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GEOLOGICAL REPORT

PENNZOIL DE QUEBEC LIMITEE EXPLORATION LICENSE NO. 204

EASTERN GASPE, QUEBEC

Prepared For

Pennzoil de Quebec Limitee

August, 1965

J. C. SPROULE AND ASSOCIATES LTD.
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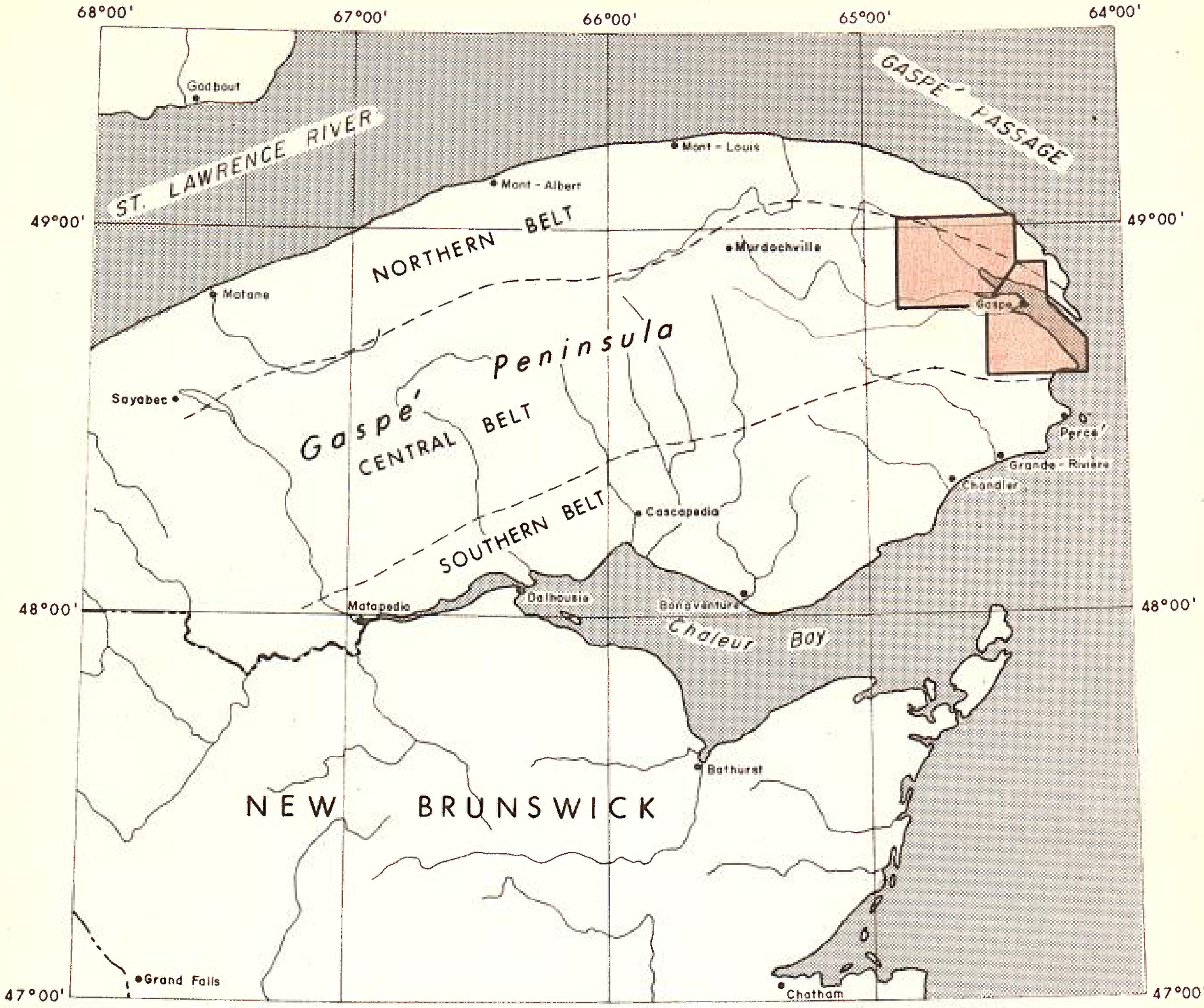

INDEX MAP
GASPE' PENINSULA
QUEBEC

SHOWING

Subject Area and Geological Subdivisions

30 0 30 60

SCALE : 1" = 30 MILES

J.C. SPROULE AND ASSOCIATES LTD., CALGARY

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PENNZOIL DE QUEBEC LIMITEE EXPLORATION LICENSE NO. 204

EASTERN GASPE, QUEBEC

INTRODUCTION

Description of Project

This report presents the results and conclusions of a combined photogeological and field geological study of Mineral Exploration License No. 204 in the eastern Gaspe area, Quebec, conducted by J. C. Sproule and Associates Ltd.

The work described herein has been authorized by Mr. R. D. Rogers, acting on behalf of Pennzoil de Quebec Limitee, hereinafter called "Pennzoil." It was anticipated that the results would enable us to make recommendations for drilling locations.

The area covered by this study (Figure I) comprises approximately 345,600 acres, 81,400 acres of which are held by Pennzoil.

The object of the report is to appraise the oil and gas possibilities of Pennzoil's holdings in the light of the structural and stratigraphic knowledge of the area gained during the course of the study, and from regional stratigraphic information gathered from the literature and from what was currently available to us from other sources. Detailed mapping of the stratigraphy and major structures found within the subject area and, where necessary, outside the area was undertaken. In addition, subsurface studies were made of some of the wells in the area to assist in the evaluation of the petroleum prospects.

The area held by Pennzoil is situated northwest and southeast of the town of Gaspe. It lies partly between the Dartmouth and York rivers and extends southeast of Gaspe to the mouth of the St. John River and the village of Douglastown. A submerged coastal strip stretching from Gaspe to the mouth of the Bois Brule Brook is included in the Pennzoil holdings. The outline of Exploration License No. 204, which appears on Figure III and the photogeological mosaics, is that provided by Pennzoil.

The photogeological study was conducted by J. W. Bakhoven in Calgary prior to the field studies.

Dr. R. de Wit left Calgary June 7 and, after conferring with Pennzoil representatives in Chicago, proceeded to Gaspe and commenced the field studies. Dr. de Wit left Gaspe on June 24. Bakhoven, who had joined de Wit on June 22, continued the field work, which was completed July 1, 1965. The work of both geologists is included in the final report. The use of a local man as assistant improved the efficiency of the field studies.

Physiography and Accessibility

Physiographically, Gaspe Peninsula forms the extreme northeastern end of the Appalachian Mountain system on the continental mainland.

The subject area has a medium relief and is rather rugged and hilly. The topography of the inland part is essentially that of a dissected plateau. The highest points occur at the headwaters of the Salmon Hole Brook and the Galt Brook, where the elevations are in the order of 2,200 feet.

The Dartmouth, York and St. John rivers form broad and open valleys near their mouth, but overall they are morphologically in a youthful stage, as are their tributaries. Some marshy areas together with a string of lakes are present south of the York River.

Wave action has caused many steep cliffs along the coast. There, the stratigraphic successions can readily be observed.

The area is in large part heavily forested, except along the coast and the major rivers, where the centres of population are located. Inland, the country becomes rather inaccessible. Lumber roads, many in bad shape, and old tracks leading to abandoned oil wells are the only means of access into the interior.

HISTORY OF PETROLEUM EXPLORATION IN GASPE

The occurrence of petroleum and gas seepages in the Gaspe region was reported as early as 1836. The first attempt to drill for oil was made in 1860 by the Gaspe Mining Company, which drilled two shallow wells near oil seeps. Neither of the wells yielded more than a trace of oil.

Prior to 1900 approximately 50 wells were drilled to a depth of 2,500 feet. The production was then sufficient to justify the erection of a refinery in 1901 in Gaspe by the Canada Petroleum Company. Shortly afterwards, however, the supply failed and the enterprise was abandoned. Some of the oil wells that have not been plugged are still discharging small quantities of oil. Up to the end of 1959 approximately 80 wells had been drilled, however, none of the wells produced gas or oil in commercial quantities. Since 1959 only two additional wells are reported to have been drilled, neither of which was productive.

Most of the wells drilled before 1939 were located in synclines or well down the flanks of anticlinal folds; the few that were on anticlines penetrated open structures. Many of the wells, although unfavourably situated, did have some oil.

In view of the unfortunate location of many wells, it cannot be said that the possibilities are exhausted. Careful geological selection of well sites, modern drilling and production practice, which has never played a sufficiently important role in the Gaspe exploration, will certainly improve the prospects of finding hydrocarbons.

A list of the wells drilled in the Gaspe region by the various companies is presented in Table I.

In compiling this table of wells drilled, the Quebec Department of Mines Report No. S-53 was utilized as well as the records of the gas and oil section of the Quebec Department of Mines. The oil and gas showings are indicated in the formation tested, when this formation is known. Some of the showings are from present conditions at the well site. The wells drilled prior to 1900 are not completely reliable and should not be considered critically.

As far as is known, all the wells, except for a few, were drilled with a cable tool-type rig. One which used a rotary type drill was the New Peninsular Oil No. 1 (P.C. No. 1) in 1954.

Table I is presented on the following pages.

Table I

Exploration Wells in the Gaspe Area

Well No.	Well Name	Year Drilled	Total Depth Feet	Thickness of Formation Penetrated: Devonian B.P. Feet	Devonian Y.R. Feet	Devonian G.G. Feet	Devonian C.B.A. Feet	Silurian Feet	Remarks
1	Assoc.Devel. No. 1 Baillargeon	1959-?	449+		449+				Oil and gas shows.
2	Assoc.Devel.Causapscal No.1	1958	4715					4635(?)	St. Leon formation (must have started in G.G.).
3	Bald Mtn. No.2	1951-59	6658					6624(?)	Gas 100 Mcf/D at 6605' in Silurian.
4	Canada Petroleum Corp.No.1	1899	1582		1565				Gas show and oil production.
5	" " " No.2	1899	1591		1556				Gas show and oil production.
6	" " " No.3	1899	2438		2150	288			Gas shown in Y.R. and oil production in G.G.
7	" " " No.4	1899-01	2100		2100				
8	" " " No.5	1900	2200		2150	50			Some oil at base of Y.R.
9	" " " No.6	1900	2360		2320	40			Oil show in G.G.
10	" " " No.7	1900	2065		2046	19			Some oil at base of Y.R.
11	" " " No.8	1900	2394		2340	54			Oil show at 2,340'.
12	" " " No.9	1900	2226		2215	11			
13	" " " No.10	1901	2383		2360	23			Some oil production.
14	" " " No.11	1901	1924		1900	24			Oil show in Y.R.
15	" " " No.12	1901	1500		1500				
16	Haldimand No.1	1941-42	4779	1397	3379				Gas show.
17	Mississippi No.1	1939-40	5995			1240	3740	1015	
18	Asphalt Base No.1	1953-54	2700		323	2350			Gas and oil show in G.G.
19	Continental Gaspe No.1	1948-50	1375			1375			Gas show and oil production.
20	Continental Gaspe Deep Test No. 1	1951-53	3235		335	2890			Oil and gas show in G.G.
21	Continental Petrol.Ltd.No.1	1943-48	2751			2735			Oil and gas show.
22	Continental Petrol.Ltd.No.2	1944-47	2932		2332	570			Gas show, oil production in G.G.
23	Imperial Gaspe No.1 (Formerly Bald Mtn.No.1	1947-50	6345					6360(?)	Gas and oil show.

Table I - Continued

Well No.	Well Name	Year Drilled	Total Depth Feet	Thickness of Formation Penetrated — Devonian — B.P. Feet	Y.R. Feet	G.G. Feet	C.B.A. Feet	Silurian Feet	Remarks
24	Eastern Canada Co.No.1	1913	2950	2950					
25	Campbell Well	1860	600		600(?)				Gas and oil show.
26	Gaspe Mining Co.No.1	1860	600	600(?)					
27	Conant (Adams) Well	1865 & 1944-45	821						Gas and oil show. Bedrock same as C2 (well.
28	Venture No.1	1946-47	2424		1235	1174			Gas and oil show, mostly in G.G.
29	Venture No.2	1947-48	2132		1930	127			Gas and oil show.
30	Venture No.3	1948-49	2399		1990	399			Gas and oil show.
31	International Oil Co.No.1	1888	2200						Started in Y.R. Formations unknown.
32	C2 (McMaster W.R.)	1945	805	590	205				Gas show and oil production in B.P.
33	Mineraux et Pet.de Gaspe No.1	1937-38	842	837					
34	New Peninsular Oil Ltd. P.C. No.1	1945-54	8138				3440	4698	Gas and oil show.
35	Petroleum Oil Trust No.1	1889-91	2430	600	1830				Some oil production in Y.R.
36	" " " No.2	1890	2582	1595	882				Oil show.
37	" " " No.3	1890-91	2225	2225					Oil scum on water at well site.
38	" " " No.4	1890-91	2970	1000	1970				Oil show.
39	" " " No.5	1891-93	2640		2372	240			Oil production in Y.R.
40	" " " No.6	1892-95	?						Started in Y.R. Oil show at 2,950'.
41	" " " No.7	1892-94 (?)	2867		2357	482			Gas show and oil production in G.G.
42	" " " No.8	1892-93	2650	1000	1650				
43	" " " No.9	1894	2719	2719					Oil show at unknown depth.
44	" " " No.10	1895	1400		1372				Gas show and oil production.
45	" " " No.11	1893-95	2957		2160	757			Gas show and oil production at base of Y.R. and G.G.
46	" " " No.12	1894-95	3002		2595	302			Gas show and oil production.
47	" " " No.13	1894-95	2050		2038				Gas show and oil production.
48	" " " No.14	1895-97	2775		2211	525			Gas show and oil production in Y.R.
49	" " " No.15	1895	2012		1880	132			Gas show and oil production in G.G.
50	" " " No.16	1895	2925		2840	85			Oil production in Y.R.

Table I - Continued

Well No.	Well Name	Year Drilled	Total Depth Feet	Thickness of Formation Penetrated: Devonian: B.P. Feet	Y.R. Feet	G.G. Feet	C.B.A. Feet	Silurian Feet	Remarks
51	Petroleum Oil Trust No.17	1895-97	2550		1987	550			Gas show and oil production in Y.R.
52	" " " No.18	1895-96	1960		1851	95			Gas and oil shows in Y.R.
53	" " " No.19	1895-96	2250		2186	50			Oil production in Y.R.
54	" " " No.20	1896	2173		2129	23			Gas show and oil production in Y.R.
55	" " " No.21	1896-97	1887		1440	367			Oil and gas show at Y.R. and G.G. contact.
56	" " " No.22	1896-97	3107		2738	357			Gas show and oil production from Y.R.
57	" " " No.23	1896-97	1795		1310	445			Oil show in Y.R.
58	" " " No.24	1896	1230		84	1130			
59	" " " No.25	1895-97	1160		690	410(?)			
60	" " " No.26	1896	2975		2720(?)	225			Gas and oil show.
61	" " " No.27	1897	2200		2000	100			Gas show and oil production in Y.R.
62	" " " No.28	1897-98	3525		3525				Gas show.
63	" " " No.29	1897-98	2183(?)		2038	83			Gas and oil show.
64	" " " No.30	1898-99	1580		1570				Gas show.
65	" " " No.31	1898-99	2815		2455	315			Oil production from Y.R.
66	" " " No.32	1899	1925		1825	100			Oil production from Y.R.
67	" " " No.33	1899-1901	2607		2595				Gas and oil show.
68	" " " No.34	1900	1677		1652				Some oil production.
69	" " " No.35	1901	1810		1786	10			
70	" " " No.36	1901	1955		1955				
71	" " " No.37	1901-02	2600		2527				Gas and oil show.
72	" " " No.38	1901-02	2089		2071				Oil show.
73	" " " No.39								Location only.
74	" " " No.40	1901-02	2305		2305				
75	" " " No.41	1902-03	465		49	395			Gas show in G.G.
76	" " " No.42	1903	2000(?)						Went through Y.R. and G.G. Oil show.
77	Quebec Oil No.1	1949-50	2440			1752	680		
78	Quebec Oil No.2	1951-53	6000			1988	4004(?)		May have penetrated the Silurian.
79	Tar Point No.1	1950-54	7070		6421	615			Gas and oil show.
80	Unidentified								

Note: Since 1959 only two additional wells are reported to have been drilled, neither of which was productive.

REGIONAL GEOLOGICAL SETTING

The Gaspe region is part of the Appalachian Mountain system, in which Paleozoic sediments and volcanic rocks have been folded and faulted by the Taconic orogeny at the close of the Ordovician and later by the Acadian orogeny at the end of the Devonian. Rocks of Carboniferous age have not been disturbed by mountain building movements and they were unaffected by the Appalachian orogeny that closed the Carboniferous period in other parts of the continent.

The Gaspe Peninsula can be divided into three geological subdivisions parallel to the longer axis of the Peninsula, in which the Paleozoic rocks are distributed (Figure I). The Northern Belt is underlain by rocks of Ordovician and,possibly, Cambrian age. The Central Belt contains some Ordovician, Silurian and Devonian rocks with the latter predominating. The Southern Belt has Cambrian, Ordovician and Devonian strata on which were laid down younger sediments of Carboniferous age. Rocks of intrusive and volcanic origin occur in all three belts.

A study of the stratigraphic sequences, thicknesses and facies changes in the various available sections in Eastern Gaspe, shows that, in general, each carbonate unit thins northwards, thickens and becomes more shaly south and south-westwards and finely becomes sandy further south and southwest. The sandstone units usually become much thicker to the south.

STRATIGRAPHY

Sediments ranging in age from Ordovician to Carboniferous (Pennsylvanian) outcrop in the subject area. Ordovician beds, here called the Cape Rosier Formation, are exposed in the area illustrated by the northeastern part of Mosaic Sheet No. 1 and the northern part of Mosaic Sheet No. 2, but they are best exposed on the shore of Cape Rosier outside the project area. The section is made up of shales and limestones with some minor conglomerates and sandstones. Ordovician rocks are also exposed in the area south of Mosaic Sheet No. 2 along the St. John River, where they form the core of the anticline in this area. An eastward plunge of the anticline carries them under younger beds west of Mosaic Sheet No. 1.

Silurian sediments rest with an angular unconformity on the Cape Rosier Formation. In the subject area they occur in the northeastern part of Mosaic Sheet No. 1 and in the northern part of Mosaic Sheet No. 2. Silurian rocks also occur at Salmon Hole Brook south of the Dartmouth River, where they rest on volcanic rocks that are probably partly Ordovician in age. The volcanic rocks and some intrusives in this area also occur at the Lady Step Brook and they are designated the Lady Step Series.

The Devonian sediments rest with an apparent conformity on the Silurian beds. They are Lower and Middle Devonian in age and total a great thickness throughout the subject area. Several writers have divided the sediments into two divisions, a lower and an upper, respectively the Gaspe limestones and the Gaspe sandstones. These general divisions are useful for descriptive purposes.

In the southern part of Mosaic Sheet No. 1 Pennsylvanian(?) rocks (Cannes de Roche Formation) rest with an unconformity on Devonian beds. The term "Carboniferous" (Mississippian and Pennsylvanian) is often used in the Gaspe region but in the project area only the Pennsylvanian is believed present.

In addition to the volcanic rocks at the Salmon Hole Brook and Lady Step Brook there are basic dykes cutting Devonian and Silurian beds. These are known at several localities in the region, but are best observed at Forillon Peninsula outside the subject area and at Tar Point (Mosaic Sheet No. 1). It is believed that the age of the intrusives is pre-Carboniferous and post-Middle Devonian.

Sand and gravel deposits occur throughout the whole region in the form of river, lagoon and bar deposits. Glacial deposits are not abundant and thick.

Parts of the stratigraphic sequence have been studied at various localities in Eastern Gaspe. The following list of formations includes only those that relate to Pennzoil's holdings.

Table of Formations

Era, Period	Formation	Description	Thickness Feet
CENOZOIC			
Quaternary	Recent and Pleistocene	River, lagoon, bar deposits, gravels.	
PALEOZOIC			
Pennsylvanian(?)	Cannes de Roche	Red conglomerate, red and green shales and sandstones.	200-250+
		- UNCONFORMITY -	
Post-Middle Devonian pre-Pennsyl-vanian	Basic Dykes	Diabase, usually amygdaloidal.	
Middle (or Upper?) Devonian	Malbaie	Red conglomerates, conglomeratic sandstones and sandstones, some shale and very occasional lime-stone.	2000+
Middle Devonian	Battery Point	Greenish grey, coarse arkosic sandstones, orthoclase content characteristic, conglomerates, some shale and siltstone.	5000-7000
	York River	Greenish grey, medium to coarse arkosic sandstones and some greenish shale and siltstone.	1300-4500
Lower to Middle Devonian	Fortin(1)	Shales, limestones, sandstones and some conglomerate.	2500+
Lower Devonian	Grand Greve	Dense, dark grey, hard, siliceous and sometimes cherty limestones, calcareous siltstones, well bedded.	885-4000
	Cape Bon Ami	Dark grey, soft to hard, argil-laceous limestones and cal-careous siltstones.	1100-4000
Silurian	St. Leon	Interbedded greenish grey and maroon calcareous mudstones and siltstones, some shale and lime-stone.	365-1700+

Era, Period	Formation	Description	Thickness Feet
	Roncelles	Interbedded grey, fossiliferous, fine-grained limestones and dense silty limestones, some calcareous mudstone. Limestones often have nodular bedding.	135-900+
	Griffon Cove River	Maroon and green laminated calcareous siltstone, conglomerates, especially towards the base some sandstone.	0-375+ (700?)
		- ANGULAR UNCONFORMITY -	
Lower Ordovician	Cape Rosier	Tightly folded and faulted thin-bedded shales and limestones, some sandstone and conglomerate, often slightly metamorphic.	380+

(1) The Fortin Formation occurs south of the St. John River Anticline and correlates with the lower part of the York River Formation, all of the Grand Greve Formation, and the upper part of the Cape Bon Ami Formation.

Description of Formations

Lower Ordovician

Cape Rosier Formation

This formation has been observed at several places. The best place to study the formation is along the cliffs between Forillon Peninsula and Cape Rosier. Other places are along the Fox River, the Sydenham River and the Griffon Cove River. At Cape Rosier Cove, the Silurian is in fault contact with the Cape Rosier Formation. Also at Cape Rosier Cove, at low tide and under certain conditions whereby the beach gravels are removed, the unconformable contact can be observed as shown by a photograph by L. M. Cumming in the Geological Survey of Canada, Memoir 304. At the other places, the contact was not exposed. The beds examined consisted, for the most part, of grey to dark grey shales and slates, and siltstones and limestones. Some grey, tight, quartzitic sandstones have also been observed. The Cape Rosier beds are often slightly metamorphic and nearly always intensly folded and faulted. The beds sometimes include black bituminous shales and at several places black pyrobitumen was observed in the limestones and sandstones. The total thickness is unknown but is believed to be at least 380 feet.

The Cape Rosier Formation is unconformably overlain by Silurian beds. Middle Ordovician rocks do not occur within the subject area but they can be studied near Griffon Cove north of the area. Upper Ordovician beds outcrop in the core of the St. John River anticline.

Silurian

The Silurian can be divided into three formations. The oldest formation of the period is the Griffon Cove River Formation, which is absent near Cape Rosier Cove at Forillon Peninsula. The Roncelles Formation rests here with an angular unconformity on the Cape Rosier Formation. The youngest formation of the period is the St. Leon Formation, which follows the Roncelles Formation.

The three formations, with the exception of the Griffon Cove River Formation at Cape Rosier Cove, have been observed at the abovementioned place and along the Dartmouth, Sydenham, Fox and Griffon Cove rivers.

Griffon Cove River Formation

The base of the formation consists of poorly sorted conglomerates and cobble conglomerates. The cobbles sometimes reach a diameter of one foot or more. At the Sydenham River the cobbles and pebbles are made up of schists, quartzites and limestones. Higher in the section the formation consists of maroon and green laminated and calcareous siltstones and mudstones. A 50-foot thick zone of pebble conglomerate, which has been described in the literature as being near the middle of the section, was not observed. Stromatoporoids and crinoid stems are locally common. The thickness varies from zero to 375 feet (at Griffon Cove River), but it may be as high as 700 feet at Sydenham River.

Roncelles Formation

The Roncelles Formation sharply overlies the Griffon Cove River Formation, except at Cape Rosier Cove at Forillon Peninsula where the formation rests with an angular unconformity on the Cape Rosier Formation. The Roncelles is well bedded and is made up of grey, sometimes very fossiliferous, dense and finely grained, crystalline silty limestones. Corals, stromatoporoids, brachiopods and crinoid stems are abundant at the base. Towards the top the limestones are less fossiliferous and become more silty. Here, calcareous mudstones and siltstones are common. Massive parts in the limestones have often been called reefs. Nodular bedding in the limestones is common. The thickness varies from 135 feet at Cape Rosier Cove to 900 feet at the Fox River section and may be more at the Sydenham River. The contact with the overlying St. Leon Formation is gradational.

St. Leon Formation

This formation is well exposed at Forillon Peninsula and along the Fox and Sydenham rivers. It is made up of green, grey and maroon coloured, calcareous laminated mudstones and siltstones showing in places slump structures. At irregular intervals successions of tight argillaceous grey limestones with somewhat nodular beds and grey silty shales with limestone concretions are found. Fossils are rare. The thickness is approximately 365 feet at Forillon Peninsula but increases rapidly towards the west. At the Dartmouth and Sydenham rivers the thickness is estimated to be more than 1,700 feet.

The Silurian Succession in the St. John River Area

Silurian rocks in Central Gaspe are exposed along the St. John River and its tributaries, on an anticlinal structure of the same name.

The oldest beds are siltstones and shales of the Burnt Jam Brook Formation, which rest on Ordovician rocks with an angular unconformity. Overlying these sediments is a succession of limestones, sandy limestones and conglomerates which has been called the Laforce Formation. A fault separates the beds from the overlying siltstones and shales of the St. Leon Formation. Within these siltstones and almost in close contact with the Laforce Formation is a thick sequence of conglomerates. They have been designated as the Owl Capes Conglomerate Member of the St. Leon Formation. The conglomerates interfinger with the siltstones of the St. Leon Formation.

Figure II gives a proposed correlation of the abovementioned formations with those of the Silurian succession of northeastern Gaspe.

Silurian Sediments and Volcanic Rocks at Salmon Hole Brook

At Salmon Hole Brook and Lady Step Brook, a succession of igneous rocks occur. They are mostly volcanic in origin but intrusive rocks are also present. They have been mapped as one unit. The rocks are usually dark green to black, amygdaloidal and schistose. Volcanic breccias, agglomerates and tuffs occur in the succession. The age and thickness of the rocks is not known but it is assumed that they are Silurian with a possibility of being Ordovician.

Sedimentary rocks, believed to be Silurian in age, overlie the volcanic sequence at Salmon Hole Brook. A conglomerate band a few feet thick, containing pebbles of quartzite and volcanic material, grades quickly into a greenish grey sandstone, which, in turn, grades upwards into a calcareous sandstone and silty limestone. A massive, slightly grey to white, coarsely crystalline limestone, which forms a cliff 100 feet high or more in this area overlies the sandstone. No fossils have been observed but it is believed that the limestone may be reefal. Further upstream the limestones are usually very dark and silty and resemble the Devonian limestones. The total thickness is estimated to be 150 feet.

Lower Devonian

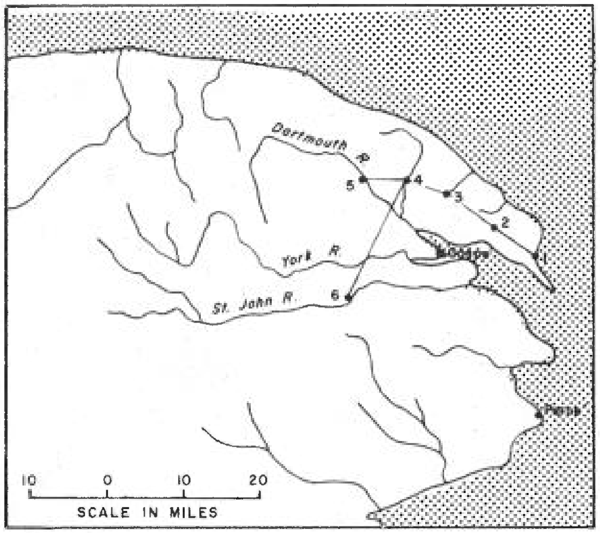
Cape Bon Ami Formation

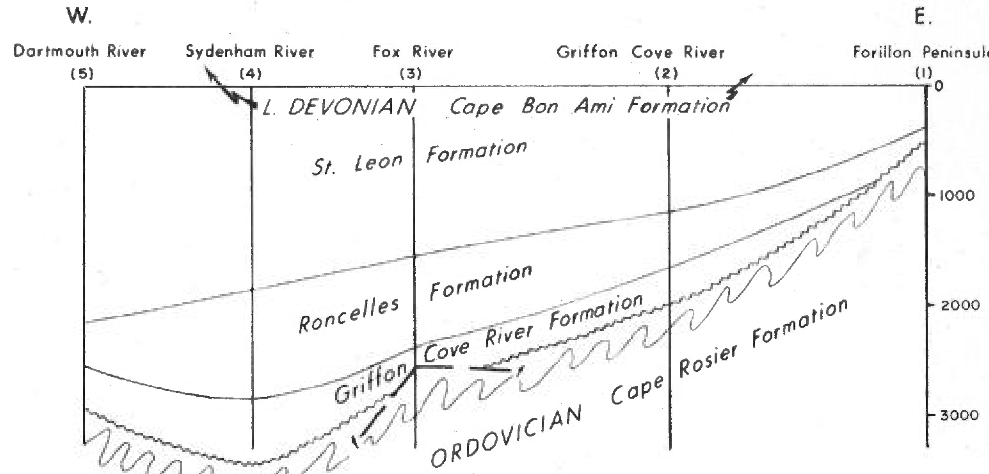
This formation and the overlying Grande Greve Formation are together often referred to as the Gaspe limestones. They are sometimes very similar in appearance and are, therefore, often difficult to separate. Overall, the formation is softer weathering than the Grande Greve Formation.

The type section for the formation is in the cliffs on the northeast side of Forillon Peninsula at a cape of the same name. The formation is in sharp contract with the underlying St. Leon Formation, which appears to be conformable.

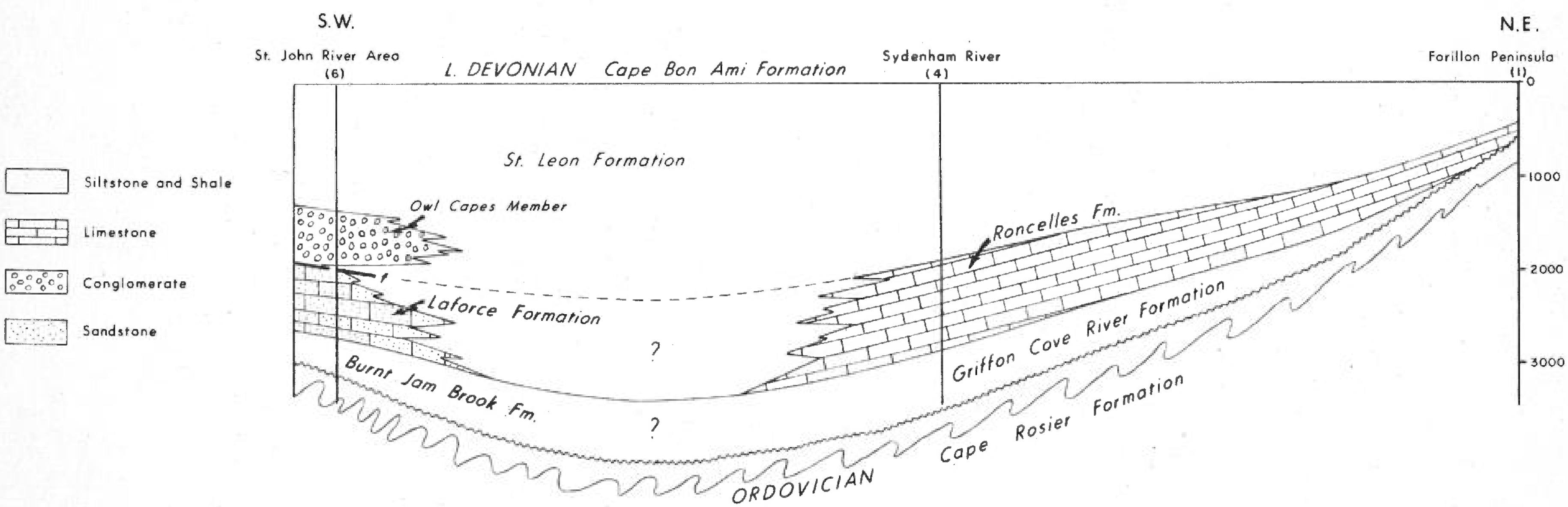
PUBLIC

INDEX MAP OF EASTERN GASPE'
SHOWING
LOCATION OF STRATIGRAPHIC SECTIONS





Silurian Stratigraphic Section of Eastern Gaspe' (Modified after C.F. Burk, 1964)



Diagrammatic Section of the Silurian System in Eastern Gaspe' (Modified after C.F. Burk, 1965)

J.C. SPROULE AND ASSOCIATES LTD., CALGARY

To accompany Geological Report to Pennzoil de Quebec Limitee, August 1965

FIGURE – II

The Cape Bon Ami is made up of an irregular succession of tight, dark grey and brownish grey, medium to fine grained argillaceous limestones, with somewhat nodular beds. At some intervals grey, silty, calcareous shale and siltstone partings occur. Freshly broken pieces sometimes have a petroliferous odour. The thickness varies from 1,100 feet at the type section to about 2,000 feet at the Dartmouth River. The formation thickens towards the southwest to approximately 4,000 feet in the St. John River area.

Grande Greve Formation

The type section of this formation is also in the northeast-facing cliffs of Forillon Peninsula. The formation is composed of dark grey, hard, siliceous and sometimes cherty limestones and calcareous siltstones. It is commonly well bedded and fossiliferous. Shale partings occur occasionally. The weathered debris usually form small sharp angular fragments with a characteristic light grey colour. The rocks are very tight and freshly broken pieces often have a petroliferous odour. Because of the relative hardness of the formation, it is often expressed in the topography, where it forms hard resistant ridges. The thickness varies from 885 feet at the type section to about 2,000 feet at the Dartmouth River section. As with the Cape Bon Ami, the formation thickens considerably towards the southwest to approximately 4,000 feet in the St. John River area.

The Grande Greve Formation conformably overlies the Cape Bon Ami Formation and appears to be conformably overlain by the York River Formation.

Lower to Middle Devonian

Fortin Formation

This formation occupies a stratigraphic position roughly equivalent to the uppermost Cape Bon Ami Formation, the Grande Greve Formation and the lowermost part of the York River Formation (York Lake Series).

It underlies an east-west-trending belt south of the St. John River Anticline and its usage is restricted to this area. In the subject area, the Fortin occurs in the southwestern part of Mosaic Sheet No. 1. The formation consists of dark shaly slates with interbeds of limestones, sandstones and conglomerates. The thickness is estimated to be more than 2,500 feet.

Middle Devonian

York River Formation

In the subject area, the Gaspe sandstones overlie the Gaspe limestones with an apparent conformity. They have been subdivided into the York River Formation and the Battery Point Formation.

The type section of the York River Formation is along the York River and the York Lake area west of the subject area. The formation is often well exposed and occurs throughout much of the subject area. The formation consists of predominantly coarse to medium grained, grey, arkosic sandstones and some greenish shales and siltstones, especially towards the base of the formation. Crossbedding appears to be common, as are intraformational conglomerate beds. The upper part of the formation contains orthoclase grains, which should, perhaps, actually place this part in the overlying Battery Point Formation that is characterized by orthoclase content. The contact with the Battery Point Formation is, therefore, not sharp. As a general field distinction, the York River Formation has been mapped as containing no orthoclase feldspar. There are many oil seeps reported in the York River Formation and in many places oil saturated sands have been observed. The York River Formation north of Gaspe Bay and the Dartmouth River is approximately 1,300 feet thick. It increases in thickness towards the south. At Tar Point and long the l'Anse-a-Brillant River, it is estimated to be 4,500 feet.

In the York Lake area, a succession of rocks occur lying stratigraphically between the Grande Greve Formation and the York River Formation. They have been designated as the York Lake Series. In later mapping these beds have been included in the York River Formation. This has been done because of the practical difficulty of mapping the divisions separately. The York Lake Series consists of interbedded shales, sandstones and limestones, and appear to be a transition zone between the York River Formation and the Grande Greve Formation.

With the possible exception of a small area southwest of the Hay Creek structure, the York Lake Series has not been noticed in the subject area. On several places along the strike a repetition of Grande Greve type limestones and York River type sandstones has been observed. We believe, however, that this repetition is mainly caused by faulting. An oil and gas seep is present in this area, which may indicate faulting. At the northwest end of the structure, along the Stanley Brook, the repetition of Grande Greve limestones and the York River sandstones has not been seen.

Battery Point Formation

The type section of the Battery Point Formation is along the coast just east of Gaspe village. It occurs widely north of Gaspe Bay, along the Dartmouth River and from the Haldimand area southward to the Malbaie River.

Generally, the formation consists of medium to coarse grained grey sandstones, which are locally conglomeratic. Some interbeds of green and red sandy shale occur. The sandstones are often crossbedded and massive; on weathered surfaces the rocks commonly have a pinkish colour. Soils usually are red, especially where the upper part of the formation outcrops. The upper part of the formation consists of various shades of red and brown sandstones, shales and conglomerates.

One of the main points of difference between this formation and the York River Formation is the feldspar content. The sandstones of both formations are feldspathic, but the Battery Point Formation contains, for the most part, orthoclase feldspar. Further, the Battery Point Formation is generally coarser, more pebbly and crossbedded, and contains less shale interbeds than the York River Formation.

The greatest development of the formation is north of St. Majorique and Fontenelle, where the thickness, based on dips and widths of exposures, is estimated to be between 5,000 to 7,000 feet.

Malbaie Formation

In the subject area, the Malbaie Formation extends from Pointe St. Pierre to the Malbaie River north of Malbaie Bay. It has a conformable relationship with the Battery Point Formation. The formation is largely made up of interbedded, usually red, conglomerates, conglomeratic sandstones and sandstones with subordinate interbeds of shales. Individual conglomerate beds are seldom more than two feet thick. Pebbles and cobbles vary from one inch to one foot. Some limestone beds occur within the formation but these were not observed. The thickness is believed to be at least 2,000 feet.

Post-Middle Devonian

Basic Dykes

In the subject area several basic dykes have been mapped. The best known is the one on the northeast side of Forillon Peninsula, outside the subject area, and the one at Tar Point. The dyke at Tar Point is about 35 feet wide. It is a dark grey, fine to medium grained diabase with amygdules that are sometimes filled with liquid petroleum and pitch. Cuttings of basic igneous rocks have been noted in samples from wells drilled in the Gaspe region, but these rocks have not been noted in surface exposures. They were apparently all found in the York River Formation. Their significance, as far as petroleum possibilities are concerned, is that they could, under proper structural conditions, contribute to the formation of traps and they should, therefore, not be completely overlooked.

Pennsylvanian(?)

Cannes de Roche Formation

The type locality of this formation is along the south shore of Malbaie Bay south of the subject area. Good exposures of the formation occur along the Beattie River. The formation rests with unconformity on the Battery Point Formation and the Malbaie Formation. It consists of red conglomerates, red and green shales and sandstones. The minimum thickness of the formation as a whole appears to be slightly more than 200 feet.

Quaternary

Recent and Pleistocene Deposits

Glacial deposits do not appear to be very widespread. It appears from striations that the ice moved from west to east through the valleys of the Dartmouth, York and St. John rivers.

Recent sand and gravel deposits occur throughout the region in the form of river, lagoon and bar deposits. Few of these deposits are very thick over an extended area.

STRUCTURAL GEOLOGY

Regional Structure

The structural features of the subject area are indicated on the accompanying structure map (Figure III) and photogeological mosaics. Figure I shows the accepted subdivisions of the Gaspe Peninsula into three geological belts. The subject area is located in the extreme eastern part of the Northern and Central belts.

The Northern belt is underlain by rocks of Ordovician and possibly Cambrian age, and these rocks are intensely folded, faulted and fractured, and sometimes slightly metamorphosed. These rocks can be considered the "basement" of the Silurian-Devonian succession, which occupies the Central belt. This Central belt can be considered a broad synclinorium in which major and subsidiary anticlines and synclines occur.

The region has experienced two periods of major folding; the Taconic orogeny at the close of Ordovician time, and affecting all Ordovician and older rocks, and the Acadian orogeny in late Devonian time. The main structural trends of the peninsula as a whole were probably established by the earlier disturbance, while the structures shown in the Silurian-Devonian rocks were the result of the later orogeny.

The main period of Appalachian mountain-building was in Permian time, but this folding had little effect on Gaspe as is shown by the flat or gentle dips of the Carboniferous rocks, which in Southern Gaspe overlie folded Devonian formations.

In studying the structure map (Figure III) of the Eastern Gaspe area, two major parallel northwest-trending fault systems become apparent. These may be referred to as the Dartmouth and Third Lake fault systems. The area north of the most northerly fault system (Dartmouth Fault) is almost non-disturbed other than tilted and the Silurian-Devonian beds dip uniformly to the south and southwest.

Major and minor anticlines and synclines appear to originate from the Dartmouth Fault and continue in en echelon fashion towards the west. Some of the folds cross the Third Lake fault system and can be followed for a considerable distance to the west.

A third major east-west-trending structure is the St. John Anticline, which is bordered by two normal faults. The St. John Anticline is an interesting structure as it may have existed during Silurian time. This is inferred from its apparent effect on the Silurian deposition in that area.

Local Structure

One of the major structures in the subject area is the Dartmouth Fault, also called the Northwest Arm Fault or Thrust. This fault originates southeast of Gaspe village and extends in a northwestern direction to Eden Brook, where it swings in a more westerly direction. We believe that the fault is basically an oblique-slip fault in the area northwest of Gaspe village in contradiction to the opinion of other investigators. The southwest side has moved northwestwards relative to the northeast side of the fault, the latter side being downfaulted. It is certainly possible, however, that some reversal has taken place that classifies this fault in this part of the subject area as a reverse oblique-slip fault. At Salmon Hole Brook and farther northwest at Eden Brook, the fault is certainly a reverse fault with an estimated dip on the fault plane of about 40° to 60° south. Here, Silurian and Lower Devonian beds have been thrust on Upper Devonian beds.

Another important fault, which parallels the Dartmouth Fault, is the Third Lake Fault in the York River area. This fault is also believed to be an oblique-slip fault with the southwest side moved northwestwards relative to the northeast side. The downthrown side is on the northeast.

Between the Dartmouth Fault and the Third Lake Fault are a number of broad anticlines and synclines with an east-west trend, changing into a southeasterly trend as they approach the Dartmouth Fault where they seem to die out. Many of the structures have a southeasterly plunge. Some of the structures are rather persistant in that they cross the Third Lake Fault. They are the Mississippi Anticline and the York River Syncline. The location of the axis of the York River Syncline when it crosses the Third Lake Fault is questionable. The Bald Mountain Anticline terminates at the Third Lake Fault. The Champou Syncline lies between the two fault systems. South of Salmon Brook it is replaced by several other subsidiary folds.

South of the broad York River Syncline and outside the project area is the St. John River Anticline. The anticline is a dominant structure of the region and it practically divides the Central belt into a northern and southern part. In the core of the anticline Ordovician beds outcrop. The trend of the structure is east-west with an easterly plunge. On Mosaic Sheet No. 1 the expression of the easterly plunge can still be noticed. The anticline is bordered by two parallel normal faults.

A domal structure northwest of Gaspe village has been called the Hay Creek Structure. Grande Greve limestones form the highest points in this area and this formation is in fault contact with the Battery Point Formation. On the southwest side of the structure the dips are fairly regular to the southwest and south, varying from 20° to 35° with steeper dips lower down the flank. On the northeast side of the fault and close to it, dips in the Battery Point Formation are irregular and vertical and sometimes steeply overturned. A repeated succession of Grande Greve limestones and York River sandstones has been observed on the southwest flank of the structure. We attribute this repetition to faulting. The York Lake Series, which forms a transition between the Grande Greve limestones and the York River sandstones west of the subject area, has not been seen in the subject area. In the northern part of the Hay Creek Structure, along the Stanley Brook, the York River Formation is in possible fault contact with the Grande Greve Formation. There, the repetition of formations has not been observed. An oil and a gas seep on the southwest flank of the structure may also point to faulting. The Hay Creek Structure may possibly relate westward to the Mississippi Anticline.

Closure on the Hay Creek Structure will be controlled by such factors as the character of the faults which flank the structure. The structure is estimated, however, to be approximately four miles by two miles in area.

An interpretation of the Hay Creek Structure in cross section is presented in Figure IV.

Southeast of Gaspe village the Dartmouth Fault branches into several minor faults and folds, one of which is the east-plunging Haldimand Anticline.

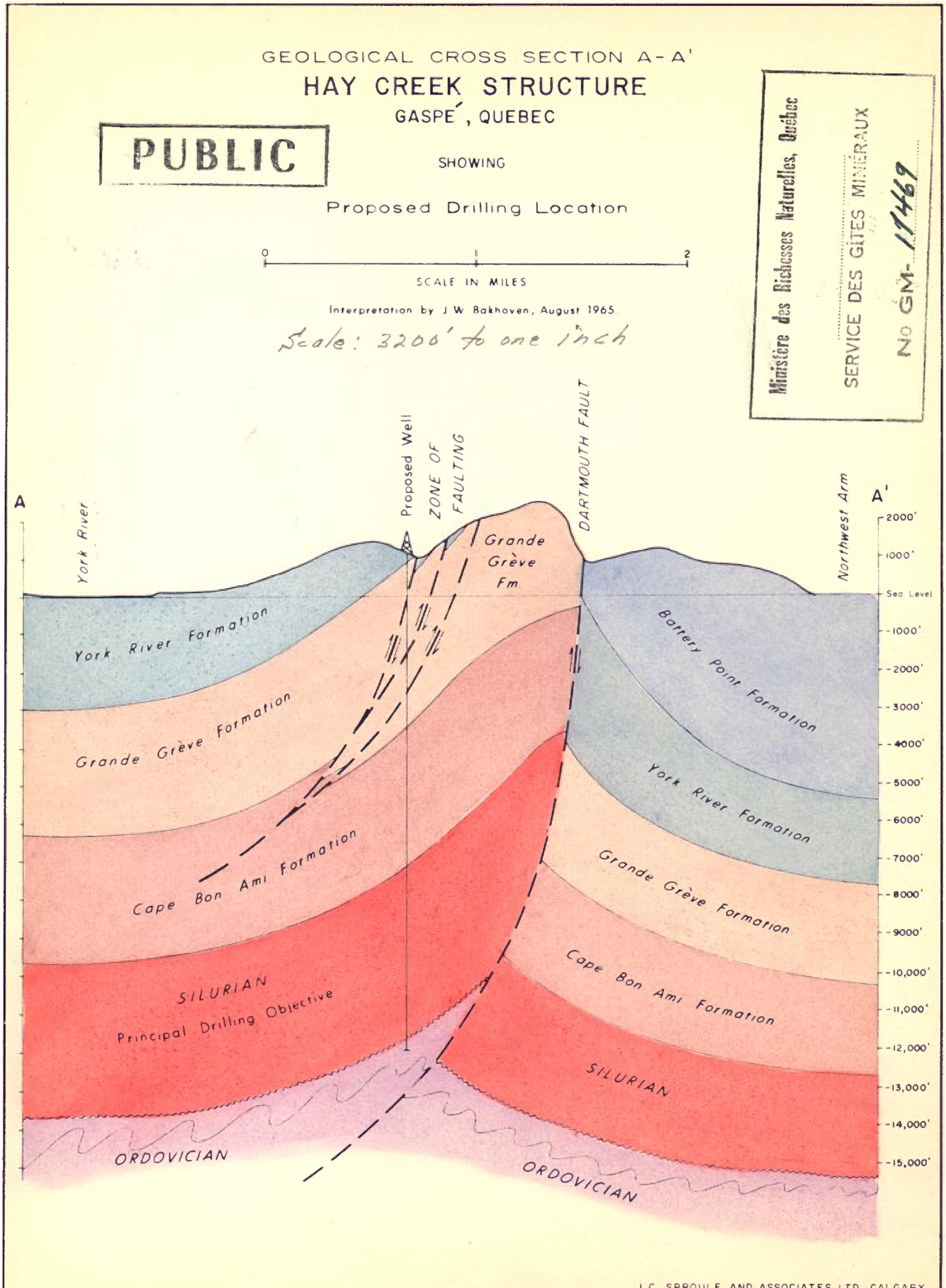
At Tar Point, a well known anticline, named the Tar Point Anticline, has the upper part of the York River Formation exposed in its core. The anticline has an east-west trend and plunges in both directions. It is considered to be a local fold without much bearing on the regional structure.

A possible east-west-trending fault along the l'Anse-a-Brillant River is probably a branch of the Third Lake Fault. Several other faults, many of them having a southeast trend, are shown on Mosaic Sheet No. 1.

From Tar Point to the Malbaie River, a succession of southeast-plunging anticlines and synclines can be observed in the Middle Devonian Gaspe sandstones. Directly north and south of the Malbaie River, the structural trend is more east-west.

It will be noted by those who are familiar with the literature on the geology of Eastern Gaspe that the interpreted structural features may not always agree with those published in previous literature. Many interpretations in the literature are based on more or less reconnaissance mapping without the help of aerial photographs.

To accompany Report to Pennzoil de Quebec Limitee, August 1965. FIGURE - IV



OIL AND GAS POSSIBILITIES

Oil and Gas Occurrences and Indications

Oil and gas occurrences are numerous and widespread through Eastern Gaspe, although gas seepages are less commonly observed as they are generally seen only in water. Gas bubbles can be seen rising to the surface from several old wells that were visited.

The oil occurrences include: (a) pyrobitumen, (b) hard, black bitumen similar to albertite, (c) dry, brown oil in sandstone, which is not soluble in CCl_4 but which gives a petroliferous odour, (d) dry, brown soluble oil (in sandstone) and tarry bitumen, (e) oil and gas in seepages, and (f) oil seeping from old wells.

Table II is a list of oil and gas occurrences in the various formations. Showings of these types were investigated. Table II is presented on the following page.

Table II

Table of Oil and Gas Occurrences

Unit	Pyrobitumen	Hard Bitumen	Insoluble Dry Oil	Soluble Dry Oil and Tarry Bitumen	Oil and Gas Seeps	Oil In Wells	Gas In Wells
Battery Point sandstone						On Haldimand Peninsula only	Rare
York River sandstone		St. John River(1)*	Hay Creek(2)	Tar Point(3)	Tar Point(4) Hay Creek(5)	Common	Common
Grande Greve limestone		In vugs and fractures(7)			Galt Brook(6) and several reported	Common	Common
Cape Bon Ami Limestone						Rare	Rare
St. Leon siltstone						1 Well	2 out of 3
Roncelles limestone							
Griffon Cove River siltstone							
Ordovician limestone, shale and sandstone	Common in vugs and fractures(8)						

*See comments re numbers in brackets on the following pages.

Note: Although few wells tested the Cape Bon Ami and older formations, it is felt that this table gives a fairly reliable indication of the frequency of bitumen and oil in the various rock units. Oil and gas have most commonly been encountered in the Lower York River Formation and in the Grande Greve Formation.

The following paragraphs further discuss the numbered references in Table II.

(1) Hard bitumen occurs in thin layers in York River sandstone on the south bank of the St. John River. The layers are generally less than one inch thick and have previously been referred to as shale. The black bitumen forms fine layers parallel with the bedding and it is associated with a reddish brown resin and probably also with carbonized plant fragments. Similar occurrences of bitumen are probably present in many places, but they may be confused with the plant fragments that are a more common constituent of the York River Formation.

(2) Near Hay Creek, less than two and one-half miles west of Gaspe village, York River sandstones are impregnated with dry brown oil. The sandstones are poorly exposed and appear to be faulted between the Grande Greve limestones. The oil-bearing sandstones were observed at several places. The oil is not soluble in CCl_4. An oil seep reported to the northwest is approximately on strike, but it was not seen by us.

(3) and
(4) Tar Point derives its name from the presence of bitumen in amygdaloidal diabase and in adjacent sandstones. The York River and lower part of the Battery Point sandstones are impregnated with oil about one quarter mile northwest of the Tar Point dyke. Several zones, which are 15 to 25 feet thick, are saturated with oil. The oil can be extracted with CCl_4. Yellow precipitous sulphur often covers the weathered oil-bearing sandstone surface. Zones in the diabase are sometimes impregnated with black heavy oil. At one place the oil could actually be seen coming out of an amygdule.

(5) On the southwest side of the Hay Creek Structure, near the creek of the same name, a gas seep has been "discovered." Gas bubbles rise here slowly from a sulphur spring at intervals of about three minutes. Another gas seep has been observed in the Grande Greve Formation at Salmon Hole Brook.

(6) A seepage of oil was visited on a tributary of the Galt Brook near the Petroleum Oil Trust 41 well. The seepage is fairly large and contains black heavy oil. The oil is probably flowing from a fault in the Grande Greve Formation.

(7) At several locations hard black bitumen has been observed in the Grande Greve limestones. The occurrence of this type of bitumen near Paint Lake was investigated. The bituminous matter seems to be less common than has been indicated in the literature. Vugs are rare in the limestones and only in a few places was some bituminous matter seen on fractures.

(8) Black pyrobitumen lines vugs and fractures in contorted Ordovician sandstones and siltstones at East Cape Rosier and near Cape Rosier light house. The material is not soluble in CCl_4, but burns when kept in a flame.

Many wells drilled in the Gaspe region has oil and gas shows. Several wells were visited during our survey and some of the wells still had oil flowing. Although oil seepage from wells is slow, it has been sustained in some localities for 50 to 75 years.

Origin and Accumulation of Oil and Gas

Potential source rocks for oil and gas do not form part of the Middle Devonian sandstones. Some hydrocarbons may have originated from the Lower Devonian limestone and from the Silurian limestons, although there is little evidence for it. However, freshly broken pieces sometimes emit a strong petroliferous odour. We agree entirely with McGerrigle (1950) who believed that the source of oil and gas must be in the Ordovician beds. He cited the occurrence of Upper Ordovician limestones exposed on the St. John River Anticline, which had a strongly petroliferous odour when freshly broken and which often yielded a faint oil film when rocks were placed in water. Oil-bearing shales of Ordovician age are known in southwestern Gaspe Peninsula. Black bituminous shales of the Ordovician Cape Rosier Formation are also known north of the subject area and pyrobitumen occurs in the sandstones and limestones of the same formation.

Recoveries of oil have been obtained from synclinal as well as from anticlinal structures. The reservoirs seem to be discontinuous.

Prospective Formations

The highly folded and faulted Ordovician beds, which unconformably underlie the Silurian sediments, are unlikely to have accumulations of hydrocarbons. The beds are also generally too tight to form potential reservoir rocks. Oil and gas generating from the Ordovician strata must have seeped upwards through vertical faults and fissures, firstly into fracture-porosity in the Silurian-Devonian limestones and subsequently into the Devonian sandstones, filling available space in the rocks.

Overlying the Ordovician strata are the Griffon Cove siltstones and conglomerates and the Roncelles limestones. The former beds do not show porosity in the localities examined. The basal Roncelles limestones are sometimes coarsely crystalline and locally contain traces of porosity. The reefal facies of these beds where observed showed little evidence of porosity. Also, the reefs that have been observed are very small. Nevertheless, where there are small reefs, larger ones can be developed nearby and it is also possible for massive reefal beds exposed at the surface, which exhibit very little porosity, to have correlative subsurface reefs with good porosity.

The St. Leon and Cape Bon Ami formations are uniformly tight and are not considered prospective as reservoir rocks.

The siliceous Grande Greve limestones locally show small vugs that contain bitumen in some places. Generally, the Grande Greve Formation is tight, however, and the limestone rock itself is not considered to be a potential reservoir rock except where the formation is intensely fractured.

The York River and Battery Point sandstones are commonly porous. Large sandstone lenses could form potential reservoirs for hydrocarbons if impervious caprocks are present. However, continuous shale or mudstone caprock zones appear to be absent, although fine-grained sandstone zones of limited extent and thickness are common in the York River Formation. Relatively small accumulations of oil and gas may be expected, therefore, to occur in the York River sandstones.

In drilling to date the best results were obtained in the upper part of the Grande Greve Formation and the lower part of the York River Formation.

Prospective Structures

Although oil and gas accumulations in Eastern Gaspe are not confined to anticlines, it appears to be advisable to concentrate the initial exploratory efforts on anticlinal structures. We have previously stressed the opinion that hydrocarbons are probably derived from deep seated sources, and that oil and gas must be seeping upward through vertical faults and fissures. This becomes apparent when studying the structure map (Figure III). Most of the reported oil and gas seeps are located near the two major northwest-trending fault systems.

Those localities where anticlinal folding occurs adjacent to transverse and normal faulting are, therefore, considered to be most favourable for oil and gas exploration. Structures of this type within the license area are the Hay Creek Structure and its western extension, the Mississippi Anticline, the Haldimand Anticline and, possibly, the Tar Point Anticline. These structures all have closures with the possible exception of the Haldimand Anticline, which terminates in the southern part of the Dartmouth Fault zone.

Fold structures northwest of the Hay Creek Structure and southwest of the Dartmouth Fault are not considered to be good for the accumulation of hydrocarbons. They die out to the west and may not have closure.

Possible pooling of hydrocarbons may occur in the Silurian strata at the headwaters of the Lady Step Brook, south of the Dartmouth Fault. The Silurian strata underlying the Lower Devonian Cape Bon Ami Formation in this area may have been shattered due to the large scale faulting and the oil may have accumulated in the fractures. The fault may provide a seal to form a reservoir.

CONCLUSIONS AND RECOMMENDATIONS

The Eastern Gaspe appears to be a favourable area in which to search for oil and gas. The relative abundance of oil and gas seepages and the many oil and gas shows in wells, some of which had minor production, suggests that we are dealing with a promising area.

The fracture-porosity in the brittle siliceous Grande Greve limestones and the porous sandstones of the Lower York River Formation are probably the most favourable parts of the Lower and Middle Devonian sections for oil and gas accumulation. Conditions in these beds, however, do not appear to be favourable for the retention of major amounts of hydrocarbons. It is expected that future oil and gas discoveries in the Devonian rocks will be small to moderate in size.

Although our knowledge of the Silurian in the project area is limited, we believe these beds may offer more possibilities for commercial oil and gas discoveries than the younger formations. There are many instances in the geological literature recording porosity and permeability in Silurian rocks. In our own observations we saw little evidence of porosity in Silurian beds but what we did note was the variability in facies in the Silurian rocks, which indicates the possibility for porous reef development.

The Silurian strata decrease in thickness from west to east and, as Figure II shows, we may expect a decrease in thickness from southwest to northeast. Facies changes may occur between the Sydenham River-Forillon Peninsula sections and that of the St. John River section, as indicated by the Silurian beds at Salmon Hole Brook.

It is believed that the Ordovician bituminous shales are the most probable sources of oil in the geological section of the Eastern Gaspe area. Oil and gas have apparently migrated upwards as high as the Devonian formations where most of the known oil and gas shows occur. Very few wells in Eastern Gaspe have drilled as deep as the Silurian but if porous strata are present the prospects for Silurian oil accumulation should be good.

Exploratory efforts should possibly be concentrated near fracture zones, which may be most extensive along systems of strike-slip faulting and other major types of faulting, particularly along the Dartmouth Fault Zone.

Of the structures that we have studied, the Hay Creek Structure is considered the most favourable. We recommend that a deep well be drilled on the Hay Creek Structure, firstly to test the fracture-porosity of the Grande Greve and Cape Bon Ami formations and secondly to test the Silurian formations in this area. The proposed well should start on the flank of the structure in the York River Formation close to the York River and Grande Greve contact. We expect that the Silurian-Devonian contact will be reached at 7,000+ feet and the Ordovician "basement" at approximately 12,500 feet.

The proposed well location is shown on the photogeological mosaics and Figure III. Figure IV is a geological cross section showing our interpretation of the structure. It will be noted that we have placed the proposed location nearly a mile southwest of the surface trace of the Dartmouth Fault. We believe this fault to have a high angle of dip but it may dip less steeply to the southwest than we have indicated in Figure IV, hence the need to place the well where we have it. Furthermore, in this location the well will evaluate possible oil and gas traps in the fault blocks on the southwest flank of the structure.

The drilling of the proposed well will not only be a test of the Hay Creek Structure, but will assist in the evaluation of the extensive prospects along the whole of the Dartmouth Fault system.

A second well may be drilled on the Hay Creek Structure close to the Dartmouth Fault, depending on the results of the first well. On the other hand, it may be advisable to drill further down flank or, if any success in fault traps is encountered, the indicated move might well be along strike.

In the time provided under the terms of the conducted program, we have not been able to do detailed work in all areas of the Pennzoil holdings. It is recommended that more detailed field work be carried out as to the exact nature of the folds northwest of the Hay Creek Structure and in the area of the Haldimand Anticline. The exact angle of the Dartmouth Fault in the Salmon Hole Brook and Lady Step Brook should also be investigated.

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