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A HYDROCARBON EVALUATION OF THE OIL CONCESSION IN WESTERN NEWFOUNDLAND

by

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A HYDROCARBON EVALUATION OF THE OIL CONCESSION IN WESTERN NEWFOUNDLAND

INTRODUCTION

The purpose of this report is to serve as a guide in delimiting areas within the oil concession in Western Newfoundland regarded by the writer as unfavourable to the accumulation of gas and oil and indicate areas where further exploration could be carried out with the maximum expectance of encouragement. A recommendation is made to relinquish certain areas on the grounds that they have no economic hydrocarbon potential based on present day geologic concepts. The following report, along with the accompanying maps presents the results of the writer's brief survey of the area.

LOCATION

The precise area of study involved the "Brinex Oil Concession," which includes the sediments of Western Newfoundland, (see Map II). Waters of the Gulf of St. Lawrence delimit the western extension of the observable strata, while to the east the basin is terminated by crystalline rocks of the Long Range Mountains.

GENERAL GEOLOGY

A marked unconformity separates the Precambrian from

the overlying sedimentary envelope which ranges in age from Lower Cambrian to Pennsylvanian. Miogeosynclinal limestones, dolomites, shales, and sandstones of Cambrian and Early and Middle Ordovician age underlie much of the westcoast north of the Port au Port Peninsula. These are overlain by eugeosynclinal black shales, conglomerates, limestones and volcanic rocks of Middle Ordovician age. Mississippian and Pennsylvanian continental-type sandstones, limestones, shales, gypsum, and coal occur south of the Port au Port Peninsula. Foliated basic and acid intrusive rocks of Pre-Devonian age make up the Bay of Islands Igneous Complex and foliated granitic intrusive rocks of Precambrian age constitute the Indian Head Intrusive Complex. The above two complexes have been intruded into the sedimentary column causing a marked metastasis effect on the neighbouring rocks. Pre-Carboniferous and Post-Ordovician acidic to basic intrusive and metamorphic rocks underlie the Long Range Mountains, with Carboniferous rocks being f[illegible]ted against this Range in the southern part of the Concession. Ultrabasic and basic volcanic rocks are interbedded with and cut upper Humber Arm strata (Middle Ordovician) north of Stephenville.

The structure of the entire area is complex, but the main structural trend is northeasterly as in other parts of Newfoundland. The Long Range fault extends from the south coast in a northeasterly direction to the north end of Grand Lake and

probably beyond that to White Bay on the north coast of Newfoundland, (see Map I). A pronounced offset in the Long Range Mountains occure in the region of Bonne Bay. To the south of Bonne Bay the crystalline rocks of Long Range and the sediments of the Cambrian and Ordovician outcrop well to the east of the principal ultrabasic plutons. North of Bonne Bay these rocks are offset to the northwest parallel to the extension of the Complex. Due to the time factor it was not possible to investigate and determine if this offsetting was due to a flexure or a transverse fault resulting from the thrusting of the Long Range rocks to the northwest. The trend of the dislocation however is parallel to those of the major faults within the Complex. Widespread evidence of minor and major faulting was observed along the entire fault line scarp of Long Range, but the absence of key beds prevents an estimate as to their magnitude.

RECOMMENDATIONS AND CONCLUSIONS

Following a short study of the sediments of Western Newfoundland which is indicated on the two maps accompanying this report the following evaluation and recommendations are put forward.

Reviewing the scattered field evidence presented at this time it seems safe to assume that rocks in several of the areas visited by the writer do have a definite petroleum

potential. Considering the geographic advantages that would apply to oil and gas reserves in this area the writer believes a concentrated effort be made on the areas recommended in this report to fully evaluate any possible potential.

Southern Carboniferous Area

(see Map II)

Much of this area has been covered by aeromagnetic and gravity surveys which has been subsequently re-interpreted for Golden Eagle by Huntec Limited (1964). The interpretation of the magnetic data showed a phenomenal sedimentary thickness which indicates the presence of Early Palaeozoic rocks below the Carboniferous mantle. It is recommended that lands forming the southern part of the Carboniferous depositional basin be retained, (see Map II).

St. George's Bay

(see Map II)

This area geologically has petroleum possibilities, but unfortunately the depths of water are beyond the capacity of most existing offshore drilling equipment. The average depth of water within the Bay ranges from 20 fathoms (120') to 72 fathoms (432') hence the drilling costs required for operating in an area such as this would be astronomical. There appears

little justification in retaining this area and tying up exploration money which could be spent profitably elsewhere on the Westcoast of Newfoundland.

Port au Port Peninsula

(see Map II)

Lack of severe faulting in the western half of the Peninsula indicates an area where favourable host and reservoir conditions exist. The Goodyear Anticline, proved by the writer to have closure, would be a favourable location for testing.

St. George's - Bonne Bay Igneous and Metamorphic Area

(see Map II)

The presence of much igneous material in this area is most discouraging. The area in addition is badly faulted and metamorphosed. Ultrabasics and volcanics of the Bay of Islands Igneous Complex, (Map I) of post-Carboniferous - pre-Ordovician age have been intruded into the area and it is assumed that all pre-Carboniferous sediments in their vicinity would be unfavourably affected by these intrusions.

The petroleum possibilities of this area are regarded as nil. The sedimentary, igneous and metamorphic rock types have been variously deformed and in some measure are locally altered by contact and hydrothermal metamorphism.

Deer Lake Oil Shales

(see Map II)

Bituminous shales occur commonly in the vicinity of Deer Lake and therefore are a potential source of petroleum using a method of destructive distillation.

Drilling by Clayber Uranium and Oil Limited (1954-57) reported gas under considerable pressure in diamond drill holes in the area, which reportedly forced stoppage of drilling. This gas suggests that accumulations of oil may occur at depth. It is for these reasons that the writer considers the area warrants further investigations.

Bonne Bay - Portland Creek Area

(see Map II)

Numerous thrust faults within the area have mashed the section and allowed the escape of reservoir pressures. Most of the strata in the area are tilted at an acute angle often close to vertical. Should an economical discovery be made, development drilling would present a problem as geological interpretations are impossible to construe. No company would feel justified in spending exploration dollars in an area where every subsequent test would have to be regarded as a wildcat. Further work is not recommended and it is suggested that the area be relinquished from the concession.

Northern Palaeozoic Area

(see Map II)

The existence of broad open folds, the development of vuggy porosity in the upper 200 feet of the St. George's dolomite and the presence of Cryptozoon reefal developments in both the Cambrian and Ordovician makes this area most interesting from a petroleum aspect. The petroliferous Green Point group is not present in surface outcrop but possibly does occur in the subsurface.

The following recommendations are made concerning this area:

(1) A study of dolomitization of the Table Head limestone near faults to ascertain if porosity increases occur.

(2) Traverse the entire area with particular attention being given to reefal developments and porosity.

(3) A study of the Cambrian beds on Doctors Brook inland from St. John Bay to ascertain if porosity is developed to any extent. Particular attention should be given to oil staining and reefoid structures. These points should aid in establishing if the Cambrian sediments have possible host and/or reservoir potentialities.

(4) An aerial magnetic survey of the area would establish the thickness of the sedimentary column which is of the utmost importance. In addition such a survey would outline basement

highs upon which well developed reefs may occur.

DETAILED GEOLOGY OF THE VARIOUS AREAS

The petroleum possibilities and geology will be discussed, commencing from the southwest coast and will be continued in a northerly direction along the Westcoast to the tip of the Great Northern Peninsula.

Southern Carboniferous Area

No attempt is made by the writer to elaborate on studies of the Carboniferous sediments made by P. R. Cote (1961) and a similar paper by the above author and D. M. Baird (1963). The reader is referred to these above works with which the present writer is in general agreement. A few comments may aid however in the appraisal of the Carboniferous sediments. Due to the terrestrial nature of the Pennsylvanian, Barachois group its only importance from a petroleum aspect would be as an overlying cap rock. Similarly, the continental nature of the Mississippian, Anguille group whose sediments are poorly sorted and often indurated makes the presence of source and reservoir beds extremely doubtful. The presence however of marine limestones within the Codroy group enhances the chances for petroleum production in comparison with other terrestrial derived deposits of the Carboniferous. In evaluating the presence of source material and porosity,

one must consider the limestones within this group as being the only beds within the series possessing both the se factors. Sediments belonging to the Carboniferous suite of formations are predominantly terrestrial in nature. Marine faunas are at a minimum and the possibility of preservation and rapid burial during accumulation of this continental series of sandstones are remote.

A re-interpretation of the available aeromagnetic and gravity data covering Southwestern Newfoundland was carried out on behalf of Golden Eagle by Huntec Limited (1964). The conclusions derived from this study indicated the southern (Carboniferous) sedimentary area, (see Map I) to contain an extremely thick sedimentary section, which is marred somewhat in the northern portion only by a large shallow anorthosite sheet. This intrusive varied in depth from zero to 2,500 feet below the surface and extends a few miles inland from the mouth of Robinsons River in the south to Flat Bay Brook in the north. Depth of basement to the south and within the intervening area between this feature and the western side of the Long Range fault, are considered to be in the order of 15,000 to 30,000 feet below surface. A sedimentary section of such magnitude must contain in addition to Carboniferous rocks a thick interval of Devonian, Silurian, Ordovician and Cambrian sediments. With such sedimentary thicknesses being indicated by the existing aero-

magnetic and gravity data it is strongly recommended that lands forming part of the Carboniferous depositional basin be retained, (see Map II).

St. George's Bay

This area geologically has petroleum possibilities, but unfortunately the depths of water would make drilling costs phenomenal. Reference to the Codroy Road to Bear Head, Hydrographic chart number 4660 indicates the 10 fathom isobath (60') occurs within a mile of the coastline. The majority of the Bay is in excess of 20 fathoms (120'). With such great depths of water it would be many years before drilling could be contemplated so at the present time there seems very little justification for tying up exploration money which could be spent more profitably elsewhere on the Westcoast of Newfoundland.

Port au Port Peninsula

The Port au Port Peninsula is regarded by the writer as the prime area within the concession for petroleum possibilities. The geology and oil potential of this area was covered by the writer in a report dated March 1965. Oil seepages coupled with a lack of severe faulting in the western half of the Port au Port Peninsula indicates an area where favourable host and reservoir conditions exist. The Goodyear Anticline, proved by the writer to have closure would be a favourable location for testing within this area.

St. George's - Bonne Bay Igneous and Metamorphic Area

A large sheet of anorthosite occurs along the west wall of the Long Range in the vicinity of St. George's, (see Map I). The longer axis of the mass which extends in a north-south direction terminates at the edge of the escarpment in a re-entrant made by the St. George's River and continues southward beyond Flat Bay Brook to Fischells Brook. The anorthosite sheet shows well developed foliations, and a constant strike not varying more than 10° from the normal N. 30° E. direction.

Cambrian and Ordovician sedimentary and volcanic rocks occupy a broad re-entrant in the crystalline rocks of the Long Range between Port au Port Peninsula and Bonne Bay, (see Map I). The Humber Arm group in this area includes clastics and volcanic rocks of middle to late Ordovician age whose occurrence on the Westcoast of Newfoundland is mainly restricted to this area. The sediments of this group constitute a typical eugeosynclinal association, composed of clastic sedimentary rocks and basic volcanic rocks that have been folded and cut by ultrabasic gabbroic, and dioritic intrusions. It appears that this immediate area has undergone several periods of folding, intrusion, faulting, uplift, and peneplanation, to constitute the most disturbed and distorted area on the westcoast.

During the course of this reconnaissance the crystalline

igneous and metamorphic rock found between Port au Port Peninsula and Bonne Bay received but scant attention as the main purpose of the investigation was to delineate areas unfavourable to the accumulation of hydrocarbons. Nevertheless, many opportunities to observe them on traverses in search of contacts plus motivation due to curiosity has made the writer familiar with the major rock types. Information so gained is recorded here but the reader should bear in mind that the limits of the various rock units are approximations, and locations referred to are without pretense of exactness.

The Indian Head Range Intrusive Complex, situated north-east of the Port au Port Peninsula is a northerly trending ridge 18 miles long which is composed of a complex series of igneous and metamorphic rocks of Precambrian age, (see Map I). The complex is isolated from the Long Range on the south and west by a 12 mile wide basin filled with glacially derived sands and gravels of Pleistocene age; to the north by Ordovician rocks. The Indian Head rocks consist predominantly of anorthosite, granite, gneiss, granite pegmatite and doleritic basalt dykes which constitute highly altered igneous rocks. The distribution of basic rocks are concentrated in the southern part of the complex while the acidic varieties are common in the northern half of the area.

Precambrian rocks form a basement complex upon which

lower Cambrian phyllites and gneisses rest unconformably at the south end of Deer Lake and in the eastern section of the gorge of the Lower Humber River. The rocks here are chiefly granitized meta-sediments or schists, cut by stringers of quartz and pegmatites composed almost entirely of light-coloured orthoclase and quartz. The greatest percentage of the mass is granitized. An anticlinal structure plunging northeast with a strike close to the regional trend (N. 30° E.) was noted in the vicinity of South Brook and appears to be a major structural feature of some importance. Lower Palaeozoic sediments were detected to lie against both flanks north of Deer Lake. In the eastern section of the gorge of the Lower Humber River in the vicinity of Corner Brook the rocks of the St. George's group are progressively altered to grey, pink, and variegated marbles. Here the strata has lost much of the identity of the more typical St. George's sequence because of the attendant metamorphism. East and northeast of the southern half of the Bay of Islands Igneous Complex, the beds of the St. George's group as well as those that follow in succession are strongly deformed with vertical to overturned strata that form broken and eroded folds east of two crumpled anticlines and synclines. The basal limestones of the eastern most anticline are exposed on the eastern flank of the promontory at Limestone Station, (the site of an abandoned marble quarry).

The road from Deer Lake to Lomond passes through a gap

excavated into Cambrian rocks. On either side, crystalline rocks form high bluffs and are by stratigraphic position Precambrian in age since Lower Cambrian sediments rest on them in normal sedimentary contact. Immediately south of the highway at the north end of Bonne Bay Pond, a hill composed of coarse-grained pegmatitic granite outcrops. This granite is composed of orthoclase, quartz, and biotite with concentrations of rutile crystals.

The Bay of Islands Igneous Complex, portions of which occur on both sides of the Bay of Islands, is a north-northeasterly trending, discontinuous belt of layered ultrabasic and gabbroic rocks, 60 miles long and up to 10 miles wide. The unit may be described in general terms as an uplifted, deeply dissected peneplane bound by steep slopes. The principal members of the Complex, from south to north, are known as the Lewis Hills, Blow Me Down Mountain, North Arm Mountain and Table Mountain plutons, (see Map I). Each has a thick basal ultrabasic zone consisting mainly of dunite and peridotite which in turn is covered by banded and massive gabbroic rocks. The four above mentioned plutons have westerly dipping floors that are generally conformable with the underlying Ordovician sedimentary and volcanic rocks. These latter rocks are metamorphosed to amphibolite and hornfels near their contacts with the intrusive rocks. Northwesterly-trending tear faults cut the ultrabasic rocks in many places, notably in Blow Me Down Mountain, which is bound by them. Serpentine Valley

probably represents a wide transverse fault zone that has split a once-continuous ultrabasic body into two separate units. The North Arm Mountain pluton and the Table Mountain pluton found immediately to the north of the Bay of Islands appear to have been a once-continuous mass now offset by the Trout River transverse fault.

A striking feature within this immediate area is the fact that most of the metamorphic rocks, (the writer was unable to identify any that were not) appear to be members or formations belonging to the Humber Arm group that were altered by the ultrabasic and gabbroic rocks. The Humber Arm sediments located between Corner Brook and Bonne Bay show ample evidence of moderate to high-grade thermal metamorphism and metasomatism related to intrusion. In the Bonne Bay area retrograde effects produced by mechanical deformation have almost obliterated the evidence of thermal metamorphism. At the northern extremity of the Bay of Islands Complex a pronounced offset in the Long Range crystalline rocks is apparent, and has been referred to previously in this report.

The presence of much igneous material in this area is most discouraging. Also, eugeosynclinal type sediments are common and as usually is the case with such material, reworking by current action to bring about sorting (and hence porosity) would be minimal. Petroleum possibilities are regarded as nil.

It is the writer's recommendation that the area located between St. George's, Bonne Bay, the coast-line and the Long Range Mountains be eliminated from the concession. The area covered by the oil shales, (discussed below) is considered to be of interest and should be retained until a more detailed evaluation is completed.

Deer Lake Oil Shales

(see Map II)

Oil shales outcrop at surface in the Deer Lake Region. Deer Lake lies in the course of the Humber River which flows in a south-westerly direction through west central Newfoundland. The oil shales of Mississippian age are located mainly along the northwest end of Deer Lake, and for a distance of approximately 18 miles in a northeasterly direction on both sides of the in-flowing Upper Humber Arm River. Grey sandstones, siltstones, shales, dark grey oily calcareous shales and medium grey limestones make up the Mississippian section. These beds in turn are over-lain by thick arkosic sandstones and conglomerates of either uppermost Mississippian or Pennsylvanian age.

The oil shales are distinctive in appearance being a bright yellowish grey on the weathered surfaces and a dark grey or black on the fresh surface. The shales are typically thin bedded, highly calcareous, and give a dark brown bituminous streak.

The structure of the area is extremely complicated so for economy of space it is suffice to say that the area of the shales lie in a trough of an asymmetrical syncline, the axis of which trends generally northeastward.

In the Deer Lake region in the exposures examined by the writer, no beds of oil shale greater than five feet thick were observed. Most average about one and a half feet thick and no beds of high quality were seen. It is thought from the observations of the outcrops round Deer Lake and the Upper Humber Valley that no beds of oil shale of sufficient thickness or richness for exploitation occur in this area. From surface indications it would appear that commercial deposits do not occur in the area, but a possibility of increased oil content may exist at depth. Recent drilling by Claybar Uranium and Oil Limited (1954-57) reported gas under considerable pressure in diamond drill holes in the area. Gas was also reported in some of the original holes drilled in the district. Thus the basin, although relatively small in area contains several beds of oil shale which are a potential source of petroleum, using a method of destructive distillation. The pockets of gas encountered during drilling suggest that accumulations of oil may also occur at depth. It is for these reasons that the writer considers the area warrants further investigations. The oil shales are confined to the

northwest end of Deer Lake and extend in a northeasterly direction along the Upper Humber River for 18 miles; an east-west limit of 10 miles either side of the Upper Humber River would encompass the area of interest, (see Map II).

Bonne Bay - Portland Creek Area

North of the Lomond Road at Bonne Bay Pond, the southern end of the Plateau rises in sheer cliffs from the Palaeozoic lowland. These hills represent the south end of the Long Range Plateau of the Great Northern Peninsula.

The prominent ridge east of the thick lower Cambrian section of sedimentary rocks that lines the shore of East and Deer Arms of Bonne Bay is assumed to be composed of grey coloured gneiss. The rocks appear light on the weathered surface, but freshly broken faces are dark grey and resemble the grey biotite-hornblende gneisses found farther east. In this area the rocks are shattered and it is likely that the nearby valley of the brook is entrenched along the locus of a fault zone striking east and west. North of Gros Morne (2651'), a great transverse fault, the Bakers Brook Fault, has offset the escarpment for more than a mile to the west; a glacial trough with towering walls, 2,000 feet high is excavated in the zone of weakness along an east-west line. Coarse-grained, reddish, biotite granite, only moderately gneissic in structure, is exposed in the north wall. Granite appears to be

the sole rock type present in the face of the escarpment at the outer end of Western Brook Gorge, situated ten miles north of Bakers Brook, but light grey, banded gneisses were observed in the cliffs of the inner pond.

Along the inner shores of St. Paul's Inlet as well as in valleys of large streams draining from the escarpment, the rocks of the plateau may be examined more conveniently. Gneiss and granite prove to be the prevailing types, but pegmatites and dykes cut through or are differentiates of the granite. Gneisses outcrop everywhere in cliffs and cirque walls rimming the east shore of Parson's Pond, but the escarpment face to the south of the Pond is veneered with more than 2,000 feet of brown weathered quartzites and quartz-biotite schists that presumably belong with the crystalline complex rather than with the lower Palaeozoic strata because of the high degree of metamorphism. The shores of Inner Portland Creek Pond show no appreciable change in lithology, except for the absence of the schists and quartzites; contorted and shattered gneisses form the bluffs on both sides of the Pond, and granite, a minor constituent in this area, invades the gneiss.

From Bakers Brook to Portland Creek a distance of 35 miles, beds of the St. George's group are never found in normal sequence with either the older Cambrian or younger Ordovician rocks. Large masses, several hundred feet in thickness

end up to a mile in length, appear as great fault blocks either in close proximity to, or adjacent to the granite gneiss of the Long Range Plateau. The most notable occurrences are exposed on the north shore of Western Brook Pond, in the valley of East Brook of St. Paul's Inlet, and the northeastern end of Parsons Pond. Each of the above blocks are of great size, variously tilted and structurally discordant to the enclosing sediments. The dips vary from overturned and vertical to nearly horizontal. It appears that these are remnants that were caught in the overthrust zone during the period of Long Range faulting. The largest, single fault block in the area lies at the foot of Long Range south from Portland Creek Pond. The topographic expression of the area is such that it seems likely to be a northward continuation of the dolomites exposed in the White Hills east of Parsons Pond.

The area between Bonne Bay and Portland Creek is greatly faulted, the degree of which has no comparison anywhere on the west coast. Divergence of dip directions over small areas suggest that the region has also been tightly folded. The possibility of the existence of petroleum in commercially extractable quantities in this area is regarded as nil by the writer. When one considers the great deal of faulting evident in this area, it is not surprising that drilling here (e.g. St. Paul's Inlet and Parsons Pond) lead to discouraging results.

Numerous thrust faults have undoubtedly mashed the section allowing the escape of reservoir pressures, thus it is recommanded that the area be dropped from the concession. A study of the section on the north side of Parsons Pond has convinced the writer that the existing oil in the area is not generated from the Green Point group but is migrating from either the St. George's or Cambrian strata below. This factor makes the area to the north of Portland Creek Pond of great interest.

Northern Palaeozoic Area

(see Map II)

Thrust slices extending throughout the Parsons Pond area progressively diminish north of Portland Creek Pond. Gentle dips of 5 to 15 degrees occur throughout the area and the existence of broad open folds and reefal developments in both the Ordovician and Cambrian makes this area most encouraging from a petroleum aspect.

Orogenic disturbances did not affect the Cambrian and Lower Ordovician sediments in this area to any great extent. Dips average from 5 to 15 degrees which may represent deposition over basement irregularities more than subsequent folding. The petroliferous Green Point group is not present in surface outcrop but it is possible that the lower St. George's may develop into a shaly facies north of Daniels Harbour. Inland from the shore

between Portland Creek Pond and the River of Ponds, the foreland is largely swamp covered and exposures are rare. Scattered outcrops found along the drift-covered coast reveal the presence of a light brown, mottled limestone which contains the fossil Hormotoma augustina (Billings) establishing its Lower Table Head affinities. Immediately north of Pond Lake an extensive width of St. George's dolomites gently undulating in large open folds is seen to be resting on Cambrian Hawke Bay quartzites.

From the River of Ponds to Port Saunders located on the north shore of Ingornachoix Bay the fossiliferous upper section of the St. George's group as well as the lowest Table Head limestone are well exposed and the contact between the two groups can be seen in several places. Characteristic features of the uppermost 200 feet of the St. George's dolomite in this area are the presence of Cryptozoon reefal developments and vuggy porosity which are encouraging from a petroleum point of view. To the north of Port Saunders, Point Riche at the south end of St. John Bay area to Cape Norman (tip of the Great Northern Peninsula) is of considerable interest as here is found Richardson's original type section of the St. George's group. The type section for this group was later transferred by Schuchert and Dunbar to the Port au Port Peninsula. In the St. John Bay area the contact between the cream-coloured dolomite of the St. George's and the greyish limestone of the Table Head

is most striking and the contact therefore appears sharp and distinct. The lower contact is exposed on the apex of a small asymmetrical anticline located at a point where Castors River enters Castors Harbour. The contact is sharp and irregular, indicating a hiatus. This contact is observed again on the northeast end of Ten Mile Lake in low, broad, westwardly pitching anticlines and synclines. The Cape Norman and Pistolet Bay areas contain a faulted and folded, incomplete sequence of rocks belonging to the St. George's group. In general rocks belonging to the upper portion of the St. George's group are exposed in almost continuous ledges that form the shoreline between Point Riche and Cape Norman. Here the strata strikes east-northeast and dips at a low angle to the southeast. A gently folded descending section is exposed at right angles to the strike between Cape Norman and Norman Cove.

North of Castors River a pinkish grey pegmatized acidic gneiss is exposed containing in some places barren quartz veins and lenses. Beyond this area, the Long Range Mountains become considerably subdued and dip under the early Palaeozoic sediments to re-appear as the northernmost limits of the crystalline rocks at St. Anthony. The area between Pistolet and Hare Bay has been metamorphosed by the intrusion of ultrabasic rocks. In addition, the sequence in this area is complicated by minor folds and some faulting is evident. The

relationship of these ultrabasic rocks to the Bay of Islands Complex is open to speculation.

This entire area north of Portland Creek is only slightly faulted and broad open folds are typical, with dips in excess of 15 degrees being seldom obtained. These factors in conjunction with vuggy porosity in the upper St. George's dolomites and the existence of Cryptozoon reefoid developments in both the Ordovician and Cambrian makes this area extremely interesting. It is recommended that this Northern Palaeozoic area be retained for further evaluation.

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