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SOURCE ROCKS FOR WESTERN NEWFOUNDLAND HYDROCARBONS

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INTRODUCTION

This is a preliminary report on research that has been undertaken as a part of a M.Sc. thesis at Memorial University. The project involves the detailing of the organic geochemistry of black shale from a range of localities within the Humber Arm Allochthon, the autochthonous platform, and the Deer Lake Basin (Figure 1). Middle Cambrian to Middle Ordovician shale of the allochthonous Humber Arm Supergroup appears to represent continental-slope deposition. Rock sequences suggest that the margin changed from a steep slope in the Cow Head Group (James and Stevens, 1986) to a low-angled margin within the Curling Group (Botsford, 1986). Ordovician shale of the Table Head Group is thought to have been deposited on a drowned shelf as a result of rapid margin collapse (Klappa *et al.*, 1980).

Carboniferous shale collected at Deer Lake lies in a late- to post-orogenic successor basin (Hyde, 1981). This area was included in the study for two main reasons: 1) the location of samples was proximal to the main study area, and 2) the basin has been studied previously, both environmentally and geochemically, and should provide a validation of technical methods by comparison to the main study section.

The major aims of the project are: 1) to determine the organic geochemical signatures of the western Newfoundland shales, including stable-carbon and nitrogen compositions, biomarker distribution and major high-molecular-weight hydrocarbon contents, 2) to correlate extracted bitumens with seep oils from Parson's Pond and St. Paul's Inlet to delineate the possible source rocks, and 3) to compare isotope analyses with accelerated maturation techniques using hydrous pyrolysis to evaluate these geochemical methods of defining or tracing source rocks.

REGIONAL GEOLOGY

Rocks of the Humber Arm Allochthon north of Bonne Bay occur in repeated thrust belts that trend to the northeast and are exposed in coastal localities and along the shores of Parson's Pond, St. Paul's Inlet, and Western Brook Pond. The allochthon is dominated by shale and carbonate of the Cow Head Group (James and Stevens, 1986) and overlying Lower Head sandstone (Williams *et al.*, 1985). South of Bonne Bay, sedimentary sequences belonging to the Curling Group, are dominated by Northern Head shale and carbonate (Botsford, 1986).

The autochthon underlies the allochthon, and also occurs in slivers between the Humber Arm Allochthon and the Long Range Inlier (Knight, 1985; Williams *et al.*, 1985) as well as to the north and south of the allochthon. At Table Point, a complete succession of the Table Head Group that dips uniformly southwest is dominated by thick fossiliferous limestone and is topped by the Black Cove Formation shale (Klappa *et al.*, 1980). Deposition of this shale likely occurred on a drowned shelf after a rapid collapse of the continental margin.

The Deer Lake Basin of Carboniferous age represents a late- to post-orogenic successor basin (Hyde, 1981). Fluvial and lacustrine sedimentary rocks are common, and include a few occurrences of black shale.

OIL OCCURRENCE

Oil seeps were first reported in Parson's Pond in 1812 when crude oil was collected and first used in the treatment of rheumatism (Fleming, 1970). The first well was drilled in 1867 and reported an oil show. Nine more wells were drilled between 1892 and 1906, six of which encountered oil and/or gas. By 1908, approximately 700 to 800 barrels of oil were shipped from the area. From 1908 to 1965, only a few wells were drilled and the results of the drillings proved inconclusive (Fleming, 1970). Recent drilling in 1965 penetrated to depths exceeding 1235 m; no oil was observed (Fleming, 1970).

Field sampling for this study involved 18 of the 27 known standpipes in the Parson's Pond area. Of these, only ten yielded collectable oil. Of two standpipes locally reported at St. Paul's Inlet, only one was located and contained oil. All standpipe samples occurred as oil slicks on top of the local water table. Oil was also collected around Parson's Pond from small streams and springs.

SHALE GEOCHEMISTRY

The west coast of Newfoundland is a unique area for this study as both the depositional environment and tectonic setting of black shale are well documented. The organic potential of these samples can be assessed using accelerated maturation through pyrolysis and bitumen extraction. In addition, shale was analysed for percent carbonate (Table 1).

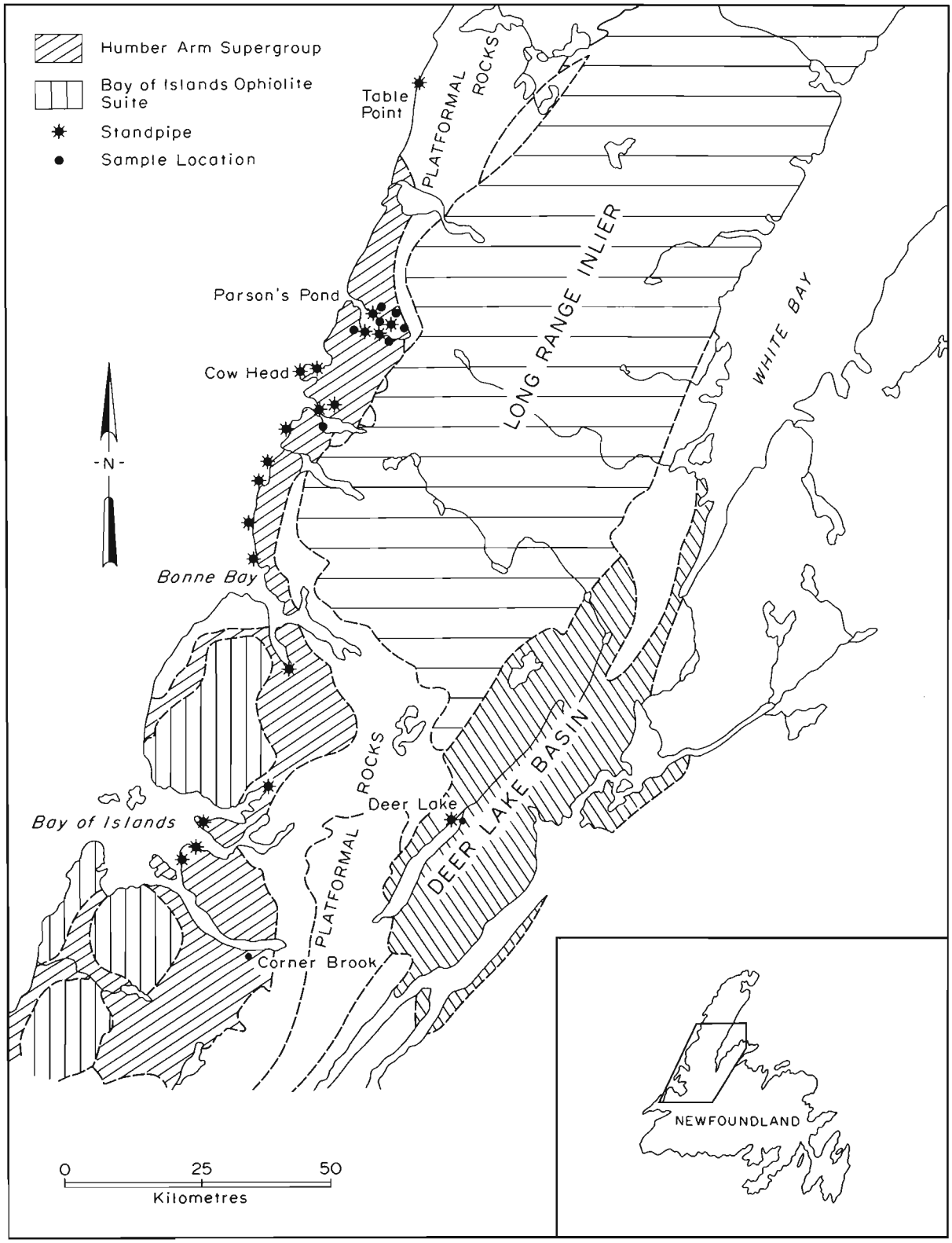

Figure 1: *Regional geology of western Newfoundland.*

Table 1. Percent carbonate and extractable bitumen from selected samples

Sample location	Carbonate	Extractable bitumen
Parson's Pond	35.29	1.45
Parson's Pond	7.80	0.10
Parson's Pond	37.57	0.02
Parson's Pond	82.81	0.10
Cow Head	23.17	0.27
Cow Head	19.62	0.11
Cow Head	25.26	0.47
St. Paul's Inlet	86.39	0.03
Broom Point	18.18	0.46
Western Brook	8.64	0.12
Martin Point	14.89	0.32
Martin Point	67.26	0.03
Green Point	25.52	0.13
Green Point	9.08	0.18
Green Point	19.34	0.02
Lobster Cove	44.53	0.07
Lobster Cove	16.43	0.02
Northern Head	13.64	0.07
Northern Head	20.56	0.05
Northern Head	13.47	0.59
Northern Head	25.27	0.16
Northern Head	18.24	1.63
Deer Lake	40.27	0.10

A total of 42 samples were collected; 38 from the Humber Arm Supergroup and four from the Deer Lake and Table Head groups. To avoid any chemical biodegradation, some weathered outcrops were not sampled.

Preliminary results suggest a larger percentage of extractable bitumen from samples of the Northern Head Formation as compared to the Cow Head and Table Head groups. Most samples range between 0.02 to 1.60 percent bitumen. There appears to be no notable variation of bitumen content in relation to percent carbonate. This fact may indicate that shale from this locality is relatively depleted in bitumens. Determination of total organic carbon using kerogen content will allow the assessment of hydrocarbon potential for each stratigraphic unit.

Additional studies of the shale will include gas chromatography of whole oils, extracts and specific oil fractions in order to determine chemical signatures. Preliminary results of the distribution of carbon-atom chain structures, or total alkanes, from a Cow Head shale extract show that odd-numbered carbon chains predominate over even-numbered ones, indicating an immature bitumen (Figure 2-A). A similar distribution from one of the seep oils shows a strongly biodegraded oil (Figure 2-B). Both patterns contain very low amounts of pristane and phytane, or isoprenoid alkane components. This may indicate that the two samples are genetically related. Stable-isotope analyses of carbon and nitrogen on kerogens, oils and extracts will determine if the

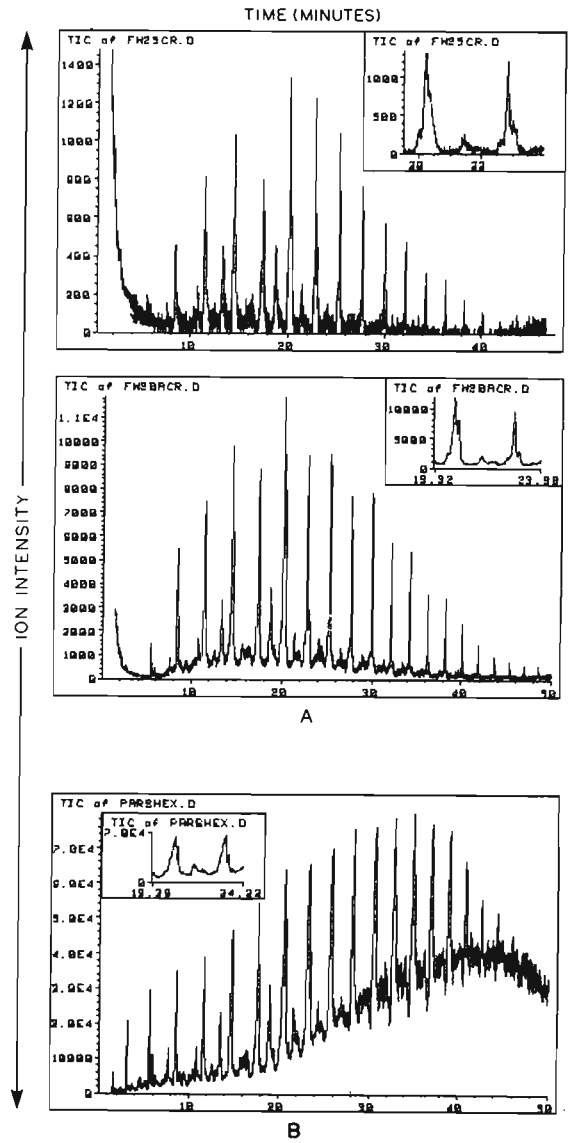

Figure 2: *A–gas chromatogram of Cow Head shale extracts; B–gas chromatogram of seep oil from Parson's Pond. Insets are pristane and phytane peaks.*

extracts from the shale can be correlated with the oils found in the standpipes. A new technique comparing asphaltenes precipitated from pyrolysates, seep oils and extracts will be attempted as a method of geochemical source-rock evaluation.

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