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ORGANIC GEOCHEMISTRY OF SOME CAMBRO-ORDOVICIAN OUTCROP SMAPLES WESTERN NEWFOUNDLAND

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ABSTRACT

Based on the mapping of previous investigators, samples were collected from surface exposures of Cambro-Ordovician strata in western Newfoundland. Sampled intervals included the Middle Ordovician Table Head Group, The Lower Ordovician Green Point Group, the Cambro-Ordovician Humber Arm Group and undivided Cambro-Ordovician beds. All samples were then geochemically analyzed by the Rock-Eval Pyrolysis technique.

Black shales of the Green Point Group were found to be the best potential petroleum source beds, containing up to 8% Type II organic carbon of marginal thermal maturity. Some Humber Arm and undivided Cambro-Ordovician beds contain in excess of 1.5% low maturity kerogen and may also be of interest as potential source beds.

INTRODUCTION

Various publications, including those of both local mapping reports and regional geological studies, have described the occurrence of oil seeps and the results of drilling programs in western Newfoundland, particularly in the Parson's Pond and Paul's Pond areas, and on Port au Port Peninsula (Fig. 1). These are well summarized in both Fleming (1970) and Sheppard and Hawkins (1981). Hydrocarbon shows, in the forms of bitumens and petroleum, occur most commonly in the sandstones of the Green Point and Humber Arm groups (Fleming, ibid.). Although oil shales are known from the Carboniferous Rocky Brook Formation in the vicinity of Deer Lake (Fig. 1) farther to the east (Fleming, ibid.), organic-rich beds have not been recognized in Lower Paleozoic strata, although many black shales have been described. Organic-rich intervals within the Cambro-Ordovician are believed to be the source for the hydrocarbon shows.

Ordovician oil shale - source beds have been studied by the writer to the north on Southampton, Baffin and Akpatok islands in the eastern Arctic, and to the south in Ontario. A prime objective has been the evaluation of the petroleum generation potential of Lower Paleozoic rocks for offshore accumulations in the northern and eastern frontier exploration areas (Hudson Bay, Foxe Basin, Hudson Strait, Labrador Sea, Gulf of St. Lawrence, offshore Atlantic).

In an attempt to understand more completely the regional distribution of Ordovician organic-rich beds, a short (6 day) field investigation to look for and sample appropriate lithologies was carried out in western Newfoundland during August, 1986. Of the six days, one was spent sampling

Carboniferous oil shales, two in actual sampling of Cambro-Ordovician beds, and the rest split between familiarization with the section and rain. Prior to the field investigation, virtually all available reports on the geology of this area were reviewed, including many unpublished private company reports available at the Newfoundland Department of Mines and Energy. All background reports are listed in the Selected Bibliography, although not all are specifically referenced within the text. Fleming (1970) became the principle reference guide for the program as his descriptive notes complemented the regional geology (Williams, 1966, G.S.C. Map 1231A) and the compilation geology of the Port au Port Peninsula.

From analysis of the literature, the main target was thought to be the black shales of the upper Table Head Group, but most shale outcrops examined were found to dark grey when dry. In contrast, samples were generally black when wet. Samples of the Lower Ordovician Green Point Formation, described as bituminous by both Corkin (1965) and Fleming (1970), appeared on visual inspection to be the most interesting of all sampled intervals. Shales of the Humber Arm Group, mostly grey rather than black, and of undifferentiated Cambro-Ordovician beds, were also collected to obtain a full representation of the stratigraphic section. Within the limited time of the field program, only some of the better, easily accessible exposures could be visited. In no way does is this report represent a full account or evaluation of the geochemistry of the Cambro-Ordovician section, but presents only the results of an initial reconnaissance.

SAMPLES

The Cambro-Ordovician geology of western Newfoundland is complex in that an autochthonous carbonate sequence is overlain by a thick allochthonous clastic succession of equivalent and older strata which was transported westward in a series of thrust sheets during the late Ordovician Taconic Orogeny (Sheppard and Hawkins, 1981). Several of the carbonate sequences are described similarly and many of the clastic beds contain few fossils and age determinations are inconclusive. Every attempt was made to ensure correct identification of the sampled beds, but lack of experience and time in the area may have resulted in some misidentification. Although only generalized sample location maps have been prepared (Figs. 1, 2) to accompany the descriptive location notes, these should suffice for the reader to locate the sample areas if used in conjunction with the maps and lithologic descriptions in Fleming (1970).

Mineral analysis was carried out for all samples using a Philips PW 1700 automated power diffraction system. The results of these mineral identifications (Table I) have been incorporated into the lithologic descriptions of the individual samples. Semi-quantitative results were calculated from diffraction peak heights which may vary with degrees of crystallinity, crystal size, and the presence of amorphous material and organic matter.

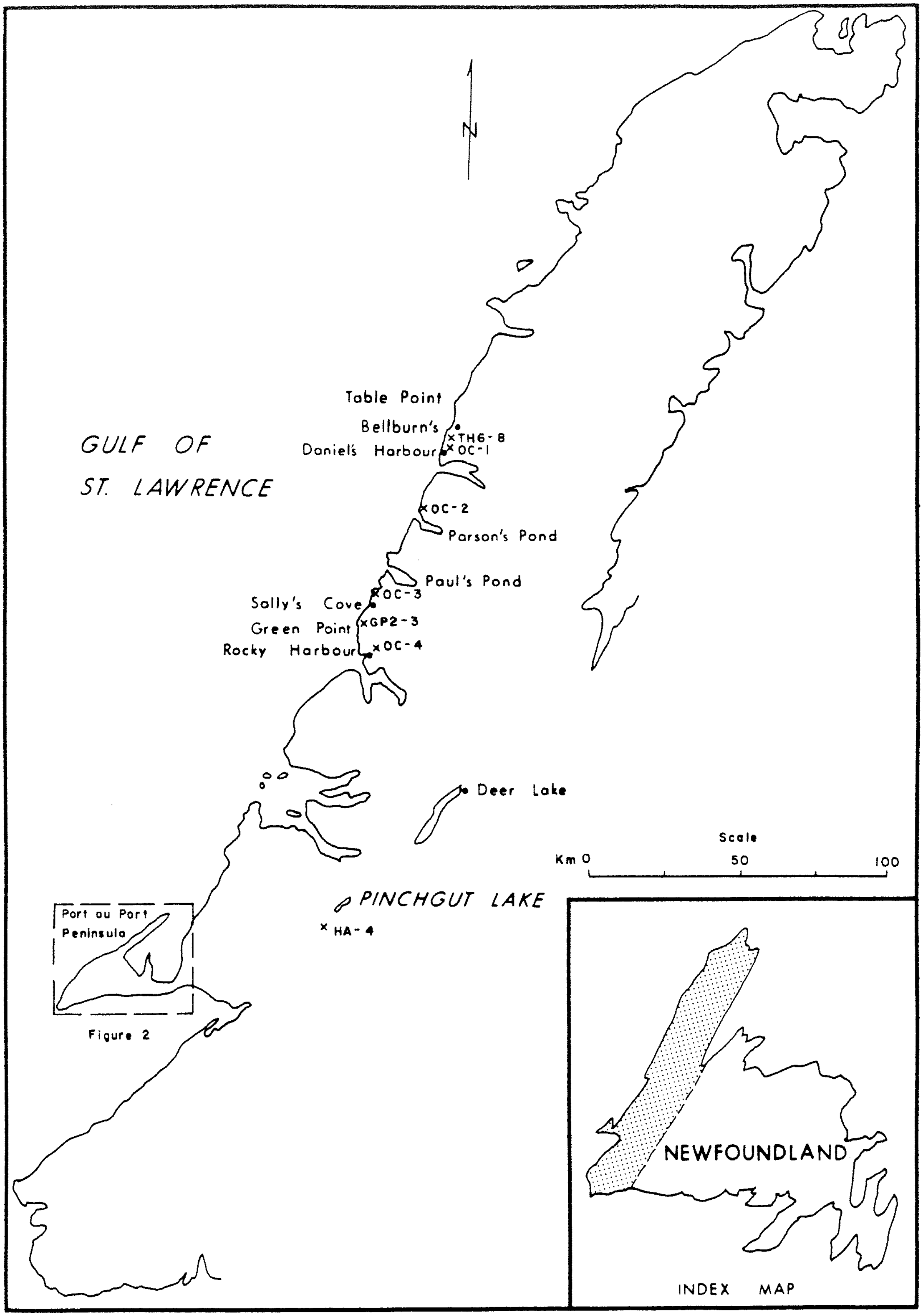

Figure 1: Sample location map, western Newfoundland, excluding Port au Port Peninsula.

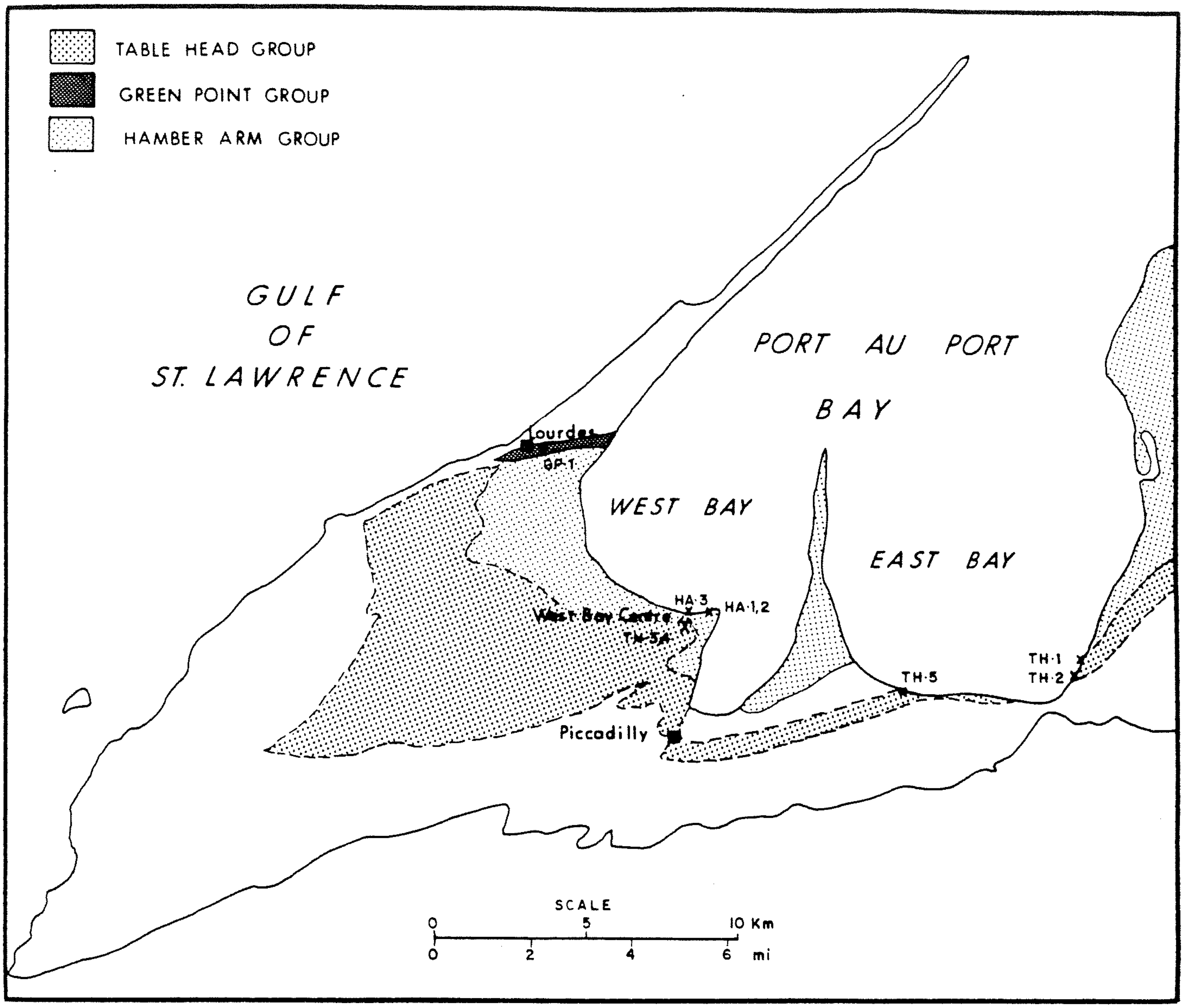

Figure 2: Sample location map, Port au Port Peninsula.

Table Head Group (Middle Ordovician)

Samples from the Table Head Group were collected from three areas, the east side of East Bay on Port au Port Peninsula, the Piccadilly Quarry and nearby exposures along the west side of East Bay on the peninsula (Fig. 2), and from the type section near Table Point (Fig. 1), which was formerly called Table Head.

TH-1 and TH-2 were collected from basal Table Head beds (?) immediately overlying Cape George Cryptozoon carbonate on the east side of East Bay (Fig. 2) with TH-1 from a 0.15 m grey fissile shale bed about 2 m below a green and red sandstone-shale section which descriptively typifies Humber Arm clastics. TH-2 is massive brown-grey shale, collected immediately above continuous Cape George carbonate. Although both of these samples have the

Sample	Clays			Quartz	Feld	Calcite	Dol	Py
	Exp/MLC	Kaol/chlor	Illite					
TH-1	-	-	-	7	2	91	-	-
TH-2	-	-	-	5	tr	95	-	-
TH-3	-	-	tr	21	3	32	42	2
TH-4	tr	tr	tr	24	2	28	44	2
TH-5	-	1	2	26	2	69	-	tr
TH-6	-	-	-	5	-	78	17	-
TH-7	-	-	-	3	-	92	5	-
TH-8	-	-	-	2	-	90	8	-
GP-1	tr	5 Chl	4	49	10 A	-	26	6
GP-2	tr	2	3	33	11 A	41	6	4
GP-3	2	2	2	40	17 S 6 A	13	14	4
HA-1	6	5	4	47	9 P	13	10	6
HA-2	6	9	4	38	10 P	19	10	4
HA-3	-	tr	-	69	3	18	16	4
HA-4	-	28 Chl	26 M	30	13 A	3	-	-
OC-1	3	6	3	42	17 A	10	19	-
OC-2	-	-	4	37	37 S	16	-	6
OC-3	-	2	2	25	9 A	44	15	3
OC-4	5	11 Chl	6	44	17 A	4	13	-

Exp/MLC: Expandable/mixed layer clays
Chlor: Chl: Chlorite
K: Kaol: Kaolinite
M: Muscovite
Dol: Dolomite
Py: Pyrite

Feld: Feldspar
P: Plagioclase
A: Albite
S: Sanidine

Table I: *X-ray diffraction data.*

bedding and color characteristics of argillaceous shales, they are mineralogically limestones with only a minor secondary quartz component.

In Piccadilly Quarry (Fig. 2), approximately 10 m of laminated, shaly(?), light to medium grey-brown graptolitic carbonate, containing both dolomite and calcite, overlies coarse nodular typical middle Table Head limestone. Over 20% quartz is indicated by the X-RD analyses. This quarry appears to be the northernmost limit of Table Head Group in this area, extending farther north than the Table Head as shown by Fleming (1970). This discrepancy may reflect only map scale detail. Although graptolitic beds occur within the Table Head Group in this area, depositional continuity to the underlying carbonate and uniform dip across the lithologic boundary indicate stratigraphic continuity with the underlying nodular limestones. These beds are thought to be the thin bedded limestones of the middle unit as reported by Fleming (1970). They are placed within the Table Head Group by deGrace (1974). The graptolites have been submitted for identification to the Paleontology Division at the Institute of Sedimentary and Petroleum Geology, Calgary. Sample TH-3 was collected from the quarry wall and TH-4, floor debris from the quarry operation, was chosen for abundant graptolite content even though slightly lighter than average in color. Light brown fossiliferous limestone is described from overlying Carboniferous beds (Fleming, ibid.), but the abundance of graptolites and apparent structural-depositional continuity with the underlying Table Head carbonate establish these beds as part of the Table Head sequence. Surface exposures of Carboniferous beds are not mapped at the quarry.

On the south side and toward the western end of East Bay, knobby limestones of the Table Head middle unit are overlain by light colored, apparently organic-poor shale (sample TH-5) which contains possible graptolite remains. These beds are more laminated than those of the Piccadilly Quarry, but are also siliceous limestones on the basis of mineralogy. Although the contact with the Table Head carbonate was covered, the structural attitude was identical for both the shaly and the massive carbonates, and the sample was taken no more than 2 m above the top of the massive beds. Further to the west along the shoreface, lighter colored, more fissile, structurally contorted shales of the Carboniferous Codroy Group are dissimilar to the strata at the sampled exposure.

Table Head beds crop out continuously in the area of Table Point (Fig. 1), with the uppermost section exposed near the settlement of Bellburns. The upper unit is a sequence of dark grey to black shaly limestone, not truly shales. Nodules of black carbonate, close to 2 cm on average, are enclosed in a dark grey matrix and are poorly resistive to weathering in contrast to the massive cliffs of the underlying resistive middle carbonate unit. Except for the mud matrix, these beds much resemble the knobby carbonates of the middle unit in the East Bay area. The soft matrix, which is the sampled lithology of this area, is barren of clay, and is a slightly dolomitic, slightly siliceous limestone. Sample TH-6 was selected less than 2 m above the top of the massive carbonate, TH-7 is approximately 13 m below the top of the upper beds and TH-8 is from the youngest exposed Table Head in the area. Because of the limited resistance to weathering, and the almost continuously wet nature of exposed surfaces, unweathered surface material is difficult to acquire. Except for color, these beds are remarkably similar in character and mineralogy to distinctive, blue-grey, Ordovician shales on Baffin Island (Macauley, in press).

Green Point Group (Lower Ordovician)

Poorly laminated, dark grey, dolomitic shale of the Green Point Group (sample GP-1) occurs as a thin interbed within a sandstone sequence (with minor conglomerate) in a roadside outcropping southwest of a bend in the road immediately east of the town of Lourdes on Port au Port Peninsula (Fig. 2; Fleming, 1970, Fig. 2)). These beds, from structural attitude, almost certainly directly underlie the Long Point limestone which is exposed along the highway within the town limits. There is little doubt as to the identification of this section when compared to the descriptions of Corkin (1965) for the Green Point Group in this area.

The type section of the Green Point beds is at Green Point where approximately 50 m of very finely laminated, calcareous, dolomitic shale, variably black and green, are exposed in near vertical beds (Fig. 1). A conglomerate bounds the shales at the north end of the outcropping and is thought to underlie the shale interval. Laminae to thin beds (<2 cm) of very fine grained sandstone and some carbonate beds up to 5 cm thick are interspersed within the black-green shales. The Green Point shale samples (GP-2, 3) react positively in a flame by igniting but do not burn freely.

There is little doubt that the beds assigned to the Green Point Group on Port au Port Peninsula are the stratigraphic equivalent of the type section shales and coarser clastics at Green Point. Bedding characteristics are identical, and both contain dominant quartz with a variety of accessory clay minerals. The major difference is the dominance of dolomite on Port au Port Peninsula in contrast to calcite at Green Point. Oxley (1953) described considerable red coloration in the Green Point Group, but none was noticed in the sampled section at Green Point, nor could the Green Point and St. Paul's Group be recognized on the basis of Oxley's descriptions.

Humber Arm Group (Lower Cambrian through Lower Ordovician)

Rocks of the Humber Arm Group crop out in a series of contorted beds along the shoreface from South Head to West Bay Center on Port au Port Peninsula (Fig. 2). Samples HA-1 and HA-2 are from the darkest of these shales and do not appear to be organic-rich, but were sampled because the other exposed shales are all much lighter in color. Both samples are calcareous, dolomitic, contain a variety of clay minerals, and are dominated by quartz.

Sample HA-3 is a fragment of black siliceous shale picked up from the above beach and certainly not in place; however, this shale does fit the published description of the "black" shales of the Humber Arm Group and is thought to be representative of possible source beds in this unit. Almost 70% of this sample is quartz. There is only a trace of clay and, dolomite and calcite in equal parts make up the remainder of the rock. This sample could also be representative of some of the siliceous carbonates or argillites described within the Humber Arm and other groups of the Cambro-Ordovician sequence.

A black slickensided sample (HA-4) was obtained from a sequence of structurally much disturbed Humber Arm and Table Head rocks along the Trans-Canada Highway 8.9 km south of the entrance to Blue Pond Park and 14.6 km south from the south end of Pinchgut Lake (Fig. 1) and was selected to determine if the slickensiding was indicative of an organic carbon content. Chlorite and muscovite are the principle minerals of this sample.

Cambro-Ordovician undivided

Strata assigned to an undivided Cambro-Ordovician sequence are dominantly clastics which are thought primarily to be equivalents of the Humber Arm Group but lacking the paleontological evidence necessary to establish exact correlations. All samples collected from this interval appear to structurally overlie the Table Head Group, but are older beds which were emplaced by overthrusting as allocthonous strata.

Sample OC-1 is a grey, calcareous, dolomitic shale, black when wet, from the shoreface along a road into the town dump approximately 500 m north of the settlement of Daniel's Harbour (Fig. 1) and 300 m south of the southernmost exposure of upper Table Head Group (Sample TH-8).

OC-2 was collected from a small exposure just north of Parson's Pond Bridge (Fig. 1). This dark grey, calcareous shale weathers blue-grey and is one of the few which reacts (smokes) in a flame.

Dark grey, calcareous, dolomitic shale float (OC-3), from the beach just north of Sally's Cove (Fig. 1), appears to be typical of the Cambro-Ordovician shales described from this area.

Sample OC-4 is from structurally deformed beds cropping out at the junction of Highway 430 and the road into Rocky Harbour (Fig. 4). The deformation here appears to be related to the southerly continuation of the Long Range Mountains which form the core of the northerly-projecting peninsula of western Newfoundland. Like the slickensided Humber Arm sample HA-4, the contorted OC-4 sample contains considerable chlorite.

ORGANIC GEOCHEMISTRY

All samples were processed at the Institute of Sedimentary and Petroleum Geology, Calgary, on a Rock-Eval Analyzer. Using a standard program, the S1 peak was obtained at 300°C, and the S2 peak was measured during heating at 25°C/min. and collected to a temperature of 600°C. The S3 peak was collected to a temperature of 390°C. TOC content was determined by burning all the carbon in a separate oxidation oven built into the analyzer and operated at 600°C in air. In order to ensure uniform results and that all the organic carbon was burned, samples were fine ground to a particle size of approximately 150 micrometres. A minimum double run was standard for each sample. Table II records the results from the Rock-Eval analyses.

All samples are from surface exposures. Whether or not weathering has affected the results must be considered, but kerogen has proven remarkably resistant when exposed to air

Sample	TOC Wt%	Tmax °C	S1	S2	S3	HI	OI	S1+S2 kg/t	TR	Ratio kg/t /%TOC
				mg/g						
Table Head										
TH 1	0.01	-	0.00	0.01	0.10	100	1000	0.01	.00	1.00
	0.02	-	0.00	0.01	0.10	50	500	0.01	.00	0.50
	0.02	-	0.00	0.01	0.14	50	699	0.01	.00	0.50
TH 2	0.05	-	0.01	0.00	0.16	0	320	0.01	1.00	0.20
	0.05	-	0.00	0.01	0.14	20	28	0.01	.00	0.20
	0.05	-	0.00	0.01	0.15	20	300	0.01	.00	0.20
TH 3	0.48	444	0.23	1.42	0.12	295	25	1.65	.14	3.43
	0.49	440	0.23	1.15	0.12	234	24	1.36	.17	2.81
	0.49	440	0.26	1.39	0.14	283	28	1.65	.16	3.36
TH 4	0.63	440	0.27	1.50	0.15	238	23	1.77	.15	2.80
	0.59	439	0.28	1.71	0.15	289	32	1.99	.14	3.37
	0.62	442	0.29	1.74	0.21	280	33	2.03	.14	3.27
TH 5	0.35	430	0.00	0.20	0.81	57	231	0.20	.00	0.57
	0.35	428	0.00	0.21	0.24	59	68	0.21	.00	0.60
TH 6	0.05	-	0.00	0.01	0.35	20	700	0.01	.00	0.20
	0.04	-	0.00	0.01	0.14	25	349	0.01	.00	0.25
TH 7	0.05	-	0.00	0.01	0.35	20	700	0.01	.00	0.20
	0.06	-	0.00	0.01	0.16	16	266	0.01	.00	0.16
TH 8	0.05	-	0.01	0.00	0.33	0	660	0.01	1.00	0.20
	0.03	-	0.00	0.01	0.13	33	433	0.01	.00	0.33
Green Point										
GP 1	7.78	440	1.62	53.98	0.38	693	9	55.60	.03	7.14
	8.37	435	1.73	57.61	0.17	688	6	59.34	.03	7.08
	8.24	441	1.56	62.06	0.26	753	10	63.62	.02	7.72
GP 2	2.76	437	0.49	13.42	0.18	486	30	13.91	.04	5.03
	-	436	0.53	14.10	0.53	-	-	14.63	.04	-
GP 3	4.09	444	1.52	20.61	0.23	650	19	28.13	.05	6.87
	5.02	441	1.70	28.71	0.28	571	13	30.41	.06	6.05
	4.74	444	1.38	28.18	0.28	594	19	29.56	.05	6.23
Humber Arm										
HA 1	0.24	436	0.02	0.24	0.38	100	158	0.26	.08	1.08
	0.26	433	0.02	0.26	0.17	100	65	0.28	.07	1.07
HA 2	0.11	441	0.00	0.02	0.26	18	236	0.02	.00	0.18
	0.14	434	0.02	0.05	0.18	35	128	0.07	.29	0.50
HA 3	1.01	450	0.76	3.60	0.53	386	52	4.36	.17	4.31
	1.11	446	0.85	3.78	0.23	340	20	4.63	.18	4.17
HA 4	0.28	-	0.00	0.01	0.28	3	100	0.01	.00	-
	0.26	-	0.00	0.01	0.28	2	77	0.01	.00	-
Cambro-Ordovician undivided										
OC 1	0.09	-	0.00	0.01	0.19	11	211	0.01	.00	0.11
	0.09	-	0.00	0.01	0.11	11	122	0.01	.00	0.11
OC 2	1.68	442	0.72	7.53	0.32	454	19	8.35	.09	4.93
	1.79	441	0.73	8.02	0.31	463	17	8.75	.08	5.05
OC 3	0.65	457	0.16	0.17	0.35	26	53	0.33	.48	0.50
	0.72	457	0.18	0.71	0.43	29	59	0.89	.20	0.54
OC 4	0.15	-	0.00	0.01	0.40	6	266	0.01	.00	0.06
	0.15	-	0.00	0.01	0.23	5	153	0.01	.00	0.06

Table II: *Rock-Eval analytical data.*

(Macauley and Ball, 1982) and weathering is not here considered to be a significant factor.

Table Head Group

All samples of Table Head lithologies are low in total organic carbon (TOC). The maximum TOC, 0.5 to 0.6%, is in the graptolitic, shaly limestone from the Piccadilly Quarry on Port au Port Peninsula. The petroleum yield (S1+S2) is too low for the parameters to be interpreted confidently as to kerogen type and thermal maturation, although the Transformation Ratios (TR), at approximately 0.15, indicate a probable low maturation level.

Green Point Group

TOC values in the range 3 to 5% at Green Point and 8% on Port au Port Peninsula represent the highest and most significant kerogen content of all the samples analyzed. Hydrogen versus Oxygen indices cross-plot as Type I kerogen (Fig. 3), although the Hydrogen Indices do not reach the values in excess of 800 common to other known Type I deposits (Macauley et al., 1986); however, values for these samples are higher than normally encountered for Type II deposits. The yield ratio, S1+S2 versus TOC (Table I; Fig. 4), is less than anticipated for Type I kerogen but is slightly higher than encountered in other Type II deposits. Approximately 1% inert kerogen can be projected on the basis of these few samples. Hydrogen Indices and recoveries are here very similar geochemically to those of the Carboniferous stellarite (torbanite) of Nova Scotia.

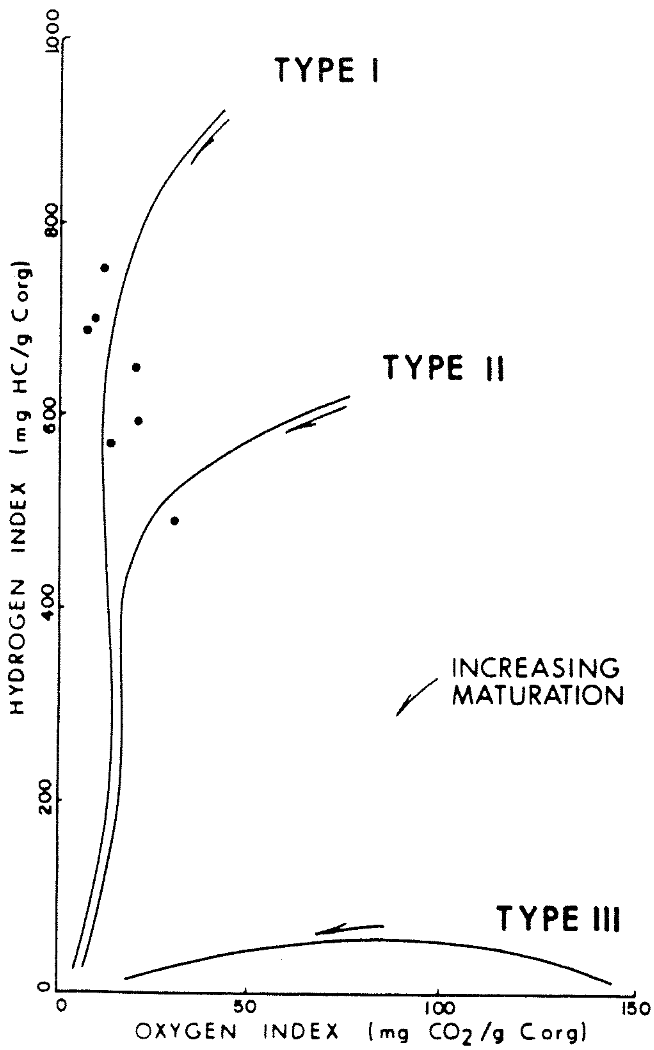

Figure 3: Hydrogen Index versus Oxygen Index, Green Point Group.

Tmax values in the range 435 to 444°C are indicative of marginal thermal maturation for Type II deposits, a level confirmed by Transformation Ratios at 0.06 or less.

The lithologies of the Green Point Group, where examined by the writer, can be interpreted as deposits of either a continental lacustrine or a marine environment. The presence of

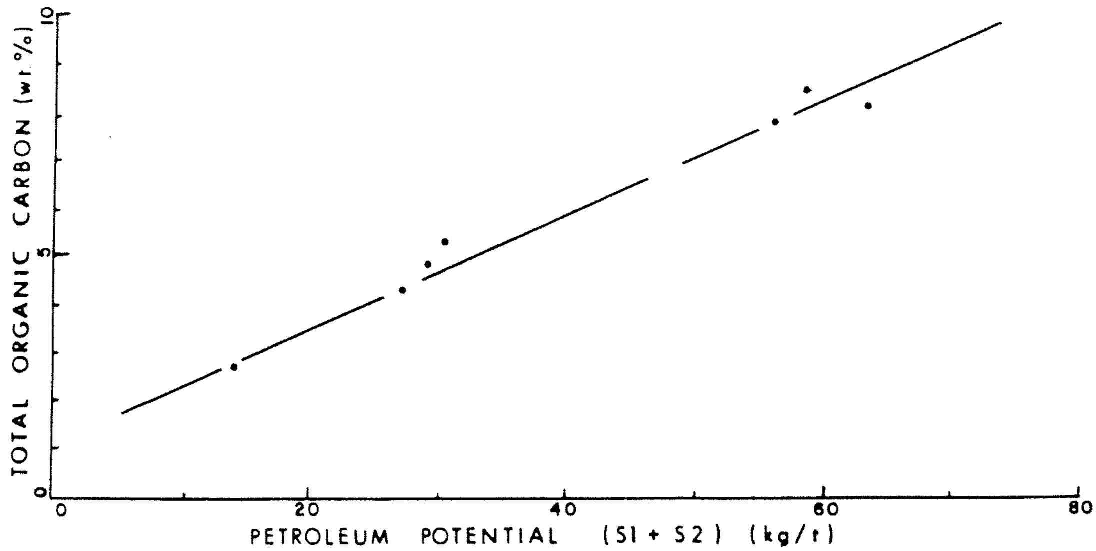

Figure 4: Total organic carbon versus petroleum potential, Green Point Group.

graptolites, by which the age has been established (Fleming, 1970), confirms these beds as marine deposits.

These oil shales can be interpreted geochemically as a poorer than average quality Type I deposit or as containing somewhat better than average Type II kerogen. From organic petrographic investigations of these samples now in progress at ISPG, Goodarzi (pers. comm.) has identified matrix bituminite as the dominant maceral, with scattered acritarchs confirming a shallow marine depositional environment. Both non-fluorescing and orange-brown fluorescing bitumens are also present, indicating a low degree of thermal maturation. These beds are thus considered to contain Type II kerogen which is at a marginal level of thermal maturity within the petroleum generation window. Bitumen and/or heavy ashphaltic oil products have been generated.

Humber Arm Group

Only one sample, HA-3 (Table I), has sufficient organic carbon (1%) to provide accurate interpretable Rock-Eval data. Tmax (446 - 450°C), HI (340 - 386), TR (0.17 - 0.18) and a low yield ratio (4.17 - 4.31) all indicate moderate thermal maturation of a probable Type II kerogen. This was a float sample from the beach in an area of Humber Arm bedrock, and is probably representative of the black shales described by many investigators in the Cambro-Ordovician of western Newfoundland.

The slickensides of the black shale HA-4 sample are not associated with organic carbon content, but result from the presence of muscovite and chlorite.

Cambro-Ordovician undivided

Only one of the four Cambro-Ordovician samples, OC-2 collected near Parson's Pond, contains sufficient organic carbon (1.7%) to be a potential petroleum source bed. Rock-Eval parameters (Tmax, 442°C; HI, 460; TR 0.09 and Yield ratio, 5.0) are indicative of a marginal to low maturity Type II kerogen deposit.

From the Rock-Eval data (Table I), a float sample from the Beach near Sally's Cove can be interpreted to contain Type II kerogen that is moderately mature within the oil shale window. The previously discussed float sample HA-3 also indicated a higher thermal maturation level than is encountered in the in-place samples. This may indicate that these two float samples have been transported some distance from their source and therefore may not represent the adjacent bedrock units. Their character does indicate that they are probably a part of this geologic sequence.

SOURCE POTENTIAL

Lower Ordovician Green Point beds have been previously considered as probable source beds for petroleum accumulations in western Newfoundland (Corkin, 1965; Fleming, 1970). Their source potential has been confirmed by this study, but the quality and quantity of generated hydrocarbons must be questioned. These oil shales are marginally mature, having generated low grade bitumens, but are unlikely to have as yet produced any high grade oil products. This is somewhat discouraging to the exploration for on-shore petroleum accumulations.

Slightly higher levels of thermal maturation can be suspected from probable Humber Arm and undifferentiated Cambro-Ordovician beds which may have reached low to moderate maturation levels. Because of the indefinite identification of these samples, a much more comprehensive sampling and analytical program should be undertaken.

Frontier exploration in the off-shore areas is in part contingent on the recognition of both reservoir and source beds. Goodarzi et al. (1985) have recognized highly mature (final gas generation phase) to overmature Lower Ordovician bedrock samples from the Grand Banks off the east coast of Newfoundland. Immature organic-rich Middle to Upper Ordovician potential source beds have been reported from Southampton Island (Macauley, 1986) and Baffin Island (Macauley, 1987) in the Arctic area to the north. Middle-Upper (?) Ordovician Collingwood oil shales have been established as the source beds petroleum accumulations in southern Ontario (Powell et al., 1984) and equivalent beds are known to be organic-rich in the St. Lawrence Lowlands and on Anticosti Island (Macauley, 1984). Ordovician beds are now known to be potential petroleum sources where buried to greater depths in all of the eastern Canadian off-shore frontier areas.

SUMMARY

Black, splintery shales of the Green Point Group contain sufficient kerogen to be a prime petroleum source in western Newfoundland, although the samples analyzed indicate only a marginal level of thermal maturity. The organic carbon is contained in an excellent quality Type II kerogen. Although the Hydrogen Indices indicate a possible Type I kerogen, a Type II character is defined by other geochemical parameters and maceral identifications.

A more comprehensive sampling of Green Point shales and continued Rock-Eval analysis in conjunction with organic petrography is warranted. Further bio-marker investigations by gas chromatography - mass spectroscopy can be used to determine possible correlation of these organic-rich beds to the oil shows of the Parson's Pond and Paul's Pond areas and to the shows on the Port au Port Peninsula.

There are indications that some shales of the Humber Arm Group and within the presently undivided Cambro-Ordovician section contain sufficient organic carbon to have petroleum source potential. A more detailed sampling of these beds by geologists familiar with their outcrop distribution is justifiable from the limited data of this report.

Acknowledgements

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