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REPORT ON PETROLEUM AND NATURAL GAS POSSIBILITIES OF ANTICOSTI ISLAND

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REPORT ON
PETROLEUM and NATURAL GAS
POSSIBILITIES of ANTICOSTI ISLAND
QUEBEC

J.C.Sproule & Associates

Ministère des Richesses Naturelles, Québec
SERVICE DE LA
DOCUMENTATION TECHNIQUE
15 JUIN 1972
Date:
No GM: 27784

REPORT ON PETROLEUM AND NATURAL GAS POSSIBILITIES

OF

ANTICOSTI ISLAND, QUEBEC

J. C. SPROULE & ASSOCIATES
GEOLOGICAL & EXPLORATION CONSULTANTS

901 EIGHTH AVENUE WEST
CALGARY — ALBERTA

TELEPHONES
24128 - 24374

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REPORT ON PETROLEUM AND NATURAL GAS POSSIBILITIES

Of

ANTICOSTI ISLAND, QUEBEC

INTRODUCTION

This study was initiated at the request of Dr. J. D. Bateman and carried out under the supervision of Dr. J. P. Nowlan of McPhar Geophysics Ltd., of Toronto, Ontario, acting for Consolidated Paper Corporation Limited. *

Mr. D. E. Duff, of J. C. Sproule & Associates, carried out a surface reconnaissance during the period June 20 to August 5, 1956, in conjunction with McPhar geologists. This survey included a careful check of the stratigraphic sections as described by Twenhofel(17) and check measurements of his formation thicknesses. Traverses were made on foot and by boat around the coast and a number of the larger rivers were ascended to their headwaters. Outcrops are nearly continuous along the coastal reef and in the cliffs, while rivers generally show outcrop only for the first few miles. This confirms the general conditions described by Twenhofel and other workers.

Field observations agree in general with the formational divisions as made by Twenhofel. However, these divisions were evidently made on the basis of index fossils of short vertical range and comparative rarity, and are of little use in an attempt to map lithologic units. His remarks on the marked facies changes within his formations from the southwest to northeast coasts can be applied on a micro scale. Many rapid and local changes were noted and it is concluded that exact zone by zone correlation is very difficult, if not impossible. This in itself is not an unfavorable feature, if other methods can be used to work out the regional structure. In fact, such changes may result in stratigraphic traps under favorable conditions. This point is discussed later under petroleum possibilities.

In addition to the field studies, a photogeological interpretation of the Island was carried out by H. L. Cameron. The results of this are given on the accompanying map, Figure I. The formational boundaries were traced between the known coastal and river sections and several faults were recognized and plotted. These faults, and the hitherto unmapped large folds constitute new and important geological data. They are discussed later under petroleum possibilities.

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(17) W. H. Twenhofel, 1927. Number refers to Bibliography at end of report.

For graphic presentation an airphoto mosaic was also constructed and presented as Figure II, East and West Sheets, and all data from all sources are given thereon. Also shown are the wellsites selected on the basis of an analysis and interpretation of this and all other relevant data.

ACCESS AND PHYSIOGRAPHY

Anticosti Island is located in the mouth of the St. Lawrence River approximately two thirds of the way between the Gaspe coast and the north shore. It is roughly elliptical in shape with the long axis at about N 65° W. It is approximately 137 miles long by 35 miles at its widest point and comprises some 3,875 square miles.

The Island is accessible by sea and air. The Anticosti Shipping Company maintains a summer schedule from Quebec City and Gaspe, and a local schedule from Gaspe to Port Menier is open for a longer period. Quebec-Air provides local air service from Gaspe and Seven Islands.

Travel around the Island is largely by boat, but a small road network for logging operations extends from Port Menier on Ellis Bay to the north and eastward for some 45 miles. The majority of the rivers are not navigable by boat or canoe. Exceptions are the Salmon and Jupiter, which are navigable by small boat and canoe for parts of the year.

Anticosti Island is, physiographically, a partly submerged cuesta, underlain by middle and upper Ordovician and lower and middle Silurian sedimentary rocks. These formations have a low regional dip to the south which shows clearly in all the coastal sections, while inland the strata appear to be horizontal over large areas. This is probably due in part to the difficulty in obtaining strikes and dips in such low-dipping beds. The horizontal areas probably represent terraces formed by folds whose axes parallel the general trend of the bedding, as discussed later under petroleum possibilities.

The scarp of the cuesta faces north with the dip slope to the south. This results in higher ground near the north coast, with heights up to 625 feet. The present drainage divide is approximately two thirds of the way toward the north coast, but many examples of stream capture and reversals of drainage were noted. All but the smallest streams show several stages of erosion with mature valleys, fall lines and rapids. These, together with the large number of marine terraces, which extend from the present marginal reef to the highest parts of the Island, indicate both eustatic and isotatic changes in sea level. In both cases the Island appears to have acted as a regional unit and was not warped or tilted locally. The general horizontal position of the terraces tends to confirm this supposition. This is important in that it refers all fold structures, such as bedrock terraces, to tectonic causes rather than to local post-glacial uplift or warping. The present marginal reef is the most important terrace because it provides an excellent and nearly continuous section around the present coast line. The higher terraces tend to mask the bedrock and can easily be confused with rock outcrop.

GENERAL GEOLOGY

The stratigraphic section exposed on Anticosti Island comprises thin bedded limestones and shales, with minor amounts of sandstone. It forms one of the most complete sequences of late Ordovician and early Silurian deposits in North America. Geological exploration began in 1856 with the work of James Richardson[10] of the Geological Survey of Canada. His basic divisions have remained unchallenged, but the formation divisions were later modified and refined by Schuchert and Twenhofel[14]. Twenhofel returned in 1919 and his findings were published as Memoir 174[17]. This remains the most complete publication and was used as a guide in the field examination of the Island.

The following Table of Formations is taken from Page 15 of Memoir 154. Richardson's section, with modern equivalents in brackets, is also given with the letters A to F, which he used to define the formations, shown in relation to Twenhofel's formational names.

Table of Formations

	Richardson	Schuchert and Twenhofel	Character and Thickness
Silurian	Niagaran (Clinton)	Chicotte (F)	Limestone, 73 feet.
		Jupiter (D & E)	Limestone and shale followed by limestone. 653 feet.
	Anticostian (Medina)	Gun River (D)	Alternating limestone and shale. 308 feet.
		Becscie (C)	Limestone with shale partings. 199 feet.
Ordovician	Gamachian (- -)	Ellis Bay (C)	On south shore, shale and limestone. On north shore, sandstone followed by limestone. 200 feet.

(10) James Richardson, 1857.
(14) Chas. Schuchert and W. H. Twenhofel, 1910.
(17) W. H. Twenhofel, 1927.

	Richardson	Schuchert and Twenhofel	Character and Thickness
Ordovician (Cont'd)	Richmondian (Richmond)	Vaureal (B)	Limestone and shale interbedded. 730 feet.
		English Head (A)	Limestone and shale. 228 feet.
	Mohawkian (Trenton-Black River)	Macasty	Black shale. (?) feet.

The total measurable thickness for the two systems is 2,301 feet, but as both the base and the summit are concealed, the thickness as given must be considered a minimum. The underlying formations, which occupy the Mingan Passage, are of unknown age and character, but they are believed to be of middle or lower Ordovician age, equivalent to the Trenton group of the St. Lawrence lowlands. The Mingan Islands comprise the Mingan formation of lower Ordovician (Chazy) age, and the Romaine formation of Lower Ordovician (Beekmantown) age. The former is limestone with a basal conglomerate or sandstone, while the latter is thick-bedded dolomite with chert nodules and cavities. A basal sandstone is possibly present, but it has yielded to erosion and is represented by the channels between the islands and the Precambrian north shore of the St. Lawrence. The contact with the Precambrian is nowhere seen. The Potsdam sandstones of Cambrian age, which form the basal members of the St. Lawrence lowland section, are not represented, but may be present downdip where overlapped by the Ordovician and Silurian strata.

No marked evidence of fold structures, other than local folds, was encountered in the field work. Faulting appeared to be minor, but the many gaps in the shore sections and the monotonous similarity of the strata can easily account for failure to recognize major faults. Two sets of joints are present, the most prominent set striking with the strata, while the secondary strikes about 65° to the primary. From the airphoto analysis, the former are strike joints which follow the strike of the bedding through their undulations. The secondary set appears to maintain about the same angle with the primary. Both would appear to be early structures formed before any appreciable folding had occurred. Other joints are present which closely parallel major fault directions. One set parallels the two igneous dykes of the de Puyjalon cliff area.

Igneous rocks are limited to two small diabase dykes on the north coast at du Puyjalon cliff. These dykes are approximately one half mile apart, with the larger on the west having a strike of 315° and a width of 50 to 60 feet.

The east dyke is 27 feet in width and strikes 330°. The age of these dykes is post-Ordovician, probably late Devonian. The strike of these dykes, as given by Twenhofel, would appear to be in error.

Description of Formations

Macasty Formation

The Macasty black shales are not found in place on the Island, but form a good percentage of the north shore beach debris from English Head to Girard Cove, a distance of about 75 miles. Fragments were observed as far east as Fox Bay and a few pebbles were found along the south coast.

This formation comprises mainly soft black bituminous shales, which yield a pronounced petroliferous odor on fresh fracture. Several pieces examined in Makasti Bay showed considerable pyrite. Fossils, particularly graptolites, were observed.

The thickness and its relation to the English Head formations is unknown, but it is probably disconformable to the English Head, and is brought close to the shoreline in the trough of the south-plunging syncline whose axis forms the submerged ridge between Anticosti and the western Mingan islands. The age of this formation is that of the Trenton or Black River.

English Head Formation

The English Head comprises alternating beds of blue, grey and green shales, and argillaceous and crystalline limestones. Many of the limestones are composed of whole or fragmentary shells. Intraformational conglomerates of pebbles, boulders and slabs of limestone were observed. Ripple marking is common and many of the beds are lenses of very small size. All these features indicate a shallow water depositional environment.

The base of the formation is unknown and representative sections are difficult to find. The type section at English Head shows interbedded brown, dense limestones and green and grey-green fissile shales. Many of these shales are composed almost entirely of bryozoans. Thin conglomerates are common with the individual boulders ranging up to two and one half feet in diameter. All the beds are lensy, particularly the conglomerates, and no good marker beds were seen.

The English Head-Vaureal contact is generally recognizable because of the presence of the so-called "track bed," which is a grey-brown, thin-bedded, dense limestone, covered with cylindrical paired impressions (Saerichnites abruptus) which are thought to be cephalopod tracks. This stratum is taken as the highest bed of the English Head. In general, the overlying Vaureal formation is more shaly, but the contact can be best described as gradational. From the sections observed, the assigned thickness of 228 feet appears reasonable.

Vaureal Formation

Lithologically, the Vaureal is similar to the underlying English Head, being mainly thin-bedded limestone and shale. From field observation, the Vaureal would appear to be more argillaceous and on many cliff faces the exposed outcrops show a distinct blue-green color. Where observed, the Vaureal comprises thin-bedded, soft, fissile to crumbly, green shales, with minor brown, dense, sometimes fossiliferous, limestones. In the western end of the Island, the Vaureal is a shale-limestone-shale sequence, while on Riviere a L'Huile, it is predominantly shale.

The Vaureal-Ellis Bay contact was readily located at Strawberry Cove, Riviere a L'Huile, Salmon River, and on the east side of Point Joseph. At the contact a change, often abrupt, from blue-green shale to a thin-bedded limestone was noted. On Point Joseph, the highest zone of the Vaureal comprised highly arenaceous shale, shaly sandstone and impure limestones, grading into the massive sandstones of the overlying Ellis Bay formation.

No complete section of the Vaureal was observed, but the upper and lower contacts were checked on Riviere a L'Huile and on the west end of the Island and thicknesses of 685 and 715 feet were measured.

Ellis Bay Formation

The Ellis Bay formation is not markedly calcareous, with the limestones as a rule occurring as thin bands between thicker bands of shale. On the northeast coast a sandstone phase is present which does not occur on the south coast. Ripple marks are common and a few conglomerates are present.

No complete section of the formation was found on the west end of the Island. An excellent section on the north coast was seen and measured, described as follows:

Section - Fox Point to Grindstone Cove (Descending Order)

Thickness (Feet)	Formation	Description
70	Limestone	Brown, dense, tight, argillaceous, with coral heads common. Occasional lensy interbeds of grey-brown, dense limestone, with grey-green to green shale and small lensy conglomerates. Top of zone characterized by a continuous conglomerate of well rounded, grey, dense limestone pebbles with a grey shale matrix.
2-10	Limestone (Reef development)	Brown to light brown, small bioherms ranging from 2 to 8 feet in height and 2 to 12 feet in length. Composed almost entirely of corals. Reef developments are small and laterally grade into brown, highly fossiliferous limestone.

Thickness (Feet)	Formation	Description
14	Limestone and shale	Thin-bedded, brown and grey-brown, dense limestone. Grey-green fissile shale.
1	Limestone	Brown, dense, argillaceous, highly arenaceous, in part a calcareous sandstone.
44	Limestone and shale	Interbedded brown and grey, dense, locally fossiliferous limestone. Grey-green and grey fissile to blocky shale, one to three inches thick. Local intraformational and mudball pebble conglomerate.
18	Shale	Green, crumbly, hard, with cobblestone appearance. Limestone nodules, concretions (?) appear to be leached from limy shale. Hormotoma gigantea Present.
1	Conglomerate	White, medium-grained, tight, slightly calcareous quartz pebbles up to 3/4-inch.
22	Sandstone	Grey, fine-grained, tight, quartzose, micaceous, argillaceous. Few thin grey shale interbeds and lenses.
6	Shale	Green, crumbly, indurated, arenaceous, highly fossiliferous. In part a green-grey argillaceous limestone.
42	Sandstone	Grey, fine-grained, abundant ostracods.
47	Sandstone	Green, brown to light brown, fine grained, micaceous, lensy, cross-bedded. A few lenses of grey-green, blocky to fissile shale.
275		

While exact identification of the zones described by Twenhofel was not possible, correlation in the observed sections of the Ellis Bay was made by three rather distinctive features, namely a green nodular shale containing Hormotona gigantea, a reef development zone, and an upper conglomerate zone.

The sandstone phase in the north shore is believed to be local in character. No arenaceous material was found in the lower Ellis Bay on the west end of the Island, while on the Salmon River, only 22 feet were seen. The north shore section, on the other hand, shows some 117 feet. This sandstone phase shows every indication of a local basin of deposition. On the west side of Prinsta Bay, a large scour channel filled with conglomerate was noted.

The contact with the overlying Becscie formation was seen on the west side of Ellis Bay and at Fox Bay, where the basal conglomerate is well exposed. The conglomerate is lensy and is composed of grey, dense, indurated, well-rounded pebbles, boulders and cobbles of limestone, with a grey shaly matrix. The contact is rather abrupt and the lensy nature of the overlying Becscie contrasts sharply with the underlying evenly bedded, thin-bedded shales and limestones of the Ellis Bay.

Becscie Formation

The Becscie formation is a series of thin-bedded, brown, tan, grey-brown and grey, dense to crystalline limestones, with thin grey-green shale partings, locally micaceous and highly calcareous. The formation, where observed, is lensy, and the lower portion on both coasts contains many small intraformational limestone conglomerates. The south shore section is quite uniform from top to bottom, except as noted above, but on the north shore the upper portion includes a thick, dark, grey-green shale zone. Small lenses and bands of highly fossiliferous limestone are characteristic of this formation in both the north and south shore sections.

The upper contact of the Bescie was only seen on the nearly inaccessible cliff faces on the north shore of Baie Innommee. The south shore section has no cliffs and a traverse of the reef in the vicinity of St. Mary Cliff showed a gradational change into the overlying Gun River formation.

No continuous or measurable section of the Becscie was found. The 200 feet thickness given by Twenhofel would appear from field observations to be correct.

Jupiter Formation

The Jupiter formation comprises a series of shales on the south shore and limestones and shales on the north shore. The limestones are grey-brown, dense to crystalline and locally argillaceous. In many sections the limestones are rubbly, while in others they are shell limestones composed entirely of shells of Stricklandinia. The shales are green, grey-brown and grey. They are fissile to blocky and, in places, arenaceous and often highly fossiliferous. In general, the shales predominate over the limestones in the lower portion of the formation, while limestones become dominant in the upper portion.

Continuous sections are not found on the east and southeast except along the east end of the Island. At East Cliff, 200 feet of good section was measured. An excellent reef zone is exposed here with bioherms up to 26 feet in height. Some of these are reflected in the overlying beds where small compaction anticlinals were noted. These tend to disappear vertically.

An excellent section of the Jupiter formation extends from near Southwest Point to a point three miles west of the mouth of the Jupiter River. This section checked with the zones assigned to the Jupiter by Twenhofel. The measured section is given below:

Section - Cape MacGilvray to Southwest Point (Descending Order)

Thickness (Feet)	Formation	Description
90±	Concealed	
44	Limestone	Light grey-brown, dense, tight, rubbly to thin-bedded (1/2 to 6 inches). Abundant fossils (brachiopods) in thin lensy bands.
32	Limestone	Brown to grey-brown, dense, tight, with thin green shale partings increasing in number.
28	Limestone	Brown, dense, tight, unfossiliferous, thin-bedded (3 to 5 inches), with 1/2 to 1 1/2 inches green-grey fissile shale partings.
23	Limestone	Brown, dense, tight, similar to foregoing, but have a decidedly rubbly appearance.
8	Limestone and shale	Limestone brown to grey-brown, dense to crystalline, from 1/2 to 2 inches thick, very fossiliferous, with some beds composed entirely of fossils of Stricklandinia, crinoid stems and brachiopods. Shale is light grey-green, fissile, beds lensy to continuous, 1/2 to 3 inches thick.
43	Limestone and shale	Limestone dark brown, grey-brown and brown, dense, in 2 to 4 inch bands. Shale is grey-green to green, fissile, in 1 to 4 inch bands. More shale than limestone.
22	Limestone and shale	As above. More massive appearing than preceding 43 feet. Limestone predominates over shale.
110	Shale and limestone	Grey, fissile to somewhat blocky. Few fossils, some graptolites and trilobites observed, locally quite calcareous and in part a highly argillaceous limestone. Considerable variations in shale/limestone ratio. Contact with overlying limestone and shale beds is sharp.
77	Shale	Green-brown to brown-green, blocky and fissile, relatively barren of fossils. Some arenaceous shales and shaly siltstone bands 1/4 inch thick. Latter slightly micaceous.
13	Limestone	Brown, dense, tight, thin-bedded, slightly argillaceous.

Thickness (Feet)	Formation	Description
0.9	Limestone	Grey, crystalline, crinoidal, very similar to Chicotte Zone No. 2.
65	Shale	Grey, blocky, rubbly, partings 1/2 to 8 inches thick. Thin-bedded, brown, dense, rubbly limestone bands 1/4 to 3 inches thick. Fossiliferous (Stricklandinia) section is predominantly shale.
465.9		

The Jupiter formation, with its thick shale zones and reef developments, indicates a deeper water depositional environment as compared with the preceding formations. Facies changes are definitely indicated from the varied rock types of the east and west sections. For example, the reef exposed at East Point has for its correlative the thick shale zone on the west shore.

The contact of the Jupiter with the overlying Chicotte formation was observed in most of the streams from Southwest Point eastward to a point three miles west of Pavillion River, where the Chicotte passes out under the sea.

Thickness of the Jupiter formation as measured on the west side was found to be 556 feet as compared to Twenhofel's 563 feet. An estimated thickness of 450 feet was obtained for the east coast, compared with 434 feet by Twenhofel.

Chicotte Formation

The Chicotte formation consists of coral reef and crinoidal limestone without bedding, and inter-reef deposits of well-bedded crystalline and crinoidal limestone. The formation is divisible into a lower, grey to green-grey, coarsely crystalline, well-bedded limestone, and an upper, pink to white, coarsely crystalline, crinoidal and coral limestone, with locally massive structure. The unit has thin, 1/2 to 1 inch, green shale partings, Locally, the joint pattern is infilled with selenite, and small stylolites were observed. The top of the section is readily distinguishable from any of the Anticosti series, but the lower zone is transitional into the underlying Jupiter formation.

An excellent section is exposed on the Chicotte River. It is given below:

Section - Chicotte River (Descending Order)

Thickness (Feet)	Formation	Description
51	Limestone	Pink to white, coarsely crystalline, crinoidal, small local structures, reefs, 2 to 4 feet thick, a few large well preserved corals.

Thickness (Feet)	Formation	Description
27	Limestone	Grey to grey-green, and green-brown, coarsely crystalline, with thin green fissile shale partings. Highly fossiliferous, abundant brachiopods, particularly (Stricklandinia) which make whole layers of limestone, together with Atrypa.
78		

The upper limits of the formation are unknown as it is truncated by the sea.

Locally small anticlinal structures were observed in the Chicotte River and at Southwest Point several well exposed small eroded anticlines were observed. These have some 20 to 25 feet of closure and appear to plunge to the southwest.

The measured section of the Chicotte was 78 feet, which checks closely with Twenhofel's 73 feet measured in the same vicinity.

STRUCTURAL GEOLOGY

General

Anticosti Island appears to be a monoclinal structure with a general inclination southwest away from the shield basement which outcrops to the north. The dips are in general below 3° and inland appear to be even lower, or to be horizontal. However, the greater inclinations on the north and south coasts may be due to local frost heave and the apparent flatness inland may be due to the difficulty of obtaining dips in areas of badly weathered outcrop. The east and west coast reef sections confirm the general south dip.

Folds

The strata have been folded into a series of major gentle undulations whose axes trend north-south and plunge southward. To accommodate this regional folding, local folds and crumples developed on the limbs of the larger folds. The axes of these local folds usually have strikes dependent on their position on the major undulation and probably also partially due to the properties of the local sediments. Some are related to compressional forces after faulting. They all plunge southward with the main folds. In contrast with these major and minor folds, all apparently related to compressional forces operating in an east-west direction, there exists a number of local undulations whose axes trend northeast-southwest, parallel to the strike of the strata, e.g., at East Cliff and on MacDonald River. These are the result of forces acting in a north-south direction and may be related to the compressional forces of the Logan fault, or be the results of couples created by east-west compression. They are the only truly closed structures in the area, and as such, are discussed under petroleum possibilities.

Joints

Two pronounced joint systems exist. The primary system ("A" on the map) constitutes strike joints and in general parallels the strike of the bedrock. The secondary "B" system usually strikes at approximately 65° to the "A". In both systems the joint planes are vertical or nearly vertical. In addition to these two well-defined systems, many other joints are found which appear to parallel faults or gash fracture directions. Examples are the well-defined fractures which parallel the du Puyjalon dykes and the jointing parallel to the Jupiter River fault. Many of the joint planes of all types are filled with white crystalline to massive calcite.

Faults

Field work confirmed the existence of many small faults which appear to be related to the local folding. Airphoto evidence indicates a number of large faults which divide the Island into a number of large fault blocks. (See Map, Figure I, [redacted] Mosaics, Sheets "E" and "W"). These faults are probably the result of continued east-west compression. Movement of these blocks relative to one another has resulted in the development of local folds, the axes of which do not parallel the axes of the major undulations and in one case, near Cap de Rebast, are obviously related to a local thrust fault. In general the west end of the Island shows more faulting and local folding than the eastern portion. This is probably due to the marked facies change, with the increase of sandstone and more massive beds in the east resulting in less disturbance. The faulting and fault block pattern are of importance structurally and are discussed under petroleum possibilities.

Summary of Structural Features

Anticosti Island appears to be a part of a regional south-dipping monocline. The strata comprising this monocline have been folded into a series of broad open folds, the axes of which trend approximately north-south. Many secondary local folds and crumples exist which plunge with the major folds and are clearly related to the primary major folds.

A number of major faults exist which form a fault block mosaic. Faulting is more prevalent in the west than in the east portion of the Island, this being due most probably to the more massive character of the strata in the east. Movements of the fault blocks relative to each other have resulted in small secondary folds, which in some cases are clearly related to local fault movements.

A small number of local folds exist, the axes of which parallel the regional strike of the bedding. These are attributed to north-south compressional forces related to the Logan fault or to north-south compression caused by east-west compressional couples.

The local east-west folds and the major fault blocks are of structural interest with regard to possible petroleum occurrences and are discussed under petroleum possibilities.

ECONOMIC GEOLOGY

General

No significant metallic deposits were noted. Weak sulphide mineralization was observed east of Fox Bay, but would appear to be of no importance. Magnetite sands are quite common along the beach, particularly in the bay at Southwest Point, but are low in magnetite and have considerable garnet. These are of glacial origin and are of no economic importance.

The majority of the limestones are lenticular and impure and are not suitable for any economic use. The Chicotte is an exception, being very pure, and, in some sections, uniform in texture. It could possibly be used for building stone, cement or flux in metallurgical operations.

The sandstones of the north shore are impure and lenticular, and would appear to have little apparent economic value.

Gravel deposits are present over most of the Island and form important sources of aggregate for concrete and road material.

The aeromagnetic map shows little significant trend with regard to the strata now exposed at the surface. It is probably a basement plus topographic picture and, in the former connection, has proved useful to the present study. Alignment of aeromagnetic contours in the western section appear to confirm the Otter River-Riviere a l'Huile fault. They also tend to confirm that the Otter River-Ellis Bay block is uplifted relative to the blocks to the east and west. These points of similarity are important in that they indicate that the surface fracture pattern is a reflection of basement fractures. In the eastern half of the Island aeromagnetic trends parallel the Broom Bay-Salmon River fault line. In some areas this could be attributed to topography, but in many others the trends are transverse to the topographic features.

Petroleum and Natural Gas Prospects

No oil or gas seeps were observed on Anticosti Island. Marsh gas occurrences were noted in almost every swampy area visited, and in many places iridescent films caused by iron salts or tree resins were observed on many pools.

Exposed formations of the Anticosti series do not present encouraging reservoir conditions. However, the lenticular nature of the rocks, together with the facies changes from east to west, do offer possibilities downdip. The occurrences of bioherms and the porous nature of some of the shell limestones, both exposed and beneath the surface, are also encouraging. These features must also be considered in connection with the underlying strata between Anticosti and the Mingan Islands. These comprise the Black River, Trenton, Lorraine and Macasty, all of Ordovician age. The Macasty, in particular, shows traces of petroleum and must be regarded as a possible reservoir or source rock.

Petroliferous dolomites, of possible Chazy or Trenton age, are also found in the Island drift and are similarly encouraging.

The Potsdam sandstone of Cambrian age is extensively exposed and known in the St. Lawrence lowlands west of Quebec. Good reservoir possibilities exist in this formation, which probably underlies the Anticosti series and which should be overlapped with a disconformable relationship.

Potential oil structures might be grouped under (a) stratigraphic and biohermal traps, and (b) fold and fault structures.

(a) The lenticular nature of the Anticosti Series has been described above. The English Head has lenses of shell limestone and intraformational conglomerate; the Vaureal being similar.

The Ellis Bay is more uniform locally, but shows a marked facies change from west to east, with sandstones replacing shales on the northeast coast. Similar facies changes downdip are possible and offer possibilities for stratigraphic traps.

The Becscie is also lensy, with intraformational conglomerates. Lateral facies changes were also noted.

The Gun River is notable for its coral zones which are reef-like in places. The basal zone on the south shore in particular shows abundant corals. The remainder of the formation is lensy.

The Jupiter shows facies changes from north to south shores from shales to limestones. The northeast shore shows an excellent reef zone with bioherms up to 20 feet in thickness.

The Chicotte is mainly coral reef in the upper zone, with bedded limestone in the basal portion.

The foregoing brief resume of facies and bedding characteristics shows the possibilities of trap formation by bioherm or lens development downdip in the various formations.

The possibility of the existence of the Cambrian Potsdam sandstone has been mentioned. This basal member of the St. Lawrence Lowland group almost certainly exists downdip from the Mingan Islands. The later strata of the Beekmantown, Chazy and Black River have overlapped it and extend over the shield rocks. The exact extent of the Potsdam can only be determined by drilling, but the possibility is good that it does underlie Anticosti Island. If it does so, it would form an excellent potential reservoir rock.

(b) With respect to fold and fault structures, the strata of Anticosti have been folded in a series of major gentle undulations, the axes of which trend north-south and plung south. The general monoclinal dip is confirmed by

the coastal sections. In a number of places, e.g. MacDonald River and East Cliff, reversals of dip are known, forming closed structures. Similar structures may also exist inland where horizontal strata have been reported. They are probably more common than supposed, but are difficult to detect because of the low dips. These local folds, the axes of which parallel the regional strike of the rocks, are believed to be the result of compressive forces acting in a north-south direction. Such forces could have been the result of movements on the Logan-Champlain thrust fault, which probably passes south of Anticosti, or they could be the result of compressive east-west forces acting as a couple. The former is more likely, and indirect evidence of possible interbed strike faulting suggests that the forces acted from the south. Depending on the mode of formation, these folds may die out at depth, or they may increase in size. This can only be determined by drilling. The known closures at the surface do not offer any encouragement for large accumulations of oil or gas, but if the folds increase at depth they could be important.

The fault pattern of Anticosti is shown on the accompanying Figures I and II. The western section from the Jupiter River to West Point shows the greatest development of faulting and is, therefore, the most interesting from a structural standpoint. The major faults appear to have resulted from east-west compression and are probably attributable to movements of basement blocks on pre-existing faults. None of the faults show indications of large movements, but the lack of key horizons and other factors make estimates difficult.

The most important faults are the Ellis Bay, Otter River, Jupiter River and Broom Bay. The block between the Jupiter River and the Ellis Bay faults is believed to have moved upward relative to the blocks to the east and west. This area is considered to have the best structural possibilities for petroleum and natural gas accumulation.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of all the available evidence from field work, air-photo interpretation, interpretation of aeromagnetic and geological maps, it is concluded that:

Anticosti Island is favorably situated from the standpoint of its position in the Appalachian Sedimentary Basin. Excessively deep drilling will not be required to test the area. It is estimated that a 2,500 to 3,000-foot hole would be required to test the full stratigraphic section on the Island.

The rock types and facies, including possible source and reservoir rocks, form a potentially favorable environment for oil and gas accumulation.

There is a good possibility that stratigraphic, overlap, or biohermal traps exist under the Island.

There is a good possibility that structural traps due to folding and faulting exist under the Island.

It is quite possible that the Champlain fault, or a related supplementary fault, may separate Anticosti Island from the north shore. If such is present potential petroleum and natural gas reservoir conditions would be greatly improved.

If Anticosti Island is not a cuesta caused by faulting, it has probably been caused by a change in dip. In any event, a drill-site located along the northern side of the Island would be indicated.

It is probable that the prominent fault and joint patterns that show on the air-photos as well as on the outcrops are related closely to deep-seated structural relief, probably at the Precambrian. It is known that such areas are of particular significance for the occurrence of favorable reservoir conditions and favorable petroleum and natural gas source conditions.

With the above in mind, the western end of the Island is of particular importance.

It is recommended that at least one deep test hole be drilled to obtain structural and stratigraphic information and to test the petroleum and natural gas possibilities of the area. With this in mind, we have worked out three possible locations, as presented on the accompanying Figures I and II. At all three sites the Vaureal formation is at the surface. The approximate depth to the basement is 2,500 feet for the hole near Cap de Rebast, 2,800 feet for the hole near Lake Faure, and 2,500 feet for the hole near Girard Cove. These depths include an estimated 100 feet for the Potsdam sandstone, if present. The Potsdam may not be present, or it may reach an estimated maximum of 300 feet. However, its thickness is more likely to be relatively small in this area, where it may be pinching out updip.

Of the three alternative locations recommended above, we would favor the easternmost, near Girard Cove.

D. E. Duff

D. E. Duff, P. Eng.

H. L. Cameron

H. L. Cameron

J. C. Sproule

J. C. Sproule, P. Eng.

901 - 8th Ave. West,
Calgary, Alberta,
November 9, 1956.

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