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Source Rock - Oil Shale Potential

of the

Jurassic Kunga Formation

Queen Charlotte Islands

by

George Macauley

Institute of Sedimentary and Petroleum Geology

Geological Survey of Canada

Ministry of Energy, Mines and Petroleum Resources

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SOURCE ROCK - OIL SHALE POTENTIAL
OF THE
JURASSIC KUNGA FORMATION, QUEEN CHARLOTTE ISLANDS

ABSTRACT

A total of 284 samples, mostly from the Kunga Formation upper banded (argillite) member, but with selected control from the overlying Maude Formation and the underlying Kunga middle black limestone unit, were analyzed for total organic carbon and subjected to Rock-eval pyrolysis.

These sediments are within the thermally mature oil generating phase in the Ghost Creek-Rennell Junction areas of the Skidegate Plateau, but are overmature westerly at Shields Bay and southerly at Maude Island, both along the easterly front of the Queen Charlotte Ranges. Oil shale potential is limited to the Ghost Creek area, but is economically questionable because of the minimum occurrence of high-grade lenses within a gross zone of low yield sediments. Both Kunga and Maude Formations have generated oil, some of which has definitely migrated from the source beds. These beds, if present, are an excellent source for oil accumulations below the Tertiary Masset volcanics in the Charlotte Lowlands of northeastern Graham Island and under Hecate Strait.

INTRODUCTION

Richardson (1874) was probably the first geologist to see the oil shales of the Queen Charlotte Islands: at that time, the carbonaceous appearing surfaces on crushed and slickensided zones were mistaken for coal. Dawson (1880) described the interval containing the oil shales beds, but no mention was made of oil shales being present. Clapp, in both 1914 and 1915, mentioned oil shales on the Queen Charlotte Islands, but placed them in the Cretaceous rather than the Jurassic because of misinterpreted paleontological data.

The stratigraphic analysis of Jurassic beds of the Queen Charlotte Islands continued intermittently, including publications by MacKenzie (1915, 1916), by McLearn (1949), a comprehensive analysis of the regional geologic framework by Sutherland-Brown (1969), and a recent paper on the Jurassic biostratigraphy of Graham Island by Cameron and Tipper (1981). None of these dealt with oil shales per se.

In late 1980, the Geological Survey of Canada, Institute of Sedimentary and Petroleum Geology, at Calgary, Alberta, instituted a review of the data on Canadian oil shales available at that time (Macauley, 1983). The results of that study led to a more detailed geological-geochemical investigation of the Albert Formation oil shales in New Brunswick (Macauley and Ball, 1982). Within that study, geochemical methods for the assessment of oil shales were established that would provide readily comparative data for oil shale deposits across Canada.

This study continues the investigation of potential oil shale deposits across Canada. Limited unpublished data provided initial direction. Only a few analyses were available for the Jurassic oil shales of Queen Charlotte Islands: Petro Canada Exploration Inc. supplied 13 analyses from 3 main areas (Macauley, 1983). Cores of the oil shale zone were cut at three locations by Intercoast Resources Corp., but had not been evaluated. Much of these cores has been subsequently been lost, but 118 samples were analyzed from 264m (866') of core remaining from the initial 618.7m (2006') cut. B.E.B. Cameron, at the Geological Survey of Canada, Pacific Geoscience Center, Pat Bay, had sampled most of the cores for micro-paleontological studies: an additional 56 analyses were made on the remains of his samples from the lost core intervals.

All samples, surface and core, were subjected to X-ray diffraction for mineral composition, analyzed for total organic carbon content, and pyrolyzed by the Rock-eval technique to determine potential hydrocarbon recovery, kerogen

type and maturation, and source rock potential.

Acknowledgements

Funding for the project was provided jointly by the Province of British Columbia, Ministry of Energy, Mines and Petroleum Resources, Victoria, and the Department of Energy Mines and Resources, Geological Survey of Canada Institute of Sedimentary and Petroleum Geology, Calgary. The geochemical analyses, including the X-ray diffraction studies, carbon determinations, and Rock-eval pyrolyses, were conducted by J. Wong, R. Fanshaw and M. Ferguson respectively at the Institute of Sedimentary and Petroleum Geology.

Surface sampling was carried out in conjunction with surface biostratigraphic studies by B.E.B. Cameron, Pacific Geoscience Center, Pat Bay, and H.W. Tipper, Cordilleran Geology section, Vancouver, of the Geological Survey of Canada. Between them, Cameron and Tipper pointed out the key outcrop areas to sample and provided significant micro - and macro - paleontological data respectively. In particular, Cameron most helpfully assisted in the inspection and sampling of several key sections and also provided generalized lithologic logs to assist in the core studies.

Assistance for the interpretation of the organic geochemistry was supplied throughout by L.R. Snowdon and T.G. Powell at the Institute of Sedimentary and Petroleum Geology, Calgary.

Thanks must be expressed to K. McAdam, Petroleum Geologist, and W. Young, Chief Geologist, of the British Columbia Petroleum Resources Branch, for their continued interest through which the Province of British Columbia participated in this joint project.

Petro-Canada Exploration Inc. had released an oil shale survey report by T.P. Chamney for the initial review prepared by Macauley (1983): references to these data, where included herein, will be specifically noted within the text.

T.G. Powell, B.E.B. Cameron and K. McAdam all read the manuscript and contributed greatly through their comments, especially with specific suggestions for expansion of some sections and for elaboration on some of the conclusions and their implications.

STRATIGRAPHY

MacKenzie (1915, 1916), in his work on Graham Island, established the Vancouver Group to include the Yakoun and Maude Formations, with the Maude Formation containing the oil shale zones, and established the Triassic-Jurassic age of his Maude Formation.

Sutherland-Brown (1968) expanded the Vancouver Group to contain the entire Triassic-Jurassic sequence of the area, comprising a basal volcanic interval (Karmutsen), conformably overlain by the limestone-argillite Kunga Formation, grading upward to the Maude Formation of shales, argillites and sandstones, all of which are disconformably overlain by a final volcanic sequence, the Yakoun Formation (Fig. 1). Sutherland-Brown restricted the Maude to the uppermost beds containing the coarser clastics, and defined the underlying argillite-limestone Kunga Formation as a distinct unit. The Karmutsen Formation is not present on Graham Island.

A three-fold sub-division of the Kunga was also established by Sutherland-Brown. A lower zone of grey massive limestone is overlain by a thinly bedded black limestone, which is succeeded by an upper thinly bedded black argillite unit. His uppermost argillites contain the oil shales.

Chamney, in his unpublished work for Petro-Canada Exploration Inc., postulates that the three unit subdivision occurs laterally as well as vertically. In this respect the grey limestone - black banded limestone - black argillite can also be projected as a south to north facies relationship. Cameron (personal communication) believes, from his micro-paleontological evidence, that the Maude-Kunga contact is diachronous, becoming older northward, and thus supporting a partial lateral facies relationship of Maude to Kunga Formation.

Cameron has found microfauna to be fairly abundant in the Maude Formation, to decrease downward through the upper Kunga, and to be absent from the two lower Kunga members. Ammonites (Tipper, personal communication) are similarly distributed, although an ammonite horizon does date the lower grey limestone as Triassic (Fig. 1). With a significant time span poorly represented by fauna, diachronism of the stratigraphic boundaries cannot be established with certainty.

Upper Kunga beds are recognized at outcrop by the "banded" nature of the bedding. Beds of the middle unit flaggy black limestone range from 7 cm to 1 m in thickness, in contrast to bands 1 & 10 cm thick of alternating

lithologies in the upper unit. The banding is particularly evident in outcrop because of differential weathering, often resembling ribbon chert. Internal laminations are more common to the banded lithologies than to the flaggy black limestones: overlying Maude shales, up to metres in thickness, are finely laminated and fissile. Although laminated, the hard (argillite) upper Kunga beds are not fissile.

Within this report, the upper Kunga may be termed the "banded member": "argillite" will not be used because no thermal metamorphism has been detected to create the "hard" aspect of the rocks on Graham Island (MacKenzie, 1916). By standard definition (Bates and Jackson, 1980), an argillite classification implies metamorphic change. Thermal metamorphism may be significant to Upper Kunga beds at the type section (Sutherland-Brown and Jeffrey, 1960, p.2) on Kunga Island (Fig. 2) at the south of this study area.

Age	Stage		Stratigraphic Unit			
	Cameron & Tipper		Mackenzie	This Paper		Sutherland-Brown
Cret.				Longarm Fm.		Longarm Fm.
Jurassic	Callovian		Vancouver Group	Yakoun Fm.		
	Bathonian					
	Bajocian					
	Aalenian					
	Toarcian			Maude Fm.		
	Pliensbachian					
	Sinemurian					
	Hettangian					
Triassic	Norian		Maude Fm.	Kunga Fm.	U. BANDED	BLACK ARGILLITE
	Karnian				M. Black Ls.	Black Limestone
					L. Grey Ls.	Grey Limestone
					Karmutsen Fm	

Fig. 1: Triassic-Jurassic correlation chart, Queen Charlotte Islands

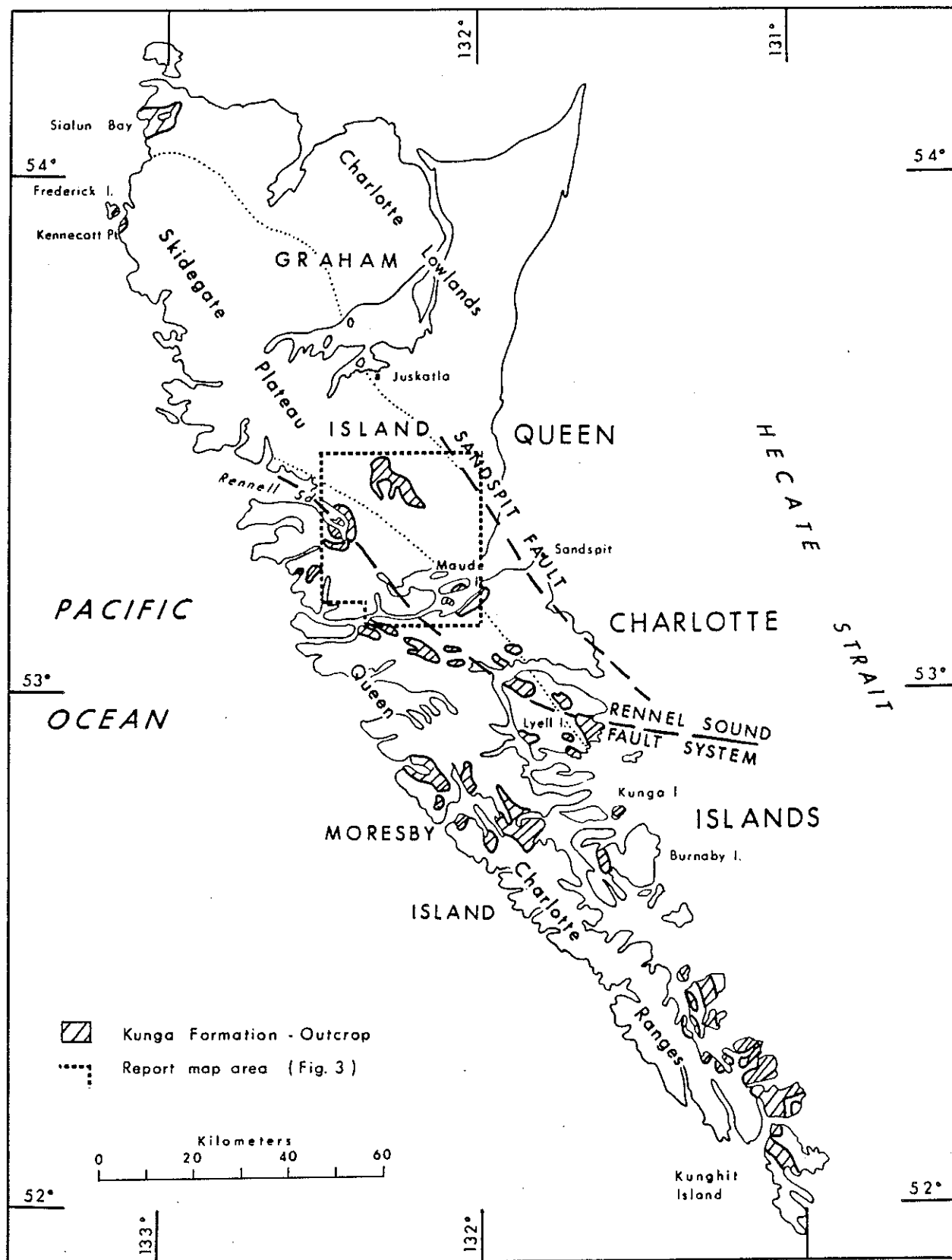


Fig. 2: Outcrop distribution of Kunga Formation, Queen Charlotte Islands (after Sutherland-Brown, 1968)

LITHOLOGY

Upper Kunga strata comprise several distinct lithologies, of which black, hard claystone to siltstone (argillite) is predominant in bands 1 to 10 cm thick, is internally laminated but not fissile, and contains some organic carbon content. In part these grade to limestone and silty limestone. Lesser lithologies include thin beds of light green claystone, greenish volcanic ash, and greenish calcareous sandstones which decrease rapidly upward in grain size to claystones. Minor dark brown to black thin beds (1 cm or less) are composed of organic-rich laminated fissile oil shale.

MINERALOGY

Quartz and feldspar, mostly albite, are the dominant minerals of all Upper Kunga lithologies, except for increased calcite in the limestone intervals. Sandstone mineralogy is similar to that of the fine claystones, although the sandstones contain much larger rock fragments. All the detrital grains are of volcanic origin.

Both mixed layer clays and undifferentiated chlorite-kaolinite are present, with the mixed layer clays more common. Illite is virtually absent.

Carbonates, other than calcite, are not significant. Only scattered traces of dolomite and siderite are noted, as are possibly related gypsum trace occurrences. Traces of several zeolites attest to the volcanic origin of the detritus in the Kunga and Maude intervals.

Much more complete descriptions of the lithology and mineralogy are available in Sutherland-Brown (1968, p. 50-56).

DISTRIBUTION

Rocks of the Kunga Formation crop out more commonly in the southern half of the Queen Charlotte Island group, especially on Moresby, Lyell, Kunga, Burnaby and Khunghit Islands (Fig. 2). Occurrences decrease northerly, but there are several important exposures in the southern part, as well as some localized outcrops at the northwest limit, of Graham Island.

From Chamney's analyses (Macauley, 1983), little or no oil shale potential is recognized from exposures on the southern islands where structural deformation and metamorphism appear to have destroyed any economic potential of the Kunga

Formation.

Because the oil yields to date have virtually all occurred over the southern part of Graham Island, the area of geochemical investigation was limited to that outlined by the map area of Figure three. Within this project boundary, data have been analyzed relative to four areas of outcrop-core hole occurrences, including Rennell Sound Road-Shields Bay at the west, Maude I. - Whiteaves Bay at the southeast, and the Rennell Junction and Ghost Creek areas in the north central part of the map area. Immediately north of Ghost Creek, exposures along King Creek were not accessible because of logging operations.

Chamney also reports oil shale potential from Kennecott Pt. at the northwest corner of Graham Island (Fig. 2): access to this area was not possible within the budget limitations.

Except for the south shore of Maude Island, all of the sampled sections are readily accessible along the logging roads; most of the outcrops result from road cuts and/or the roadside quarries which provide road fill material. Access along the main logging roads is restricted during normal Monday-Friday logging hours, but is otherwise open to the public; however, clearance is best obtained from the operators prior to use of any of these roads. Secondary logging roads are closed entirely when being actively logged, but may be open at all times when not in use. The initial Queen Charlotte main road, easterly of the Yakoun River, has been abandoned, with local low spots now in bad condition, and river crossings no longer in service. Road data and maps are available from the McMillan-Bloedel operations office at Juskatla, and from the Crown-Zellerbach office in Sandspit (Fig. 2).

ORGANIC GEOCHEMISTRY

A total of 284 samples were analyzed for total organic carbon content and subjected to a Rock-eval pyrolysis. Of these, 110 samples were collected from the surface exposures, 118 were from the remaining core of the three Inter-coast Resources coreholes, and 56 were selected from the least affected of Cameron's core samples which had been treated to obtain microfauna. X-ray diffraction was used to determine the gross mineralogies of all samples.

The geochemical data are presented in three ways. A log form follows the generally accepted technique for illustration of Rock-eval pyrolysis data, with columns for organic carbon percentage, maximum pyrolysis temperature, hydrogen and oxygen indices, hydrocarbon potential and production index. The

plots of hydrogen and oxygen indices assist in maturity interpretation as does the graph of hydrocarbon potential versus organic carbon. This latter graph is significant to the assessment of economic potential.

Discussion of the four main areas of upper Kunga will be in order from greatest maturation-least hydrocarbon potential to that of least maturation-greatest potential.

Sutherland-Brown (1968) considered the black flaggy limestones of the middle Kunga member to be carbonaceous. More recently, Cameron and Tipper (1981) reported bitumen occurrences within the Maude Formation and Cameron (personal communication) has questioned whether or not some of the Maude lithologies could have source rock potential. Because of these observations, sampling was continued, to a limited extent, into underlying black limestones and overlying Maude lithologies, even though the prime purpose has been an evaluation of the source rock and/or oil shale potential of the upper Kunga beds.

RENNELL SOUND ROAD-SHIELDS BAY AREA

Possibly the only complete section, which is sufficiently undisturbed so as to be measurable, is located on the south side of a steep hill where the Rennell Sound logging road descends to the shores of Shields Bay (Fig. 3). Proceeding westerly down the hill, Yakoun sandstones overlies about 9 m (30') of light colored shale (mineralogically all quartz and feldspar) over approximately 98m (320') of banded upper Kunga. This is separated by 12m (40') of covered interval from 21m (70') of rocks transitional to, or within, the black limestone unit. A further 18m (60') of covered interval overlies 12m (40') of definite black limestone equivalent (Fig. 4). The possible transitional unit is included in the middle member because of characteristic grey weathering in contrast to multi-colored weathering, including distinctive red, for the banded interval. The above thicknesses are approximations only as the section was not measured in detail.

Beds dip steeply to the east ($70-80^{\circ}$) providing prime conditions for examination of an excellent exposure. The road grade is extremely steep, requiring a minimum 1-ton pick-up truck for good weather travel, or a four wheel drive vehicle under wet conditions.

Two additional road-cut outcrops were sampled northward along the shore of Shields Bay. About 15m (50') of black limestone (or transition zone) is exposed at the southerly of these road cuts. Further north, the road bends around a small outcrop (6m, 20') of upper Kunga. Grey limestone beds are

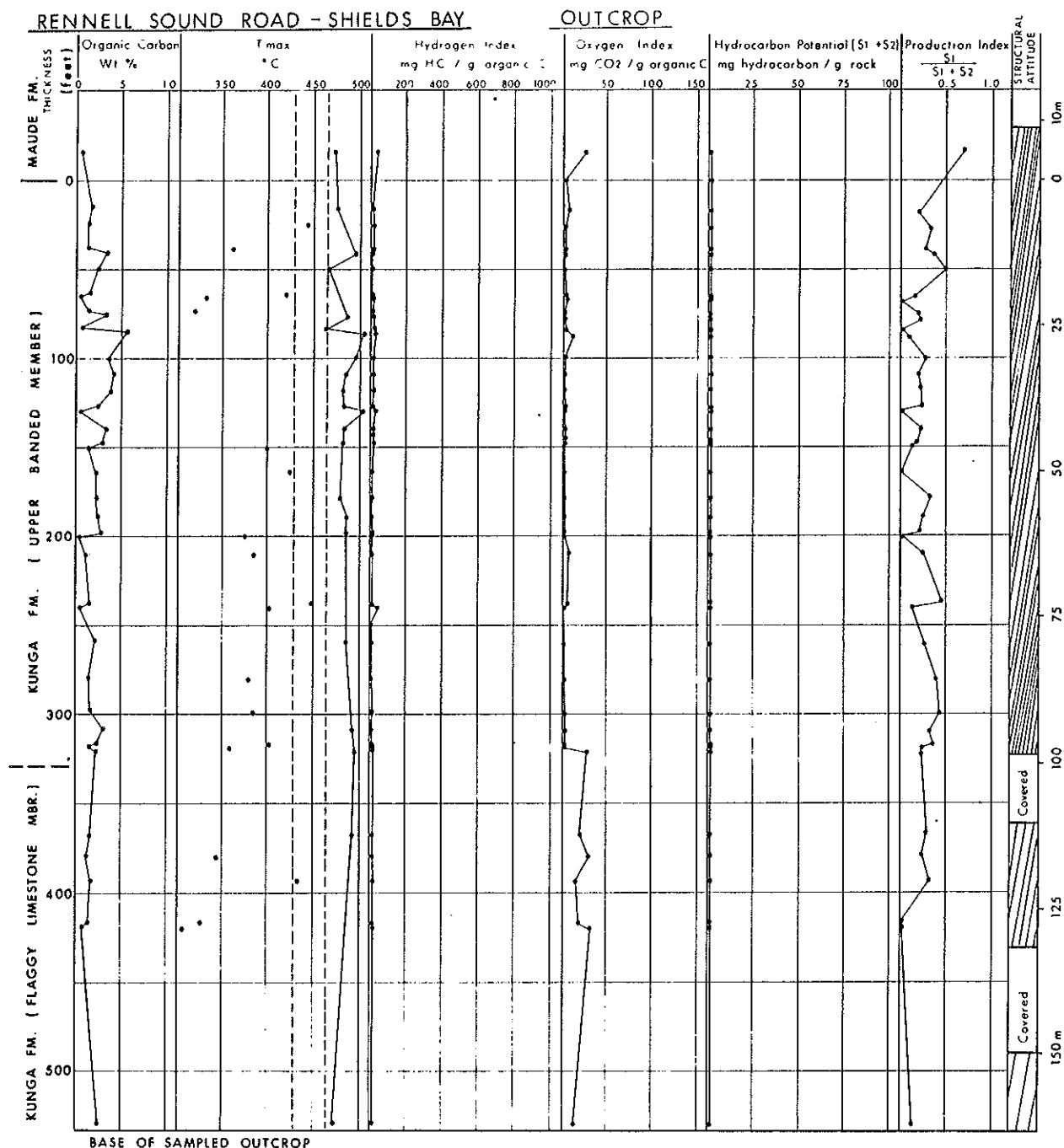


Fig. 4: Rock-eval pyrolysis data, Rennell Sound Road-Shields Bay section

exposed further along the shore at the northwest but were not accessible because of road repair work.

The banded character is shown by color changes from dark to light and from black to grey and brownish-grey, although occasional light green bands and laminae as well as thin laminated fissile shale beds can be recognized.

Sampling for organic geochemistry omitted the extremely light grey and green beds as these were considered unlikely to contain significant organic content. Fissile shales were included, but an attempt was made to ensure that their numbers did not over-emphasize their net quantity within the total section.

Organic Maturity: Organic carbon contents up to 5% by weight (Fig. 4) were recorded. This is adequate for a source rock, but is low for oil shale potential. The maximum temperature of pyrolysis (T_{max}) is above that normally encountered in the oil generation window (430–465°C). The hydrogen index is virtually zero as was the recovery of actual hydrocarbons.

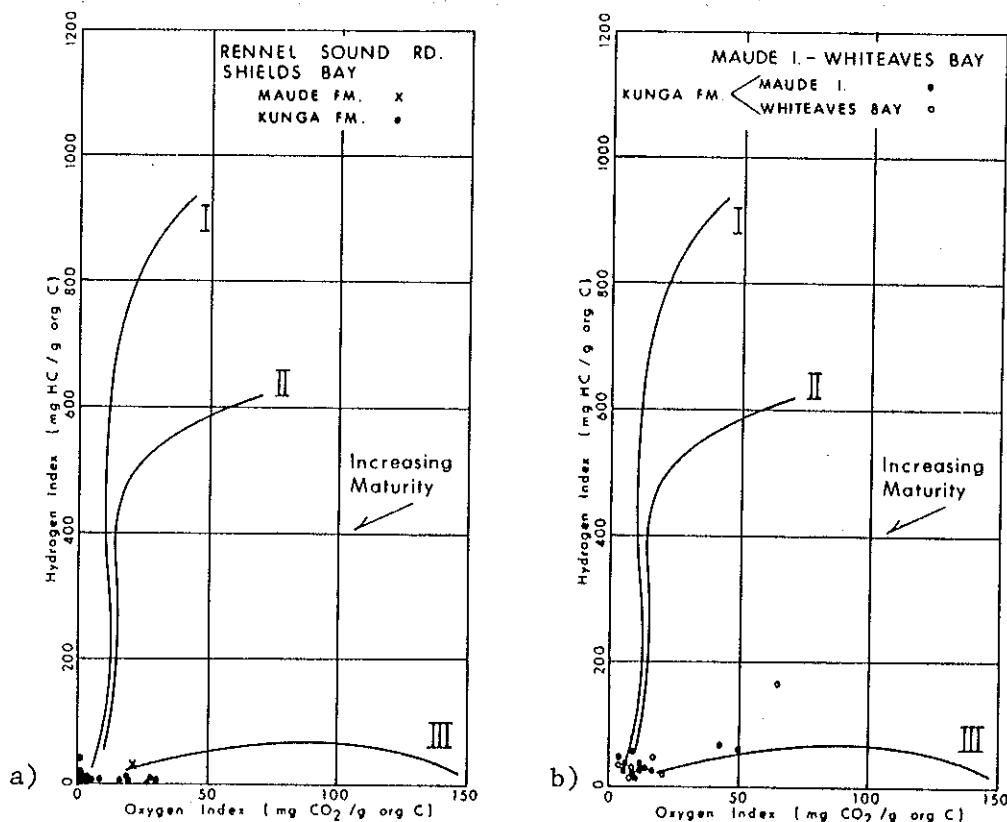


Fig. 5: Hydrogen vs oxygen indices; 5a) Rennell Sound Road-Shields Bay area; 5b) Maude Island-Whiteaves Bay area

The plot of hydrogen versus oxygen index (Fig. 5a) indicates overmaturity for this area. This is confirmed by the low hydrogen index coupled with the negligible hydrocarbon yield from the organic carbon present (Fig. 6a).

Kerogen Type: The hydrogen indices (Fig. 5a) are much too low to allow definitive characterization of the kerogen type. The movements of some points toward higher oxygen indices can indicate the presence of humic kerogen (Type III), although CO₂ may have originated with the volcanic origin of detrital grain material. The higher oxygen indices are concentrated within the flaggy black

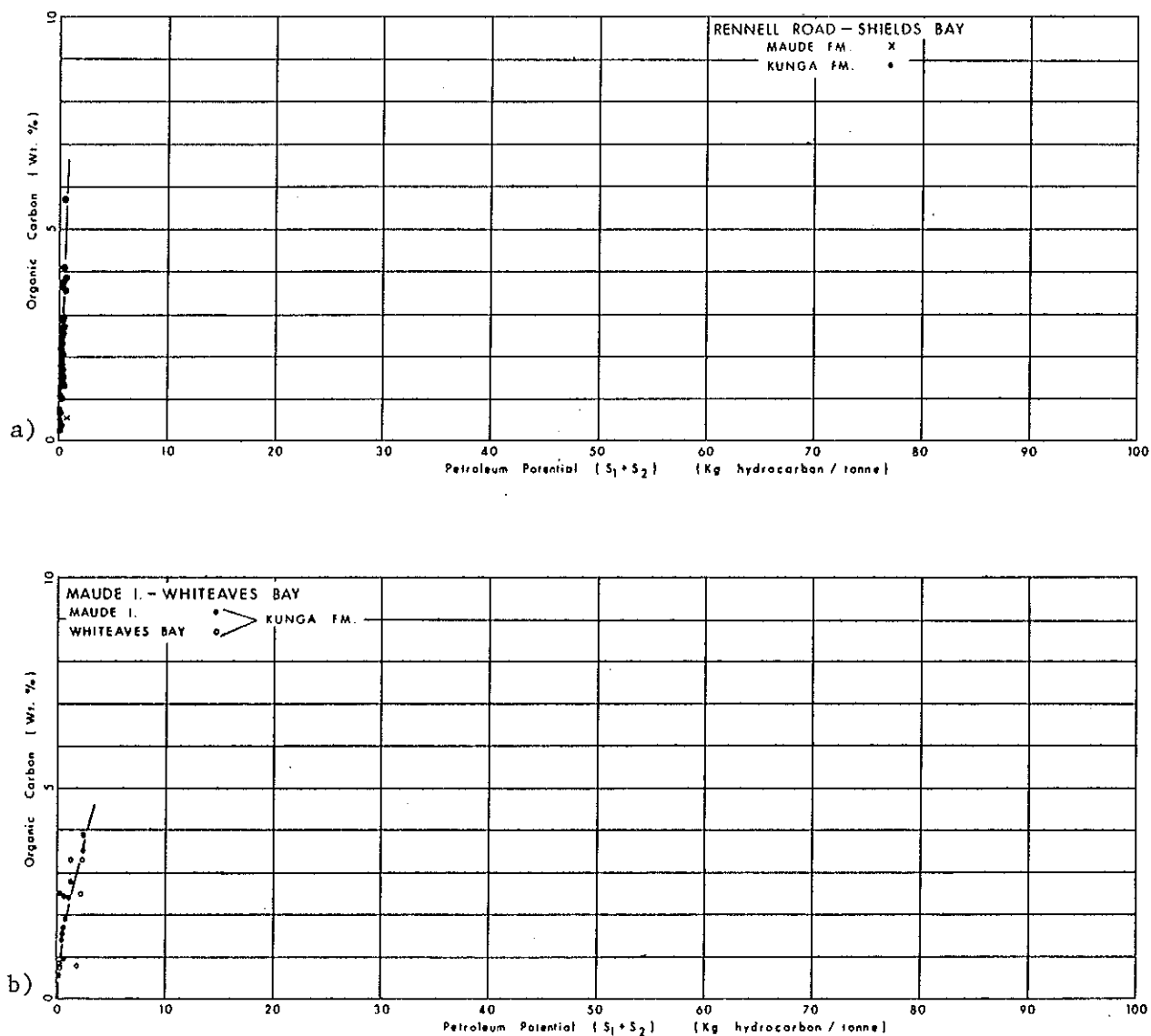


Fig. 6: Comparison of petroleum potential (yield) to organic carbon content; 6a) Rennell Sound Road-Shields Bay area; 6b) Maude Island-Whiteaves Bay area

limestone section (Fig. 4)

Economic Potential: The maturation level is considerably beyond that required for oil shale potential, but the sequence has sufficient organic carbon to have been a source bed. The low values of the production index (Fig. 4) can be interpreted to mean that oil has been generated and expelled in the past, especially from the higher carbon interval 23-61m (75-200') below the top of the Kunga section. This places the significant organic content within the upper half of the upper Kunga member.

In contrast, the low production index might also indicate that the initial kerogen was basically Type III humic, in which case this would not have been a source rock area.

MAUDE ISLAND - WHITEAVES BAY AREA

Upper Kunga beds are well exposed at low tide only in an intermittent series of outcrops along the south shore beach of Maude Island (Fig. 3) and as a few isolated exposures west from Whiteaves Bay (where MacMillan Creek enters the inlet). On Maude Island, dips are near vertical and over-turn is suspected in the upper three samples (Fig. 7). At one location, a fault brings together beds with 90° strike variations across the fault. Although these beds crop out along 300 to 350m of shoreline, and are bounded by Maude exposures at the east and black limestone member at the west, the net

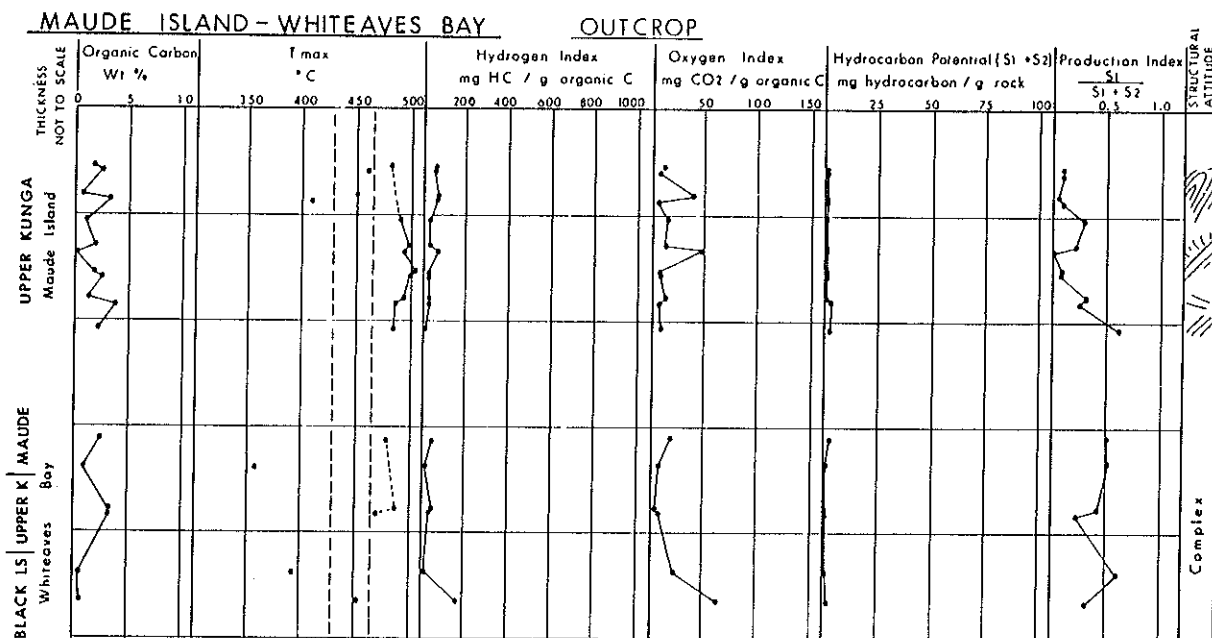


Fig. 7: Rock-eval pyrolysis data, Maude Island-Whiteaves Bay area

depositional thickness is considerably less than, probably as little as one-third of, the shoreline exposure distance.

The Maude Formation is exposed at the eastern promontory of Whiteaves Bay. At the western promontory, a small exposure of on-end drag-folded upper Kunga is covered by, or faulted against, Yakoun sandstone. South-westerly along the shore, two small exposures of black limestone were sampled. The most southwesterly outcrops, reportedly lower Kunga (Tipper, personal communication), were not examined.

Organic Maturity: Maximum pyrolysis temperatures indicate that most of the Maude Island samples are overmature (Fig. 7). Those from Whiteaves Bay show a diverse range, two of which are in the immature range. When hydrocarbon

recoveries are extremely low, the S₂ peak of the Rock-eval pyrolysis graph is often indistinct, which creates error in the computerized selection of Tmax; consequently, these low values must be omitted from interpretation. Hydrogen-oxygen indices (Fig. 5b) also indicate thermal overmaturity.

Kerogen Type: Because of the high maturation level, plots of the hydrogen-oxygen indices provide little indication of kerogen type. Three points indicate some humic content (Fig. 5b) with a single point (Fig. 7) indicating humic plus sapropelic (Type II) kerogen content in the black limestone facies.

Economic Potential: There is no oil shale potential in the area. Production indices (Fig. 7) for Maude Island indicate that generation and migration of oil may have occurred. At the Whiteaves Bay area, the upper Kunga probably generated and expelled any oil component of the kerogen, even though there is a slightly better yield/% organic carbon (Fig. 6b) than at the Shields Bay area. This yield is too small to be of any economic significance.

RENNELL JUNCTION AREA

Three outcrop areas and one corehole are combined to provide the interpretation of oil shale-source rock potential of the Rennell Junction area. Six samples were collected from the lowermost 55m (180') of Maude shale (Fig. 8) along a creek due east of Rennell Junction, in a steep stream cut accessible from the abandoned Queen Charlotte main logging road. Sampling was discontinued upward as shale color became too light to justify analysis. The lowermost sample of this sequence is from an ash bed exposed in the roadside ditch. Cameron (personal communication) states this to be the oldest Maude Formation encountered, all of Early Pliensbachian age. Almost across the road from this Maude section, Cameron dates the uppermost beds of Intercoast Resources I 1-78 as Pliensbachian Maude equivalent (Fig. 9) overlying Kunga strata. As the cores have been lost for this location, no lithologic review was possible by the writer.

Two small outcrops of banded Kunga lithologies are present nearby. About 2.4 km south of the corehole location, the main road cuts across a contorted, possibly faulted, upper Kunga exposure, which may in part repeat section. About 8m (25') of section was sampled. Along branch road 57, north of Rennell Junction, about 12m (40') of shaly appearing banded Kunga is brought to the surface by faults within an outcrop trend area of Maude sediments. There is no stratigraphic thickness or position in section implied on Fig. 8: the

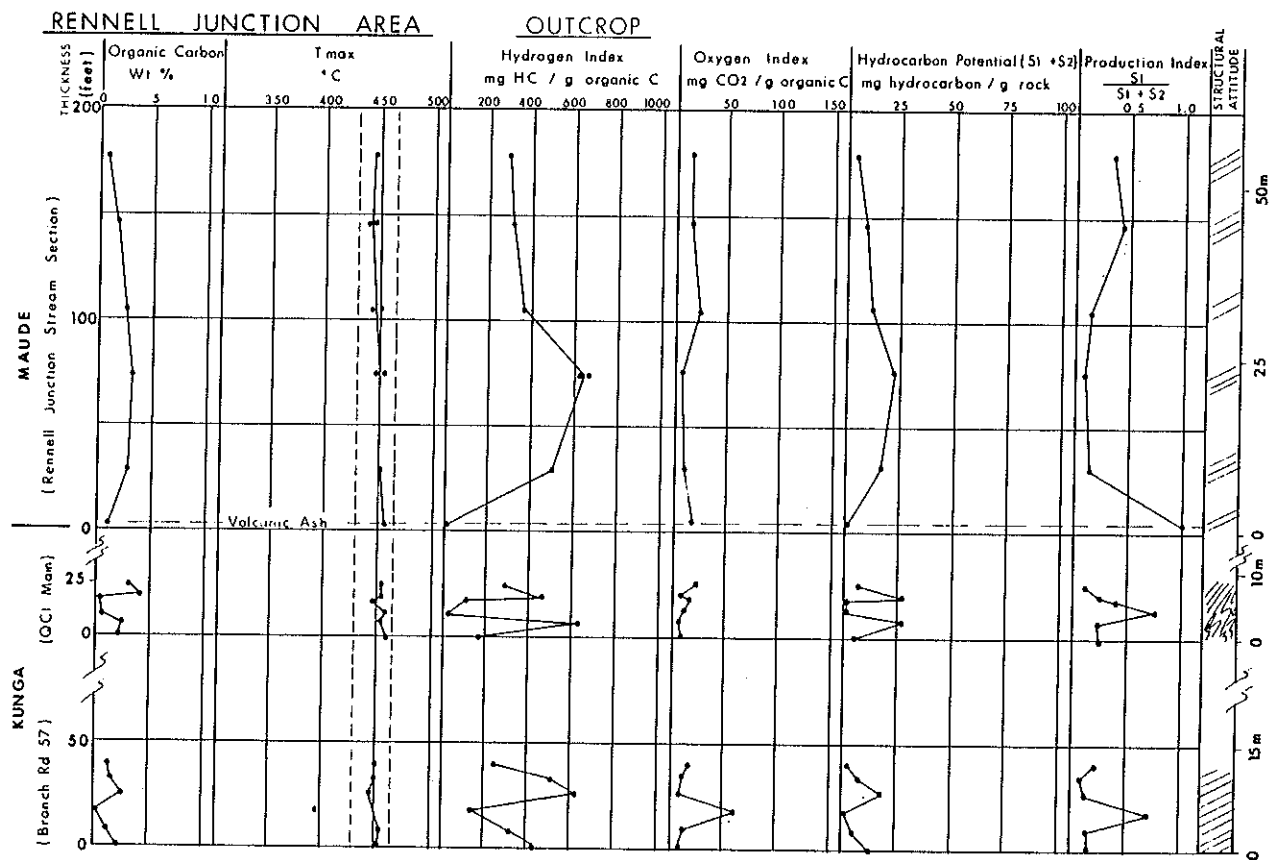


Fig. 8: Rock-eval pyrolysis data, Rennell Junction area

sections are plotted together because of their geological - geographical relationship. Tipper (personal communication) believes the outcrop on branch road 57 to be of Early Sinemurian age, equivalent stratigraphically to black limestone beds; however, the lithology is here distinctly that of the upper banded unit, and consequently may be more appropriately assigned a late Sinemurian age.

Small upper Kunga exposures are understood to be present along Phantom Creek, as well as other creek beds in the area. Logging operations have left a considerable amount of heavy timber debris and the undergrowth is thick; consequently, traversing of the creeks beds is an arduous task by which very little data can be obtained. Road cuts and quarries are by far the best source of surface geological information.

At least 152m (500') of upper Kunga were penetrated at Intercoast I 1-78. Cameron describes considerable intra-formational breccia and highly fractured intervals starting in the upper Kunga and increasing downward. From comparison with the other cores, this section is considered to be expanded considerably by faulting, and by possible folding and overturning, and to be indicative of a

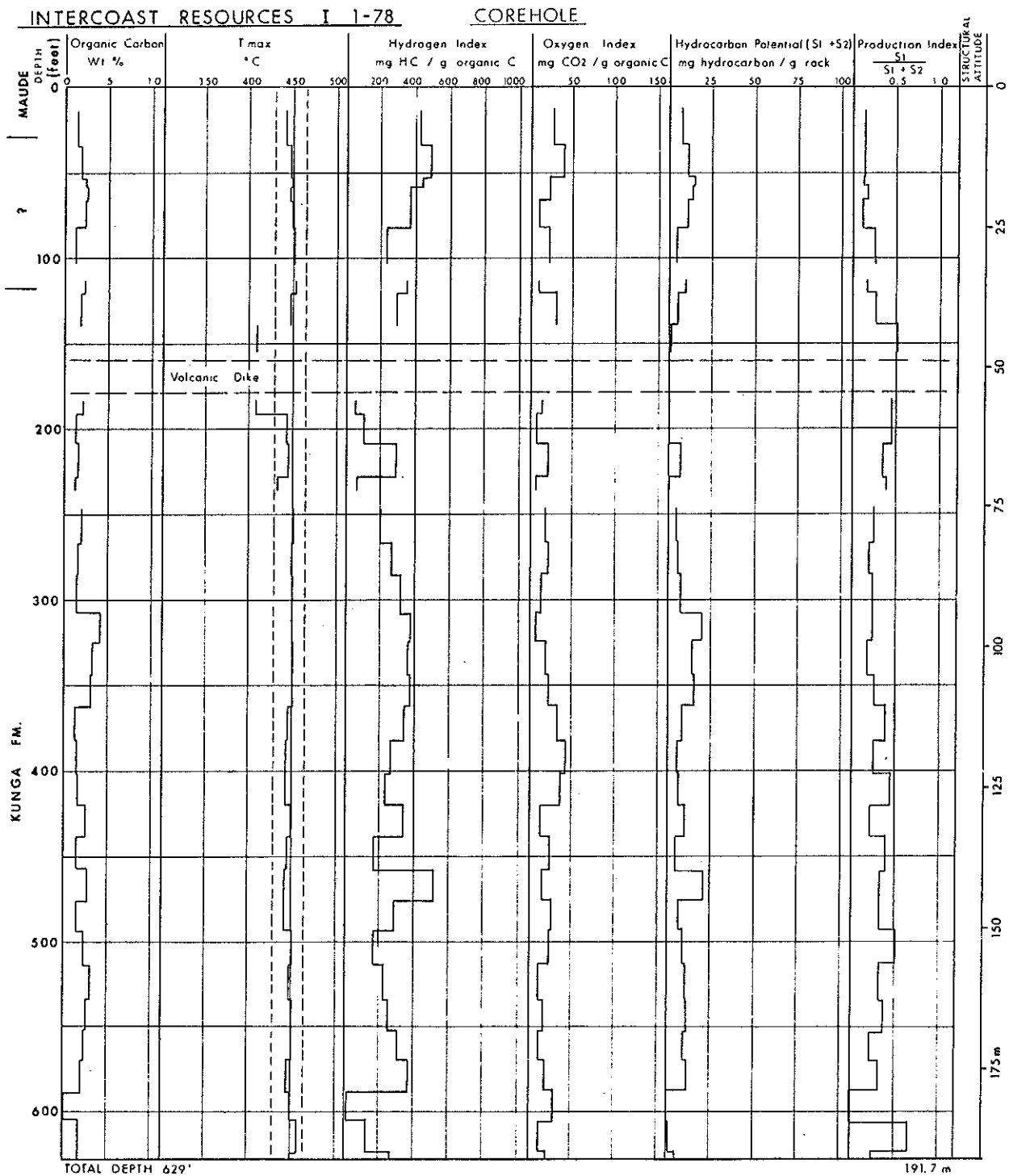


Fig. 9: Rock-eval pyrolysis data, Intercoast Resources I 1-78 corehole

much thinner depositional interval.

Maturity: T_{max} averages 450°C , corresponding to the center of the oil generation window. Values of about 455°C occur in samples from the more southerly section on the Queen Charlotte main road (Figs. 8, 9). A similar degree of maturity is also indicated by the hydrogen and oxygen indices (Figs. 10a, 10b)

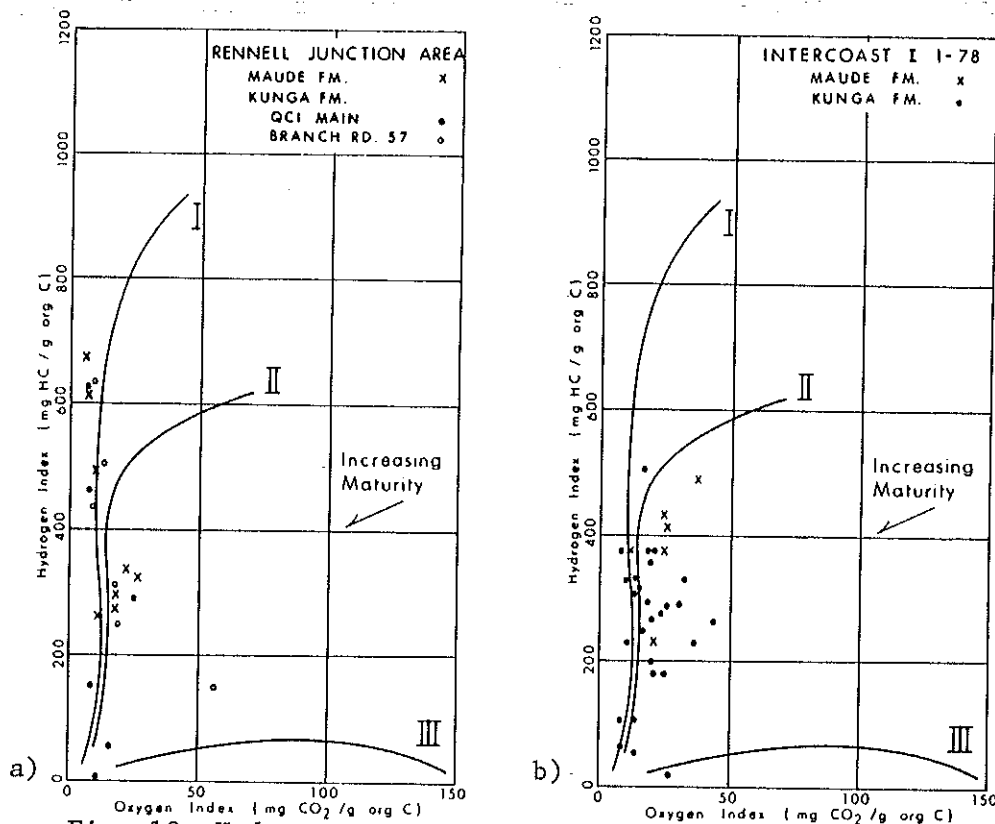


Fig. 10: Hydrogen vs oxygen indices, Rennell Junction area; 10a) surface samples; 10b) Intercoast Resources I 1-78 corehole

A gradual downward increase of T_{max} is noted through the 55m of sampled lower Maude section. This rate of increase is greater than would be expected from normal geothermal gradient related to depth of burial alone.

Cameron has logged a volcanic dike through the approximate interval 47.8 - 54.3m (157'-178') in the I 1-78 corehole. Negligible hydrocarbon potential and related incorrect low T_{max} values are a heat effect on the immediately adjacent beds by the intrusive dike.

Kerogen Type: From figures 10a and 10b, the kerogen is dominantly Type II sapropel, although some Type I algal kerogen is indicated from the results of surface samples. Some of the hydrogen indices above values of 600 (Fig. 10a) may indicate the presence of bitumen in place from the partial maturation of the kerogen rather than Type I material. Bitumen and kerogen are often difficult

to differentiate from the Rock-eval data alone (Clementz, 1980).

Economic Potential: Organic carbon content does not exceed 5% on any of the analyses, although only the harder beds, which did not decompose noticeably under treatment to remove microfauna, were sampled from the I 1-78 corehole. Laminated fissile oil shale beds, if present, were not included in that sample series. The bar log plot for the corehole symbolizes a series of single analyses from samples obtained within the gross intervals shown on the log.

Hydrocarbon potentials are a maximum 25 mg/g rock (=kg/tonne), equal to about 27 litres/tonne at an estimated oil gravity of 0.920 (PetroCanada unpublished data). This is equivalent to 6.5 U.S. gal/ton, considerably below values of economic interest.

The yield lines (Figs. 11a, b) indicate that no yield can be expected at 1% organic carbon, which is anticipated compared to other oil shales. From the variable production index values (Figs. 8, 9), some of the good yield may relate to retained bitumen derivative from the partially matured kerogen. Complex bitumens cannot be differentiated from the shale oil derived from the kerogen by Rock-eval pyrolysis as both are recovered within the S_2 peak. Bitumen is known in vugs and along fractures (Cameron and Tipper, 1981) and was also noted throughout thin sections, of the Intercoast cores, that had been prepared by Cameron for microfaunal identifications.

The range of production indices may indicate migration of generated oil from some beds of the section, and remaining in others, or may also relate to differential movement and accumulation within individual beds of the source rock interval. The 1.0 production index value of the volcanic ash bed (Fig. 8) indicates migration of light hydrocarbon traces into the ash.

Although this area is in the mature oil generating phase, and the generating capability of the remaining kerogen-bitumen is relatively good, there is generally insufficient organic carbon to be economically attractive as an oil shale deposit. This may have been in part a source rock area as indicated by the Tmax data and by the loss of the light oil (S_1) phase.

GHOST CREEK AREA

Four quarries and two coreholes provided the samples of the Ghost Creek area: these samples are the bulk of the study and contain the only economically potential oil shale yields recorded.

On the Ghost Main road, a part of the Queen Charlotte Main road system, quarries A and C are in Maude Formation. Quarry A exposes about 15m of black

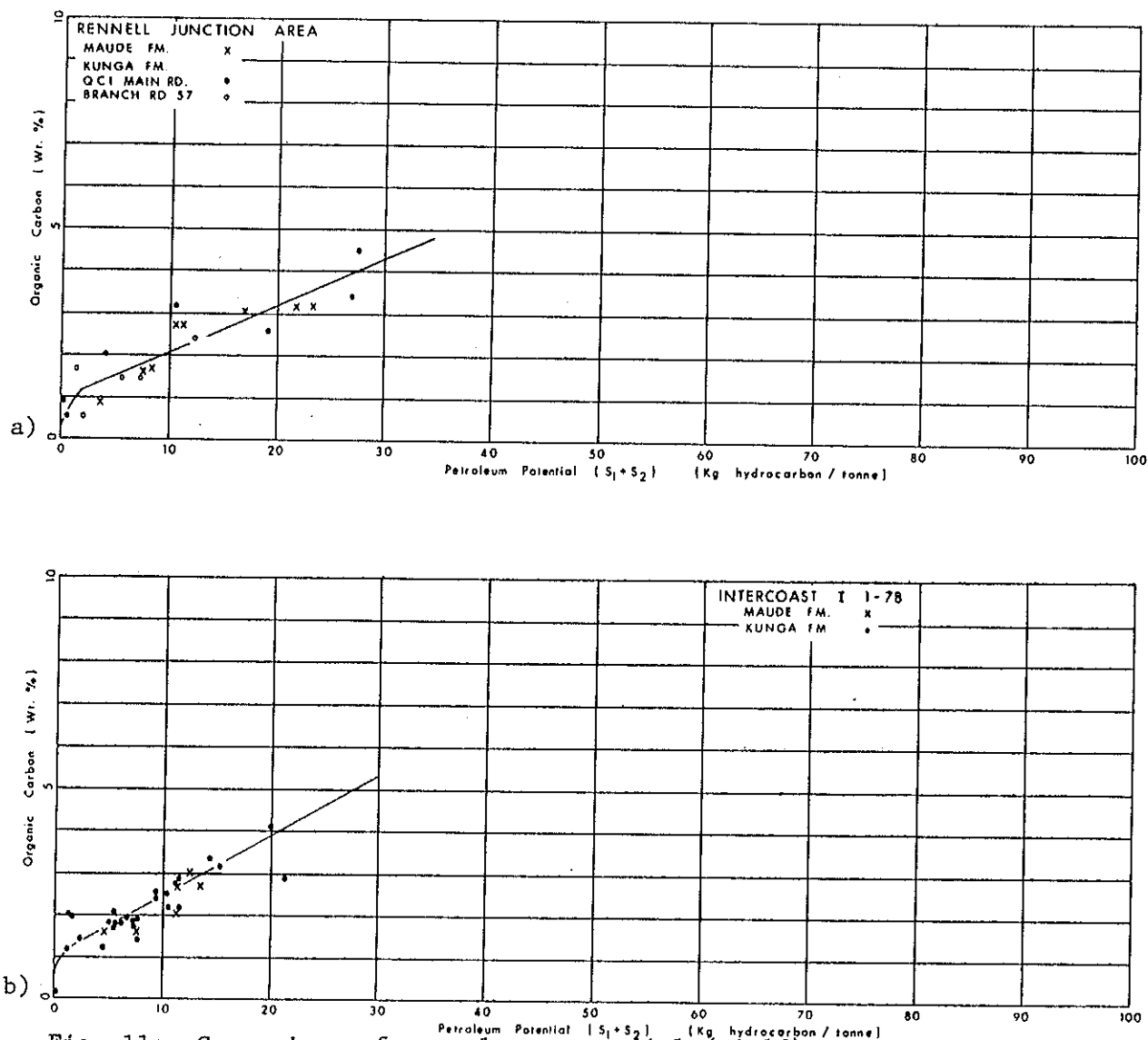


Fig. 11: Comparison of petroleum potential (yield) to organic carbon content, Rennell Junction area; 11a) surface samples; 11(b) Intercoast Resources I 1-78 corehole

calcareous siltstone, thick bedded and only poorly flaggy. Although this superficially resembles the Kunga black limestone facies, Tipper (personal communication) has established a Pliensbachian age for these rocks.

At Quarry B, 23m (75') of banded upper Kunga contains numerous thin (up to 1cm) fissile laminated oil shale beds in the lower third of the exposed section. These oil shales smoke readily and some can be ignited in an open flame. Because of the steepness of the quarry walls, the top 8m interval was not sampled (Fig. 12).

The Intercoast Resources I 1-79 corehole, located nearby to Quarry C, encountered 120m (395') of Maude Formation overlying 91m (297') of structurally contorted upper Kunga member (Fig. 13). The contact is defined microfaunally

(Cameron, personal communication) and lithologically where banding becomes more evident downward. Faulting, folding, and brecciation all increase significantly in the Kunga beds.

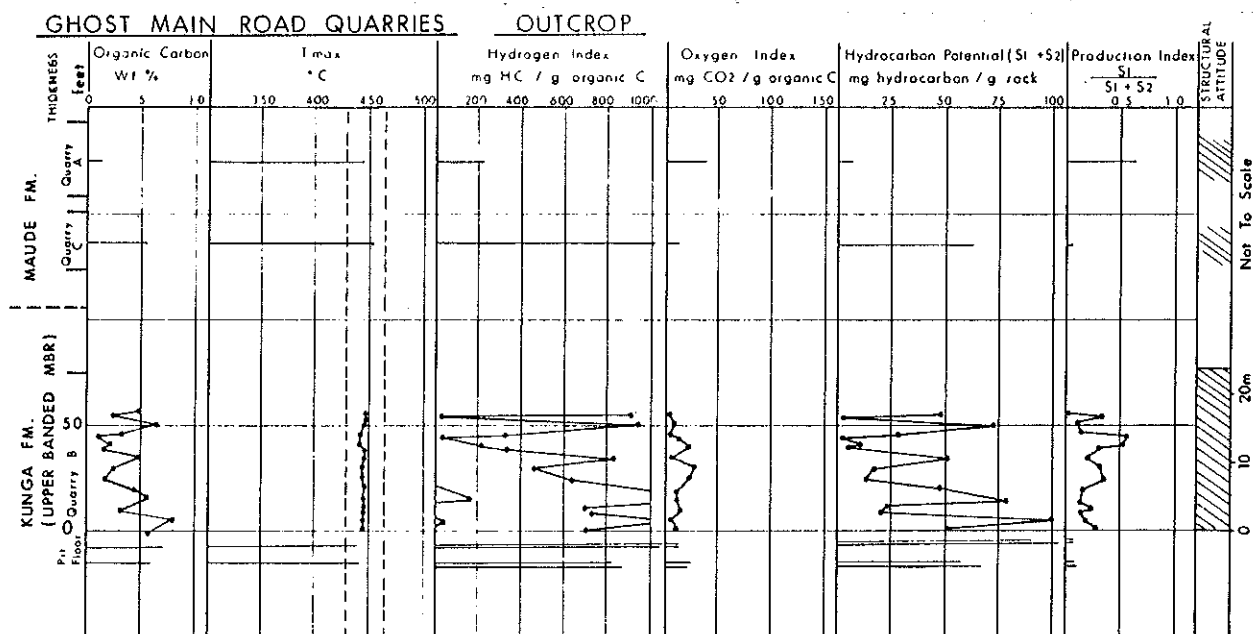


Fig. 12: Rock-eval pyrolysis data, Ghost Creek area, quarry sections

Estimating an average dip of 30° for the Maude Formation beds, 103m (340') of depositional thickness is represented. From the structural attitudes encountered, the true depositional thickness of the Kunga beds must be considerably less than the thickness of Kunga section penetrated in the hole: an estimation of the amount of structural expansion would be too conjectural to have any value.

A second corehole, I 2-78, is located 1100m west of the first location. Analytical data for the upper part of the section at I 2-78 (Fig. 14) are from the residue of Cameron's samples and a single value thus represents an averaged interval. Good thin laminated oil shale beds, if present, are probably not represented in these analyses. All analyses in the lower part of the section are from core.

Structural contortion is also evident in the available core, although not so extreme as at I 1-79; however, the net depositional section represented at I 2-78 will definitely be much less than the 242m (795') total depth of the corehole. Cameron has established all this section to be Sinemurian. Tipper dates an ammonite at approximately 204m (670') as early Sinemurian. Corehole

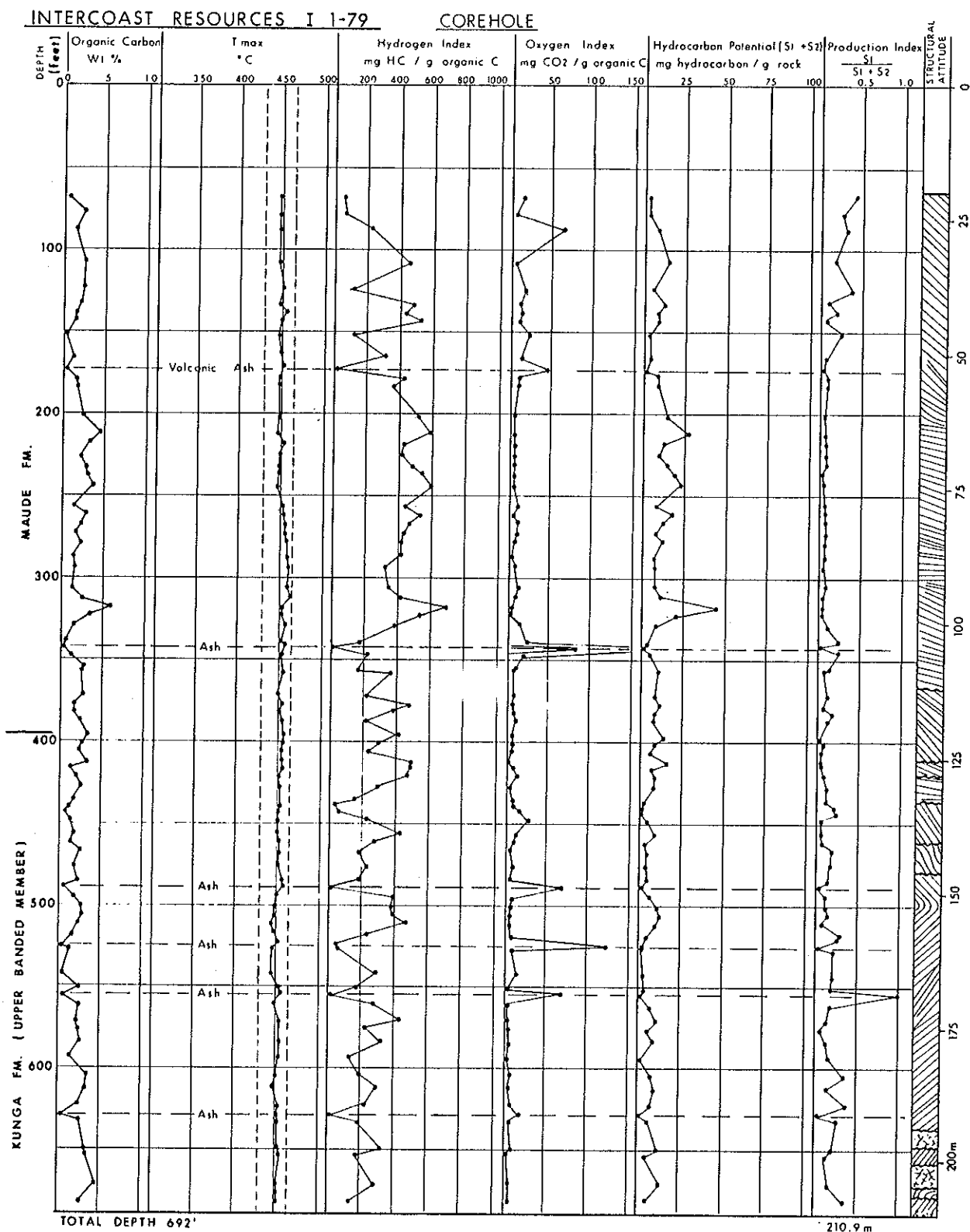


Fig. 13: Rock-eval pyrolysis data, Ghost Creek area, Intercoast Resources I 1-79 corehole

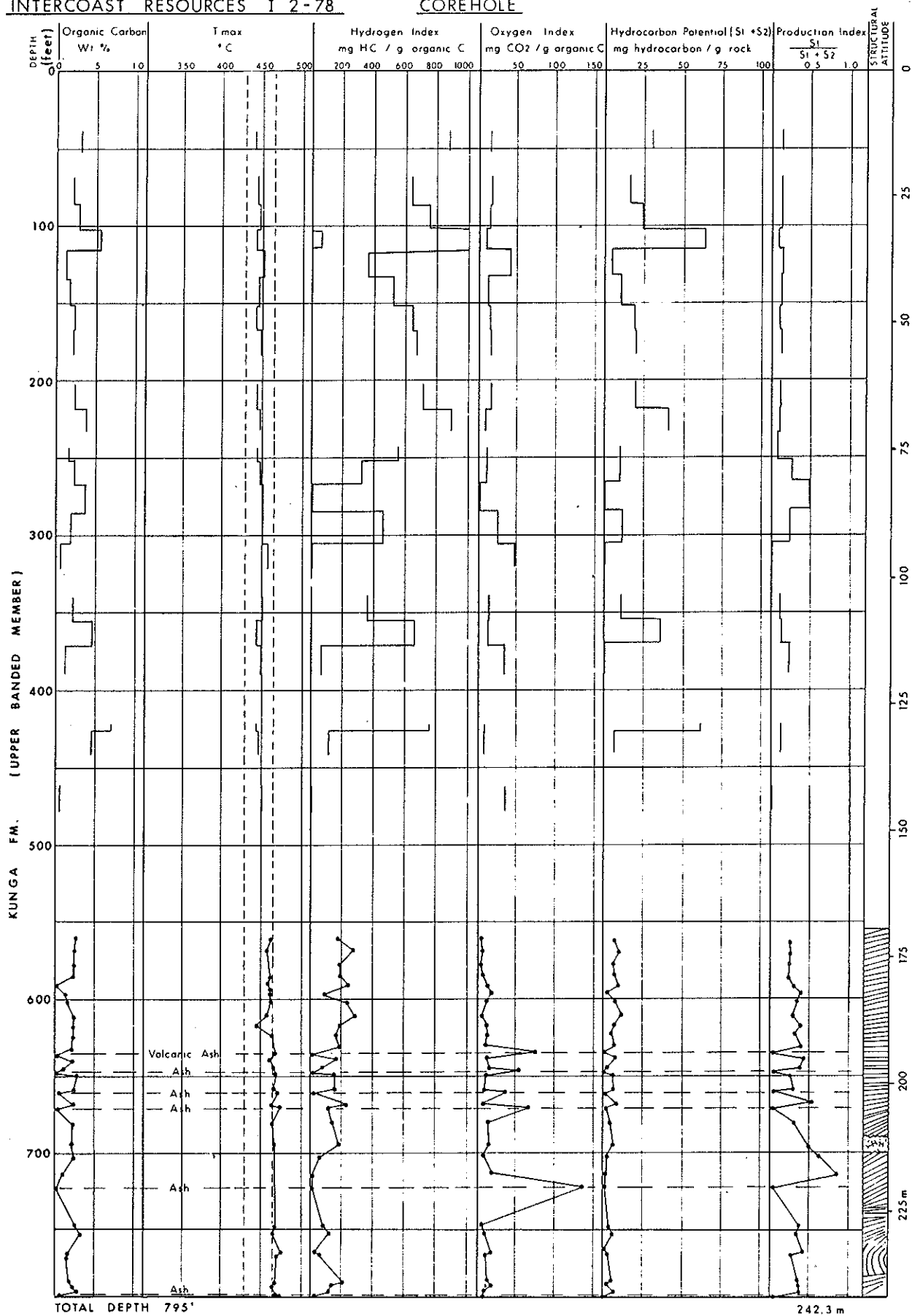


Fig. 14: Rock-eval pyrolysis data, Ghost Creek area, Intercoast Resources I 2-78 corehole

I 2-78 probably bottomed near the base of the Upper Kunga banded member. An estimate of true depositional thickness penetrated at this location is not possible.

Quarry D, on the north side of Ghost Main alternate road, is one of the larger quarries, but is separated from the road by a narrow treed strip. The entrance is narrow, at a road curve, and is easily missed unless watched for closely. An estimated 84m (275') of steeply dipping to overturned, black to black-green banded, hard, massive, calcareous claystone to siltstone resembles the black limestone facies, but is unfossiliferous, and is overlain by Yakoun beds. On general characteristics, this section is considered to be middle Kunga with the entire Maude - upper Kunga missing by erosion below the Yakoun.

Maturity: Tmax increases from 445°C at Quarry B (Fig. 12) to just over 450°C at the bottom of the I 1-79 corehole (Fig. 13) indicating a slight increase of maturity from surface to subsurface, but all within the oil generating range. This maturation increase is confirmed by a corresponding reduction of the hydrogen index (Figs. 15a, 15b).

At a corehole I 2-78, Tmax increases downward from 445°C to 470°C along a uniform gradient in a depth change of 230m. This is an abnormally rapid increase for Tmax values. Volcanic activity is common to this area: dissipation of heat from an underlying igneous intrusive is a possible explanation for this temperature phenomenon. Maturity varies from the lower limit (marginally mature) of the oil window to the overmature zone. This is confirmed by the corresponding decrease and the wide range of values for the hydrogen index (Figs. 14, 15c),

Kerogen Type: Kerogen is a combination Type I and II from plots of hydrogen-oxygen indices (Figs. 15a-c). Some of the hydrogen indices greater than 800 may indicate the presence of bitumen, derived from the Type I or II kerogen, and not yet migrated from the source rock. Both oxygen and sulfur concentrate in the residual bitumen, which produces pyrolyzable hydrocarbons of increased molecular weight. During the acid treatment to remove carbonate-derived CO₂ in determining total organic carbon, the heating process breaks down some of the bitumen. This hydrocarbon loss results in a measured organic carbon that is lower than the true value. The combination of increased weight of recovered hydrocarbon plotted against reduced organic carbon values results in an incorrectly high hydrogen index.

The average oxygen indices are less than encountered in the Rennell Junction

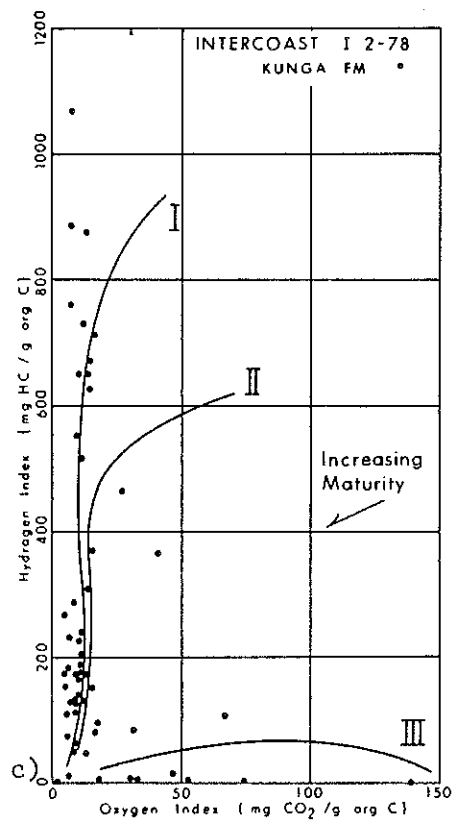
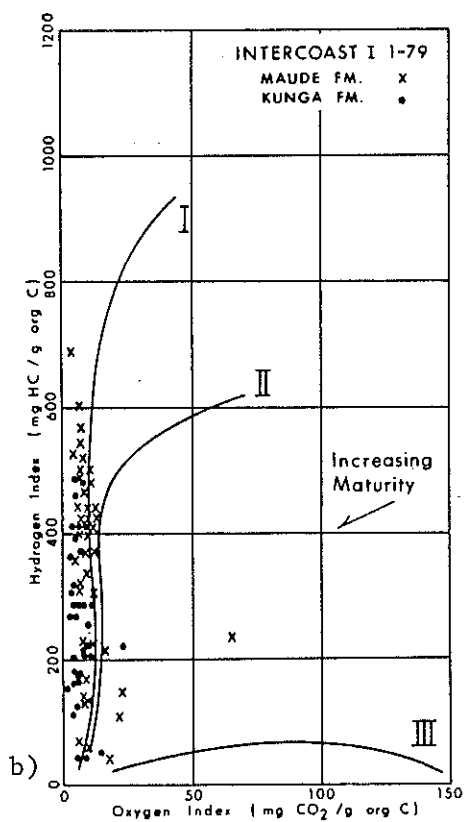
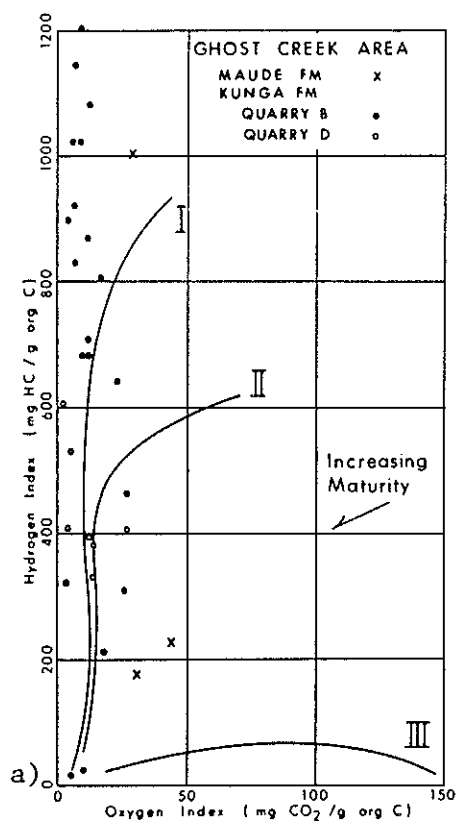


Fig. 15: Hydrogen vs oxygen indices, Ghost Creek area;
15a) quarry exposures; 15b) Intercoast Resources
I 1-79 corehole; 15c) Intercoast Resources I
2-78 corehole

area and there is little indication of humic material. The high oxygen indices, essentially zero hydrogen values, at I 2-78 (Fig. 15c) are plots of the volcanic ash bed values and should not be construed as Type III kerogen. Volcanic ash results were omitted from the I 1-79 plot (Fig. 15b).

Economic Potential: Within the lower 8 to 10m exposed at Quarry B, and also from high grade samples from the pit floor, yields are obtained in the range 50 to 100 mg/g (Fig. 12), equal to 13 to 26 US gals/ton, which is within the range of interest for oil shale potential. These beds also have the generally highest carbon contents and hydrogen indices encountered throughout all sampled locations.

No equivalent high yield upper Kunga beds were encountered at the nearby I 1-79 corehole: the high yield beds may be absent by facies change, or the net depositional section penetrated at the corehole may have been insufficient to reach beds equivalent to the high yield section of Quarry B; however, the grey beds at the base of the core may indicate penetration of the oil shale-bearing section into lower strata.

A zone of higher carbon and greater hydrogen indices and hydrogen potential is present at corehole I 1-79 in the Maude interval 53-100m (175'-330'). Over this interval, an extremely low production index can be interpreted that oil has been generated and has subsequently migrated out of the source rock. The

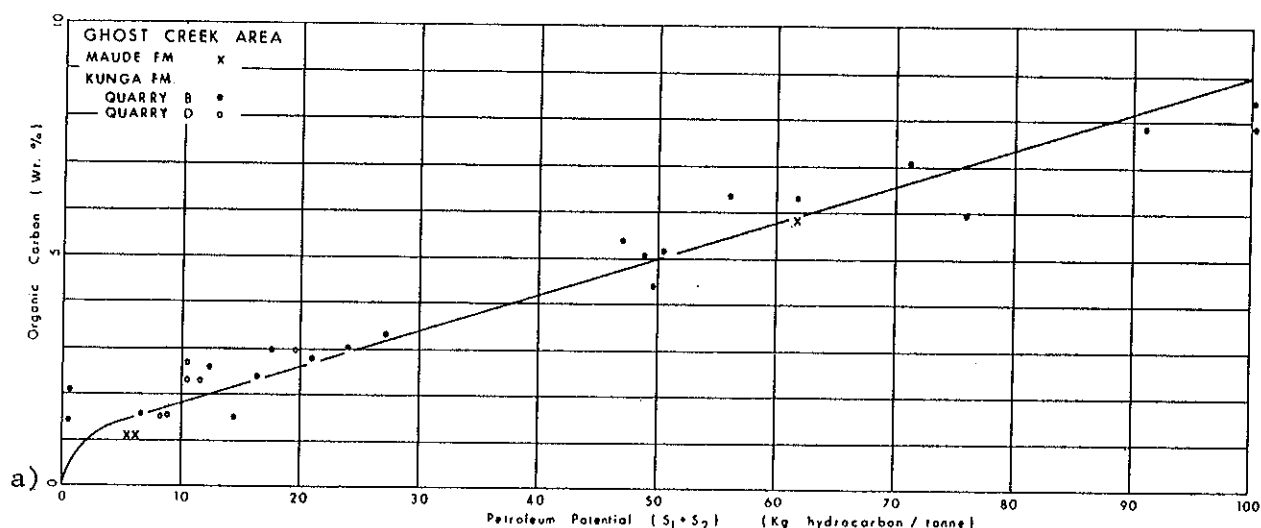


Fig. 16: Comparison of petroleum potential (yield) to organic carbon content, Ghost Creek area; 16a) quarry exposures

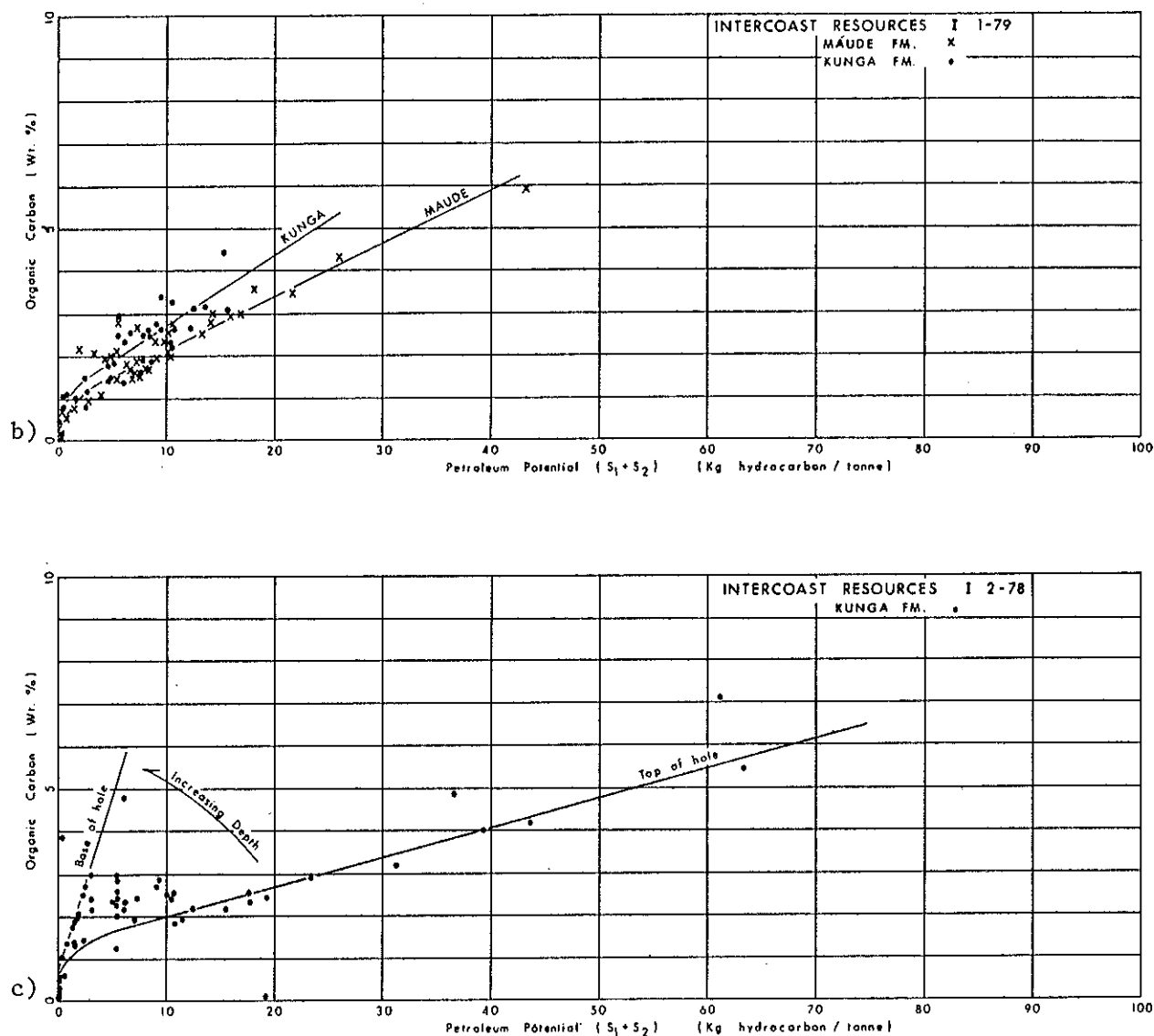


Fig. 16: Comparison of petroleum potential (yield) to organic carbon content, Ghost Creek area; 16b) Intercoast Resources I-7-79 corehole; 16c) Intercoast Resources I 2-78 corehole

variable production indices at the Ghost Creek outcrop may indicate either differential expulsion of generated liquid hydrocarbons or local accumulation within individual beds.

At corehole I 2-78, the production index increases downward comparable to the increasing maturity indicated by the Tmax curve. In this case, the lower production indices in the upper section do not necessarily indicate loss of petroleum products by migration.

From the I 1-79 data, the Maude Formation is a significant oil source rock. The few samples from Quarry D, the possible middle Kunga equivalent, contain sufficient carbon (Appendix B) and have appropriate hydrogen indices (Fig. 15a) to be also of interest for oil source potential.

The best yield, relative to organic carbon content, occurs in the uppermost beds of the I 2-78 corehole (Fig. 16b) where yields average 14 kg/tonne/1% organic carbon. This is in excess of 15 l/t or 3.6 US gal/t for each one percent organic carbon above the basal non-productive 1% of kerogen present. Two hydrocarbon potential values here exceed 60 kg/t (approximately 15 US g/t). The high indices and the excellent yield ratios indicate the presence of bitumen. Excellent immature to marginally mature Type I kerogens in Colorado and New Brunswick are essentially bitumen free. These optimum kerogen types both yield only 9 to 9.5 l/t per 1% organic carbon.

The downward decrease in yield is striking at the I 2-78 location where the basal overmature beds have yields similar to those of the Maude Island area (Fig. 6b). Good yield ratios are obtained at the Ghost B quarry (Fig. 16a), reaching 12.5 kg/t/1% organic carbon. This is in excess of the anticipated yield from kerogen alone, again indicating the probable presence of bitumen.

The yield ratios at corehole I 1-79 (Fig. 16c) are less than at Quarry B, possibly because of increased maturity as T_{max} averages 5° higher in the corehole. The expulsion of generated liquid hydrocarbon, possibly including bitumen, as interpreted for a significant interval of the cored section, would also lower average yields.

CONCLUSIONS AND INTERPRETATIONS

Organic carbon is present in sufficient quantity for petroleum source potential in the upper Kunga banded member as well as in some beds of the overlying Maude Formation and in the underlying middle Kunga flaggy black limestone unit. The organic carbon content generally ranges one to five percent by weight, and is at a maximum in the Ghost Creek area. Locally at Ghost quarry B, carbon content exceeds 5%. The carbon content decreases at the west in the Rennell Road-Shields Bay area and also south-southeasterly at Maude Island Whiteaves Bay, which probably relates to loss of carbon by overmaturity, but which could also be affected by a west-southwesterly change of kerogen type and quantity.

Several kerogen types are present. In the Ghost Creek area, Type I appears to be more common, but is admixed with Type II. This relationship reverses southward to the Rennell Junction area where Type II becomes more common. Maturation levels are too high at Shields Bay and Maude Island to define kerogen type with any certainty but some Type III humus is indicated. A regional change of kerogen type from northeast to southwest, from Type I toward Type III, can be inferred, but is certainly not established.

Kerogen in the Ghost Creek area is mature, that is, at the point of optimum oil generation. Maturity increases south and southwesterly to overmature at Shields Bay and Maude Island (Fig. 3). There is a slight increase in maturity from the Ghost Creek to the Rennell Junction area.

Petroleum substances have been generated, are partly in place (bitumen) and have partly migrated from the source, in both the Ghost Creek and Rennell Junction areas.

Petroleum may have been generated at both the Shields Bay and Maude Island areas, but this would depend on the presence of Type II, and possibly Type I, kerogens. If Type III were dominant in these areas, which is a possibility, the potential for generated and migrated hydrocarbons would be severely reduced.

Oil shale potential is restricted to the Ghost Creek area from present data. Only at Ghost quarry B is there sufficient yield to be of interest, but these yields are from thin fissile oil shale beds, generally 1 cm thick, within a sequence of 4 to 10cm hard claystone and siltstone beds which have considerably lower hydrocarbon potential. The average yield over the gross section may be insufficient to be of economic interest.

Kerogen content improves northeasterly, with increasing Type I, increasing quantities, and decreasing maturation (Fig. 3). The King Creek area outcrops may be of significant interest for further delineation of kerogen quantity and quality.

The Maude-Kunga sequence is potentially an excellent source rock in the subsurface in the north and northeasterly part of Graham Island.

Chamney (PetroCanada Exploration Inc.) recovered the best yields of his project, 9.6 g/t (37 kg/t) from Kennecott Pt. on the northwesterly corner of Graham Island. A projection of the maturity levels northwestward from the study area would place Kennecott Pt. within the range of thermal maturity for upper Kunga sediments. The regional strike of thermal maturation parallels the tectonically complex mountainous backbone of the Queen Charlotte Island chain. Within these westerly Queen Charlotte Ranges, Kunga sediments are overmature.

The degree of change in thermal maturation westerly across such a short lateral distance (10 km) from Ghost Creek to Shields Bay would require a considerable difference in depth of burial for the sediments of the two areas. The westerly mountain building may have moved the Shields Bay and Maude Island sections easterly from their depositional area. Alternately, thermal metamorphism related to underlying igneous activity during mountain building may have induced a much higher degree of thermal maturity than had been reached by depth of burial alone.

The structural deformation of Kunga and Maude strata is considerably greater than that of Yakoun beds. Also, the degree of erosion of Maude-Kunga section below Yakoun is much greater than suspected by earlier workers. Cameron (personal communication) has found Maude Formation of Aalenian age (Fig. 1) and middle Kunga appears to be overlain by Yakoun at Ghost Quarry "D". Much of the structural deformation of Kunga beds was early, prior to any significant depth of burial and before thermal maturation of the kerogen. This is confirmed by the uniform change in thermal maturity downward through the structurally contorted beds at the I 2-78 corehole.

Although not large, the thermal effect of the volcanic dike is evident on adjacent beds at I 1-78. According to Cameron (personal communication), this dike has characteristics similar to the younger Tertiary Masset Formation which covers most of northeastern Graham Island. In this case, underlying Kunga-Maude source beds may have in part retained their oil until recently. Depth of burial would have matured these sediments under Hecate Strait. If hydrocarbon reservoirs can be recognized in the intervening section between Maude and Masset Formations, good petroleum potential may be present over northeasterly Graham Island and under Hecate Strait.

Macauley (1983) has referred to tectonics studies in the area by Chase et al, 1975, Jones et al (1977) and Yorath and Chase (1981). The Queen Charlotte Islands were geographically very different in Jurassic time than recognized today: the distribution of Kunga-Maude sediments in the northeasterly part of Graham Island beyond the Sandspit fault (Fig. 2), and under Hecate Strait, is still to be confirmed.

REFERENCES

- BATES, R.L., and JACKSON, J.A.
1980: Glossary of Geology, 2nd ed; American Geological Institute, Falls Church, Virginia
- CAMERON, B.E.B., and TIPPER, H.W.
1981: Jurassic biostratigraphy, stratigraphy and related hydrocarbon occurrences of Queen Charlotte Islands, B.C., Project 750035; Geological Survey of Canada, Current Research, Paper 81-1A, p. 209-212
- CHASE, R.L., TIFFIN, D.L., and MURRAY, J.W.
1975: The western Canadian continental margin; in Canada's Continental Margins and Offshore Petroleum Exploration, eds. C.J. Yorath, E.R. Parker and D.J. Glass; Canadian Society of Petroleum Geologists, Memoir 4, p. 701-721

CLAPP, C.H.

- 1914: A geological reconnaissance of Graham Island, Queen Charlotte Group, B.C.; Geological Survey of Canada, Summary Report, 1912, p. 39-40

CLAPP, F.G.

- 1915: Petroleum and natural gas resources of Canada; Canada, Department of Mines and Resources, Mines Branch, Report no. 291, v. II, p. 364

CLEMENTZ, D.M.

- 1979: Effect of oil and bitumen saturation on source-rock pyrolysis; American Association of Petroleum Geologists Bulletin, v-63, no. 12, p. 2227-2232

DAWSON, G.M.

- 1880: Report on the Queen Charlotte Islands; Geological Survey of Canada, Annual Report, 1878, pt. B

JONES, D.L., SILBERLING, N.J., and HILLHOUSE, J.

- 1977: Wrangellia - a displaced terrain in northwestern North America; Canadian Journal of Earth Sciences, v. 14, p. 2505-2577

MACAULEY, G.

- 1983: Geology of the oil shale deposits of Canada; Geological Survey of Canada Paper 81-25; also 1981: Geological Survey of Canada open file Report OF754

MACAULEY, G., and BALL, F.D.

- 1982: Oil shales of the Albert Formation, New Brunswick; New Brunswick Department of Natural Resources open file Report 82-12

MacKENZIE, J.D.

- 1915: Graham Island, British Columbia; Geological Survey of Canada, Summary Report, 1914, p. 34-36
- 1916: Geology of Graham Island, British Columbia; Geological Survey of Canada, Memoir 88, p. 40-47, 86-89, 159-160

McLEARN, F.H.

- 1949: Jurassic formations of Maude Island and Alliford Bay, Skidegate Inlet, Queen Charlotte Islands, British Columbia; Geological Survey of Canada, Bulletin no. 12, p. 1-9

RICHARDSON, J.

- 1874: Coal-bearing rocks of the Queen Charlotte Islands; Geological Survey of Canada, Progress Report 1872-1873, p. 7, 56-63

SUTHERLAND-BROWN, A.

- 1968: Geology of the Queen Charlotte Islands, British Columbia; British Columbia Department of Mines and Petroleum Resources, Bulletin no. 54, p. 50-66, 179

SUTHERLAND-BROWN, A., and JEFFREY, W.G.

- 1960: Preliminary geological map, southern Queen Charlotte Islands; British Columbia Department of Mines

YORATH, C.J., and CHASE, R.L.

1981: Tectonic history of the Queen Charlotte Islands, and adjacent areas -
a model; Canadian Journal of Earth Sciences, v. 18, no. 11, p 1717-1739

APPENDIX A

CORE DESCRIPTIONS

INTERCOAST RESOURCES I 1-79

0-19.5m (0-64') Casing - no core

Core starts in Maude Formation

19.5-32.6m (64-107') Siltstone, light grey to brownish-grey, calcareous and in part grading to silty limestone, hard, massive, occasional greenish-grey fine grained calcareous sandstone beds, interbeds light to medium grey shale in part with brownish tinge, very little fissility in section except for occasional 5 to 8 cm laminated grey shale, net silt content decreases downward, occasional ash beds - dips at 45° fairly uniform from lithologic alternations in 3 to 15 cm beds.

Samples 1) silty limestone, 20.3m (66.5'); 2) silty shale, 23.6m (77.5'); 3) argillaceous siltstone, 25.0m (82')

32.6-45.4m (107-149') Shale, brownish-grey to brown, massive, in part calcareous to some poorly laminated non-calcareous, in part grades to argillaceous limestone - fairly uniform 45-50° dip with bedding noted best by variations of calcareous content - crossed by occasional 0.3 cm calcite veins at 90° to dip.

Samples 4) sub-laminated calcareous shale, 32.8m (107.5'); 5) massive slightly calcareous claystone, 37.5m (123'); 6) massive very calcareous claystone, 40.2m (132'); 7) sub-laminated calcareous shale, 42.4m (139'); 8) massive calcareous claystone, 43.4m (142.5')

45.4-46.6m (149-153') Siltstone, grey, very calcareous, fine grained, hard, massive, with brownish-grey shale zones to 10cm thick - 45° dip.

Sample 9) siltstone, argillaceous and calcareous 46.0m (151')

46.6-52.7m (153-173') Shale-claystone, brown to greyish-brown, hard, massive, scattered bands 0.3cm at top thickening to 15cm at base of interval, minor fracture planes coated with dark brown tarry bitumen residue - dips decrease downward from 45° at top to 30° at base with rubble and brecciation in basal 30 cm.

Samples 10) Shale, 40.1m (164.5'); 11) ash, 52.4m (172.0'), mostly mixed larger clays and abundant zeolites (Appendix C)

52.7-58.2m (173-191') Shale-claystone, brown, massive and hard to scattered sub-laminated sub-fissile zones, in part calcareous, laminated is non-calcareous 0.5 cm light grey sandstone bed 30 cm below top of interval, thin ash bed at 55.8m, some brown bitumen on fracture surfaces - 40° dip; Samples 12) massive calcareous claystone, 56.6m (179'); 13) massive slightly calcareous claystone, 56.1m (184')

58.2-59.4m (191-195') Rubble, blocks of brown shale (to 8 cm) in matrix of soft grey rubbly shale debris, crystalline calcite on rubble surfaces often has honeycomb appearance, thin wavy calcite laminae along fractures - 30 to 40° dip on larger shale blocks

- 59.4-62.8m (195-206') Shale-claystone, brown, massive to some poorly laminated sub-fissile, hard, slightly calcareous, calcite veins to 0.6 cm perpendicular to bedding, some calcite laminae along bedding planes toward base - 35° dip evident by slight fessility changes; Sample 14) massive very calcareous claystone, 61.3m (201')
- 62.8-63.4m (206-208') Shale, brown, much as above - dips decrease rapidly from 30° at top to horizontal and back to contorted 45° at base, abundant thin laminae of white crystalline calcite along bedding planes throughout, separated from underlying shale by 2.5 cm of extremely contorted greenish clay in coarse crystalline white calcite (fault gouge)
- 63.4-87.2m (208-286') Shale, brown, more laminated and fissile than above, calcareous, becoming greyer downward and fissility improves as calcareous content decreases - dip 35° at top of zone decreasing to 15° by 83.8m and thin fairly uniform, occasional 0.3 to 0.6 cm calcite veins across dip, scattered zones fine wavy crystalline calcite along laminae in semi-breccia zones and along movement planes, bitumen on fractures, occasional ash bed Samples 15) laminated shale, glows and smokes in a flame, 64.2m (210.5'); 16) massive to sub-laminated calcareous shale 66.1m (217'); 18) massive claystone, calcareous veinlets, minor faults, 68.6m (225'); 18) sub-laminated calcareous shale, 70.7m (232'); 19) sub-laminated calcareous shale, 72.2m (237'); 20) grey massive hard calcareous claystone (argillite), 74.5m (244.5'); 21) massive greyish-brown slightly calcareous claystone, 78.0m (256'); 22-26) massive brownish-grey calcareous claystone, 79.4m (260.5'); 81.2m (266.5'); 83.1m (272.5') 84.9m (278.5'); 87.0m (285.5')
- 87.2-93.6m (286-307') Shale-claystone, brown to brownish-grey, much as above but with zone grading to light grey which may contain volcanic ash material, massive to very finely laminated seen by color, some calcite veins parallel to bedding, a few green shale laminae - dip 15° at top to horizontal by 90.8m and back to 15° at base Samples 27) slightly calcareous claystone, 89.3m (293'); 28) slightly calcareous shale, 93.0m (305')
- 93.6m-100.9m (307-331') Shale-claystone, dark greyish-brown, massive to very fissile, occasional calcite veins in breccia zones and on bedding planes in top 3m, upper half also greenish-grey laminated ash-bearing zones with pyrite crystals - uniform 20° dip Samples 29) calcareous claystone, 95.1m (312'); 30) calcareous shale, organic, 96.8m (317.5'); 31) calcareous claystone, 98.0m (321.5'); calcareous claystone, 100.1m (328.5')
- 100.9-103.6m (331-340') Shale-claystone, as above, occasional zones of grey calcareous volcanic (?) sandstone, some slickensides and a few small rubble intervals, in part with network of very fine calcite veins Sample 33) calcareous claystone, 103.3m (339')
- 103.6-106.1m (340-348') Shale-claystone, as above, but increasing bands of volcanic, sandstones less calcareous than above, zones light greenish-grey hard volcanic claystone Samples 34) light grey volcanic claystone (ash), 103.9m (341'); 35) calcareous claystone, 105.8m (347')

106.1-111.6m (348-366') - Shale-claystone, dark brownish-grey, massive to sub-laminated slightly fissile, calcareous, occasional calcite along bedding and some perpendicular to bedding in fine swarms.
Samples 36) massive claystone, 108.5m (356'); 37) laminated fissile shale, smokes slightly and glows in a flame, 108.8m (357')

111.6-111.9m (366-367') Rubble zone of brownish shale and green volcanics in a white calcite matrix, very distorted, angular discordance on underlying shale which has criss-cross calcite network in upper 10 cm.

111.9-120.4m (367-395') Shale-claystone, dark brown to brownish-grey, massive to occasional very finely fissile laminated that smokes readily in a flame but is a minimal part only of the interval, generally calcareous but fissile is least calcareous, increasing zones downward of light grey to greenish-grey sandy volcanic beds and waxy soapy talc-like claystones-dip 30° uniform throughout
Samples 38-41) calcareous claystones at 113.2m (371.5'); 115.2m (378'); 116.4m (382'); 118.0m (387')

Top of Kunga 119.4m (395')

120.4-127.3m (395-417.5') Shale-claystone, as above, but banded effect becoming much more evident as minor lithologic variations occur more frequently, still only minor amount of fissile shale-dip 30° as above except for zone at 125.6-125.7m where dip increases to a rubbled zone with extreme calcite criss-cross veining, possibly a fault interval, the lithology is basically identical to overlying Maude Formation, and the contact is gradational but has been picked on the increase in banded character and to relate to Cameron's biostratigraphic zonation (personal communication).
Samples 42-46) calcareous mudstones, selected by minor color and fissility variations to represent interval, at 120.7m (396'); 122.5m (402'); 124.1m (407'); 125.7m (412.5'); 126.9m (416.5')

127.3-127.6m (417.5-418.5') Rubble zone of brown and grey shale, in part rounded pebbles to breccia, white calcite matrix, associated volcanics

127.6-128.8m (418.5-422.5') - Shale and Volcanics, banded greyish-brown shale and volcanic sandstones, considerable fine irregular calcite veinlets, slickensided and rubbled toward base - 20° average dip
Sample 47) calcareous shale, 128.6m (422')

128.8-134.4m (422.5-441') Fault Zone, rubbled brown and grey shale in a mashed matrix of brown slickensided shale, some larger blocks show dips varying shallow to 50°, occasional zones grade to argillaceous limestone, some blue chert (?) bands, rubble most concentrated in center of interval, decreasing upward and downward as both bedding and fracturing also decrease, offsets apparent in bedded blocks, calcite fracture fill, dips 50° at base
Samples 48) argillaceous limestone, 130.6m (428.5'); 49-50) calcareous shale at 132.9m (436'); 134.1m (440')

139.4-140.0m (441-458') Shale and Volcanics, banded, brown and brownish grey shales, volcanics are calcareous sandstone to shale - 40° dip throughout increasing to 50° at base, some slickensides in brown shales, most common in better laminated zones, brecciated calcite veining near base, small drag fold in 1.3 cm volcanic claystone in center of interval

Samples 51-53) very calcareous to calcareous claystone at 135.3m (414'); 136.4m (447.5'); 139.0m (456')

140.0-147.0m (458-482') Fault Zone of interbedded brown shale, green shale and sandy volcanics (?) - blocks dip 40° to 70° , numerous bedding offsets, calcite in fractures, blocks of bedded material separated by zones of brown extremely slickensided rubbled fault gouge matrix
Samples 54-56) mostly brownish bedded shale at 140.4m (460.5'); 142.3m (467'); 144.8m (475'); fault gouge not sampled

147.0-163.5m (482-536.5') Shale, banded brown to brownish-grey, grey and greenish-grey, with lenses greyish-green sandstone and light green sandy shale, green and grey may relate to volcanic origin, brown shale is calcareous to some argillaceous limestone, green is non-calcareous, brown is most massive and appears organic, green is laminated and fissile, several zones pale greyish-green limestone in upper 3m, amount of brown decreases downward from 60% at top to 40% at base of interval and also becomes lighter colored and more greyish - dip generally uniform $35-40^{\circ}$ down to 151.5m where beds overturn with uniform 30° dip below the overturn, basically only the brown intervals were sampled.
Samples 57) slightly calcareous shale, 147.8m (485'); 58) volcanic ash(?) mostly calcite, 148.6m (487.5'); 59-63) calcareous claystone to shale at 150.9m (495'); 152.6m (500.5'); 154.4m (506.5'); 155.8m (511'); 158.2m (519'); 64) volcanic ash at 159.7m (524'); 65) calcareous shale, 160.3m (526')

163.5-169.2m (536.5-555') Fault Zone, interbanded 0.6 to 2.5 cm brown and grey shales, occasionally greenish (45-45-10 ratio), with 30% of zone composed of brown to grey rubbled fault gouge, brecciated throughout with fracture infill by white calcite, some criss-cross breccia calcite network, slickensides in gouge zones - dips average 60° but about 65° in center of zone
Samples 66) close to argillaceous limestone, 165.7m (543.5'); 67) calcareous shale, 167.9m (551')

169.2-193.5m (555-636') Shale, banded brown to grey variable, 0.6 to 2.5 cm bands, fairly uniform but thinner bands more common, brown - calcareous, grey - non-calcareous, 50% brown, 40% grey, 10% other, green to white sandy volcanic beds which are calcareous, and blue-grey non-calcareous volcanics, occasional light greyish-green argillaceous limestone, two thin green rubbled shale zones in top 1.5m, otherwise appears unfaulted, occasional slickenside and calcite veinlets, thin gouge zone at 186.5m, does not appear as organic as zones above so not too many samples selected, samples a good average for zone as samples are banded - fairly uniform 45° dip
Samples 68-76) mostly brownish bands of calcareous claystone to shale at 169.2m (555'); 171.3m (562'); 174.3m (572'); 175.6m (576'); 178.2m (584.5'); 181.1m (594'); 184.4m (605'); 187.0m (613.5'); 189.9m (623'); 77) volcanic ash, 192.0 (630'); 78) calcareous shale, 192.9m (633')

193.5-197.2m (635-647') Fault Zone - Rubble, mostly gouge material, small fragments of brown and grey shale in matrix of fine brown and grey shale and some light green clay (volcanic)

197.2-200.0 (647-656') Shale and limestone, banded, 0.6 to 5 cm bands of variably grey and brown shale and light grey limestone, occasional calcareous

volcanic sandstone, 30% brown at best, some brown glows and smokes in flame but occurs only as minor laminated beds, 1.2 cm limestone band at base, occasional calcite veinlet perpendicular to bedding - 45° dip
Samples 79) calcareous shale, 198.4m (651'); 80) slightly calcareous shale, 199.3m (654')

200.0-203.9m (656-668') Fault Gouge Rubble, mashed grey to brown and some green shale, extreme rubbling has destroyed most evidence of bedding - few dips to 75° maximum in center of zone and minimum 10° near base

203.9-205.1m (669-673') Shale, brown, grey, some green, finely laminated, one 5 cm limestone bed, some rubble and calcite veins near base, black slickensides on some bedding planes - dips flat at top increasing rapidly in basal 30 cm to 60°
Sample 81) brown calcareous shale, 204.8m (672')

205.1-206.3m (673-677') Fault Rubble, mashed up shales, only scattered dips evident from 45 to 60° maximum

206.3 - 210.3m (677-690') Shales, banded, mostly green with little brown, limestone beds, several thin rubble intervals, limestone is sandy at base, grey only in basal 2m of interval, mostly slightly to non calcareous - dips average 45° but decrease to 20° in basal 30 cm
Sample 82) slightly calcareous shale, 207.9m (682')

Total depth: 210.3m (690')

INTERCOAST RESOURCES I 2-78

0-9.1m (0-30') Casing, no core

9.1-169.2m (30-555') Core lost

169.2-204.8m (555-672') Shale, banded, dark brown to greyish-brown calcareous shale, dark grey non-calcareous shale, banded to color laminated at top, with zones light grey to greenish-grey argillaceous limestone, light green to greenish-grey shale increases downward, banding becomes thicker and more pronounced as brown diminishes and calcareous content decreases, pale grey shale zones toward base, some thin green ash zones, brown is 60% at top decreasing to 30% at base, pale green to greenish-grey goes from 0% at top to 40% at base, rest is grey shale; some calcareous sandstone interbeds best developed in top half of zone, grades calcareous sandstone upward to argillaceous limestone, basically a very poor oil shale zone even though scattered thin brown bands and laminae smoke and glow in a flame - no evidence of fault zones as some rubbled green shale appears to be coring rubble, dips 30° downward to generally horizontal
Samples 1, 2) brown calcareous shale, 171.3m (562'); 173.4m (569'); 3) silty limestone, 176.3m (578.5'); 4,5) calcareous shale, 178.3m (585'); 180.4m (592'); 6) ash (?), 180.4m (592'); 7-12) variably calcareous shale, 181.7m (596'); 183.9m (603.5'); 186.5m (612'); 188.4m (618'); 190.2m (624'); 192.8m (632.5'); 13) calcareous shale or ash, 193.7m (635.5'); 14-15) calcareous shale, 194.8m (639'); 196.9m (646'); 16) argillaceous limestone, probable ash content, 197.5m (648'); 17-18) calcareous shale, 198.1m (650'); 200.9m (659'); 19) light colored cal-

careous shale (ash?), 201.8m (662'); 20) slightly calcareous shale, 203.8m (668.5'); 21) ash bed, 204.5m (671')

204.8-212.9m (672-698.5') Fault Rubble Zone, banded shale lithologies as above in rubble matrix of dark brown calcareous shale hash, matrix increases downward as banded component lessens, basal 3m is rubble only, scattered black shaley slickensides in rubble, breccia network of calcite veins through banded fragments - dips increase from 20° at top to 30° at base of zone
Samples 21, 22) calcareous shale, 207.6m (681'); 211.5m (694')

212.9m (698.5') Base of possible significant fault

212.9-224.6m (698.6-737') Claystone and shale, banded but distinctly different from above, dominantly pale grey to greenish-grey massive (beds to 15 cm) claystone, non-calcareous but with white calcite veinlets, looks like some of the pale limestones above but is definitely different, represents about 60% of zone, also bands to 15 cm of brown laminated fissile calcareous shale, slickensides on bedding laminae and apparent slippage along bedding planes, bedding offsets by small fractures, some rubbling in basal 3m - dips 40° at top increasing to 45° in center of zone and decreasing through the basal 3m to 10°
Samples 23, 24) brown calcareous shale, browner than average for zone, at 214.6m (704'); 217.3m (713'); 25) volcanic ash, 220.4m (723')

224.6-227.5m (737-746.5') Rubble, blocks of banded (0.5 cm) brown and medium grey shale with minor pale grey to greenish-grey as above, brown is calcareous, grey slightly calcareous, pale in non-calcareous, rubble matrix is brown to light grey shale - blocks dip 20° at top to flat in center of interval and back to 15° at base

227.5-232.9m (746.5-764') Shale, banded to finely laminated brown, grey greenish-grey, calcareous content decreases with lightening color, probably 60% brown over total interval, occasional rubble zones, rare slickensides along bedding planes, similar in character to the uppermost beds described for this core, scattered very thin ash beds - dips 20° decreasing downward to flat over basal metre
Samples 26-28) brown laminated calcareous shale, at 228.3m (749'); 229.8m (754'); 231.5m (759.5')

232.9-234.1m (764-768') Shale-claystone, 50-50 brown and grey, no pale grey, quite similar to top banded section of core but banding here is finer, definite fault break at 232.9m (top of interval), lithologic change insufficient to indicate overthrust - dip 90° at top decreasing downward to 45°
Sample 29) brown slightly calcareous shale, 233.5m (766')

234.1-238.0m (768-781') Shale-Claystone, as above but brown decreasing significantly, greenish tinge to the grey color but no pale shales, rubbled zones, slickensides and calcite veinlets throughout - extreme dip variations, 45° at 234.0m, 85° at 235.2m, 90° at 235.8m, 85° at 236.4m, overturns 236.7-237.6m, decreasing to 30° at 238.0m

238.0-292.3m (781-795') Shale-claystone, banded as above, mostly grey with only minor brown, banding from laminated to 10 cm massive beds, very calcareous, some slickensides on bedding planes, brown laminated shales glow and smoke very slightly in a flame, sandy calcareous volcanic laminae to thin 0.5 cm beds
Samples 30-32) brown calcareous shale, 239.0m (784'); 240.0m (787.5'); 241.1m (791'); 33) pale argillaceous limestone, containing ash (?), 241.9m (793.5')

Total depth: 242.3m (794')

*Note: Core sample numbers are marked in the core boxes for easier identification

COMMENTS

Interpretation of the configuration of oil shale, where kerogen laminae are developed, depends on the recognition of features resulting in structural deformation of the rock. Such features include: brecciation, slickensides, crenulation and folding, faulting and fracture filling. Kerogen laminae act as greased planes, creating zones of minimum competency relative to adjacent less organic beds; consequently, diastrophically induced deformation is much more prevalent in oil shale units. This is recognized in the Maude-Kunga interval of corehole I 1-79. All the above mentioned features, recognizable in these cores, are considered to be the result of structural deformation: other than planar bedding, no significant sedimentary structures are present. Similar conditions occur in the Albert oil shales in New Brunswick (Macauley and Ball, 1982), where diastrophic structures prevail in the less competent strata and sedimentary features are logged only in adjacent competent beds.

Because of the increasing grey coloration encountered near the base, corehole I 1-79 probably penetrates the optimum interval for oil shale development, which elsewhere occurs in the upper part of the upper Kunga. Similarly, the logged part of the I 2-78 core is considered indicative of lower upper Kunga.

The estimated upper Kunga thickness at the Shields Bay outcrop is about 100m with approximately 50m of suspected better organic interval in the upper part of the section. From the structural attitudes encountered in the cores, a doubling of the depositional section by structural deformation is not unlikely. The upper part of I 2-78 is considered to penetrate the upper oil shale bearing section. An estimated maximum undisturbed Kunga can be assumed at 100-120m in this area. This would also be a reasonable net depositional thickness at Maude Island.

APPENDIX B
ROCK-EVAL PYROLYSIS DATA

TOC: total organic carbon
 HI: hydrogen index, mg hydrocarbon/g organic carbon
 OI: oxygen index, mg CO₂/g organic carbon
 HC: hydrocarbon potential, S₁+S₂, mg/g rock
 PI: production index, S₁/S₁+S₂

Interval		TOC	Tmax	S ₁	S ₂	S ₃	HI	OI	HC	PI
m	ft	wt%	°C	mg/g.rock						
Intercoast Resources I-1-78 (Maude-Kunga)										
4.0- 10.4	13- 34	1.60	444	1.11	6.55	.42	419	26	7.66	.14
10.4- 15.8	34- 52	2.05	448	1.57	9.89	.77	487	37	11.46	.13
14.8- 17.7	52- 58	2.72	449	1.87	11.74	.67	431	24	13.61	.13
17.7- 19.8	58- 65	3.08	447	2.14	10.48	.66	372	23	12.62	.16
19.8- 25.0	65- 82	2.73	449	1.47	10.00	.31	375	11	11.47	.12
25.0- 31.1	82-102	1.67	452	1.33	3.59	.32	228	20	4.92	.27
34.1- 36.6	112-120	2.53	453	1.57	8.51	.26	348	10	10.07	.15
36.6- 42.1	120-138	1.19	448	1.22	3.45	.36	289	30	4.67	.26
42.4- 46.6	139-153		410	1.24	1.17	.48			2.41	.51
55.8- 58.2	183-191	2.05	409	0.93	1.06	.29	52	14	1.99	.46
58.2- 63.7	191-209	1.55	446	1.14	1.39	.12	100	8	2.53	.45
63.7- 69.8	209-229	1.80	447	2.60	4.85	.31	290	18	7.45	.34
69.8- 72.2	229-237	1.32	432	0.40	0.71	.10	60	8	1.11	.36
75.3- 81.1	247-266	2.05	450	1.53	4.09	.41	200	20	5.62	.27
81.1- 86.9	266-285	1.75	449	1.20	4.70	.42	273	24	5.90	.20
86.9- 93.0	285-305	1.80	450	1.73	5.62	.27	315	15	7.35	.23
93.0- 98.8	305-324	4.14	450	4.76	15.24	.33	371	8	20.00	.23
99.1-104.5	325-343	3.27	451	2.70	11.55	.64	358	19	14.25	.18
104.5-110.3	343-362	3.16	451	3.97	11.56	.64	368	20	15.53	.25
110.6-116.1	363-381	1.44	447	3.08	4.70	.46	328	32	7.78	.39
116.1-122.2	381-401	1.79	446	1.42	4.50	.76	260	43	5.92	.23
122.2-127.7	401-419	1.76	444	3.34	4.03	.64	228	36	7.37	.45
127.7-133.5	419-438	2.69	449	2.36	8.88	.38	330	14	11.24	.20
133.5-139.6	438-458	1.80	444	1.91	3.19	.45	179	25	5.10	.37
139.6-145.4	458-477	2.90	442	7.11	14.51	.33	502	16	21.62	.32
145.4-150.6	477-494	1.81	441	2.40	5.14	.32	285	26	7.54	.31
150.9-156.4	495-513	2.57	451	4.89	4.54	.57	178	22	9.43	.51
156.7-162.5	514-533	3.18	448	3.40	7.25	.40	227	12	10.65	.31
162.5-168.2	533-552	2.86	451	4.37	6.93	.47	242	16	11.30	.38
168.2-173.7	552-570	2.40	451	1.99	7.35	.35	307	14	9.34	.21
173.7-179.5	570-589	2.17	446	3.71	8.09	.42	376	19	11.80	.31
179.5-184.4	589-605	0.24	449	0.00	0.03	.07	12	29	0.03	.00
184.7-190.2	606-624	2.04	456	0.89	2.44	.29	122	14	1.33	.66
190.2-191.7	624-629	1.93	450	1.75	5.23	.41	270	21	6.98	.25

No.	Depth		TOC wt%	Tmax °C	S ₁	S ₂	S ₃	HI	OI	HC	PI
	m	ft									
Intercoast Resources I 1-79 (Maude-Kunga)											
1	20.3	66.5	0.66	448	0.20	0.29	.12	43	18	0.49	.40
				438	0.32	0.46	.08	69	12	0.78	.41
2	23.6	77.5	2.19	446	0.51	1.54	.16	70	7	2.05	.24
3	25.0	82	1.97	449	1.31	3.28	.18	169	9	4.59	.28
				440	2.19	4.75	.12	244	65	6.94	.31
4	32.8	107.5	2.74	448	1.83	8.73	.20	320	7	10.56	.17
				443	2.53	12.29	.15	451	5	14.84	.17
5	37.5	123	2.18	450	1.56	2.91	.21	135	9	4.47	.34
6	40.2	132	2.07	450	0.79	9.79	.24	489	12	10.58	.07
7	42.4	139	1.58	454	0.97	6.81	.23	433	14	7.78	.17
8	43.4	142.5	1.58	451	0.49	7.40	.17	506	11	7.89	.06
9	46.0	151	0.54	446	0.18	0.66	.13	124	24	0.84	.21
10	50.1	164.5	1.17	450	0.35	3.57	.16	307	13	3.92	.08
11	52.4	172	0.18	453	0.00	0.04	.08	23	47	0.04	.00
12	54.6	179	1.74	450	0.38	7.26	.20	427	11	7.64	.04
13	56.1	184	1.85	449	0.50	6.75	.21	368	11	7.25	.06
14	61.3	201	2.55	448	0.53	12.83	.20	507	7	13.36	.03
15	64.2	210.5	4.27	449	0.83	25.17	.27	589	6	26.00	.03
16	66.1	217	3.09	454	0.72	13.24	.22	434	7	13.96	.05
17	68.6	225	2.08	451	0.49	8.34	.18	402	8	8.83	.05
18	70.7	232	2.83	452	0.43	13.88	.22	493	7	14.31	.05
19	72.2	237	3.03	452	0.26	16.36	.20	547	6	16.62	.01
20	74.5	244.5	3.55	450	0.49	21.24	.24	598	6	21.73	.02
21	78.0	256	1.52	453	0.38	6.50	.17	430	11	6.88	.05
22	79.4	260.5	2.90	453	0.62	16.56	.21	538	7	16.18	.03
23	81.2	266.5	2.16	455	0.46	9.70	.23	451	10	10.16	.04
24	83.1	272.5	1.78	455	0.58	7.65	.19	432	10	8.23	.07
25	84.9	278.5	2.35	457	0.64	9.43	.20	401	8	10.07	.06
26	87.0	285.5	1.59	458	0.42	6.26	.07	403	4	6.68	.06
27	89.3	293	1.85	461	0.24	6.05	.14	327	7	6.29	.03
28	93.0	305	1.46	460	0.41	4.89	.17	341	11	5.30	.07
29	95.1	312	2.34	462	0.30	9.39	.23	403	9	9.69	.03
30	96.8	317.5	5.99	455	1.56	41.59	.18	696	3	43.15	.03
31	98.0	321.5	3.54	451	0.76	18.48	.17	526	4	18.24	.04
32	100.1	328.5	1.72	456	0.69	6.52	.24	379	13	7.21	.09
33	103.3	339	0.71	455	0.36	1.22	.16	174	22	1.58	.22
34	103.9	341	0.05	459	0.00	0.00	.12	0	240	0.00	.00
35	105.8	347	1.02	454	0.64	2.24	.20	219	19	2.88	.22
36	108.5	356	2.91	455	0.70	5.03	.28	175	9	5.73	.12
37	108.8	357	2.64	457	0.64	9.60	.18	365	6	10.24	.06
38	113.2	371.5	2.78	449	1.04	6.51	.22	237	8	7.55	.13
39	115.2	378	1.69	455	0.73	8.11	.15	479	8	8.84	.08
40	116.4	382	1.66	451	1.48	6.14	.19	376	11	7.62	.19
41	118.0	387	2.18	455	0.73	4.80	.25	224	11	5.53	.13
42	120.7	396	3.26	456	0.53	13.03	.20	404	6	13.56	.03
43	122.5	402	2.85	459	0.64	8.25	.21	289	7	8.89	.07
44	124.1	407	2.50	456	0.43	5.48	.21	226	8	5.91	.07
45	125.7	412.5	3.11	456	0.61	15.01	.13	485	4	15.62	.03
46	126.9	416.5	1.39	456	0.52	5.43	.13	482	9	5.95	.08
47	128.6	422	1.90	451	1.01	7.66	.23	405	12	8.64	.11

No	Depth		TOC wt%	Tmas °C	S ₁	S ₂ mg/G	S ₃	HI	OI	HC	PI
	m	ft									
48	130.6	428.5	2.56	452	1.07	7.14	.17	284	6	8.21	.13
49	132.9	436	1.48	455	0.34	2.05	.12	138	8	2.39	.14
50	134.1	440	1.17	455	0.13	0.47	.10	43	9	0.60	.21
51	135.3	444	0.80	452	0.14	0.41	.12	53	15	0.55	.25
52	136.4	447.5	1.22	452	0.15	2.55	.29	212	24	2.70	.05
53	139.0	456	1.68	451	0.70	7.07	.20	420	11	7.77	.09
54	140.4	460.5	1.24	452	0.28	3.20	.13	260	10	3.48	.08
55	142.3	467	2.04	453	0.95	3.79	.13	185	6	4.74	.20
56	144.8	475	1.77	451	0.89	3.62	.17	204	9	4.51	.19
57	147.8	485	2.54	457	0.78	4.07	.16	171	6	4.85	.16
58	148.6	487.5	0.22	460	0.00	0.00	.81	0	68	0.00	.00
59	150.9	495	1.91	450	0.59	7.18	.17	377	8	7.77	.07
60	152.6	500.5	2.66	449	1.04	9.63	.14	313	5	10.67	.09
61	154.4	506.5	2.71	449	1.33	10.75	.14	396	5	12.08	.11
62	155.8	511	2.17	447	0.77	9.92	.12	461	5	10.69	.07
63	158.2	519	1.78	450	1.33	3.75	.16	209	8	5.08	.26
64	159.7	524	0.06	454	0.00	0.03	.07	50	116	0.03	.00
65	160.3	526	1.14	448	0.14	0.55	.08	48	7	0.69	.20
66	165.7	543.5	0.82	446	0.57	2.35	.10	290	12	2.92	.19
67	167.9	551	2.40	452	0.56	3.91	.08	162	3	4.47	.17
68	169.2	555	0.16	456	0.28	0.00	.11	0	68	0.28	.00
69	171.3	562	2.60	448	1.37	6.94	.14	268	5	8.31	.16
70	174.3	572	2.27	453	1.03	9.22	.12	407	5	10.25	.10
71	175.6	576	2.58	455	0.48	5.06	.10	203	4	5.54	.08
72	178.2	584.5	2.61	452	2.00	7.93	.12	305	4	9.93	.20
73	181.1	594	1.05	459	0.22	1.28	.06	123	5	1.50	.14
74	184.4	605	3.48	452	3.13	6.40	.22	187	6	9.53	.32
75	187.0	613.5	3.30	450	1.26	9.29	.16	282	4	10.55	.11
76	189.9	623	2.56	451	2.79	5.22	.25	203	9	8.01	.39
77	192.0	630	0.45	454	0.00	0.05	.06	11	13	0.05	.00
78	192.9	633	2.65	455	1.83	4.78	.15	182	5	4.78	.27
79	198.4	651	3.24	452	2.17	10.41	.14	323	4	10.41	.17
80	199.3	654	3.56	458	0.87	5.39	.08	158	2	5.39	.13
81	204.8	672	4.54	453	2.00	12.46	.15	277	3	12.46	.13
82	207.9	682	3.10	454	1.62	3.53	.13	117	4	3.53	.31

Interval

m ft

Intercoast Resources I 2-78 (Kunga Fm)

11.9- 15.8	39- 52	3.18	444	3.46	27.76	.40	875	12	31.12	.11
20.7- 26.2	68- 86	2.29	446	1.65	13.97	.34	626	15	15.62	.10
21.2- 31.1	86-102	2.90	447	2.64	21.03	.36	730	12	23.67	.11
31.1- 35.7	102-117	5.51	442	4.91	58.48	.40	1069	7	63.39	.07
35.7- 40.8	117-134	1.20	451	0.76	4.31	.50	362	42	5.07	.14
40.8- 46.0	134-151	1.92	447	1.28	9.98	.23	517	11	11.26	.11
46.0- 51.2	151-168	2.53	444	1.32	16.37	.35	649	13	17.69	.07
51.2- 56.1	168-184	2.36	448	2.01	15.97	.32	676	13	17.98	.11
61.3- 66.4	201-218	2.40	445	1.93	17.26	.40	719	16	19.19	.10
66.4- 71.3	218-234	4.03	447	3.65	35.53	.31	888	7	39.13	.09
74.4- 76.5	244-251	1.78	445	0.93	9.92	.19	557	10	10.89	.08
76.5- 81.4	251-267	2.38	448	2.43	7.69	.33	321	13	10.12	.24
81.4- 86.9	207-285	3.77	451	0.02	0.02	.11	0	2	0.04	.50

Interval		TOC	Tmax	S ₁	S ₂	S ₃	HI	OI	HC	PI
m	ft	wt%	°C	mg/g rock						
86.9- 92.7	285-304	2.14	451	2.97	9.15	.55	462	27	12.13	.24
92.7- 97.8	304-321	0.62	454	0.00	0.07	.30	11	48	0.07	.00
103.6-108.2	340-355	2.48	451	1.21	9.10	.35	371	14	10.31	.11
108.2-113.1	355-371	4.82	445	5.00	31.54	.54	654	11	36.54	.13
113.1-118.6	371-389	1.39	448	0.30	1.08	.31	81	31	1.38	.21
128.3-129.5	421-425	7.13	445	6.80	54.20	.44	760	6	61.00	.11
129.5-134.7	425-442	4.78	447	0.72	5.31	.29	111	6	6.03	.11
140.5-145.7	461-478	0.64	451	0.00	0.02	.20	3	32	0.02	.00

No.	Depth		TOC	Tmax	S ₁	S ₂	S ₃	HI	OI	HC	PI
	m	ft									
1	171.3	562	2.94	461	1.28	4.49	.17	154	5	5.77	.22
2	173.4	569	2.73	455	2.04	7.16	.16	263	5	9.20	.22
3	176.3	578.5	2.33	458	1.13	3.94	.13	170	5	5.07	.22
4	178.3	585	2.52	460	1.24	4.47	.16	177	6	5.71	.21
5	180.4	592	0.10	458	2.40	7.05	.34	231	11	9.45	.25
6	181.7	596	1.52	460	0.80	1.39	.27	96	18	2.19	.36
7	183.9	603.5	1.91	462	2.53	4.55	.23	240	12	7.08	.35
8	186.5	612	2.54	459	2.89	7.18	.22	282	8	10.07	.28
9	188.4	618	2.95	447	2.92	4.56	.27	188	11	7.48	.39
10	190.2	624	2.31	464	1.59	3.52	.31	152	13	5.11	.31
11	192.8	632.5	2.30	464	2.30	3.89	.28	169	12	6.19	.31
12	193.7	635.5	0.20	467	0.00	0.01	.15	0	75	0.00	.00
13	194.8	639	2.22	464	2.55	3.75	.27	171	12	6.30	.40
14	196.9	646	1.33	466	0.63	1.06	.23	80	17	1.60	.37
15	197.5	648	0.25	469	0.00	0.00	.13	0	52	0.00	.00
16	198.1	650	3.04	466	1.35	4.49	.30	149	10	5.84	.23
17	200.9	659	2.46	467	1.46	3.69	.25	151	10	5.15	.28
18	201.8	662	0.44	470	0.00	0.01	.15	0	34	0.01	.00
19	203.8	668.5	2.83	461	2.95	6.57	.22	232	7	9.52	.53
20	204.5	671	0.17	472	0.00	0.17	.11	106	68	0.17	.00
21	207.6	681	2.17	462	1.29	2.92	.24	134	11	4.21	.30
22	211.5	694	2.03	468	2.90	3.78	.25	190	12	6.68	.43
23	214.6	704	2.45	394	1.90	1.22	.22	50	9	3.12	.60
24	217.3	713	1.08	249	0.30	0.06	.21	5	19	0.36	.83
25	220.4	723	0.05	251	0.00	0.01	.07	0	140	0.01	.00
26	228.3	749	2.40	467	1.00	1.88	.17	75	6	2.89	.34
27	229.8	754	3.00	465	1.87	3.52	.25	113	8	5.34	.34
28	231.5	759.5	1.75	471	0.52	1.16	.31	65	9	1.68	.29
29	233.5	766	1.88	469	0.56	0.82	.25	45	13	1.38	.40
30	239.0	784	1.91	468	2.12	3.84	.23	202	12	5.96	.35
31	240.0	787.5	2.06	465	1.70	2.88	.25	140	12	4.58	.37
32	241.1	791	2.81	468	2.17	3.68	.25	133	9	5.85	.37
33	241.9	793.5	1.31	473	0.01	0.13	.09	10	7	0.14	.07

Rennell Sound Road-Shields Bay Section (Maude-Kunga)

1	+4.6	+15	0.54	474	0.44	0.19	.12	35	22	0.63	.69
2	4.6	15	1.75	477	0.44	0.16	.02	9	1	0.20	.20
3	7.6	25	1.46	446	0.11	0.22	.08	15	5	0.33	.33
4	12.2	40	1.36	362	0.07	0.17	.02	12	1	0.24	.29
5	12.2	40	3.54	497	0.20	0.37	.10	10	2	0.57	.35
6	15.2	50	2.70	467	0.09	0.09	.07	3	2	0.18	.50

No.	Depth		TOC wt%	Tmax °C	S ₁	S ₂	S ₃	HI	OI	HC	PI
	m	ft									
7	19.8	65	1.48	421	0.03	0.14	.06	9	4	0.17	.17
8	19.8	65	0.43	332	0.00	0.06	.03	13	6	0.06	.00
9	22.9	75	1.41	319	0.02	0.08	.04	5	2	0.10	.20
10	22.9	75	3.34	486	0.10	0.34	.07	10	2	0.44	.22
11	25.9	85	0.86	468	0.00	0.15	.03	18	3	0.15	.00
12	25.9	85	5.70	508	0.11	0.77	.57	13	10	0.88	.12
13	30.5	100	3.72	496	0.19	0.45	.14	12	3	0.64	.29
14	33.5	110	4.16	487	0.13	0.49	.05	11	1	0.62	.20
15	36.6	120	3.79	482	0.13	0.47	.04	12	1	0.60	.21
16	39.6	130	2.18	485	0.08	0.29	.02	13	0	0.37	.21
17	39.6	130	0.41	504	0.00	0.13	.00	32	0	0.13	.00
18	42.7	140	3.75	484	0.16	0.55	.09	14	2	0.71	.22
19	45.7	150	3.17	481	0.10	0.45	.06	14	1	0.55	.18
20	45.7	150	1.38	401	0.02	0.18	.01	13	0	0.20	.10
21	50.3	165	2.21	425	0.00	0.06	.00	2	0	0.06	.00
22	54.9	180	2.65	479	0.08	0.17	.04	6	1	0.25	.32
23	57.9	190	2.61	488	0.08	0.22	.03	8	1	0.30	.26
24	61.0	200	2.94	486	0.08	0.25	.06	8	2	0.33	.24
25	61.0	200	0.35	375	0.00	0.03	.00	8	0	0.03	.00
26	64.0	210	1.12	386	0.03	0.09	.09	8	8	0.12	.25
27	73.2	240	1.65	449	0.15	0.18	.10	10	6	0.39	.45
28	73.2	240	0.27	404	0.02	0.13	.00	48	0	0.15	.13
29	79.2	260	2.34	488	0.07	0.18	.03	8	1	0.25	.28
30	85.3	280	1.50	381	0.08	0.12	.01	8	0	0.20	.40
31	91.4	300	1.86	384	0.08	0.11	.13	5	6	0.19	.42
32	94.5	310	3.00	493	0.11	0.24	.07	8	2	0.35	.31
33	97.5	320	2.32	401	0.07	0.13	.00	5	0	0.20	.35
34	97.5	320	1.60	359	0.03	0.10	.00	6	0	0.13	.23
35	97.5	320	2.16	495	0.05	0.16	.59	7	28	0.21	.23
36	112.8	370	1.63	493	0.03	0.08	.29	5	19	0.11	.27
37	115.8	380	1.27	346	0.02	0.07	.37	5	29	0.09	.22
38	120.4	395	1.83	435	0.05	0.11	.30	6	16	0.16	.31
39	128.0	420	1.37	328	0.00	0.05	.28	3	20	0.05	.00
40	128.0	420	1.03	308	0.00	0.04	.31	3	30	0.04	.00
41	161.5	530	2.74	471	0.02	0.13	.32	4	11	0.15	.13

Shields Bay Shore - South Quarry (Kunga black limestone)

42	4.6	15	1.87	297	0.00	0.01	.57	0	30	0.01	.00
43	9.1	30	1.91	306	0.00	0.07	.10	3	5	0.07	.00
44	9.1	30	1.08	341	0.00	0.07	.06	6	5	0.07	.00
45	9.1	30	0.51	315	0.00	0.06	.20	12	40	0.06	.00
46	12.2	40	0.71	284	0.00	0.01	.09	1	13	0.01	.00
47	15.2	50	1.26	313	0.00	0.05	.04	4	3	0.05	.00

Shields Bay Shore - North Quarry (Kunga banded member)

48	3.0	10	0.79	337	0.00	0.05	.09	6	11	0.05	.00
49	6.1	20	1.11	270	0.00	0.02	.24	1	22	0.02	.00

Whiteaves Bay (Westerly along Skidegate Channel)

50	Top		2.61	479	1.26	1.17	.48	45	18	2.43	.51
51			0.80	359	0.13	0.11	.07	13	8	0.24	.54
52			3.28	489	1.07	1.26	.16	38	4	2.33	.45

No.	Depth		TOC wt%	Tmax °C	S ₁	S ₂	S ₃	HI	OI	HC	PI
	m	ft									
53			3.22	471	0.30	0.86	.32	26	9	1.16	.25
54			0.82	395	0.27	0.17	.18	20	22	0.44	.61
55	Base		0.82	452	0.69	1.34	.52	167	65	2.03	.33

Maude Island (Kunga Formation)

56	Top		1.74	400	0.10	0.60	.20	34	12	0.70	.14
57			2.98	461	0.17	0.99	.19	34	6	1.16	.14
58			0.91	451	0.03	0.56	.38	63	43	0.59	.05
59			3.48	410	0.31	1.96	.34	56	9	2.26	.13
60			1.36	490	0.16	0.29	.22	21	16	0.45	.35
62			2.42	499	0.19	0.57	.29	23	12	0.76	.25
63			0.47	495	0.00	0.29	.24	60	50	0.29	.00
64			1.94	508	0.12	0.67	.13	34	6	0.84	.14
65			2.46	501	0.07	0.40	.20	16	8	0.47	.14
66			1.66	497	0.20	0.38	.19	23	11	0.58	.34
67			3.96	490	0.63	1.77	.16	45	4	2.40	.26
68	Base		2.30	490	0.63	0.38	.22	16	9	1.01	.62

Rennell Junction Section (Maude Formation)

69	Top		0.90	447	1.25	2.60	.16	285	17	3.85	.32
70			1.73	445	3.37	5.13	.33	300	19	8.50	.39
				440	3.22	4.60	.22	269	12	7.82	.41
71			2.76	450	1.47	9.42	.75	350	27	10.89	.13
				444	1.41	9.74	.61	362	22	11.15	.12
72			3.24	456	1.74	19.92	.24	618	7	21.66	.08
				448	1.82	21.80	.17	677	5	29.62	.07
73			3.01	450	2.13	15.07	.31	500	10	17.20	.12
74	Base		1.01	455	0.01	0.00	.19	0	18	0.01	1.00

QCI Main Road (Kunga banded member)

75	Top		3.22	452	1.37	9.17	.82	285	25	10.54	.12
76			4.52	455	6.87	20.80	.34	461	7	27.67	.24
77			0.54	447	0.20	0.31	.09	57	16	0.51	.39
78			0.90	458	0.12	0.04	.09	4	10	0.16	.75
79			3.41	458	6.30	20.84	.22	627	6	27.14	.23
80	Base		2.02	459	0.99	3.09	.19	153	9	4.08	.24

Branch Road 57 (Kunga banded member)

81	Top		1.17	450	0.49	2.94	.21	253	18	2.43	.20
82			1.39	449	0.47	7.08	.19	509	13	7.55	.06
83			2.62	446	2.43	16.59	.23	633	8	19.02	.12
84			0.44	396	1.50	0.03	.25	143	56	2.13	.70
85			1.47	453	0.88	4.65	.26	316	17	5.53	.15
86	Base		2.38	452	1.86	10.38	.22	437	9	12.24	.15

Ghost Quarry C (Maude Formation)

87			5.88	453	2.75	59.19	.34	1008	5	61.94	.04
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Ghost Quarry B (Kunga banded member)

88	+16.8	+55	5.15	449	2.62	45.83	.17	900	3	48.45	.05
89	+16.8	+55	2.14	450	0.23	0.44	.13	20	6	0.67	.34
90	+15.2	+50	7.01	448	6.52	64.73	.43	927	6	71.25	.09

No.	Depth		TOC wt%	Tmax °C	S ₁	S ₂ mg/g rock	S ₃	HT	OI	HC	PI
	m	ft									
91	+13.7	+45	3.27	445	4.18	22.50	.30	322	4	26.68	.15
92	+13.7	+45	1.38	419	0.34	0.31	.15	22	11	0.05	.52
93	+12.2	+40	2.65	445	6.63	5.46	.51	208	19	12.09	.54
94	+12.2	+40	1.00	449	1.41	4.93	.41	314	26	6.34	.22
95	+10.7	+35	5.34	447	6.40	43.88	.42	834	7	50.28	.12
96	+9.1	+30	2.47	445	4.79	11.38	.70	464	28	16.17	.29
97	+7.6	+25	1.54	445	4.40	9.90	.34	642	22	14.30	.30
98	+6.1	+20	4.30	447	5.86	43.94	.36	1024	8	49.80	.11
99	+4.6	+15	5.99	448	7.53	68.86	.43	1151	7	76.39	.09
100	+3.0	+10	3.05	447	3.40	21.00	.37	688	12	24.40	.03
101	+3.0	+10	2.91	448	1.10	20.24	.36	712	12	21.34	.05
102	+1.5	+5	8.70	447	12.36	87.67	.43	1028	5	100.03	.12
103	0	0	5.51	447	9.53	37.39	.53	684	9	46.92	.20
104	Pit Floor		7.88	443	6.47	84.68	.93	1080	11	91.15	.07
				442	6.51	94.41	.66	1204	8	100.92	.06
105	Pit Floor		6.41	444	5.74	51.73	1.10	807	17	51.47	.09
				443	5.61	56.04	.80	874	12	61.65	.08

Ghost Quarry A (Maude Formation)

106			1.10	449	4.11	2.55	.48	231	43	6.66	.38
				443	3.73	2.02	.31	183	28	5.75	.64

Ghost Quarry D (Kunga black limestone?)

107	+45.7	+150	2.83	453	1.29	9.01	.38	328	13	10.30	.12
108	+30.5	+100	0.07	456	0.00	0.01	.06	14	85	0.01	.00
109	+22.9	+75	1.52	453	2.76	6.16	.41	405	26	8.92	.30
				449	2.58	6.02	.19	396	12	8.60	.30
110	+15.2	+50	2.28	451	2.91	8.72	.36	382	15	11.63	.25
				445	3.20	9.46	.10	414	4	12.66	.25
111	+7.6	+25	3.02	453	1.71	15.92	.16	536	5	17.63	.09
				449	1.79	18.11	.08	609	2	19.90	.08

APPENDIX C

X-RAY DIFFRACTION DATA

Semi-quantitative results have been obtained from diffraction heights, which vary with degrees of crystallinity, crystal size and any amorphous material present. The recorded mineral percentages must be interpreted for their relative significance and not as absolute values.

Ill:	Illite	Ap:	Apatite
MLC:	Mixed layer clays and expandable clays	Gyp:	Gypsum
Ch/K:	Chlorite-kaolinite undifferentiated	Dol:	Dolomite
Qtz:	Quartz	Sid:	Siderite
Flspr:	Feldspar undifferentiated		
	A - Albite		
Cal:	Calcite		
Py:	Pyrite		

Interval (m)	Ill %	MLC %	Ch/K %	Qtz %	Flspr %	Cal %	Pr %	Others
Intercoast Resources I 1-78 (Maude-Kunga)								
4.0- 10.4	tr	21	4	41	10	22	2	
10.4- 15.8	--	11	5	45	6	31	2	
15.8- 17.7	--	11	4	64	6	13	2	Zeolite-tr
17.7- 19.8	--	17	3	49	15A	13	3	
19.8- 25.0	--	11	5	58	9	15	2	
25.0- 31.1	--	6	5	64	11	12	2	
34.1- 36.6	--	17	2	56	6	17	2	
36.6- 42.1	--	14	4	58	10	11	3	
42.4- 46.6	--	7	4	56	13	18	2	
55.8- 58.2	tr	14	5	63	7	11	-	
58.2- 63.7	tr	21	9	34	14	18	4	
63.7- 69.8	tr	12	3	61	8	14	2	Ap-tr, Gyp-tr, dol-tr
69.8- 72.2	--	31	8	19	24A	12	6	
75.3- 81.1	tr	14	5	58	8	13	2	
81.1- 86.9	--	14	7	60	7	9	3	
86.9- 93.0	--	10	4	66	10	9	1	
93.0- 98.8	--	13	5	54	13	12	3	
99.1-104.5	--	8	5	63	11	11	2	
104.5-110.3	--	tr	4	70	13A	11	2	
110.6-116.1	tr	10	7	68	6	7	2	
116.1-122.2	tr	18	7	45	16A	6	4	Ap-4
122.2-127.7	--	14	3	57	13A	6	3	Gyp-4
127.7-133.5	4	8	4	64	10	8	2	
133.5-139.6	--	tr	3	64	19A	11	3	
139.6-145.4	tr	10	5	55	12	16	2	
145.4-150.6	--	9	6	62	12	9	2	Sid-tr
150.9-156.4	--	13	5	59	10	10	3	
150.7-162.5	--	9	4	55	20A	8	4	
162.5-168-2	tr	12	6	57	14	9	2	
168.2-173.7	--	8	3	56	15A	16	2	
173.7-179.5	--	7	3	75	8	5	2	
179.5-184.4	tr	33	17	33	5	9	3	

Interval (m)	Ill %	MLC %	Ch/K %	Qtz %	Flspr %	Cal %	Pr %	Others %
184.7-190.2	--	12	5	65	10	5	3	
190.2-191.7	--	tr	3	77	13A	5	2	

No. Depth

m

Intercoast Resources I 1-79 (Maude-Kunga)

1	20.3	--	tr	-	35	4	58	-	Analcdme 3
2	23.6	--	12	7	43	25	7	6	
3	25.0	--	6	4	66	12	9	3	
4	32.8	--	10	5	64	9	12	tr	
5	37.5	--	10	4	58	16	9	3	
6	40.2	--	11	5	48	11	22	3	
7	42.4	--	17	5	49	15	9	5	
8	43.4	--	11	5	53	14	14	3	
9	46.0	--	13	7	46	19	8	7	Dol-tr
10	50.1	--	tr	4	82	8	6	-	
11	52.4	--	52	5	6	25	tr	3	Zeolite-9
12	54.6	--	9	4	57	15	12	3	
13	56.1	--	7	6	70	8	7	2	
14	61.3	--	6	3	46	13	29	3	
15	69.2	--	11	-	54	12	19	4	
16	66.1	--	10	5	52	10	20	3	
17	68.6	--	10	3	53	10	21	3	
18	70.7	--	12	2	52	10	21	3	
19	72.2	--	10	4	48	9	27	2	
20	74.5	--	7	2	57	8	24	2	
21	78.0	--	10	5	53	16	16	tr	
22	79.4	--	tr	6	56	7	29	2	
23	81.2	--	12	4	44	13	24	3	
24	83.1	--	tr	4	59	6	31	tr	
25	84.9	--	9	-	63	7	18	3	
26	87.0	--	12	tr	66	8	10	4	Hematite-tr
27	89.3	--	11	tr	66	7	13	3	
28	93.0	--	9	tr	75	6	7	3	
29	95.1	--	16	3	44	13	21	3	
30	96.8	--	10	--	53	14	18	5	
31	98.0	--	8	4	43	15	24	6	
32	100.1	--	12	tr	50	8	27	3	
33	103.3	--	tr	4	75	7	13	-	
34	103.9	--	22	tr	71	7	--	-	
35	105.8	--	tr	4	67	6	23	-	
36	108.5	--	11	3	50	12	21	3	
37	108.8	--	tr	6	60	8	23	3	
38	113.2	--	6	2	62	10	17	3	
39	115.2	--	13	tr	55	11	17	4	
40	116.4	--	8	5	54	15	15	3	
41	118.0	--	12	4	63	8	13	tr	
42	120.7	--	9	3	67	7	12	2	
43	122.5	--	20	--	51	11	14	4	
44	124.1	--	11	tr	46	10	29	4	
45	125.7	--	7	2	49	7	23	2	
46	126.9	--	6	2	73	5	12	2	

No.	Depth (m)	Ill %	MLC %	Ch/K %	Qtz %	Flspr %	Cal %	Pr %	Others %
47	128.6	--	11	tr	62	10	14	3	
48	130.6	--	6	3	50	7	34	tr	
49	132.9	--	8	4	62	6	20	tr	
50	134.1	--	9	4	49	7	31	tr	
51	135.3	--	tr	--	43	11	37	9	
52	136.4	--	tr	8	62	13	17	tr	Sid-tr
53	139.0	--	7	5	55	8	19	2	Dol-4
54	140.4	--	21	7	44	13	9	6	
55	142.4	--	7	2	64	8	12	2	
56	144.8	--	6	3	72	6	11	2	
57	147.8	--	11	5	56	16	9	3	
58	148.6	--	tr	-	9	8	83	--	Ap-tr
59	150.9	--	11	5	60	8	18	tr	
60	152.6	--	7	3	52	9	27	2	
61	154.4	--	5	3	61	12	17	2	
62	155.8	--	11	6	38	14	28	3	
63	158.2	--	6	3	74	5	12	tr	Ap-tr
64	159.7	--	51	-	--	49	tr	--	
65	160.3	--	11	8	54	10	9	4	Ap-4, Maghemite-tr
66	165.7	--	7	2	41	5	43	2	
67	167.9	--	9	4	48	9	27	3	
68	169.2	--	11	9	44	25A	11	--	
69	171.3	--	8	3	66	9	11	3	
70	174.3	--	8	3	69	10	6	4	
71	175.6	--	13	6	52	11	14	4	Gibbsite-tr
72	178.2	--	tr	4	77	6	13	--	
73	181.1	--	12	6	45	19	10	8	
74	184.4	--	11	5	54	13	14	3	
75	187.0	--	14	6	47	14	14	5	Ap-tr
76	189.9	--	9	3	56	6	24	tr	Sid-2
77	192.0	11	39	10	19	15	--	6	
78	192.9	--	10	4	61	8	14	3	
79	198.4	--	5	5	55	9	22	2	Ap-2
80	199.3	--	10	5	59	15	6	5	
81	204.8	--	tr	4	73	6	11	3	Ap-3
82	207.9	--	11	7	46	21A	11	4	

<u>Interval</u>									
(m)									
Intercoast Resources I 2-78 (Kunga Formation									
11.9- 15.8	--	8	6	67	8	9	2		
20.7- 26.2	--	11	--	74	6	6	3		
26.2- 31.1	--	tr	4	66	5	23	2		
31.1- 35.7	tr	8	4	66	8	11	3		
35.7- 40.8	4	27	5	31	7	26	--		
40.8- 46.0	tr	14	6	67	5	5	tr	Gyp-3	
46.0- 51.2	tr	18	5	56	11	7	3		
51.2- 56.1	--	7	4	74	6	9	--		
61.3- 66.4	tr	5	4	70	12	9	tr		
66.4- 71.3	--	9	4	72	6	7	3		

Interval (m)	Ill %	MLC %	Ch/K %	Qtz %	Flspr %	Cal %	Pr %	Others %
74.4- 76.5	--	13	5	54	19A	5	4	Sid-tr
76.4- 81.4	--	tr	4	81	8	5	12	
81.4- 86.9	11	28	15	14	15	--	17	
86.9- 92.7	--	13	5	74	4	6	--	
92.7- 97.8	--	tr	26	35	12	7	4	Vermiculite(?)-16
103.6-108.2	--	10	7	64	7	12	--	
108.2-113.1	--	10	5	64	9	8	4	
113.1-118.6	6	11	4	63	7	7	2	
128.3-129.5	4	tr	3	52	7	30	4	Hematite-tr
129.5-134.7	--	tr	4	67	8	13	8	
140.5-145.7	8	48	9	19	13	--	3	

No.	Depth	Ill	MLC	Ch/K	Qtz	Flspr	Cal	Pr	
1	171.3	--	tr	5	72	15	6	2	
2	173.4	tr	10	3	66	14	5	2	
3	176.3	--	--	--	38	11	51	--	
4	178.3	--	tr	2	74	13	9	2	
5	180.4	--	tr	3	76	8	12	1	
5	180.4	17	33	18	22	10	--	--	
6	181.7	--	13	5	55	12	8	tr	Analcline-7
7	183.9	--	6	2	70	6	14	2	
8	186.5	--	tr	5	73	14	8	tr	
9	188.4	--	tr	--	54	9	36	1	
10	190.2	--	tr	3	80	8	8	1	
11	192.8	--	10	--	52	5	33	tr	Ap-tr
12	193.7	5	14	3	41	4	33	--	
13	194.8	--	6	--	78	7	7	2	
14	196.9	tr	15	7	57	9	12	tr	
15	197.5	--	20	tr	26	--	54	--	
16	198.1	--	9	3	72	10	4	2	
17	200.9	tr	9	2	74	7	8	tr	
18	201.8	--	12	--	68	3	17	tr	
19	203.8	--	8	5	64	14	9	tr	
20	204.5	tr	13	3	80	2	2	--	
21	207.6	--	7	2	68	7	16	tr	
22	211.5	--	7	tr	60	tr	26	1	Ap-tr
23	214.6	--	5	5	56	17A	17	--	
24	217.3	--	tr	5	60	19A	16	--	
25	220.4	4	14	4	63	12	--	tr	Ap-3
26	228.3	--	8	tr	65	8	17	2	
27	229.8	--	8	5	55	6	23	3	
28	231.5	--	10	3	69	5	11	2	
29	233.5	--	7	3	72	7	9	2	
30	239.0	--	9	--	69	3	17	2	
31	240.0	--	9	2	69	4	16	tr	
32	241.1	--	7	2	71	5	13	2	
33	241.9	--	22	3	8	11	52	4	

Rennell Sound Road-Shields Bay Section (Maude-Kunga)

1	+4.6	--	--	--	--	40A	--	--
2	4.6	--	14	8	37	41A	--	--
3	7.6	--	tr	3	59	13A	18	--

No.	Depth (m)	Ill %	MLC %	Ch/K %	Qtz %	Flspr %	Cal %	Pr %	Others %
4	12.2	--	tr	5	50	36A 6	--	3	
5	12.2	--	8	4	65	11A 4	8	--	
6	15.2	--	tr	tr	21	27A	18	4	
7	19.8	--	10	5	61	19A 5	--	--	
8	19.8	--	--	--	78	22	--	--	
9	22.9	tr	16	10	35	17A 17	5	--	
10	22.9	--	--	6	79	13	tr	2	
11	25.9	--	tr	tr	63	33A	--	4	
12	25.9	--	tr	tr	93	7	--	--	
13	30.5	--	8	3	76	4	9	--	
14	33.5	--	tr	tr	61	7	28	4	
15	36.6	--	tr	5	57	9A 10	15	4	
16	39.6	--	tr	tr	83	7	8	2	
17	39.6	tr	6	--	79	5	7	-	Clinoptilolite-3, Dol-tr
18	42.7	--	10	tr	63	5	20	2	
19	45.7	--	tr	--	64	11	25	-	
20	45.7	tr	12	7	24	21A 13	--	4	Clinoptilolite(?)7 Analcime-12
21	50.3	--	tr	4	70	12	11	3	
22	54.9	--	--	4	56	19A	18	3	
23	57.9	--	tr	--	61	7	30	2	
24	61.0	--	tr	3	66	11	17	3	
25	61.0	4	8	3	68	9	5	-	Dol-3
26	64.0	--	--	--	29	tr	52	tr	Laumontite-19
27	73.2	--	8	tr	64	10	14	tr	Analcime-4
28	73.2	tr	7	4	55	4	3	--	Analcime-27
29	79.2	--	tr	tr	72	13	7	3	Analcime-5
30	85.3	--	8	5	51	11	15	-	Analcime-10
31	91.4	--	11	tr	63	16	7	3	
32	94.5	--	tr	3	68	15A 5	7	2	
33	97.5	--	tr	--	52	35A	8	5	
34	97.5	--	9	4	27	25A	33	2	
35	97.5	--	tr	7	39	37A 5	8	4	
36	112.8	--	tr	4	67	21A 4	tr	4	
37	115.8	--	tr	8	72	11	9	--	
38	120.4		tr	4	63	16A 6	9	2	
39	128.0		13	18	35	16	--	10	
40	128.0		tr	4	58	15A	21	2	
41	161.5		--	4	79	7	7	3	

Shields Bay Shore-South Quarry (Kunga block limestone)

42	4.6	--	7	2	72	7	10	2
43	9.1	--	8	13	63	--	13	3

No.	Depth (m)	Ill %	MLC %	Ch/K %	Qtz %	Flspr %	Cal %	Pr %	Others %
44	9.1	--	7	6	69	--	16	2	Anatase-5
45	9.1	--	10	9	59	--	15	2	
46	12.2	--	6	2	83	2	7	tr	
47	15.2	--	8	5	80	3	4	tr	

Shields Bay Shore - North Quarry (Kunga banded member)

48	3.0	4	tr	4	74	9	9	tr
49	6.1	--	tr	6	63	17A	8	tr

6

Whiteaves Bay (westerly along Skidegate Channel)

50	Top	--	12	4	61	8	14	2
51		--	6	5	74	5	10	tr
52		--	tr	tr	72	11	13	4
53		tr	tr	3	75	10A	8	1
					3			
54		--	tr	--	17	6	77	tr
55	Base	--	6	2	66	6	10	1

Laumontite-6, Anatase-3

Maude Island (Kunga Formation)

56	Top	--	tr	3	64	19A	12	2
57		--	tr	2	71	21A	4	2
58		tr	6	2	54	15A	21	2
59		tr	tr	2	83	14A	--	1
60		4	5	tr	82	7A	2	--
61		--	9	3	64	12A	5	tr
62		--	tr	3	67	5	23	2
63		--	8	4	21	8	59	tr
64		--	tr	3	71	18A	tr	tr
					8			
65		tr	12	6	52	27A	--	--
					3			
66		--	tr	7	58	15A	8	3
					9			
67		--	11	3	61	20A	2	3
68	Base	--	tr	6	74	6	13	1

Sylvite-7, Halite(?)

Rennell Junction Section (Maude Formation)

69	Top	--	tr	--	32	7	61	tr
70		--	10	3	55	17A	12	3
71		--	11	--	77	9	3	--
72		--	10	4	57	11A	15	3
73		--	tr	4	64	4	26	2
74	Base	--	tr	7	41	13	39	tr

QCI Main Road (Kunga banded member)

75	Top	--	8	4	83	5	--	--
76		--	tr	5	85	6	4	--
77		--	tr	11	36	47A	--	6
78		--	3	4	19	6	66	2
79		--	tr	2	76	6	14	2
80	Base	--	7	2	73	8	8	2

No.	Depth (m)	Ill %	MLC %	Ch/K %	Qtz %	Flspr %	Cal %	Pr %	Others %
<u>Branch Road 57</u> (Kunga banded member)									
81	Top	--	tr	--	87	13	--	--	
82		--	tr	tr	81	19	--	--	
83		--	tr	tr	88	9	3	--	
84		--	6	tr	81	4	6	--	Hydrophilite(?) -3
85		--	tr	tr	88	10	--	2	
86	Base	--	tr	--	87	9	2	2	
<u>Ghost Quarry C</u> (Maude Formation)									
87		--	tr	tr	54	7	31	4	Hydrophilite(?) -4
<u>Ghost Quarry B</u> (Kunga banded member)									
88	+16.8	--	tr	5	76	7	11	1	
89	+16.8	--	tr	tr	55	25A	15	5	Ap-tr
90	+15.2	--	tr	tr	71	11A	14	4	
91	+13.7	--	tr	tr	72	7	15	21	Analcmite-1
92	+13.7	--	tr	6	27	25A	13	4	
						25			
93	+12.2	--	10	7	35	32A	13	3	
94	+12.2	--	9	10	62	7	12	--	
95	+10.7	--	tr	tr	79	8	11	2	
96	+9.1	--	tr	4	85	8	3	tr	
97	+7.6	--	--	3	71	11	13	2	
98	+6.1	--	--	2	76	5	7	2	Analcmite-6
99	+4.6	--	5	3	69	11A	6	3	
						3			
100	+3.0	--	--	--	79	7	8	2	Dol-4
101	+3.0	--	13	8	56	19	4	tr	
102	+1.5	--	5	3	69	9	7	2	
103	0	--	--	3	74	13	8	2	
104	Pit Floor	--	5	4	80	8	3	tr	
105	Pit Floor	--	5	--	88	6	--	1	
<u>Ghost Quarry A</u> (Maude Formation)									
106		--	4	6	60	6	16	1	Ankerite-7
<u>Ghost Quarry D</u> (Kunga black limestone?)									
107	+45.7	tr	7	4	54	15A	9		Laumontite-6
						3			
108	+30.5	--	--	12	18	56A	--		
						11			
109	+22.9	--	tr	4	36	41A	4		Laumontite-6
						5			
110	+15.2	--	tr	--	70	18A	5		
						4			
111	+7.6	--	--	3	67	13A	5		
						3			