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OIL SHALES NEAR DEER LAKE, NEWFOUNDLAND

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Introduction

This brief report gives a more detailed coverage of certain areas described in the review of Deer Lake oil shales by Macauley (1984), and is based largely on a geological mapping program of the Carboniferous Deer Lake Basin conducted by Hyde (1979, 1983), and the Rock-Eval pyrolysis analysis of a suite of surface samples.

Stratigraphic and Tectonic Setting

Oil shales in the Deer Lake region of western Newfoundland (Fig. 1) are contained within the Rocky Brook Formation (Deer Lake Group) of Viséan (Early Mississippian) age. This unit is mainly lacustrine in origin (Belt, 1968, Hyde, 1979), and is stratigraphically sandwiched between two fluvial units (the North Brook and Humber Falls Formations, Fig. 2). in the western part of the basin. These nonmarine sediments accumulated in a pull-apart basin in which rifting developed in response to dextral wrenching along the Cabot Fault system (Hyde, 1979).

Within the Rocky Brook Formation, oil shales are most abundant in the upper part, corresponding to the Squires Park Member (Hyde, 1983). The Squires Park consists of grey to green, dolomitic siltstones and mudstones that are intercalated with grey to buff-coloured, calcareous dolostones. In its grain size, composition, bedding style, presence of fossil fish, and oil shale, the Rocky Brook Formation greatly resembles the Albert Formation of New Brunswick (Macauley and Ball, 1982). The Rocky Brook Formation has been dated as Viséan on the basis of spores (Barss, pers. comm., 1980), and is thus younger than the Albert Formation (Tournaisian).

Oil Shale Facies Associations

In the Squires Park Member, oil shales occur in three distinct stratigraphic contexts, which are here termed Facies Associations I-III. This is a preliminary classification that will probably be revised when a detailed study of the oil shales is completed. There is no clear relationship between this three-fold stratigraphic classification of Deer Lake oil shales and the lithologic classifications of Hatch (1919) and Landell-Mills (1954)

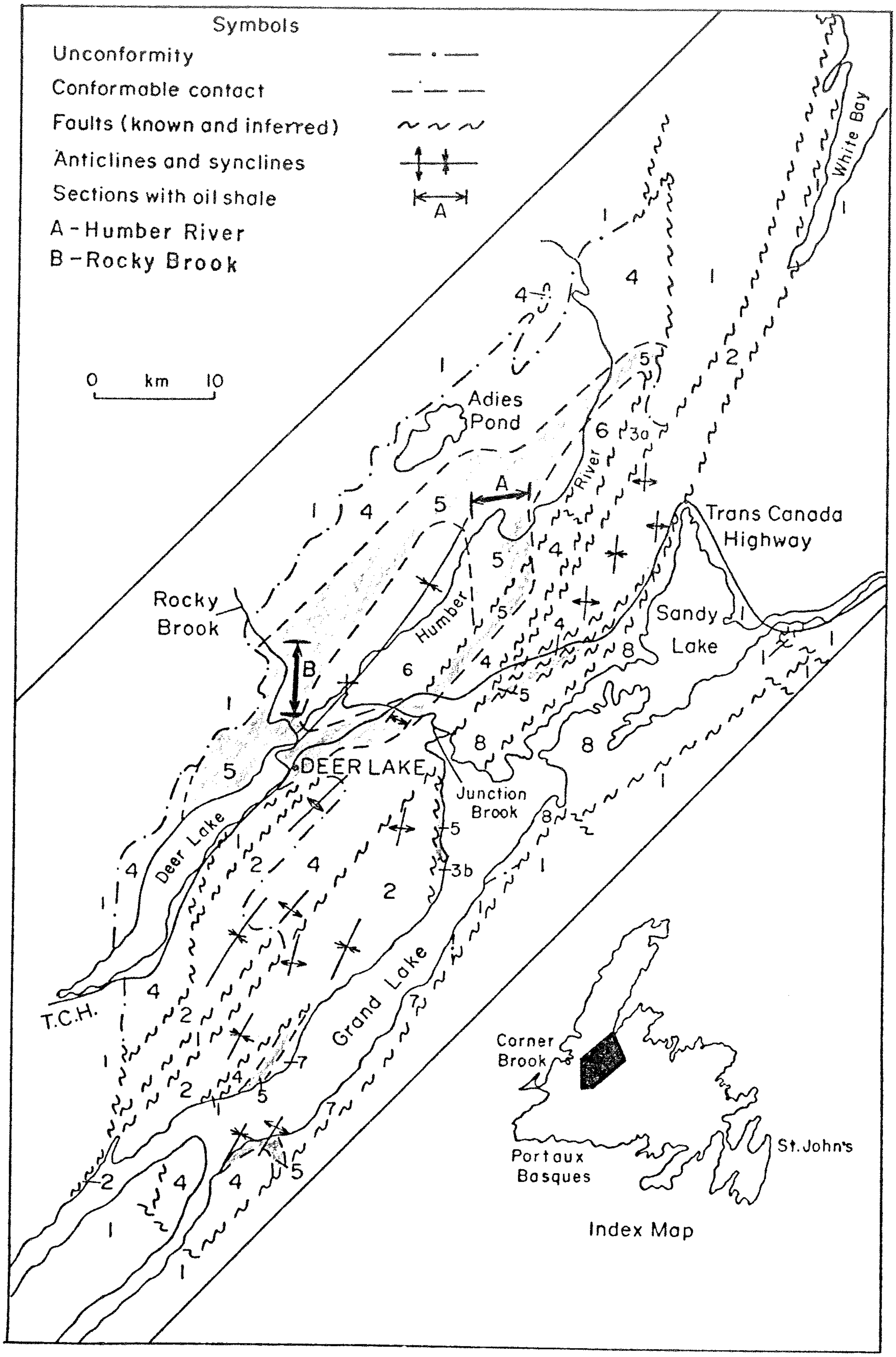

Figure I Simplified geologic map of Deer Lake Basin showing those surface sections with oil shale.

Stratigraphic Legend, Fig. 1

CARBONIFEROUS
Westphalian A
[8] Howley Fm.

Namurian (?) - Viséan
[7] Little Pond Brook Fm. [6] Humber Falls Fm.
[5] Rocky Brook Fm.

[4] North Brook Fm.

Tournaisian
[3b] Wetstone Point Fm.
[3a] Wigwam Brook Fm.

[2] Anguille Grp (undivided)

PRE-CARBONIFEROUS
[1] mostly granitic gneiss and metasediments on west; mostly volcanic and granitic rocks on east.

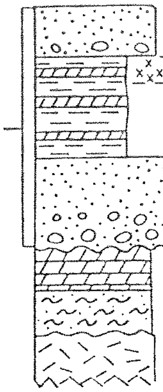

Fig.2. Stratigraphic succession in the western part of the Deer Lake Basin.

(See Macauley, 1984, p. 45, 46).

Facies Association I

Dark brown oil shales are interbedded with thin (2.5 cm) layers of allochemical dolostones. Dolomitic allochems are cemented by blocky calcite spar, and consist of peloids, ooids, and pisoids. Fish scales, bones, and plant stems are also detrital constituents. The oil shale is dolomitic and ordinarily splits in a platy fashion, although some is more fissile. In addition, the oil shales have a light brown streak and a faintly petroliferous odor. Layers of oil shale separating the thin allochemical dolostones are usually about 2-10 cm thick. The thin beds of oil shale and dolostone form couplets which can be repeated many times to form units from less than one to several metres thick. A stratigraphic section, measured along the Humber River within Sir Richard Squires Provincial Park, illustrates this Facies Association (Fig. 3).

Facies Association II

Although oil shales along Rocky Brook occur as Facies Association I, they are more commonly interbedded with stromatolitic carbonate rocks at this locality (facies Association II). In these latter examples, the oil shales are much thicker (tens of centimetres) than those associated with the allochemical rocks. Lithologically, Association II oil shales are broadly similar to those in Association I (dark brown color on fresh surfaces, light brown streak, platy, dolomitic), but weather to a distinctive blue-gray color. Some ripple cross-laminated silty lenses (starved ripples) indicate that, periodically, stronger currents were able to transport slightly coarser sediment. The oil shale layers are usually less than 1 m in thickness. Up to

Squires Park Member
- Squires Park Section -

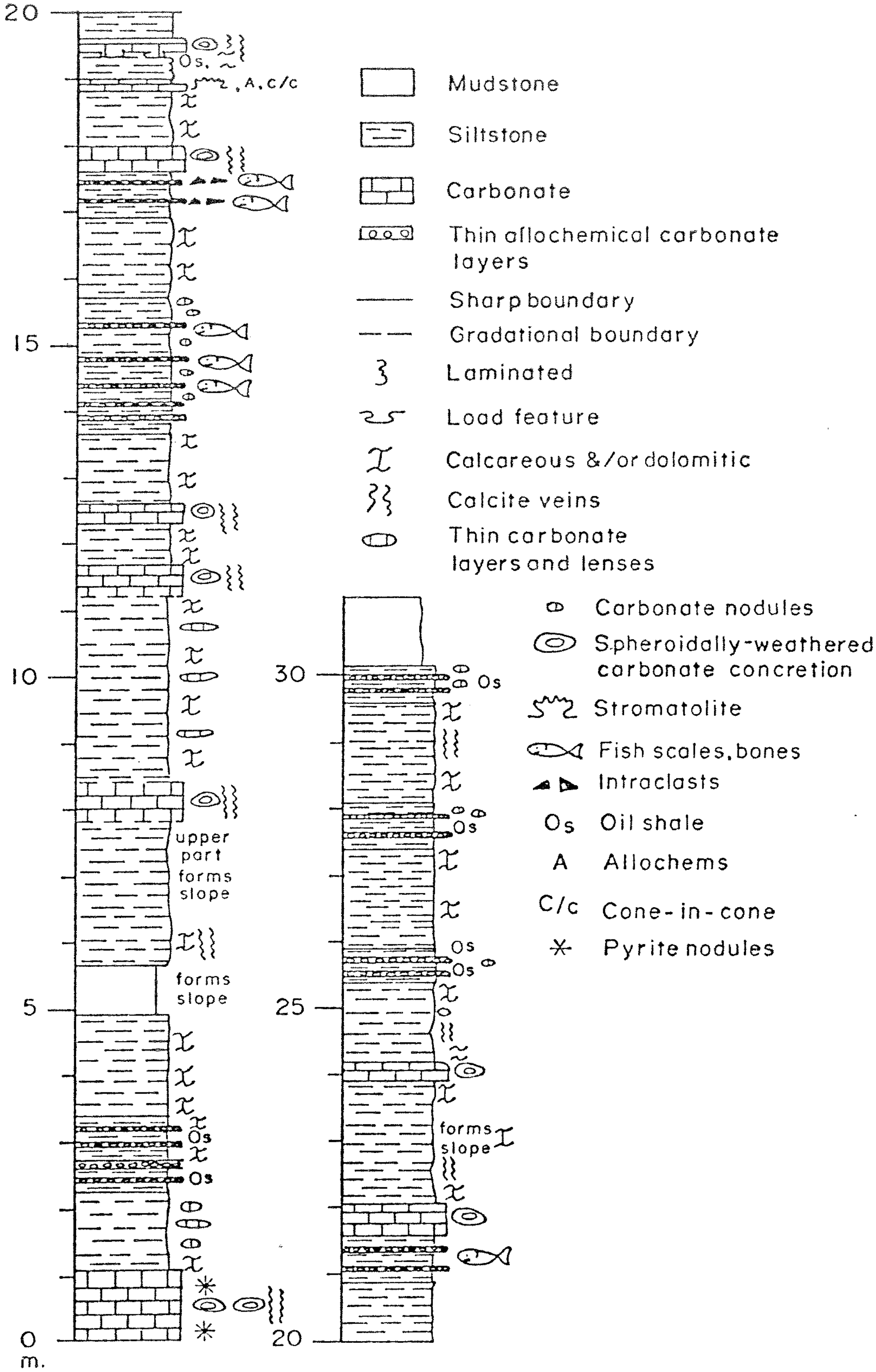

Fig.3 Section along Humber River showing oil shales of facies association I

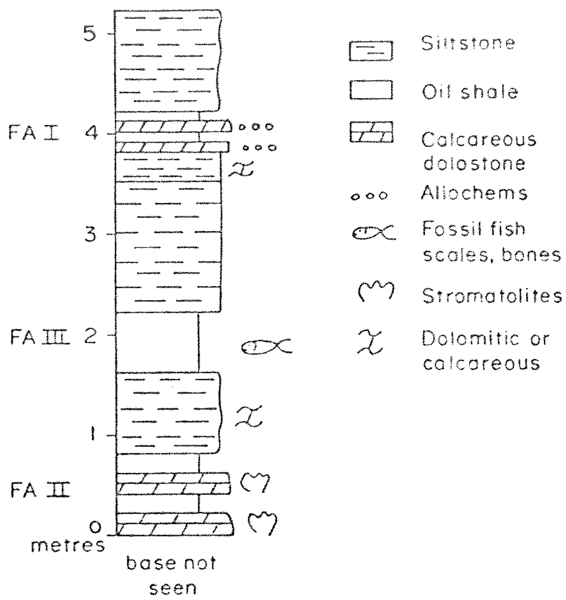

Fig.4 Facies associations of oil shale, Squires Park Member, along Rocky Brook.

1.6 m of oil shale over a 2.0 m stratigraphic interval has been observed. This facies association has only been noted along Rocky Brook. The following short measured section (Fig. 4) illustrates this association.

Facies Association III

As shown in Figure 4, oil shales can also occur that are not in contact with carbonate rocks, but with mudstones that contain much less kerogen than the oil shale. These oil shales grade into the underlying and overlying mudstones, and are lithologically similar to those oil shales in Association II.

Petrography and Mineralogy

In thin section the oil shales show abundant orange/brown, amorphous kerogen intimately intermixed with fine-grained dolomite. Disseminated quartz grains and opaque organic matter are also present. One sample contains pustule-like concentrations of dolomite, which are reminiscent of Botryococcus-type algal growth in sapropelic coals.

A few samples of the clay size fraction ($<2\mu m$) of crushed oil shales were analyzed by x-ray diffraction. Based on air-dried and glycolated samples only, the main clay minerals seem to be chlorite and smectite or interstratified chlorite/smectite. Illite is present in subordinate amounts, but in other non-petroliferous mudstones it can be the dominant clay mineral.

The diffraction spectra also revealed the presence of dolomite, analcite, quartz, and feldspar.

Rock-Eval Analyses

Sixteen samples of oil shale from the Rocky Brook Formation were analyzed by Rock-Eval pyrolysis at the Institute of Sedimentary and Petroleum Geology, Calgary. Table 1 summarizes the results.

A plot of the hydrogen index against the oxygen index (Fig. 5) indicates the kerogen to be the Type I variety of Tissot and Welte (1978). This is especially evident in the samples with high total organic carbon (TOC) content (>5%) and commensurate high hydrogen indices (HI 600). Four samples, all with low TOC values (<4%), have hydrogen indices below 500: these probably reflect an admixture of Type III kerogen, but could also result from bitumen migration into otherwise low or non-organic beds. These samples are sporadically located within the sampled section.

Tmax values (Table 1) in the range 440-450°C (Average 440°C) indicate low to moderate thermal maturity. Although the orange/brown color of kerogen indicates a greater degree of maturation and vitrinite reflectance values in other samples from the Rocky Brook range from 0.60 to 1.04% (maximum values in oil), Type I kerogen may require higher temperatures for hydrogen generation than do Type II and Type III kerogens (Macauley et al., 1984 Macauley, 1984). Extremely low production indices (S1/(S1 S2)), generally .01 to .04, also verify low thermal maturation in the bitumen generation phase.

The yields on pyrolysis are best correlated to the total organic carbon content (Fig. 6). Excluding the four abnormal low yields, an average 7.0-7.3 kilograms/tonne can be expected for each 1% TOC content. This is almost identical to that recovered on an average of all zones at the New Brunswick Albert Mines deposit (7.5 kilograms/tonne) (Macauley, Ball and Powell, 1984).

No specific gravities have been reported for the Deer Lake oil shales. For Type I kerogen at a marginal to low maturation by comparison to the Albert oil shales, 0.91 should be an acceptable specific gravity estimate. The range of the yield/carbon ratio, 7.0-7.3 kg/tonne/%TOC, will approximate 7.7 to 8.0 litres/tonne/%TOC.

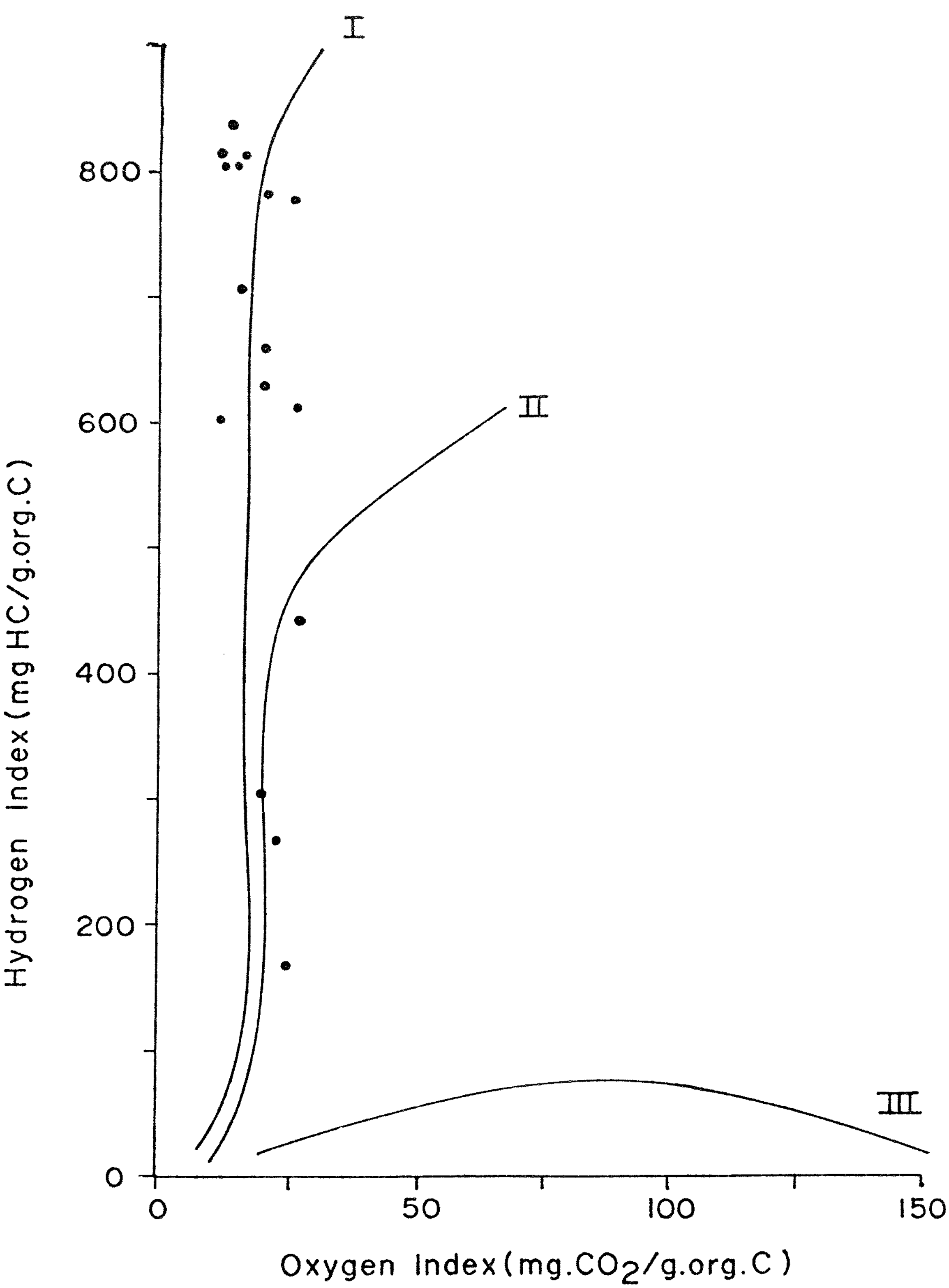

Figure 5. Plot of hydrogen index against oxygen index for Deer Lake oil shales.

Table 1. ROCK-EVAL DATA, ROCKY BROOK FM. OIL SHALES

Sample No.	Member	% organic C	$S_1 + S_2$ (kg/ton)	T_{max} (°C)	S_1	S_2	S_3	HI	OI
RH-OS-1	?(float)	9.67	76.26	437	0.96	75.30	2.53	778	26
RH-OS-2	?(float)	15.93	132.20	450	2.80	129.40	1.90	812	11
RH-OS-4	?(float)	14.91	122.05	446	2.19	119.86	1.82	803	12
RH-82-46	Spillway	8.88	73.62	448	1.58	72.04	1.35	811	15
RH-82-47	Spillway	8.02	65.90	451	1.34	64.56	1.20	804	14
RH-82-52A	Squires Park	2.77	4.89	438	0.26	4.63	0.67	167	24
RH-82-124	Squires Park	3.54	17.06	441	1.46	15.60	0.96	440	27
RH-82-126A	Squires Park	5.08	33.40	444	1.40	32.00	1.03	629	20
RH-82-128	Squires Park	5.45	34.21	444	0.96	33.45	1.46	610	26
RH-82-131	Squires Park	5.23	35.88	445	1.41	34.47	1.05	659	20
RH-82-132	Squires Park	9.73	83.09	448	1.86	81.23	1.30	834	13
RH-82-143A	Squires Park	5.92	42.86	444	1.05	41.81	0.89	706	15
RH-82-172	Spillway	3.72	10.75	442	0.82	9.93	0.82	266	22
RH-82-176	Squires Park	9.62	58.19	448	0.44	57.75	1.05	600	10
RH-82-190	Squires Park	3.67	11.41	440	0.26	11.15	0.72	303	19
RH-82-192	Squires Park	8.32	67.43	445	2.43	65.00	1.73	781	20

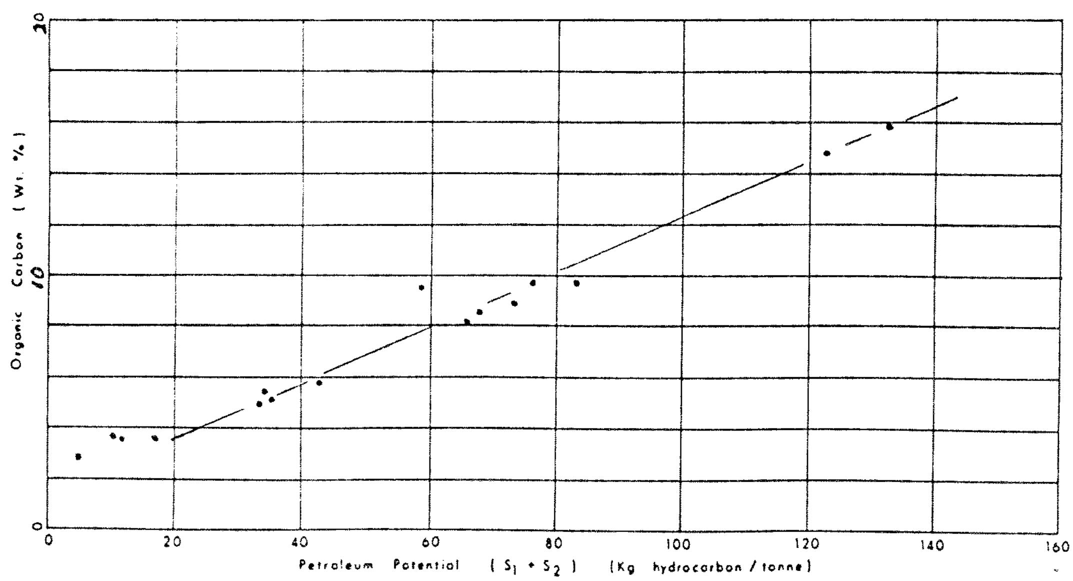

Figure 6: Plot of petroleum potential against total organic carbon content

Potential for Exploitation

Our existing knowledge of the oil shales near Deer Lake is based only on two surface sections (along Rocky Brook and the Humber River), plus a few scattered outcrops, and a few drillholes that were discussed by Landell-Mills (1954). This is woefully inadequate for a proper assessment of the potential for exploitation of this resource, but, based on the data at hand, such an assessment would be a negative one. Although some of the grades are good (up to 155 litres/tonne; Macauley, 1984, p. 46), such grades are not sustained over a sufficient thickness to justify mining. Mining and oil extraction would also be rendered difficult by the presence of the thin allochemical carbonate layers in Facies Association I.

On the positive side, there is a vast, largely unexplored, region on the western side of the Deer Lake Basin, between the sections along Rocky Brook and at Sir Richard Squires Provincial Park (sections shown on Fig. 1), that is underlain by the Rocky Brook Formation and might contain richer and thicker deposits. This part of the basin is structurally very simple, with gentle stratal dips to the southeast of less than 10°, and the Rocky Brook Formation is close to the surface with only a thin cover of Pleistocene till. There is also reasonably good access to all areas potentially underlain by the oil shales.

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