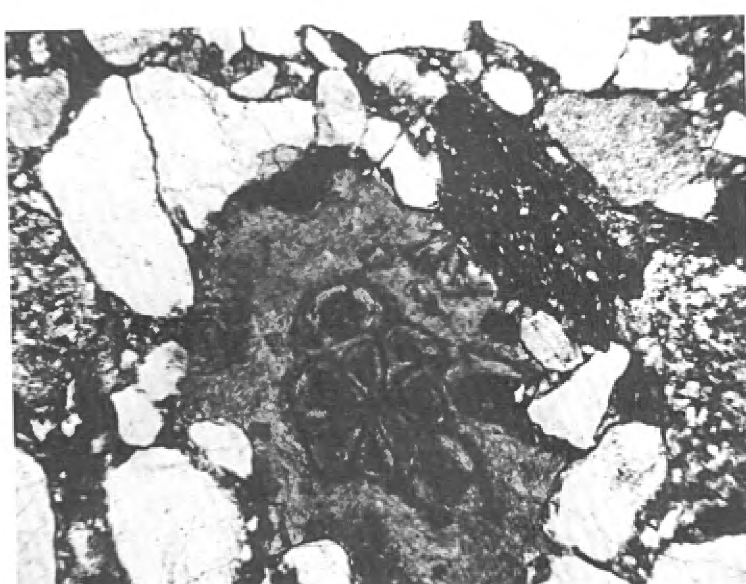

Plate XVIII- Lac Des Baies sandstone. Fossil occurence (Cladopora sp.). x40

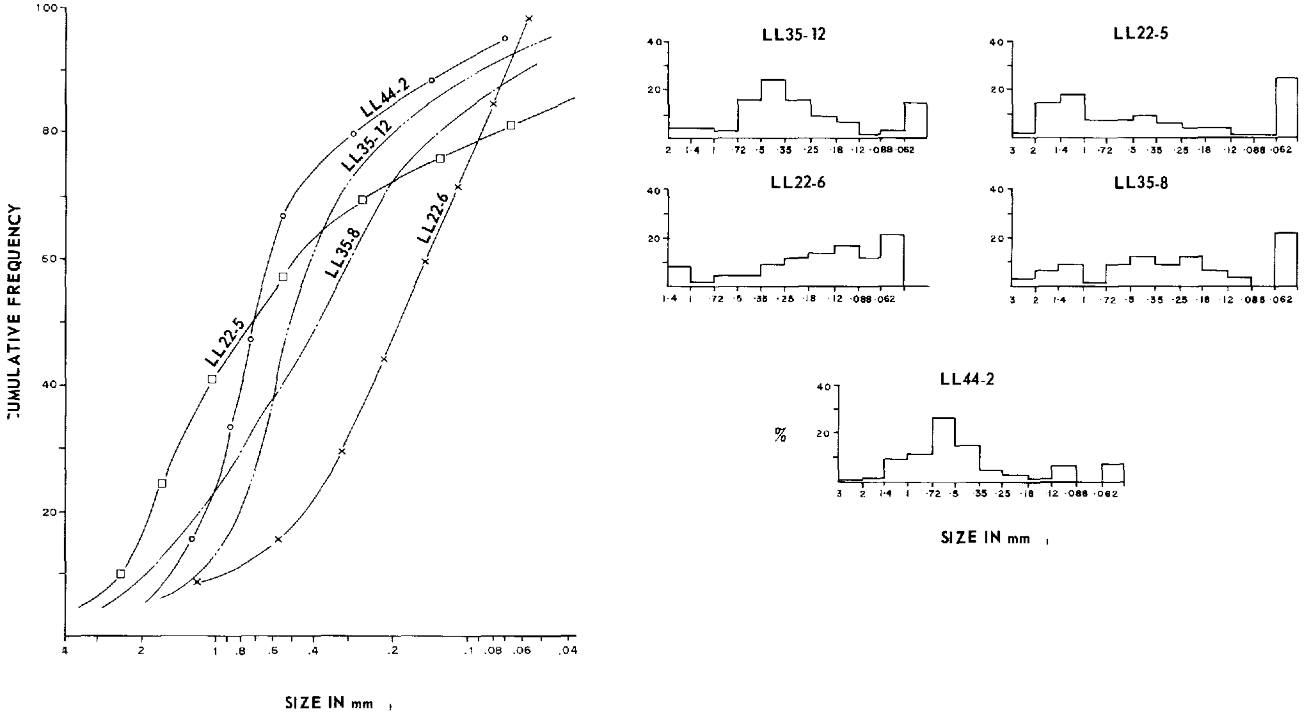

Figure 14

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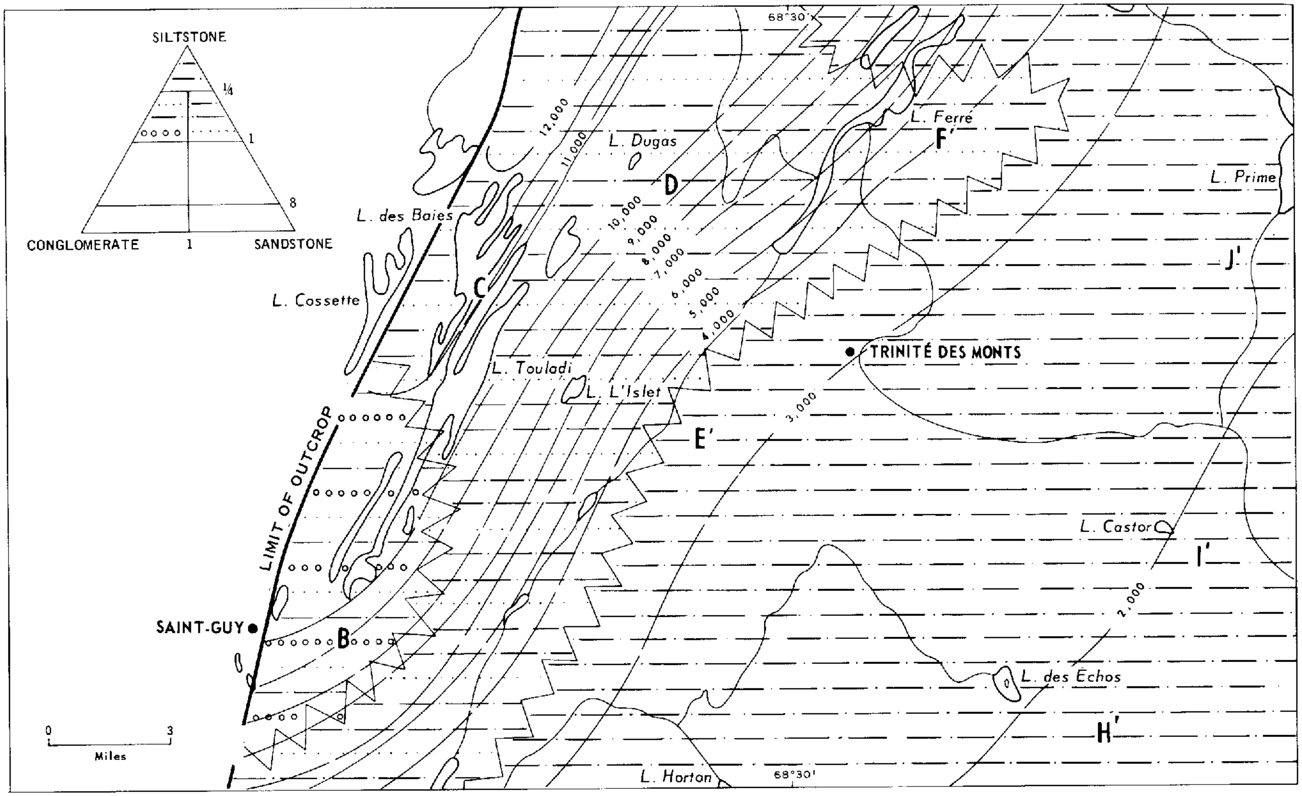

Figure 15

PALINSPASTIC ISOPACH AND FACIES MAP
OF THE SAINT-LÉON FORMATION

D.N.R.Q. 1969 B-913

The two large exposures of conglomerate are 3 miles apart and at different stratigraphic horizons. The conglomerate pebbles are relatively well sorted (1.6).

The sandstone ranges in size from 0.25 to 0.71 mm. (medium to coarse). The coefficient of sorting ranges from 1.63 to 3.55; thus the sands are moderately to poorly sorted.

The pebbles are generally rounded, and a few are subrounded. Most are disk shaped or roller shaped, or both; a few have a higher sphericity.

Isopach and Facies Map

The coarse clastics of the Saint-Léon decrease steadily from west to east. The conglomeratic facies is restricted to the western half of the area; to the northeast the member grades laterally into the sandstone facies which in turn intertongues with greenish gray calcareous siltstones.

Crickmay (1932) estimated that the minimum thickness of the Saint-Léon was 2,000 feet. Béland (1960) recorded a thickness of about 7,000 feet for the Saint-Léon to the west of the type-section. In the present area, the thickness ranges from 2,000 feet at Castor lake to about 12,000 feet. This maximum thickness coincides with the presence of the coarse clastics in the formation.

Mineralogy

Table 16 summarizes the results of the analyses of 24 thin-sections of Saint-Léon rocks; the samples are listed in order of increasing depth in the formation.

In all the thin-sections quartz is the predominant mineral, except for samples C33-8 and L2-4, which were collected near the base of the formation, in transition to the Sayabec limestones. The feldspars include potassic types (most commonly microcline) and plagioclases.

Under "miscellaneous" are grouped limestone fragments (numerous in thin-sections LL32-1, LL44-1), white micas (muscovite-illite), chloritic material, and minor constituents such as zircon and tourmaline; in sample L2-4, it includes intraclasts, pellets, and fossil debris.

The siltstone fragments are very similar in composition to the siltstone underlying the Lac Des Baies Member. They have a high quartz content and are cemented by calcium carbonate.

The volcanic grains in the upper part of the Lac Des Baies consist of subhedral plagioclase in a groundmass of anhedral quartz. Under

Table 16

Mineralogy of Saint-Léon Formation

SAMPLE No.	Quartz %	Feldspars %	Misc. %	Rock Fragments %			Matrix %	Cement %
				Siltstone	Quartzite and Chert	Volcanic		
L1-1$_{S}$	60		5				15	20
LL35-12$_{SS}$	35	3	9	6	7	10	15	15
LL35-11$_{SS}$	54	2	3		trace			40
L3-8$_{SS}$	65	5	3	5		2	10	10
L3-7$_{SS}$	65	trace	2	5	2	1	15	9
L3-6$_{SS}$	57	3	5	3		2	20	10
L3-5$_{SS}$	75	2	2		1	trace	10	9
LL22-6$_{SS}$	45	3	3	15		2	20	12
LL22-5$_{SS}$	15	2	8	60	5			10
LL32-1$_{SS}$	60	7	10	2	3		15	3
C32-5$_{S}$	80		3		2		5	10
LL39-11$_{S}$	58	1	1					40
LL41-4$_{SS}$	70	3	5	10	5			7
LL44-2$_{SS}$	60	2		10	5		3	20
LL44-1$_{Cgl}$	10	4	1	50	10		15	10
C13-16$_{SS}$	40	5	15	8	10		10	12
C13-15$_{S}$	60	10	10					20
LL18D-1$_{S}$	90	2	5					3
LL9-7$_{S}$	25							75
C33-5$_{S}$	70	5					10	15
C33-6$_{S}$	50	5	15				20	10
C33-8$_{S}$	15	3	2					80
W1-5$_{S}$	50	2	3				5	40
L2-4$_{SS}$	10		50					40

S : siltstone
SS : sandstone
Cgl: conglomerate

this heading are included a few diabase grains present in samples LL35-12 and LL22-6.

The matrix consists of a fine powder of clay or micaceous minerals, or both, plus quartz grains. In the sandstone and conglomerate the matrix is coarser. The cement is mostly calcite, although locally it is dolomite or iron oxide.

Source

The siltstone underlying the Lac Des Baies Member could have been supplied from surrounding areas of low relief. Most of the fragments in the Lac Des Baies conglomerate have a Silurian source; many quartz and quartz arenite grains are similar to material from the underlying Robitaille Formation; the quartz siltstone grains are identical to the underlying

Saint-Léon siltstones; and the limestone fragments contain fossils identical to some in the underlying Sayabec Formation. The facies map (Fig. 15) indicates a western source for the Saint-Léon coarse clastics. However, the Lac des Baies member contains a few particles (volcanics and diabase) that could best be supplied from the south or southeast, since these rocks do not exist to the north. Such material from the south would have had to by-pass at least 10,000 feet of silt.

Environment of Deposition

The fossils and the crossbedding in the Saint-Léon siltstones indicate that the environment of deposition was marine and shallow water, most probably above wave base.

The Lac Des Baies Member is anomalous but local, and may reflect instability in the Silurian trough at the time of its formation. Fossils in the sandstones and the matrix of the conglomerate, well-rounded pebbles and sand grains, orientation of pebbles parallel to bedding and cross-bedding indicate deposition in a marine trough of relatively shallow depth, into which sediments were shed periodically.

STRUCTURE

Evidences of both Taconic and Acadian orogenies are apparent in the area. The entire northern Appalachian region in Quebec appears to have been relatively stable during the Appalachian orogeny of Late Paleozoic time.

Taconic Orogeny

The age of the Taconic orogeny varies from place to place (Neale et al., 1961), but most of the deformation took place in Ordovician time. In the present area, the Middle Ordovician Trinité Group is deformed, and the Lower Llandovery Cabano conglomerate rests on the Trinité with angular discordance. Thus, the deformation probably occurred here in Upper Ordovician time.

Folds

Taconic orogeny caused the most intense folding of the general region, the Ordovician being sharply folded and faulted. In the present area, Ordovician strata dip steeply (70^{o} on the average) to the southeast. The folds are isoclinal and most axial planes are inclined to the southeast. The pressure which produced these folds most probably acted from the southeast.

The Ordovician sequence is much drag-folded. The axes of the drag-folds are either parallel to the general direction of the strata or cut them at an angle. They plunge generally in the two directions.

Cleavage

Cleavage, both flow and fracture, is well developed in the Ordovician rocks. Flow cleavage (slaty cleavage or schistosity) predominates, particularly in the mudstones and siltstones. It generally parallels bedding, except at the noses of folds, and dips steeply southeast.

Fracture cleavage is relatively rare in the area but is common in hard, relatively brittle sandstones, and in conglomerates.

Faults

Minor transverse faults are common in the Ordovician rocks of the area. Minor thrusts are common to the north on the Saint-Laurent shore. Major thrusts probably are present but have not been recognized.

Acadian Orogeny

The Acadian orogeny at the end of the Devonian period (Neale, et al., 1961) deformed the Siluro-Devonian sequence and possibly also rocks previously deformed by the Taconic orogeny. The Acadian deformations are less intense and shallower than those of the Taconic.

Folds

The Acadian orogeny folded the Siluro-Devonian sequence into broad, shallow structures, all trending northeast. The Silurian strata have an average dip of 35°. A few structures are relatively flat or shallow: the Saint-Guy and Porc-Epic synclines are very shallow (5° to 10°) near the Siluro-Ordovician contact. The Islet Lake is overturned to the northwest (see Structural Section AA').

The Devonian York Lake and York River Formations, which are exposed to the south of Prime Lake area (Wild Goose area), are folded into a broad, northeastward-plunging synclinorium having its axis partly in New Brunswick (Personal communication from J. Béland).

Along Rimouski river, the fine clastics of the Cabano Formation are folded into a series of anticlines and synclines. These folds are difficult to trace, owing to the scarcity of Cabano exposures, but two fold axes were seen on Orient brook, north of Echos lake.

The Lac des Echos syncline is doubly plunging, with southwest arching very near the lake. Farther south, the fold plunges southwest. North of the arching axis the syncline plunges northeast, as may be seen on Rimouski river. The Porc-Epic syncline also is doubly plunging, the reversal of plunge being evident a little north of the junction of Castor and Blanc brooks.

The western half of the area is crossed by two northeast-trending synclines. The Islet Lake syncline is overturned to the northwest. Strata on the south limb are vertical or dip steeply southeast, and,north of Ferré lake, the Val-Brillant Formation overlies the younger

Sayabec Formation. The plunge is northeast. The second, or Saint-Guy syncline, is broad and shallow (Structural Sections AA' and BB', in pocket), and is apparently arched in the southwestern corner of the area, where it becomes almost horizontal (Structural Section CC', in pocket). North of Islet lake, only the northern limb of the Saint-Guy syncline is present, the southern limb having been cut out by a fault. North of the fault, the Lac Des Baies Member has many large-scale drag-folds, some of which on Rimouski river have a width of nearly 300 feet. Drag-folds are rare in other Silurian units.

Cleavage

Flow cleavage is well developed in the fine clastic rocks of the Siluro-Devonian sequence. Generally it strikes N.40°-45°E. and dips vertically. It dips steeply southeast in parts of the Islet Lake syncline. Fracture cleavage is present in the coarser Silurian rock units.

Joints

The Lac Des Baies Member has a well-developed AC joint system which strikes northwest and dips steeply to the southwest.

Faults

The Siluro-Devonian sequence of the area has been broken by both gravity and thrust faults. They trend northeast, parallel to the major structural trends of the region.

In the southeastern part of the area, a fault trends roughly N.45°E. between the Lower Silurian Lac Raymond and the Lower Devonian Cap Bon Ami Formations. The fault is necessary to explain the plunge of Cap Bon Ami strata beneath Lower Silurian rocks on Rimouski river, south of Castor lake. If the fault extends southwest, it could explain the disappearance of Cap Bon Ami strata 3 miles south of Castor lake. The fault would also explain the abrupt ending of the anticline east of Echos lake. Field evidence for the presence of the fault consists of disturbed bedding along its presumed trace; on Rimouski river and Echos Lake road the Lac Raymond strata are vertical. South-southwest of Echos lake, the Lac Raymond strata become very steep to vertical close to the fault. This fault is interpreted as being high-angle gravity, with the southern block down thrown.

In the center of the eastern half of the area, a fault trending N.45°E. involves Ordovician and Lower Silurian rocks. The northern block of this fault was down thrown; the displacement seems to be relatively small, but appears to have offset the anticlinal axis that passes just south of Longue Vue mountain. The fault is probably indirectly responsible for the erosion of Cabano strata, which were most probably deposited south of the fault, near Rimouski river, south of Trinité-des-Monts village. At Grand Matinal brook the fault branches to produce a triangular graben. These two fault branches are indicated by thick breccias on Rimouski river, north and south of Trinité village; the breccias can be traced a few miles to the west. Bedding near the fault is steeply dipping to vertical in many places.

In the western part of the area, a fault separates the Islet Lake and Saint-Guy synclines. Exposed on Rimouski river, ½ mile north of the Touladi Lake road, this fault connects with a fault in the Squatec West area which Lespérance (1960) thought to be a normal fault. The fault in the present area could be a gravity (normal), a strike-slip, or a thrust fault. If it were a gravity fault, the Islet Lake and Saint-Guy synclines would be parts of the same structure and the Saint-Guy structure would be the upper part of this faulted syncline. If this were so, the same rock units would be found in both parts of the faulted structure, but they are not. The rocks at the crest of the Islet Lake syncline belong to the Cap Bon Ami Formation, whereas those at the crest of the Saint-Guy syncline belong to the Lac Des Baies Member of the Saint-Léon Formation. There is no Lac Des Baies conglomerates south of Saint-Guy, in the Islet Lake syncline. Nor does a strike slip fault solve the problem. Dip slip must have taken place to explain the geometrical setting of these two folds. Then, the above objection would hold. Strike slip may be involved but by itself does not explain the structure. If the two synclines are different, they must be separated by an anticline. However, the closeness of the two synclinal axes leaves little place to put the anticline. Thus, these two synclines must have been brought together by faulting.

The above reasoning leaves a thrust as the most likely type of fault. A thrust fault would explain other features observed in the field: 1) the development of drag-folds in the conglomeratic-sandy facies of the Saint-Léon Formation north of the fault; 2) the overturning of parts of the two synclines; 3) the fine clastic sequences close to their coarse equivalents. The two facies would have been brought together by faulting. This thrust fault is here named the Rimouski River thrust.

Near Moose lake, in the center of the western half of the area, a block ("slice") seems to have been caught in the Rimouski River thrust plane.

Two normal faults in the northern part of the area trend northeast and are down thrown on the south. They combine to the northeast, and eastward the combined fault connects with the Neigette fault of the Sainte-Blandine area (Béland, 1960). The combined fault, like the Neigette fault, is between Silurian and Ordovician rocks, and the Lower Ludlow section is missing at the contact.

ECONOMIC GEOLOGY

Metallic Minerals

A few grains of galena were found in Sayabec limestones, in Bédard township, Range VIII, Lot 10, or 5 miles northeast of Saint-Guy and ½ mile southeast of the road leading to Cossette lake.

Pyrite is very common in the bedding planes of the Ordovician mudstones, and in the Silurian Cabano Formation. It occurs as small (½-inch) nodules or as disseminated, small, cubic crystals.

Cement

The Sayabec Formation has a high $CaCo_3$ content and probably could form the base for a local cement-producing industry. The silt and clay fraction of the limestones (about 10%) could provide the silica and aluminum necessary. If a high silica source is needed to correct the lime content, the Val-Brillant quartz sandstones could serve the purpose.

Gravel

Most of the many fluvioglacial deposits in the area are concentrated on the Lac-des-Aigles - Trinité-des-Monts high, along the Ferré Lake - Saint-Isidore road. Near the southern boundary of the eastern half of the area, gravel deposits are up to 50 feet thick. Although their grain size is quite variable, coarse sand makes up the bulk of the deposits.

The sand of these deposits could serve for cement aggregate, and the small gravels could be used for roads.

Building Stone

The pink quartz arenite of the Robitaille Formation has been used in small volume for decorative purposes on houses, hotels, and churches. This stone has low permeability, as the sand grains are silica cemented. The quartz arenite is abundant along the new Saint-Guy - Rimouski road, north of the fire-tower. Here the beds are 2-3 feet thick and dip 10-15^{o} southeast. Joints are relatively rare.

Petroleum

In Gaspé and in the Matapédia-Témiscouata region, the Silurian sequence is regarded (Jones, 1962; Béland, 1962) as favorable for oil accumulation, the Sayabec limestones being the main potential reservoir, and the Saint-Léon siltstones and shales, the cap rock.

In the present area the thick Saint-Léon Formation could well serve as a cap rock for a Sayabec oil reservoir. However, the Sayabec limestone here is much thinner than to the east, its silt content is much higher, and its surface porosity appears to be low. Dolomitization is probably too slight to affect porosity, although secondary porosity formed either by dolomitization or solution could be present at depth. The terrigenous Silurian formations of the area (Robitaille, Val-Brillant, Lac Castor, Cabano) are well cemented, mostly by silica, and the matrix content is relatively high in some cases.

The Silurian-Devonian succession is folded into broad, shallow synclines and steep anticlines, all plunging to the northeast with no closure to the southwest. However, stratigraphic or structural traps may exist in some of the folds, particularly along the Rimouski River thrust fault.

BIBLIOGRAPHY

Alcock, F.J., - 1935 Geology of Chaleurs Bay region: Geol. Surv. Can. Mem. 183.

Aubert de la Rüe, E., - 1941 Matapédia Lake area; Que. Bur. Mines, Geol. Rept. no. 9.

Bailey, L.M., and McInnes, W., - 1889 Can. Geol. Surv. Ann. Rept. 1887-1888, Report M, 52 p.

Bailey, L.M. and McInnes, W., - 1893 Can. Geol. Surv. Ann. Rept. 1890-1891, Report M. 28 p.

Béland, J., - 1960 Preliminary report on Rimouski-Matapédia area: R.P. 430, Que. Dept. Min., 20 p.

Béland, J., - 1962 Geology, and petroleum possibilities of the Rimouski-Matapédia region: C.I.M.M. transactions, vol. LXV, pp. 103-106.

Berdan, J.M. - 1963 Eccentricosta, a new Upper Silurian brachiopod genus: Jour. Paleon., vol. 37, no. 1. pp. 254-256.

Boucot, A.J. - 1959 Early Devonian ambocoeliinae brachiopoda: Jour. Paleon., vol. 33, pp. 16-25.

Boucot, A.J. et al., - 1960 A Late Silurian fauna from the Sutherland River Formation, Devon island, Canadian Arctic archipelago: Geol. Surv. Can. Bull. 65.

Boucot, A.J. and Pankiwskyi, K.A., - 1962 Llandoverian to Gedinnian stratigraphy of Podolia and adjacent Moldavia, Symposium Silver/Devon - Grenze, 1960, Stuttgart E. Scheveizerbort'sche Verlagobuchhandharg.

Boucot, A.J., and Berry, W.N., - (in preparation), North American Silurian.

Burk, C.F. Jr., - 1964 Silurian stratigraphy of Gaspé peninsula, Quebec: Bull. Am. Ass. Petro. Geo. vol. 48, pp. 437-464.

Crickmay, G.W., - 1932 Evidence of Taconic orogeny in Matapédia valley: Am. Jour. Sci., 5th ser., no. 24, pp. 368-386.

Cumming, G.M., - 1959 Silurian and Lower Devonian formations in the eastern part of Gaspé peninsula, Quebec: Can. Geol. Surv., Mem. 304, 45 p.

Ells, R.W., - 1884 Report on explorations and surveys in the interior of Gaspé peninsula and P.E.I.: Geol. Surv. Can., Report of Progress, Part E, pp. 1-34.

Farkas, S.E., - 1960 Cross-lamination analysis in the Upper Cambrian Franconia Formation of Wisconsin: Jour. Sed. Pet., vol. 30, pp. 447-458.

Fisher, D.J., - 1938 Problem of two tilts and the stereographic projection: Am. Ass. Petro. Geol. Bull., vol. 22, pp. 1261-1271,

Folk, R.L. - 1951 Stages of textural maturity in sedimentary rocks: Jour. Sed., vol. 21, pp. 127-130.

Folk, R.L., - 1959 Practical petrographic classification of limestones: Am. Ass. Petro. Geol. Bull., vol. 43, pp. 1-38.

Folk, R.L., - 1962 Spectral subdivision of limestone types: Am. Ass. Petro. Geol., Memoir no. 1, pp. 62-84.

Friedman, M., - 1958 Determination of sieve-size distribution from thin-section data, for sedimentary petrological studies: Jour. Geol., vol. 66, pp. 394-416.

Friedman, M., - 1961 Distinction between dune, beach, and river sand from their textural characteristics: Jour. Sed. Pet., vol. 31, pp. 514-529.

Friedman, M., - 1962 Comparison of moment measures for sieving and thin-section data in sedimentary petrological studies: Jour. Sed. Pet., vol. 32, pp. 15-25.

Gorman, W.A., - 1957 Preliminary report on Southern Témiscouata area: unp. MS., Que. Dept. Nat. Res., 11p.

Greeman, N.N., - 1951 On the bias of grain-size measurements made in thin-section: Jour. Geol., vol. 59, pp. 268-274, 447-462.

Greiner, H.R., - 1958 Cabano area, west half: unp. MS., Que. Dept. Nat. Resources, 30 p.

Hubert, C., - 1963 Silurian Stromatoporidea and Favositidae of the Matapédia-Témiscouata area, Quebec: unp. M.Sc. thesis, McGill University.

Illing, L.V., - 1954 Bahama calcareous sands: Am. Ass. Petro. Geol. Bull., vol. 38, no. 1, pp. 1-95.

Jones, I.W., - 1935 Upper York River map-area, Gaspé peninsula: Que. Bur. Min., Ann. Rep., Pt. D.

Jones, I.W., - 1962 Sedimentary basins and petroleum possibilities of Quebec: Proceedings of Geol. Ass. of Can., pp. 43-58.

Kay, G.M., - 1937 Stratigraphy of the Trenton Group: Bull. Geol. Soc. Am., vol. 52, pp. 1-23, 97-116.

Krumbein, W.C., and Sloss, L.L. - 1953 Stratigraphy and sedimentation: W.H. Freeman and Co., 497 p.

Krumbein, W.C., - 1941 Measurement and geological significance of shape and roundness of sedimentary particles: Jour. Sed. Pet., vol. 11, pp. 64-72.

Krumbein, W.C., and Pettijohn, F.J., - 1938 Manual of sedimentary petrography: Appleton-Century-Crofts Inc. N.Y., 594 p.

Lajoie, J., - 1961 The origin of the Val Brillant and Sayabec formations: unp. M.Sc. thesis, McGill University, 112 p.

Lajoie, J., - 1961 Preliminary report on Lac Prime West area, and part of Wild Goose area: Que. Dept. Min. P.R. 448.

Lajoie, J., - 1962 Preliminary report on Chenier-Bédard (Lac Des Baies) area: Que. Dept. Nat. Res., P.R. 493.

Lajoie, J., - 1963 Stratigraphy and sedimentation of the Siluro-Devonian rocks in the central parts of the Témiscouata-Matapédia area: unp. Ph.D. thesis, McGill University.

Lajoie, J., Lespérance, P., and Béland, J., - 1968 Silurian stratigraphy and paleogeography of Matapédia-Témiscouata region, Quebec; Am. Ass. Petro. Geol. Bull., vol. 52, pp. 615-640.

Laverdière, J.W., and Morin, L.G., - 1941 Geologie des Appalaches canadiennes entre Rivière-du-Loup et Matane: Nat. Can., vol. 68, pp. 216-260.

Leighton, M.W., and Pendexter, C., - 1962 Carbonate rock types: Am. Ass. Petrol. Geol. Mem. no. 1, pp. 33-61.

Lespérance, P.J., - 1959 Preliminary report on Squateck West area: Que. Dept. Min., P.R. 385, 10 p.

Lespérance, P.J., - 1960 Preliminary report on Squateck East area: unp. MS., Que. Dept. Nat. Res., 10 p.

Lespérance, P.J., - 1960 The Silurian and Devonian rocks of the Témiscouata region, Quebec: Ph.D. thesis, McGill University, 257 p.

Lespérance, P.J., and Greiner, H.R., - 1969 Squatec-Cabano area, Rimouski, Rivière-du-Loup and Témiscouata counties; Que. Dept. Nat. Resources, G.R. 128.

Logan, W.E., - 1863 Geology of Canada, Can. Geol. Surv., 983 p.

McCrossan, R.G., - 1958 Sedimentary boudinage structures in the Upper Devonian Ireton Formation of Alberta: Jour. Sed. Pet., vol. 28, pp. 316-320.

McGerrigle, H.W., - 1934 Western Témiscouata with parts of Kamouraska and Rivière-du-Loup counties: Rep. Min. Mines, Quebec, 1933, pt. D., pp. 93-128.

McGerrigle, H.W., - 1950 The geology of Eastern Gaspé: Geol. Rep. 35, Que. Dept. Min.

McGerrigle, H.W., - 1953 Geological map of Gaspé peninsula: Que. Dept. Min., Map no. 1000.

Milner, H.B., - 1962 Sedimentary petrography:George Allen and Unwin Ltd., London, 2nd vol., 715 p.

Neale, E.R.W., et al.,- 1961 A Preliminary Tectonic map of the Canadian Appalachian region, based on age of folding: Can. Int. Min. Met. Bull., vol. 54, pp. 687-694.

Oliver, W.A. Jr., - 1962 Silurian Rugose corals from Lake Témiscouata area, Quebec: U.S.G.S., Prof. Paper 430.

Packham, G.H., - 1955 Volume-, weight-, and number-frequency analyses of sediments from thin-section data: Jour. Geol., vol. 63, pp. 50-58.

Pettijohn, F.J., - 1957 Sedimentary rocks: Harper and Brothers, N.Y., 718 p.

Pettijohn, F.J., - 1962 Paleocurrents and paleogeography: Am. Ass. Petro. Geol. Bull., vol. 46, pp. 1468, 1493.

Potter, P.E., and Olson, J.S., - 1954 Variance components of cross-bedding direction in some basal Penn. sandstones of the Eastern interior basin: Jour. Geol., vol. 62, no. 1, pp. 50-73.

Richard, L.V., - 1962 Late Cayugan and Helderbergian stratigraphy in New York: N.Y. State Mus. Sc. Serv. Bull. 386, 157 p.

Spencer, J.E., - 1963 The interpretation of grain size distribution curves of clastic sediments: Jour. Sed. Pet., vol. 33, pp. 180-190.

Stearn, C.W., - 1959 Causapscal area (east half): Que. Dept. Min., Preliminary report 382.

Strakhov, N.M., - 1957 Méthodes d'études des Roches Sédimentaires, 2 tomes, Moscou.

Tanner, W.F., - 1955 Paleogeographic reconstruction from cross-bedding studies: Am. Ass. Petro. Geol. Bull., vol. 39, pp. 2471-2483.

Tanner, W.F., - 1959 The importance of modes in cross-bedding data: Jour. Sed. Petro., vol. 29, pp. 221-226.

Williams, H., Turner, F.J., and Gilbert, C.M., - 1954 Petrography: W.A. Freeman and Co., San Francisco, 406 p.