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GEOLOGICAL RECONNAISSANCE REPORT, MINERAL EXPLORATION LICENSE NO 171, RIMOUSKI-MONT JOLI AREA

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GEOLOGICAL RECONNAISSANCE REPORT

MINERAL EXPLORATION LICENSE NO. 171

RIMOUSKI-MONT JOLI AREA, QUEBEC

PUBLIC

Ministère des Richesses Naturelles, Québec
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TABLE OF CONTENTS

	Page No.
INTRODUCTION	1
Description of Project	1
Previous Work	3
Physiography	3
Acknowledgments	4
REGIONAL GEOLOGICAL SETTING	4
STRATIGRAPHY	5
Table of Formations	6
Description of Formations	7
Cambrian	7
Ordovician	7
Quebec Group	7
The Matapedia Group	8
Silurian	9
Awantjish Formation	9
Val Brilliant Formation	10
Sayabec Formation	11
St. Leon Formation	15
Devonian	17
Cape Bon Ami-Grande Greve Formation	17
Pleistocene and Recent	18
STRUCTURE	18
Regional Structure	18
Local Structure	20
Neigette Fault	20
Neigette Syncline	21
St. Narcisse Fault	21
St. Marcellin Anticline	22
Mistigougeche Syncline	22
Minor Structures	22
OIL AND GAS POSSIBILITIES	23
Oil and Gas Indications	23
Prospective Formations	23
Ordovician and Older Beds	23
Val Brilliant Formation	23

LIST OF PLATES

Plate I-A View of terrain underlain by Ordovician rocks, northeast part of Quebec Mineral Exploration License No. 171, east of St. Gabriel.

-B The Neigette fault-line scarp, near St. Donat. Silurian sandstones form hills and Ordovician beds occur in the valley.

Plate II-A Detail of Ordovician phyllitic shales, probably of the Quebec group, near St. Donat.

-B View of outcrop of the Silurian Val Brilliant formation, near St. Gabriel.

Plate III-A Typical outcrops of Silurian St. Leon formation in farm lands near St. Gabriel.

-B Detail of St. Leon formation showing well developed vertical cleavage.

Plate IV-A View of blocky weathering limestone conglomerate in St. Leon formation at Neigette falls.

-B Detail of limestone conglomerate in Plate IV-A showing large boulders cemented in detrital groundmass.

Plate V-A View of Little Neigette River in area of Devonian outcrops, near axis of Neigette syncline.

-B Typical outcrop of the Lower Member of the Cape Bon Ami-Grande Greve formation, northeast flank of Neigette syncline.

Table of Contents - Continued

	Page No.
Sayabec Formation	24
St. Leon Formation	24
Cape Bon Ami-Grande Greve Formation	24
Pleistocene and Recent	24
Prospective Structures	24
Basement Highs	25
Neigette Fault	25
St. Narcisse Fault	25
St. Marcellin Anticline	25
Minor Faults and Anticlines	25
CONCLUSIONS AND RECOMMENDATIONS	26
BIBLIOGRAPHY	28

LIST OF ILLUSTRATIONS

Figure	I	- Map of Southeastern Quebec showing Distribution of Ordovician, Silurian and Devonian Units and location of study area in Southeastern Quebec, Quebec.	Frontispiece
Figure	II	- Generalized Geological Structure Cross-Sections.	In Pocket
Figure	III	- Composite Stratigraphic Section, Rimouski-Mont Joli Area, Quebec.	After p. 29
Figure	IV	- Photogeological Mosaic, Mineral Exploration License No. 171, Rimouski-Mont Joli Area, Quebec.	In Pocket

GEOLOGICAL RECONNAISSANCE REPORT

MINERAL EXPLORATION LICENSE NO. 171

RIMOUSKI-MONT JOLI AREA, QUEBEC

INTRODUCTION

Description of Project

This report presents the results of a combined geological and photogeological study of Mineral Exploration License No. 171 area, near Rimouski and Mont Joli, Quebec, conducted by J. C. Sproule and Associates Ltd. during the summer of 1961. The work was done at the request of Dr. G. C. McCartney, President of Crackingstone Mines (Quebec) Ltd., hereinafter referred to as the "Company." The objective of the field study has been to evaluate the petroleum and natural gas prospects of the area by detailed mapping of the structure and stratigraphy found within and adjacent to the subject Permit.

Prior to the field work, studies of the air photographs were undertaken and preliminary photomosaics prepared. During the field work the photographs were studied further, and following completion of the field work the photographs were again studied, resulting in the compilation of the final photomosaic presented herein. The photogeological work proved to be one of the most important aspects of the study, primarily because the area is one of sparse outcrops and complicated structure with a relatively thin mantle of drift and alluvium, and secondarily because it is a type of investigation which can be conducted not only in the office but also in the field, as a supplement to examination of rocks and structure at the outcrop.

The region encompassed by the study forms an area of about 275 square miles lying mainly within the boundaries of Fleurian, Neigette, Masse, Ouimet, Flynn and Macpes townships, south of the towns of Rimouski and Mont Joli, Gaspe Peninsula area, Quebec. The area is located about 220 miles northeast of Quebec City and about 460 miles northeast of Montreal.

Access to the area is relatively simple by automobile. The road network is close and all parts of the area can be reached fairly readily from the roads. The roads are mainly of good quality, with some hard surfaced. In

addition to the public roads there are numerous private roads built into logging camps, as well as many narrow trails that lead to small chalets and hunting lodges.

The field work was conducted by a two-man geological party under the supervision of G. V. Lloyd, assisted in the field by Mr. A. Latulippe of Sillery, Quebec. The preliminary photogeological work was done by Mr. Lloyd and the final photogeological compilation was prepared by Mr. J. Bakhoven of J. C. Sproule and Associates Ltd. In order to make the stratigraphic studies as complete as possible, it was found necessary to incorporate some of the work previously done by the other geologists in the general Gaspe area. This general area lies mainly to the east of the Permit and provides an extension of the control necessary to adequately evaluate the subsurface section; consequently, the discussion of the stratigraphy as presented herein is based on not only the field data but also on information derived from the literature available to J. C. Sproule and Associates Ltd., as well as on our previous experience in this area.

The field work involved traverses by auto along all of the roads in the area and traverses by foot across the intervening areas and along the major creeks and ridges, as well as a grid coverage across most of the Mineral Exploration License area. In addition, trips were made beyond the boundaries of the map-area to find information concerning the lateral extent of some of the units. An attempt was made to examine all significant outcrops within the Permit. Where practical, these sections were described and mapped, so that the geological sections and structure could be compiled with as much confidence as possible. The outcrops, however, with few exceptions, are of small extent and expose only relatively thin parts of the total units present. Fossil collections were made where possible and although searches were conducted for direct evidence of oil, such as oil-stained outcrops or interstitial bitumen, none was found.

The preliminary photogeological work began in late June with an examination of the aerial photographs in conjunction with preparation of a preliminary photogeological mosaic. Several days of discussions with geologists at the Quebec Bureau of Natural Resources in Quebec City were followed by the field work which began at Mont Joli on June 28th. For the first two weeks of the field mapping the party was based at Mont Joli. They then moved to Rimouski for the following two weeks.

Rimouski and Mont Joli are on the main line of the Canadian National Railway from Quebec City and both have airports which are connected with Quebec City by daily scheduled flights. In addition, Rimouski has harbour facilities.

This report describes in detail the geological features of Mineral Exploration License No. 171 area, based on information gathered during the course of this field and photogeological study. It is illustrated by three generalized geological structure cross-sections, a composite stratigraphic section, a map showing the distribution of Ordovician, Silurian and Devonian units and major structures in the Gaspe area, Quebec, and colour photographs which show broadly some aspects of culture, geology and terrain. In addition, an index map of Eastern Canada is presented, as well as a photogeological mosaic.

Previous Work

In contrast to some of the other parts of the sedimentary areas of Quebec, there has been little previous detailed geological work in this area, with the exception of a recent study by J. Beland (1960) (1).

Several of the map units present in the study area were originally identified nearby in the Matapedia Valley by Crickmay (1932). Correlations within the general area have been attempted by Alcock (1935), and Laverdiere and Morin (1941). Earlier studies were conducted by Logan (1863), Ells (1883), and Bailey and McGinnis (1888).

There have been no previous deep tests drilled for oil or gas in the general area of the Exploration License. The nearest deep well was drilled in 1958 by Associated Developments Limited in an area some 40 miles to the east at Causapscal. This well, Associated Developments Causapscal No. 1, drilled through more than 4,700 feet of Silurian sediments but was abandoned before encountering the basal Silurian carbonate beds.

The area to the southeast of the Mineral Exploration License is currently being mapped in detail by geologists of the Quebec Bureau of Natural Resources.

Physiography

The Company Exploration License area lies south of the St. Lawrence River in the western part of the Gaspe Peninsula, about 220 miles northeast of Quebec City. The area is well drained by the Rimouski, Neigette and Metis rivers and their tributaries. The most prominent topographic feature is a range of hills lying along the north boundary of the Permit. These hills have elevations generally from 700 to 1,200 feet above sea level and represent the surface expression of the Neigette fault. The area to the north of this is about 500 feet above sea level and the region to the south may be described generally as a plateau with elevations somewhat higher than 500 but less than 750 feet. In the southwest part of the study area lakes, hills and forests are more common than in the central and northeastern part, where the farm lands are fairly common on land that is gently rolling. The forest cover is dense where present and mainly composed of small trees. Wood cutting operations are underway in most parts of the forest area.

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(1) Names and dates in brackets refer to bibliography at end of report.

Acknowledgments

Acknowledgment should be made first to geologists of the Quebec Bureau of Natural Resources at Quebec City, not only for the use of their office facilities when required but also for discussions and advice prior to the field season concerning significant features of the rocks in the map-area, as well as features relating to the regional characteristics of the structure and sediments present there. Our appreciation is particularly extended to Dr. I. W. Jones and Dr. J. Beland at Quebec and also to Mr. J. Lajoie, who accompanied the author in the field during a field examination of some of the rocks.

In addition to the photogeological work by J. Bakhoven, other members of this firm also provided valuable suggestions and information concerning regional correlation of the strata throughout the eastern Quebec area.

REGIONAL GEOLOGICAL SETTING

The lands held under Mineral Exploration License No. 171 by Crackingstone Mines (Quebec) Ltd. in the Rimouski-Mont Joli area of Quebec may be considered to be structurally related to the Appalachian Mountain system and stratigraphically part of the Gaspe Basin. The structural trends are northeast, approximately parallel to the old Appalachian chain. To the northwest of the Permit lies the south shore of the St. Lawrence River, approximately parallel to and in part controlled by, Logan's fault. The north shore consists of Precambrian rocks. From the south shore to the Permit area is a belt of intensely folded and mildly metamorphosed Ordovician and, possibly, Cambrian sediments. Southeastward from this belt, the margin of which approximately parallels the north Permit boundary, lies a downwarped area of folded and faulted Silurian and Devonian marine sediments which comprise the main part of the Permit area. The northern margin of the Silurian and Devonian strata occurs along a northwest-trending fault zone and the northeast and eastern limit is represented at the surface by a profound angular unconformity. Numberous outcrops are present with within the Permit area.

Deposition of sediments in this general area was initiated at least as early as Ordovician time and has continued, with numerous interruptions, until the present. Upwarps of the sediments during certain geological periods have resulted in the destruction of the sedimentary record in many places, and these events are left as unconformities in the geological section. The Ordovician and earlier rocks, for example, were deformed during the Taconic orogenic episode. Following deposition of Silurian carbonates and siltstones and Devonian carbonates, the area was again folded and faulted by stresses arising during the Acadian orogenic episode. Although the record of subsequent geological periods is missing in the map-area due to post-Devonian erosion, it is probable that further structural disturbances such as the Appalachian episode are also reflected in the present structure and strata.

Outcrops within the Permit area are mainly of Silurian and Devonian age, although some Ordovician beds are present. The Ordovician rocks occur in fairly common outcrops in the area to the north of the Neigette fault, which is a northeast-trending high-angle fault of the normal type which has brought Silurian beds on the south down relative to the Ordovician on the north side. The area to the south of this fault, which comprises the main part of the map-area, is composed of complexly folded sediments of Silurian and Devonian age. The sediments occur in scattered outcrops throughout; however, the number of outcrops relative to the total thickness present is exceedingly small indeed. The Val Brilliant and Sayabec formations, which form the basal part of the Silurian sequence, are found in numerous places. The St. Leon formation outcrops throughout a very large part of the Permit block. The Devonian beds are found in the axis of the Neigette syncline in the central part of the map-area. Overlying the Paleozoic rocks are Pleistocene and Recent gravels and drift.

The sediments in the study area form part of a downwarp area that trends northeast-southwest. This downwarp has been normally faulted and folded, resulting in a complex pattern of northeast-trending faults and folds. The two largest features are the Neigette syncline and the St. Marcellin anticline. The anticline exposes Ordovician beds in its core and plunges gently northeastwards to form a saddle in the area of the Permit. Other short, discontinuous faulted anticlines are present, as well as synclines.

STRATIGRAPHY

Outcrops in the map-area consist of Ordovician, Silurian and Devonian sediments. A thin layer of Pleistocene glacial and Recent gravels is also present. The thickest section is believed to be present in the Neigette syncline where some 15,000 feet of Devonian and Silurian beds are believed present above the post-Ordovician unconformity.

The following table outlines the stratigraphic section believed present in the map-area.

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Table of Formations

Era, Period, Epoch	Group or Formation	Lithology	Thickness Feet
CENOZOIC			
Recent and Pleistocene	Unnamed	Recent gravels and silt, moraines.	0-50±
		UNCONFORMITY	
PALEOZOIC			
Lower Devonian	Cape Bon Ami-Grande Greve	Dark grey calcareous siltstone, argillaceous limestone, cherty limestone, calcareous shale.	0-5,000
		DISCONFORMITY	
Silurian	St. Leon	Green and grey calcareous sandstone, siltstone, dolomite, minor limestone and calcarenite, limestone conglomerate, pebble conglomerate.	0-7,500
	Sayabec	Dark grey to black, fossiliferous limestones.	0-2,000±
	Val Brilliant	White quartzitic sandstone.	50-300±
	Awantjish	Green-grey shale.	0-2,000
		UNCONFORMITY	
Ordovician	Matapedia	Limestone, slate and sandstone.	
	Quebec	Phyllitic slate, shales, quartzites.	
		DISCONFORMITY(?)	
Cambrian(1)	Caldwell(?)	Possibly metamorphosed slates, quartzites	

(1) The presence of these and underlying rocks has not been established in the study area.

Description of Formations

Cambrian

Evidence pointing to the presence of rocks older than Ordovician age near the Permit area was not noted during the course of the field work. In this regard, however, Alcock (1947) records that Cambrian rocks occur in southeastern Quebec, Gaspe Peninsula, southern New Brunswick, and in Cape Breton Island. They are metamorphosed, more or less, and in southeastern Quebec are highly schistose. Near Vermont Lower Cambrian slate, quartzite, dolomite, greywacke, and sericite schist occur. In the Thetford-Beaucenville region of southern Quebec possibly Cambrian beds of the Caldwell group consist of quartzites, slates and basic pillow lavas. At Gaspe, grey limestones of late Cambrian age are known. In view of the foregoing evidence it is more than likely that metamorphosed Cambrian beds underlie the Quebec group in the study area.

Ordovician

Quebec Group

The Silurian beds lie with profound angular unconformity on a "basement" complex of more or less slightly metamorphosed and highly disturbed Ordovician and possibly older beds.

Previous workers in the general area have recognized two groups, the Quebec and Matapedia. The Quebec group, of Lower to Middle Ordovician age, consists mainly of phyllitic slate, quartzite, sandstone and basic volcanics. The Matapedia group consists of limestone, slate, and sandstones. In addition to these, post-Quebec intrusive serpentines and diorite are known.

The total thickness and detailed structural features of the Ordovician beds could not be determined near the map-area, owing to extensive structural deformation, lack of adequate outcrops and the apparent absence of reliable marker beds in the sequence. In general, however, they are steeply inclined and the maximum angular discordance noted between Ordovician and Silurian beds was 90 degrees.

Ordovician beds are found as outcrops north of the Neigette fault zone, which marks the approximate northwest Permit boundary, and along the highway that leads between the villages of St. Gabriel and St. Donat. Other exposures are also present to the east of the Permit, particularly near the Riviere Metis in Fleurian Township.

The presence of phyllitic slates, quartzites, and conglomerates in the Ordovician exposures along the road between St. Donat and St. Gabrial suggests that these beds are probably correlative with the Quebec group. The quartzites and conglomerates are particularly distinctive.

The quartzites are very fine-grained, close to siltstones in size range, olive brown on the fresh surface and pale brown-grey weathering, well sorted, carry fairly common fine muscovite flakes, and are poorly bedded. At

several outcrops near St. Donat they grade in composition through fine-grained layers to quartzitic conglomerate beds. These conglomerates are greenish grey and light grey weathering. The components vary from fine to grit size, are poorly sorted, mainly subrounded, frosted, very well cemented, quartz grains in association with rare mica grains and rather common black shale grains that collectively form a thick-bedded unit. The above outcrops are steep-dipping and have slickensided surfaces present, in addition to a fairly well developed "slaty" cleavage in a vertical plane.

The quartzites and conglomerates are resistant to erosion in contrast to the shale exposures that flank them and are, as a consequence, ridge forming. These ridges are easily recognized on the aerial photographs and photomosaics.

The conglomerate and quartzite beds may be correlative with the Kamouraska Quartzite of the Quebec group.

If this is the case, then the Silurian beds here rest on Lower or Middle Ordovician beds. It has been suggested by Burke (1959, p. 11) that an unconformity also exists between strata of Late Ordovician and Silurian age.

The Matapedia Group

The Matapedia group is found along the Matapedia River near its confluence with the Restigouche River. The beds reportedly consist here of slates and limestones.

Little has been written concerning the post-Quebec intrusives which outcrop in the Gaspe area. One of these, a serpentine body, occurs about eight miles southeast of the map-area, near the village of La Redemption, in Awantjish Township. The body is reported by Beland (1960, p. 11) to be about two miles long and 1,500 feet wide. It is reported by Beland (Ibid., p. 11) that contact metamorphism is restricted to rocks of the Quebec group, indicating a pre-Silurian age for the intrusion. Burke (1960, p. 27) also suggests a similar age. In this regard, the writer examined numerous outcrops of the Silurian Val Brilliant quartzites along the north flank of the intrusive body and could find no field evidence that indicates metamosphism or wall-rock alteration in these beds. On the other hand, the lack of serpentine grains or pebbles or talc fragments in the overlying beds here may indicate that the body was not exposed to erosion during deposition of these beds; consequently, the age of this intrusive still remains in doubt.

Concerning the serpentine body, it is well known that a belt of ultrabasic plutons, now more or less serpentinized, extends from Quebec to Vermont. Similar linear belts of ultrabasics are known in Newfoundland and in New England. The linear arrangement of these intrusives suggests to many authors that they were intruded under the influence of tectonic control and the conclusion has been reached that their presence indicates the zone of maximum Taconic orogeny.

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A. View of terrain underlain by Ordovician rocks, northeast part of Quebec Mineral Exploration License No. 171, east of St. Gabriel.



B. The Neigette fault-line scarp, near St. Donat. Silurian sandstones form hills and Ordovician beds occur in the valley.

Photos by G. V. Lloyd



A. Detail of Ordovician phyllitic shales, probably of the Quebec group, near St. Donat.



B. View of outcrop of the Silurian Val Brilliant formation, near St. Gabriel.

Photos by G. V. Lloyd



A. Typical outcrops of Silurian St. Leon formation in farm lands near St. Gabriel.



B. Detail of St. Leon formation showing well developed vertical cleavage.

Photos by G. V. Lloyd



A. View of blocky weathering limestone conglomerate in St. Leon formation at Neigette falls.



B. Detail of limestone conglomerate in Plate IV-A showing large boulders cemented in detrital groundmass.

Photos by G. V. Lloyd



A. View of Little Neigette River in area of Devonian outcrops, near axis of Neigette syncline.



B. Typical outcrop of the Lower Member of the Cape Bon Ami-Grande Greve formation, northeast flank of Neigette syncline.

Photos by G. V. Lloyd

COMPOSITE STRATIGRAPHIC SECTION
RIMOUSKI - MONT JOLI AREA, QUEBEC

ERA	SYSTEM	SERIES	GROUP, FORMATION OR MEMBER			LITHOLOGY	APPROX. THICKNESS FT.	MAIN OROGENIC EPISODE
CENO-ZOIC	QUATERNARY	RECENT AND PLEISTOCENE	UNNAMED			Recent gravel and silts, glacial and glacio-fluvial deposits	0 – 100	
PALEO-ZOIC	DEVONIAN	LOWER	CAPE BON-AMI, GRANDE GREVE		"B" MEMBER	Grey and black, light grey weathering, fine crystalline limestones and interbedded grey and black chert	1,500+	ACADIAN
					"A" MEMBER	Very dark grey to black, argillaceous, locally silty, thin-bedded limestone	300+	
	SILURIAN	UPPER AND MIDDLE	ST. LEON	UPPER UNIT		Brownish grey sandstones, pebble conglomerates, limestone boulder conglomerates	1,500+	CALEDONIAN(?)
				LOWER UNIT	DOLOMITE FACIES	Dark grey and greenish grey dolomites, thick bedded and massive weathering.	1,500+	
					SILTY FACIES	Dark grey to pale olive grey, dense, thinly laminated, calcareous siltstones		
			SAYABEC			Dark grey to black, fossiliferous, argillaceous limestones, stromatopora zones, and dark grey, micro crystalline argillaceous limestones	750 - 2,000±	
			VAL BRILLIANT			White, resistant weathering quartzites, local maroon staining, very fine grained, gently cross-bedded but medium to thick bedded	50 - 300+	
			AWANTJISH			Green grey shale, interbedded pale brownish grey and reddish brown siltstones and olive to greenish brown shale, and probably light grey, shaly, thin-bedded limestones	150 - 1,000±	
	ORDOVICIAN	UPPER	MATAPEDIA			Post Quebec serpentine, diorite	Unknown	TACONIC
						Limestone, calcareous slate, calcareous sandstone, green shale and siltstone		
		MIDDLE AND LOWER	QUEBEC			Phyllitic slate, shales, quartzites, pebble conglomerates	Unknown	
	CAMBRIAN (1)		CALDWELL ?			Metamorphosed slates and quartzites	Unknown.	

(1) These and older units not seen in map area.

Silurian

Awantjish Formation

The name "Awantjish formation" was recently proposed by Beland (1960, p. 3) for a succession of green and grey, slightly calcareous and very fossiliferous shale and siltstones found lying below the Val Brilliant quartzite and above Ordovician beds below in the Matapedia Lake area. Beland notes that the succession thins towards the Permit area from a maximum thickness of 1,000 feet at the lake to a minimum of about 150 feet near the northwest border of the Permit at the village of La Redemption.

These beds were originally described by Burke (1959, p. 23) from localities on Madeleine River. He describes the sequence as brown and grey, calcareous claystone, soft to hard, well bedded and laminated, beds of thin (less than two inches) alternating light weathering, sublithographic limestone and mudstone, thin beds of crinoidal, grey limestone with common galena crystals, and minor siltstone near the top locally. Neither the base nor top of this section was observed. Graptolites are reported to occur in these beds.

Beds lying between the Ordovician and the Silurian Val Brilliant quartzites were not seen in the northern part of the Permit. In several places near the highway that leads between St. Gabriel and St. Donat the Val Brilliant quartzite overlies Ordovician shales with profound angular unconformity and, although the actual contact was not observed, a graphic reconstruction reveals that there is only a thin covered interval, and it is concluded that, in this region at least, beds correlative with the Awantjish are either very thin or not present.

On the other hand, strata lying below the Val Brilliant quartzites and above recognizable Ordovician slaty shales are present but poorly exposed in the southwest part of the Permit area along the axial trend of the northeast-trending St. Marcellin anticline which passes near Petit Lac Ferre and Riviere Ferre. Immediately below the Val Brilliant occurs a sequence of interbedded siltstone and shaly siltstone (50 percent each) in beds up to 15 inches thick.

The siltstone is pale brownish grey and pale reddish brown weathering, slightly shaly, firm, and carries common, very fine pyritohedral crystals of a dark red, hard, vitreous mineral.

The shaly siltstone is olive brown-grey and weathers olive brown to greenish brown, and grades through reddish brown to maroon in thin zones. It is easy frangible, flaky and poorly thin-bedded.

Near the southeast shore of Petit Lac Ferre a sequence of limestone beds is fairly well exposed. The limestones are medium to light grey and light brownish grey weathering, fine-grained, soft, thin well bedded (one-quarter to one inch) and medium well bedded (two inches), with good bedding fissility and shaly interbeds. Some white secondary calcite veining is present. The beds dip 75 degrees southwestward and strike 025 degrees azimuth. They are apparently faulted nearby.

In close geographic position to these limestones are fairly extensive outcrops of shale that are mostly either vertical or steeply dipping. The shale is characteristically light olive grey and pale brown weathering, easy frangible, locally calcareous, fibrous to splintery and has a distinctive waxy texture.

On the basis of its stratigraphic position and similar lithology, this sequence of siltstones, shaly siltstones, shales and thin-bedded limestones is probably correlative with the Awantjish formation, which is of Early Silurian age.

The following fossils are reported from the Awantjish formation (Lajoie, 1961): Atrypa reticularis, Chilidiopsis sp., "Coelospira" hemispheria, Cyrtia sp., dalmanellid unident, Dolerorthis sp., Isorthis ?sp., pentemeroid unident, Plectodonta transversalis, Resserella cf. elegantula, stropheodontid unident, Favositids, Halysites sp., Drummocrina sp., and Trilobites.

Neither the upper or lower contact of the sequence was seen in the field and, although the interval of cover present between them and the Val Brilliant is very small at one outcrop, extreme structural disturbance in the beds there does not permit us to state that the difference in dip between the beds is due to an unconformity. For the same reason it is not possible to accurately determine the thickness of these beds in the Permit.

Val Brilliant Formation

The Val Brilliant formation consists of an easily recognizable, distinctive, resistant weathering, white quartzitic sandstone sequence that forms a reliable marker horizon throughout the Permit. Outcrops occur in a few places along the Neigette fault scarp between St. Blandine and St. Donat, in addition to excellent outcrops near St. Gabriel, as well as exposures on the flanks of the St. Marcellin anticline in the southwest corner of the Permit area.

The term "Val Brilliant" was originally applied by Crickmay (1932) for quartzite beds in the Matapedia valley area.

The Val Brilliant lies with profound angular unconformity on Ordovician beds near St. Gabriel but elsewhere is underlain by the Silurian Awantjish formation. It is overlain by the Sayabec limestone.

No complete sections were observed in the field and it is consequently difficult to determine its thickness; however, it is readily apparent that the formation thins in a southwesterly direction from about 500 feet in the northeast part of the Permit near Riviere Metis to about 200 feet or less in the southwest part of the Permit near Riviere Ferre.

The sandstone is typically white and white or pale brown weathering with maroon partings. It is very fine-grained, well sorted, well cemented by secondary quartz, thinly and gently crossbedded and medium (six inches) to thick (36 inches) poorly and irregularly bedded. Scattered, small rusty weathering spots are a feature in places.

Under the binocular microscope the quartzite is seen to be composed of very fine grained, very well cemented, subangular quartz grains with scattered rare medium grains of subrounded, frosted grey quartz. Also present are scattered very fine black grains that weather maroon. The quartzite is very clean and, due to the interstitial secondary silica cement, neither apparent porosity nor permeability was detected in the samples examined.

It will be noted on the maps and sections accompanying this report that the Sayabec and Val Brilliant formations are shown to extend intermittently along the Neigette fault scarp in the vicinity of St. Blandine in the north part of the Permit area. This extension is in contrast to the preliminary map prepared by Beland (1960), which shows only the St. Leon formation here. The presence of these two formations is based on the outcrops of typical Sayabec limestones along the fault line scarp in numerous places extending as far southwesterly as the Rimouski River, in addition to a good outcrop of white quzrtzitic sandstone at the base of the mountain near Lac de la Montagne in the northwest corner of Neigette Township. On the basis of lithologic similarities, and apparent stratigraphic position below Sayabec limestones, it seems probable that this sandstone represents the Val Brilliant formation.

The Val Brilliant has been the subject of a recent study by J. Lajoie (1961). On the basis of a microscopic examination he concluded that this formation is composed of 86 to 97 percent quartz, averaging 94 percent, with five percent of this as cement. Also present are minor amounts of quartzite fragments, detrital and small mounds of chert, plagioclase, microcline, dolomite, zircon, iron oxides, tourmaline, apatite, rutile, and pyrobitumen in some samples.

Fossils collected by Lajoie (1961) include the following forms: Atrypa reticularis, "Coelospira" cf. hemispherica, dalmanellid unident, Dolerorthis sp., Dolerorthis cf. flabellites, Eospirifer sp., Leptaena "rhomboidalis," Oriostoma sp., Plectodonta transversalis, rhynchonellid unident, Stricklandia sp., Stricklandia gaspensis, Euomaphus sp., Eumphalopterus sp., Tetracorals, Trilobite. It is noted by Lajoie that the presence of Stricklandia gaspensis suggests a "Wenlockian" age, which approximates the Niagaran stage in Canadian nomenclature.

Lajoie concludes that on the basis of textural analysis, sedimentary structures, and mineralogical composition the Val Brilliant represents a multicycle sand, derived from a source to the north, and deposited in a stable, normal marine, near-shore environment.

Sayabec Formation

The term "Sayabec formation" was originally applied by Crickmay (1932) to a sequence of well-bedded, grey, dark grey and black limestones exposed near the town of Sayabec, in the Matapedia valley. The exposures here, however, are in quarries and represent only a very small interval of the total present; for example, about 20 feet are present in a quarry near the village of Val Brilliant, in contrast to nearly 2,000 feet of limestones present near La Redemption, some 16 miles to the southwest.

The Sayabec is in gradational contact downward with the Val Brilliant formation and grades upward to the St. Leon formation. The lower contact is placed at the lowest limestone bed. The upper contact is arbitrarily placed where silt is present in large enough amounts to dominate the rock type. These changes are also marked by a difference in weathering characteristics; for example, the Sayabec limestones are more resistant to weathering than the overlying St. Leon siltstones but less so than the underlying Val Brilliant quartzites. This difference is also evident on the aerial photographs.

The thickness of the Sayabec is seemingly quite variable, due partly to difficulty in establishing accurately both upper and lower contacts and also to poorly exposed sections. The maximum thickness measured occurs at La Redemption where at least 1,500 and possibly 2,000 feet are present, and the minimum noted occurs near St. Gabriel where the limestones are only 800 feet thick. About 800 feet of limestones are also estimated to be present in the outcrops near Lac de la Montagne, and from there the unit extends in a southwesterly direction so that near Riviere Ferre about 950 feet of limestones are calculated to be present.

Where exposed in the Permit, the formation consists mainly of dark grey, argillaceous limestone. The following summary description is based on an outcrop along a road-cut some two miles southeast of St. Narcisse-de-Rimouski. The upper and lower contacts are covered at this outcrop, and there is also a good possibility that the section is inverted; consequently, the section is summarized here as follows:

> Dark grey, fine crystalline, tough and brittle limestone associated with dark grey but mottled grey and light brown weathering limestone that is microcrystalline with fine- to coarse-grained calcite spars, commonly fragmental in thin layers, slightly silty, and irregularly nodularly bedded.

A short distance to the northeast, the limestones of the Sayabec carry abundant fossil fragments including corals and, rarely, scattered patelate stromatoporoids to four inches in diameter.

Near St. Gabriel the limestone is typically black and medium grey weathering, fine-grained to fragmental and sparry, with rare fossil fragments, and carries thin siliceous stringers and laminae.

The following Sayabec section was described in descending order near La Redemption by J. Lajoie (1961, p. 74) and, although outside of the Permit area, is included here to illustrate the nature of one of the thickest outcrops in the general area.

Sayabec Formation

Location: On the south limb of the Matapedia syncline, about one and one-half miles southeast from the village of La Redemption, in Awantjish Township.

Described by: J. Lajoie (1961, p. 74).

Upper-Middle Silurian Sayabec Formation	Description	Thickness Feet
	Silt zone; the first ten feet of Sayabec are composed of 60% calcareous sandstone and 40% silty limestone, Favositids common.	50
	Intraclast-sparite limestone, beds are two inches to two feet thick. Few corals present.	60
	Unexposed interval, approximately	175
	Limestone, argillaceous, dark grey, finely crystalline, thinly bedded.	30
	Stromatoporoid zone; limestone with high content of stromatoporoids in biostromal beds, up to two feet thick, minor Favositids and brachiopods. Intercalated beds are of Micrite-Sparite-Intraclast limestone.	250
	Unexposed interval.	200
	Intraclast-Micrite and Skeletal Micrite-Sparite limestone.	125
	Unexposed interval.	50
	Second stromatoporoid zone; stromatoporoid coral, Sparite biolithite.	75
	Unexposed interval.	25
	Intraclast-Sparite limestone, interbedded with dense crystalline limestone. Beds are six inches thick.	75
	Unexposed interval, approximately	300

Upper-Middle Silurian Sayabec Formation	Description	Thickness Feet
	Intraclast-Sparite limestone, inter-bedded with fine crystalline limestone.	125
	Unexposed interval	500
		2,040
	Val Brilliant sandstone, base of measured section.	

An outcrop of poorly exposed, probable Sayabec formation is present at the base of the cliff which forms the south bank of the Rimouski River, some four miles southwest of St. Blandine. The outcrop consists of very dark grey, argillaceous limestone that is fine to medium grained and somewhat detrital. It is poorly nodularly bedded and horn corals to one inch in diameter are fairly abundant. The outcrop is densely fractured and thin calcite veining is common.

About five miles northeast of St. Blandine, on road cuts along the north face of the Neigette fault-line scarp near Lac de la Montagne, numerous outcrops of limestone, herein placed with the Sayabec formation, are present. They are typically very dark grey to black, argillaceous, fine to coarse grained, and fragmental in thin layers, very tough and brittle, poorly medium (two to six inches) nodularly bedded and carry fairly common but poorly preserved horn corals and, rarely, brachiopods. White weathering, quartzitic sandstones of the Val Brilliant formation form the outcrops stratigraphically below these limestones, and light greenish grey, tough dolomites of the St. Leon formation outcrop to the south, or stratigraphically above.

The following fossils were collected from the Sayabec formation by Lajoie (1961, p. 71), but the locality is not stated: Atrypa reticularis, Conchidium cf. knight., Dolerorthis aff. rustica, Lissatrypa sp., Merista sp., Pentamerus oblongus, Plectatrypa aff. marginalis, Rhipidium sp., rhynchonellid unident, Sieberella sp., Trimerella sp., and Ptychopleurella sp. In addition to the foregoing, the following rugose corals were collected by him from west of Awantjish Lake: Briantelasma sp., Kodonophyllum sp., Phanlactis sp., and Spongophylloides sp. It is noted by Beland (1960, p. 6) that the formation is of Wenlockian and Ludlovian age, which he places in the Upper Silurian. Many modern stratigraphers, however, place not only the Wenlockian stage in the Middle Silurian but also the lower part of the Ludlovian. For this reason we have shown the Sayabec formation as "Upper and Middle" Silurian age in this report.

From the viewpoint of oil and gas prospects the fossiliferous and calcareous nature of much of this formation, combined with the slight petroliferous odour noted on outcrops, places it in the category of a prospective horizon.

It will be noted that at even this relatively well exposed section there is a large percentage of covered intervals.

St. Leon Formation

The St. Leon formation lies gradationally above the Sayabec formation and below the Devonian Cape Bon Ami-Grande Greve formation and its correlatives. It is found throughout a large part of the Permit area.

The term "St. Leon" was first established by Crickmay (1932), but his definition has been considerably broadened by later workers, including Stearn (1959), Burke (1959), and particularly Beland (1960), to comprise a very thick sequence of calcareous sandstones, siltstones, silty limestones, pebble conglomerates and limestone conglomerates. To this we can add also a substantial amount of greenish silty dolomites.

In spite of their great thickness and widespread occurrence, the St. Leon beds are poorly exposed in the Permit area. Most of the outcrops are of small size and are widely distributed so that any reconstruction of the section present is necessarily generalized. The presence of faults between outcrops further obscures the stratigraphic relationships of these beds. In addition, numerous outcrops display a well-developed slaty cleavage that on the weathered surface can easily be mistaken for bedding, especially at small outcrops.

The St. Leon can be arbitrarily divided into two general units which are herein referred to, in ascending stratigraphic position, as the Lower and Upper units. The Lower unit lies above the Sayabec limestone and is separated from the overlying Cape Bon Ami-Grande Greve formation by the Upper unit.

The Lower unit is particularly widespread near the village of St. Gabriel in the southeast part of the Permit and is found in the hills that form part of the Neigette fault-line scarp along the north and northeast part of the Permit. It apparently undergoes a facies change near the Neigette River, changing from predominantly calcareous siltstones of the northeast and east to form a thick section of dense dolomites in the west and southwest.

The dolomites are exposed at several places along the Neigette fault-line scarp where it extends southwestward from St. Blandine to the Rimouski River. At the Rimouski River the following section was described and measured:

Lower Unit, St. Leon Formation (dolomite facies).

Overlying beds not seen.

80'(±) (Incomplete Section)	Dolomite, dark grey and greenish dark grey weathering, very fine crystalline, common very fine muscovite flakes and possibly silt grains, probably slightly argillaceous, very hard and brittle, gently laminated, thick-bedded and cliff-forming. Also present are some interbedded white, quartzite beds to 18 inches thick.

The base of the outcrop is covered by a large talus slope; however, at the base of this slope nearby occurs an exposure of fossiliferous dark grey, fine- to medium-grained, poorly nodularly bedded limestone that is tentatively correlated with the Sayabec formation.

The silty facies of the Lower unit outcrops over a wide area and can be summarized in the following description, which represents a generalized summary of these beds:

Lower Unit, St. Leon Formation (siltstone facies).

Siltstone, calcareous, dark grey to pale olive grey and pale olive green weathering, dense, thinly laminated to thinly (two inches) bedded, and flaggy weathering.

The Upper unit has a total thickness in the neighbourhood of 1,500 feet, although this figure is only an approximation due to the difficulty in establishing accurately the upper and lower limits. It is characterized by deposits reflecting a high energy environment of deposition that probably reflect an unconformity in the sequence. These include limestone conglomerates, which outcrop in the village of St. Blandine, near the road two miles northeast of St. Marcellin, and at Neigette Falls on the Neigette River. Sandstones and a quartz pebble conglomerate outcrop some three miles northeast of Mont Lebel, approximately at the boundary line between Macpes and Neigette townships.

The limestone conglomerate which outcrops at St. Blandine near the graveyard, on the east side of the road at the southeast side of the village, is summarized as follows:

Limestone, fragmental, light to medium grey and mottled grey weathering. A grey fine-grained matrix surrounds fossil fragments and poorly sorted limestone pebbles. Very abundant algal-like forms and colonial tabulate corals are present in this outcrop which is poorly thick and nodularly bedded.

Only about six feet of limestone are exposed here, but the unit may be thicker. It is seemingly both overlain and underlain by medium grey, olive brown weathering, tough dolomites.

Excellent outcrops of limestone conglomerate occur at the Neigette Falls about two and one-half miles east of the village of Neigette. About 250 feet of conglomerate or breccia are massively exposed here. The unit consists of very angular to subrounded, light and dark grey limestone fragments, that vary in size from grit to large blocks as much as 15 feet maximum diameter, although commonly the component fragments are about five feet across. They are randomly oriented and set in a matrix of fine-grained to dense, dark grey limestone groundmass. In addition, thin (two inches) light olive grey and grey weathering, fine-grained, well cemented, calcareous, thinly laminated, and crossbedded sandstones are present as thin layers between beds of conglomeratic limestone. Stromatoporoids of large size are common, as are the tabulate corals Halysites sp., and Favosites sp., Most of the fossils are apparently of detrital origin in the conglomerate.

This conglomerate zone is underlain by a massive, olive grey sandstone sequence. The overlying beds are not exposed, but black limestones lie close at hand on Neigette River. The conglomerate apparently thins in a southeasterly direction. In the St. Gabriel-de-Rimouski region, for example, no indication of the conglomerate was seen.

The source of the fossiliferous limestone blocks in the conglomerate remains unsolved. Their large size, angularity and poor sorting suggest that they have not been transported far from their original site of deposition. On lithologic evidence it would seem that the limestone fragments may have been derived from the Sayabec formation of the La Redemption area.

The quartz pebble conglomerate and sandstone zone which outcrops east of Mont Lebel comprises a series of poorly exposed linear ridges trending southwesterly across fields and through the forest. The sandstone is light brown-grey and brownish grey weathering, very fine grained, well sorted, and well cemented with calcareous material to form a poorly medium bedded unit.

The conglomerate, of which about 15 feet is exposed, consists of a greenish grey and grey weathering unit of poorly sorted, grit and pebbles of well rounded, densely compacted, grey and white chert, limestone, shale and dolomite pebbles set in a fine- to medium-grained, poorly sorted, subangular to subrounded, slightly calcareous sandstone matrix. The unit is very well cemented and thick massively bedded except for rare thin sandstone interbeds. Neither the lower nor upper contact of this zone was seen in the area.

Devonian

Cape Bon Ami-Grande Greve Formation

The term "Cape Bon Ami-Grande Greve unit" was applied by Beland (1960, p. 8) to a thick sequence of Lower Devonian sediments exposed in the axis of Neigette syncline in the central part of the map-area. Several distinctive lithologies were reported by Beland, including cherty limestone, calcareous siltstone, argillaceous and silty limestones, and grey limestones and calcareous shales. These units were grouped into one unit because of the difficulty of locally separating the beds into mappable units.

In this report we have followed Beland in the use of the term Cape Bon Ami-Grande Greve formation for strata unconformably overlying the Silurian St. Leon formation. We differ, however, in that we recognize two main members in this unit which are herein referred to as the "Lower Member"and the "Upper Member."

The "Lower Member" is present in the central part of the map-area, mainly along the axis of the Neigette syncline. Outcrops are composed almost exclusively of very dark grey to black and brown weathering, argillaceous, very fine-grained and dense, locally silty, thin-bedded limestone. The exposures are characteristically resistant weathering and form sharp, linear, slabby weathering ridges up to three or four feet high that strike across the fields. Large boulders of limestone as much as five feet in diameter are abundant in the areas of outcrop

or "near-outcrop" of this member. From evidence on the aerial photographs the "Lower Member" is possibly separated from the overlying "Upper Member" by an angular unconformity.

The "Upper Member" is very poorly exposed although its photogeological features are quite distinctive. At the outcrop it consists of grey to black, and light grey weathering, fine crystalline to sparry limestone that is interbedded with black and grey chert nodular beds that are commonly about two inches thick and about four inches apart. In places the chert may also be smoky grey in colour and occur as scattered walnut-sized to orange-sized nodules.

The combined thickness of the "Lower Member" and "Upper Member" in the Neigette syncline is estimated to be at least 6,000 feet.

A review of the literature concerning the Cape Bon Ami formation of Eastern Gaspe, as well as the Grande Greve of the same general area, reveals that the latter is composed of well-bedded chert limestone and calcareous siltstone and that the Bon Ami comprises shaly and sandy limestone. Due to poor exposure in the map-area, it is not known if other units are present in the Neigette syncline; however, the correlation with the type outcrops at Gaspe is not well established.

Beland (1960, p. 9) indicates that fossils found in the cherty limestone in the Neigette syncline are of Oriskany or Lower Devonian age.

The beds which normally overlie the Cape Bon Ami-Grande Greve formation were not seen, and it is believed that this formation represents the stratigraphically highest beds exposed in the Permit area.

Pleistocene and Recent

Gravels and sands of Pleistocene and Recent age are found in many parts of the Permit, especially in the river valleys and along the front of the Neigette fault-line scarp. The veneer of glacial deposits is very thin; however, outcrops or near-out material are found at the surface throughout most of the Permit. Glacial erratics are present but not commonly so. In several places below the drift the top of the outcrop surface was polished and grooved by glacial action.

STRUCTURE

Regional Structure

From the broad standpoint of regional structure, the Permit area lies near the northern border of a broad synclinorium or downwarp of folded and faulted Silurian and Devonian sediments that extends from near the Temiscouta Lake on the southwest toward Gaspe Peninsula on the northeast. The northern edge of this synclinorium is found along the Neigette fault in the northern part of the Permit, and along a line of unconformity throughout the northeastern and eastern part of the Permit. The folded sediments of the synclinorium roughly form a

broad plateau. The Ordovician beds found north of the Neigette fault are somewhat metamorphosed and intensely folded and faulted. They separate the Devonian and Silurian sediments to the south from the Precambrian Shield on the north side of the St. Lawrence River. It is in this zone of Ordovician beds in the channel of the St. Lawrence River that the Logan Line or Logan's fault passes through. The Ordovician sediments form the basement complex in this area. From a brief reconnaissance study of these beds it seems probable that the main structures are northeasterly trending and are approximately sub-parallel to the structures found in the sedimentary trough to the south.

Before deposition of the Silurian and Devonian sediments, the map-area was subject to structural deformation at the close of Ordovician time. These stresses arose during the Taconic orogenic episode. As a result of these forces the Ordovician and older strata are tightly folded and extensively faulted. In this area drag folds, faults, steep dips and a mild degree of metamorphism are common features in the Ordovician strata.

The Silurian beds were deposited on the Ordovician "basement complex" across a surface of probable slight relief, which is indicated in the geological record by a profound angular conformity that, in places, displays an angular discordance of as much as 90 degrees.

The Devonian strata were laid on the Silurian beds with a slight degree of angular discordance separating the two ages of strata, which suggests that some movement may have taken place during the Caledonian orogeny here. Following deposition of the Devonian, the area was once again deformed by structural stresses established during the Acadian orogeny at the close of Devonian time. It is believed that the main structures of the Permit area were brought about during this orogeny. The area, however, has probably been subsequently deformed, but the record of these movements cannot be confirmed due to the absence of the consolidated rock younger than Devonian age.

The northeast-trending folds present in the map-area exhibit considerable lateral extent, although they vary somewhat in their width. The main syncline, the Neigette syncline, plunges in a southwesterly direction. On the other hand, to the south, the northeasterly trending Mistigougeche syncline plunges in a northeasterly direction. Separating these two synclines lies the St. Marcellin anticline. This fold trends northeasterly through the Permit area from the southwest, where it exposes Ordovician beds at the surface, and plunges in a northeasterly direction to fade out as a depression, or perhaps is continued weakly as a gentle nose to the northeast part of the Permit area where it is expressed as a gentle flexure in the basal Silurian beds near St. Gabriel, where they are exposed above the Ordovician "basement complex."

Parallel to these fold axes are numerous high-angle normal faults which, in some cases, have a considerable amount of movement present on them. The two principal high-angle normal faults are the Neigette, which separates the Ordovician rocks to the north from the folded Silurian and Devonian strata to the south, and the Narcisse fault, which has Devonian beds in its footwall and Silurian beds in its hanging wall on the southern side. These faults, where

examined, are apparently of the steep normal type. With the exception of overturned beds on the northwest flank of the St. Marcellin anticline, there is little suggestion that overthrusts of the Rocky Mountain type are present in this area, and it is evident that most of the faults are steep-dipping. It is probable that the surface features of the Permit area reflect the nature of the basement complex, which has been broken up into blocks as a result of orogenic stresses. It may be that these follow some of the older pre-existing fault features formed in the Ordovician beds.

Due to the presence of these high-angle normal faults and their relative narrow spacing in the Permit area, it is believed that they have exercised an unfavourable effect on reservoirs that may have existed in this area at one time. In addition to these closely spaced normal faults, there are abundant oblique faults. Only the major ones of these are shown on the photomosaic accompanying this report.

The displacement or structural effect of the fault trends in the map-area may be small in the case of the oblique trends, in which event it is possible that the surface expression may not be of great significance. On the other hand, however, some of these faults may have originated before deposition of the sediments in which they are now found and they could have played a very important role during sedimentation. The faulting may have occurred in Silurian time and may have continued through Devonian time, possibly permitting the sea floor to adjust to environments of deposition favourable for rapid and continued growth of organic deposits or conglomerates such as are found at Neigette Falls. It may also be inferred, in some cases, that displacement along the fault planes may increase with depth and, conversely, that the fault displacement could conceivably decrease with depth.

The fault and fold features of Mineral Exploration License No. 171 area are discussed more fully in the following section, which deals with local structure.

Local Structure

Neigette Fault

The Ordovician "basement complex" is in fault contact with folded and faulted Silurian and Devonian sediments along the northwestern border of the Permit. This fault is a steep, normal type and has been named the "Neigette fault" by Beland (1960). It is represented topographically by a series of hills and a northwest-facing escarpment formed in the resistant weathering beds of the downthrown side (see Plate I-B), in contrast to the easily weathered Ordovician shales of the upthrown side.

The fault trends northeasterly, following a gently arcuate trend throughout the Permit, and is seen to pass into an unconformity and a series of fault splays in the Ordovician beds near the village of St. Donat. The St. Leon formation is exposed mainly along the downthrown south side, but outcrops of the

Sayabec occur, indicating that culminations and depressions are present in the beds of the footwall. In this regard, beds on the south side of the Neigette fault are intersected by several sets of north-trending, steep faults and these may also account for depressions along the fault trend. The amount of net slip on the fault cannot be accurately determined, due mainly to the absence of reliable marker horizons in the beds on either side. It is clear, however, that in areas of outcrop of the Sayabec in the footwall of the fault that the stratigraphic throw must be of a small amount.

Neigette Syncline

The Neigette syncline (Beland, 1960) is a major fold extending from Fleurian Township in the northeast to Duquesne Township in the southwest. It is fairly broad and asymmetrical, with the northwest limits carrying shallower dips than the southeast side. The area of maximum depression in the Permit, that is, the place where the youngest sediments are exposed along its trend, is present a short distance north of Lac Noir, between Petite Riviere Neigette and Riviere Neigette, in Neigette Township. Farther northeast, the synclinal axis is replaced by a broad southwest-dipping fold or broad plate that exposes the Ordovician "basement complex" at an unconformable contact below Silurian sediments.

The northwest limb of the structure dips from 10 to 40 degrees with steeper dips occurring near the axis. The southeast limb carries dips of 50 to 70 degrees. The asymmetry apparently remains uniform throughout the length of the syncline in the Permit. Subsidiary minor folds on the northwest flank of this structure are remarkably absent, although several steep-dipping, normal faults are shown on the photomosaic (see Figure IV). The southwest limb of the fold is truncated sharply by the St. Narcisse fault.

St. Narcisse Fault

The term "St. Narcisse fault" is applied herein to a northeasterly trending fault, or closely spaced fault zone, that separates the Neigette syncline from the St. Marcellin anticline. As interpreted on the generalized geological structure cross-sections (see Figure III) which accompany this report, it is shown to be a steep, southeast-dipping, reverse or thrust fault which has brought the Silurian St. Leon formation up and over the Devonian Cape Bon Ami-Grande Greve sequence.

This fault parallels nearby major folds but is sub-parallel to nearby faults. The fault plane is not exposed in the Permit, but faulted beds are present near its surface trace south of the village of St. Narcisse. The fault has a definite topographic expression and it can be delimited fairly well by scattered exposures on both sides.

The angle of dip of the fault is believed to become less at depth, and perhaps may agree with the dip of the axial plane of the recumbent fold directly southeast of the fault which is further discussed below. It is difficult to calculate the stratigraphic throw on this fault but near St. Narcisse it may be in the order of 500 to 1,500 feet.

St. Marcellin Anticline

This name has been applied by Beland (1960) to a prominent, asymmetrical anticline in the southwest corner of the map-area that continues northeastward to fade out in the central part. The total length of the structure in the Permit is about six miles. The northeastern limit is near the Neigette River; farther northeast the structure plunges and leaves no definite axial trace except for a broad plate which is gently arched near St. Gabriel, where the Ordovician "basement complex" is exposed. The southwestern extent of the anticline is not known. The axis follows a straight course, trending about 050 degrees azimuth.

The St. Marcellin anticline in the Permit is asymmetrical northwestwards, and steeply dipping to recumbent and overturned on the northwest limb. The overturned dips of the limbs range from 40 to 90 degrees, with the maximum measured in outcrops south of St. Narcisse. The northwest limb is cut by the St. Narcisse fault, a major southeast-dipping fault about two miles from the fold axis. Strata of the Ordovician "basement complex" are exposed in the densely faulted core of this fold in the southwest part of the Permit. The plunge of the fold ih the central part of the Permit is gentle northeastward and the anticline becomes narrower, and faults are more common. Minor peri-anticlinal faults and folds are present and include a narrow but laterally persistent syncline that trends northeasterly from St. Marcellin toward St. Gabriel.

From the foregoing, and as illustrated by the structure cross-sections (Figure III) and photomosaic (Figure IV), it can be seen that the axis of the St. Marcellin anticline plunges northeastward to form a depression in the central part of the Permit from which it rises gently toward St. Gabriel.

Mistigougeche Syncline

The south border of the Permit area lies a short distance from the axis of Mistigougeche syncline, a major fold that trends northeastward from the Lac Chic-Chocs and Lac Tache area in Macpes Township, approximately parallel to the south border of the Permit, and passes to the south of the village of Les Hauteurs, in Masse Township. This fold plunges gently to the southeast, and Devonian sediments are exposed in its core southeast of the Permit.

Minor Structures

In addition to the major southwest-northeast trending faults and folds outlined in the foregoing paragraphs, there are numerous less persistent faults and discontinuous sharp folds. The minor faults and folds are abundant in St. Leon strata. The faults are mainly of the normal or gravity type, steep-dipping, and the amount of displacement can rarely be calculated with the evidence at hand.

OIL AND GAS POSSIBILITIES

A discussion of the oil and gas possibilities of the Company's Permit falls naturally into three subdivisions; oil and gas indications, prospective formations, and prospective structures. These are discussed in the following paragraphs.

Oil and Gas Indications

No direct evidence of oil or gas, such as seeps or bituminous matter, was observed in the Permit during the course of the field study. To our knowledge, at this time, there are no oil or gas seeps in the adjoining areas. In an area such as this that has both favourable structure, and abundant faults, as well as extensive outcrops of bedrock, this fact is rather discouraging.

On the other hand, seepages of petroleum are known at many localities in the east-central Gaspe area. It has been reported that seepages occur from the Lower Devonian, the Grande Greve limestones, and the Middle Devonian York River and Battery Point formations (McGerrigle, 1950).

Two wells have been drilled near the acreage. Neither was successful. One of these was located about 14 miles east of the Permit. This well, according to Beland (1960, p. 17), was started in Ordovician slates and after drilling 800 feet bottomed in probably the same formation. The other well was situated some 41 miles southwest of the Permit, at Causapscal. This well was apparently spudded and abandoned in the Middle Silurian St. Leon formation after drilling 4,915 feet of these beds. It should be noted that the first of these wells was drilled in rocks which form part of the "basement complex" in the Permit, and that the second failed to penetrate to the potential source and reservoir beds; consequently, neither well can be considered a satisfactory test.

Prospective Formations

Ordovician and Older Beds

Strata of Ordovician and older age exposed near the Permit area are slightly metamorphosed and are extensively dissected by faults and steeply folded as a result of pre-Silurian orogeny. Consequently, they are not considered prospective, although the shales may have served as source beds of hydrocarbons for the overlying Silurian sediments in this area.

Val Brilliant Formation

The base of the Silurian sequence in a large part of the Permit area is probably marked by the Val Brilliant formation, which is a 300- to 500-foot thick sequence of quartzitic sandstones. These sandstones, where examined, were very well cemented by secondary silica to form a rock almost quartzitic in texture. The outcrops examined, however, displayed only a small amount of the total sequence present. The covered intervals could represent less well cemented, easily weathered porous sandstone interbeds that might provide prospective reservoir beds.

Sayabec Formation

As in the case of the underlying and overlying beds, the outcrops of Sayabec limestone present at any one section reveal only a small percentage of the total thickness present in the sequence. Where examined, it is composed of dark grey argillaceous limestones that are locally fragmental and silty. In addition, stromatoporoidal layers have been noted. This formation, at the freshly fractured surface, almost everywhere has a weak petroliferous odour.

Due to the presence of the petroliferous odour and fragmental and stromatoporoidal layers in this formation, it is considered to provide a prospective source and reservoir bed for hydrocarbons. Dense layers within the formation, as well as the calcareous siltstones of the overlying St. Leon, could provide the cap rock.

St. Leon Formation

Although the largest part of the St. Leon formation is composed of dense calcareous siltstones or silty dolomites, it does contain fragmental limestone conglomerate beds, some sandstone beds and a pebble conglomerate horizon that are probably porous in places. In addition, the composition and texture of the St. Leon beds apparently vary both laterally and vertically so that stratigraphic traps on the flanks of folds may form reservoir beds within this unit.

Cape Bon Ami-Grande Greve Formations

This unit comprises a considerable thickness of black, dense and fragmental limestones that have a petroliferous odour. These beds could provide prospective horizons in other areas, but in the Permit are exposed to the surface in a synclinal fold; consequently, the potentialities of these rocks are regarded as unfavourable.

Pleistocene and Recent

Recent natural gas discoveries at Pointe-du-Lac, near Three Rivers, Quebec, have been reported from Pleistocene deposits there. The reservoir is reportedly at a relatively shallow depth in gravel or sand, overlain by marine clay which provides the cap rock. In the Permit, the Pleistocene deposits consist mainly of gravels that are exposed at the surface; consequently, the prospects of finding natural gas in the Permit under a similar setting are not considered favourable.

Prospective Structures

It has been discussed previously in this report that the Permit area includes a downwarped, faulted and folded area of Silurian sediments underlain and flanked by an Ordovician "basement complex" sequence that is essentially in fault contact along the northwest, and in an unconformable, exposed contact along the northeast Permit boundary. To the southwest the "basement complex" is exposed in the core of the St. Marcellin anticline.

Basement Highs

In this structural setting prospective structures could not only be present in anticlines and along faults, but also cover areas of high structural relief in the Ordovician "basement complex." Due, however, to the great thickness of sediments present, in addition to the large area that is synclinal in structure, the areas of structural relief on the "basement complex" are not considered to provide good prospects here. These regions, however, may have exercised a structural control during deposition of the overlying sediments so that these may be reflected upward in the section as zones of favourable sediments.

Neigette Fault

The Neigette fault is a northeast-trending, high-angle, normal or gravity fault with the southeast, or Silurian sediment side, downthrown relative to the northwest side which is composed of the Ordovician "basement complex." In several places the Neigette fault is intersected by north-trending, steep, gravity faults. Due to the presence at the surface of the main prospective horizon, the Sayabec limestone, in several places along the fault-line scarp which marks the Neigette fault, the possibility of a prospective structure here is not considered favourable.

St. Narcisse Fault

The St. Narcisse is a northeast-trending, high-angle gravity fault with St. Leon formation on the southwest side, brought up relative to the northwest side of Cape Bon Ami-Grande Greve limestones. It is possible that this fault arrangement has resulted in a favourable prospect here in the downthrown side (which is flanked to the northwest by a narrow, steep syncline) of the fault; however, due to the small width of this prospect in addition to its complexity, as well as the exposures of the prospective beds nearby, it is not favourably rated.

St. Marcellin Anticline

The St. Marcellin anticline presents the major anticline in the Permit area and trends northeasterly across the southern part. In the southwest part of the Permit it exposes the Ordovician "basement complex" in its core and Awantjish, Val Brilliant, Sayabec and St. Leon formations on its flanks. The northwestern flank is apparently overturned in some places. The anticline plunges northeasterly fairly steeply so that near Lac des Joncs only St. Leon beds are present at the surface. This area is apparently also one of structural depression along the axial trend. The apparent absence of closure in the most prospective beds involved in this anticline suggests that it is an unfavourable prospect.

Minor Faults and Anticlines

Numerous small, steep faults and short, sharp anticlinal folds are present within the Permit, particularly near Lac Noir. Due to their small extent and the thickness of sediments present involved, they are not, at this time, considered to offer good prospective structures.

CONCLUSIONS AND RECOMMENDATIONS

The Company's License area is located in a broad plateau area on the south shore of the St. Lawrence River about 220 miles northeast of Quebec City, Quebec. It is easily accessible and is dissected by a dense system of roads and trails. Part of the Permit area is thickly forested, but the trees are small and road construction here should not present any problems.

Heavy freight shipments can reach the Permit area by railroad, unloading at either Rimouski or Mont Joli, and also by ship. Large docking facilities are available at Rimouski.

Bedrock is at or close to the surface over almost the entire Permit area. Exposed rock consists of Ordovician and Silurian and Devonian sediments. Pleistocene and Recent gravels are present as a thin cover.

The regional structural position of the Permit holdings can be described as that of a large downwarp or synclinorium bounded on the north by somewhat metamorphosed Ordovician sediments which are also found to the northeast and also in the core of the large anticline present in the map-area. This synclinorium is modified by the presence of several northeast-trending steep-dipping normal faults as well as a major syncline and many associated minor structures.

In view of the fact that extensive bedrock outcrops are present, as well as numerous faults and folds, the absence of oil seeps within the study area is not encouraging from a potential productive standpoint.

The total stratigraphic section in the area is at least 5,000 feet thick and the prospective Sayabec formation can be expected to be about 800 feet thick.

The principal prospective oil and gas horizons within the Exploration License area are the intermediate conglomeratic and fossiliferous units of the St. Leon formation and the petroliferous limestones and black argillaceous carbonates of the Sayabec formation. The rocks of Ordovician age are expected to form an unproductive "basement complex."

With respect to any continuing program of exploration in the Permit area, and in consideration of the above facts, it is thought that additional exploration would do little to further the evaluation of the area with regard to oil and gas possibilities within the Permit area itself.

It might be possible, by utilizing the services of a small portable rig such as a diamond drilling outfit, that a structure test program could be carried out over some of the faults and further establish their presence. On the other hand, it may be possible to drill stratigraphic tests, drilling, for example, to a deeper depth, say in the order of 1,000 feet, to determine more accurately the position of the minor folds. If either of the latter two programs is considered, it would also be possible to extend the geological field mapping into the area surrounding the Permit in order to fully evaluate the

structures further. This would be particularly true in the case of the St. Marcellin anticline, which could be mapped in the area southwest of the Permit.

Considering the possibilities of the oil and gas prospects within the Permit area, the large anticlinal feature known as the St. Marcellin anticline is considered unfavourable because it exposes the "basement complex" in its core at the southwest part of the Permit and plunges northeasterly to form an area of depression in the central and northeastern part of the Permit, and is expressed farther northeastward as an exposure or gentle dome near St. Gabriel. It is apparent that on this structure closure does not exist within the Permit. Another prospect lies along the Neigette fault, where updip migration against the downthrown side of this steeply dipping fault, that is, in the footwall or attic-type reservoir, is not considered likely because the Lower Silurian beds are exposed in several places along this fault. The other prominent fault in the Permit area, the St. Narcisse fault, is not considered prospective due to its thin width and the fact that the prospective beds in this case form the downthrown side with little room for updip accumulation against the fault. Structural closure may be present in some of the minor folds; however, due to their small lateral extent, unknown structure at depth, and the large thickness of sediments over the prospective beds in them they cannot, at this time, be regarded as important petroleum prospects.

During the course of this study it became apparent that in the area of exposed Silurian and Devonian sediments in the central and western Gaspe areas there were portions of the country that have large persistent anticlinal folds which, from our preliminary studies, appear to be closed. It is considered that these areas of folds constitute an important prospective area and no doubt, in the future, will prove to be productive upon drilling in the areas of culmination. In this regard, it is suggested that further preliminary geological work be done by the Company to outline these features and possibly acquire them. Some of the major folds are shown on Figure I.

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