
SOUTHAMPTON
ISLAND

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GEOLOGICAL RECONNAISSANCE MAP

SOUTHAMPTON ISLAND

FOR

SOGEPET LIMITED

COMPILED BY

R.D. JOHNSON

SCALE : 1 : 250,000 (Approx. 1 Inch = 4 Miles)

PRECAMBRIAN

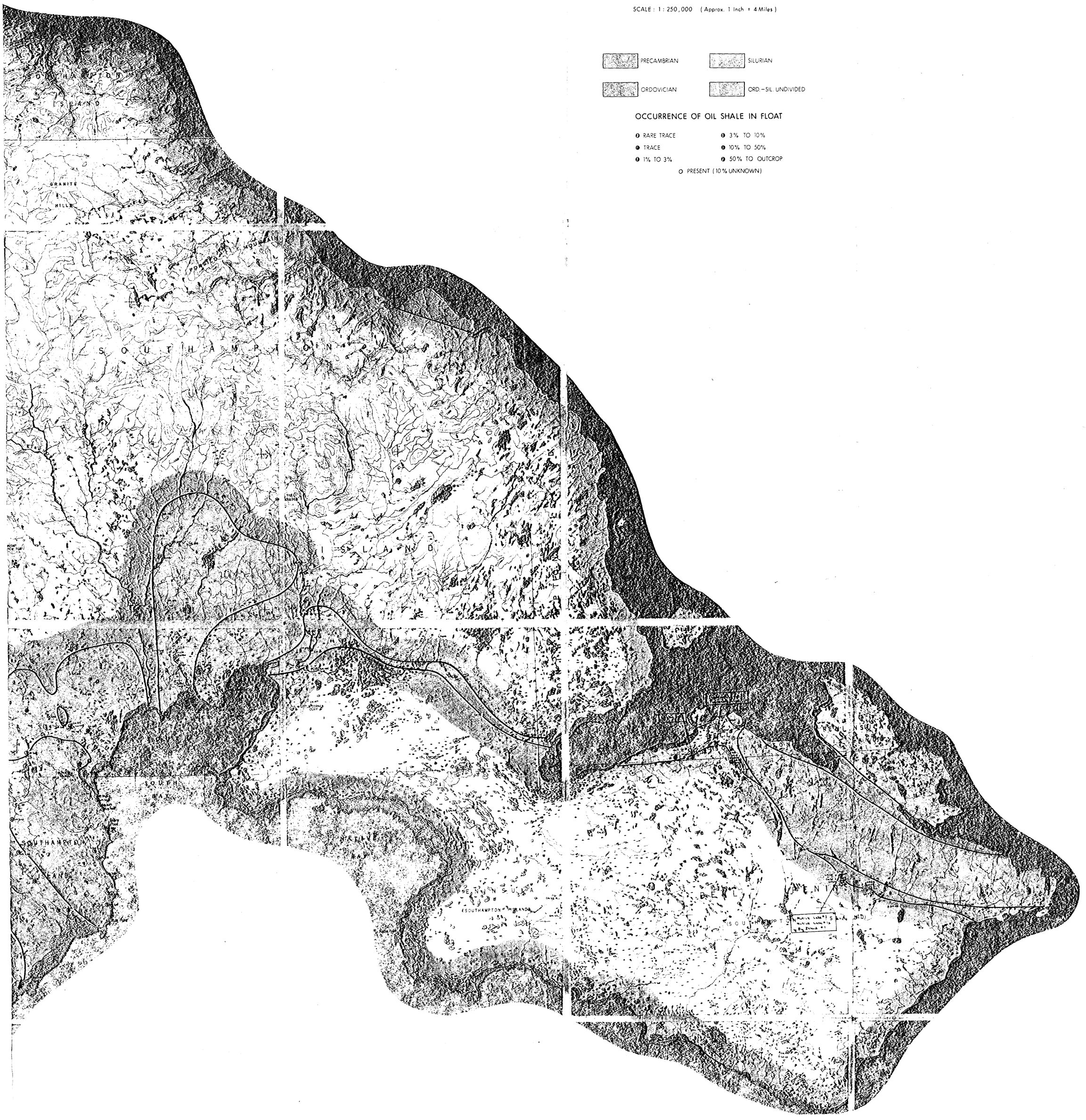
SILURIAN

ORDOVICIAN

ORD.–SIL. UNDIVIDED

OCCURRENCE OF OIL SHALE IN FLOAT

- RARE TRACE
- TRACE
- 1% TO 3%
- 3% TO 10%
- 10% TO 50%
- 50% TO OUTCROP
- PRESENT (10% UNKNOWN)



SUMMARY

OIL SHALE EXPLORATION

SOUTHAMPTON ISLAND

1964

for

SOGEPET LIMITED

by

R. D. JOHNSON & ASSOCIATES LTD.

March 1965

R. D. Johnson, P.Geol.

This report summarizes the work done to date in the search for and examination of oil shales on Southampton Island. It is accompanied by the report of Dr. S. J. Nelson, "The Oil Shales of Southampton Island". The report includes notes, data and analyses from various sources related to the interest of Sogepet Limited in the oil shale.

Introduction

During August 1963, a party of Sogepet geologists carried out a brief geological reconnaissance of Southampton, Coats and Mansel islands. The results of the survey were presented in a report by this writer. At the time of the survey, efforts were made to track down reports of "burning stone" which appeared as unsubstantiated accounts in the literature (Bird, 1953). These efforts were unrewarded. However, funds were forwarded by Sogepet to the Hudson Bay Company in Coral Harbour, in trust, as encouragement to the Eskimos to produce samples of the rock. Subsequently, a sixteen-pound sample was submitted to the factor by a young Eskimo, Jimmy Nakalak, and forwarded to Calgary. The sample of rock was found to be an oil shale, similar in colour and other characteristics to the famous oil shales of Colorado. The first rough analysis of the shale yielded 16.5% oil and 2.4% water by weight. These tests which were performed under rather poor conditions, indicated the shale had an oil content in excess of 35 gallons per ton.

Work by L. B. Halladay

With the encouraging results of the first analysis of the shale indicating commercial grade, Sogepet Limited decided to do follow-up work immediately. A geologist, L. B. Halladay, was dispatched to Southampton Island on April 8, 1964, remaining there approximately a month. During this period, Halladay made long traverses of several days by dog sled with an Eskimo companion. These traverses took him through the Ford River and Native Bay areas and east along the south coast of Bell Peninsula to near Leyson Point at the southeastern tip of the island. Southwestward from Coral Harbour, Halladay visited the lower reaches of the Kirchoffer River, Rocky Brook and Sixteen Mile Brook and continued towards Renny Point.

Despite the fact that the area was entirely snow-covered, Halladay collected samples of shale as float in such widely separated areas as the lower Ford River and beaches near the Kirchoffer River, Rocky Brook

and Sixteen Mile Brook. Further, he visited and collected the shale from Nakalak's outcrop on Sixteen Mile Brook about one mile above the mouth. Some idea of the difficulty of Halladay's assignment is portrayed by the accompanying photographs. Halladay returned with further rumors that the oil shale was also present at three localities on Bell Peninsula: near Gore Point, in the centre of the Peninsula and in the Native Bay area. His work in the Sixteen Mile and Rocky Brook area left him with the impression that the shale occurs interbedded with limestone and at more than one stratigraphic horizon.

Halladay's work had served the purpose of validifying the oil shale occurrence and further suggested the material might be widespread. Sogepet therefore approached a large oil company knowledgeable about oil shales, with a view to carrying out further investigations. An agreement was reached whereby the oil company would send a qualified geological party to Southampton Island as soon as ground conditions permitted in the summer of 1964. The company was obligated to submit all basic data and shale analyses to Sogepet.

In addition, Sogepet decided to send a geologist, Dr. S. J. Nelson of the University of Alberta (Calgary), to serve as an observer to the geological party and provide what specialized paleontological information he could to the party. Dr. Nelson was also commissioned to do whatever geological work was possible independent of the main party.

Work by the Oil Company

The oil company geological party entered the field on July 11 as soon as field conditions permitted and returned August 4. The party, which made its headquarters at the airstrip in the Department of Transport facilities, consisted of: party chief (a geologist), another geologist, geological assistant, expediter, technician, plus a helicopter pilot and an engineer. Complete equipment and gear for the party were flown to Coral Harbour including a Bell G3 helicopter, a small Hughes helicopter, a small water-cooled diamond coring machine, a small shale retort, all supplies, etc.

The party used the Bell helicopter for traverses and kept the Hughes machine for emergencies. In all, over 350 locations were visited by the party. The field notes are presented herein as Appendix I. The station numbers refer to locations on the enclosed map. This work was largely limited to the areas immediately peripheral to the central granitic highland mass since the shale occurrence seemed related to areas of Ordovician exposure. Some large areas such as Cape Low, Cape Kendall, the western flank of the island and the north-central flank were not visited at all as these areas were assumed to have Silurian cover. Detail work was limited to three areas: near the mouth of

Sixteen Mile Brook, inland from Gore Point, and the mid-interior of Bell Peninsula. Shale outcrop was found only at Sixteen Mile Brook but drilling indicated that shale was also present in Bell Peninsula.

The enclosed map indicates in a crude way the "percentage of shale in the rubble" at a number of localities. These values appear logical and relate very well to the Ordovician distribution. One feature is puzzling and that is the relatively high occurrences in the general Mount Saorre area along the upper Sutton River. In the Sixteen Mile Brook area the shale is the uppermost Ordovician and definitely related to the "Stony Mountain" sequence. However, near Mount Saorre, the Ordovician is known at least in part to be of the "Red River" sequence which underlies the "Stony Mountain". Therefore, lacking further evidence one wonders if the shale here is actually related to the Stony Mountain, or whether the shale overlies the "Red River" with "Stony Mountain" absent, or whether there is another shale unit in the Ordovician of which we are unaware. The latter seems unlikely but should be kept in mind.

The field notes and discussion with the oil company personnel indicate that the Company believes the oil shale is limited to the top fifty feet of the Ordovician section. The greatest thickness actually observed was a series of stringers totalling nine inches of shale in an eighteen-inch interval. There is evidence of a hiatus at the top of the shale interval. The fifty-foot interval in which the shale appears is divided into three units: an upper and a lower unit containing thin-bedded limestones with oil shale, and a middle more massive limestone. Their conclusion is essentially that the two shale parts of the interval are limited to perhaps a total of twenty-five feet. Further, in their opinion the shale forms only perhaps fifty per cent of this and then is in thin beds. Therefore, they conclude the area may contain something in the order of twelve and one-half feet of shale. Again, they would conclude that there are probably no single thick shale units of high value.

The company ran nearly one hundred retort analyses for oil content on shale samples in the field. These are submitted in this report as Appendix II. It will be noted the result ran from 0 to 32.5 gallons/ton. The great majority of the analyses are low. This may be accounted for by the fact that at least part of the shale is low grade, and also that the low grade material resists weathering better and therefore was transported to and collected from a greater number of localities. No averaging of the assays is valid for the above reason. It must be remembered that many of the samples analyzed are of "float material".

Analysis of the oil shale in the field indicated that the grade of shale differs markedly but falls into two categories: oil rich with oil content generally in excess of 22 gallons/ton, and oil lean with generally less than 12 gallons/ton. The oil-rich variety is described

as dark brown to black, dark streak, slightly calcareous, flammable, fissile and generally free of silt. The oil-lean variety is brownish with a lighter streak, moderately calcareous, non-flammable, non-fissile and generally contains thin silt laminae. The odor of the oil-rich material from a scratched fresh surface is pungent compared with the poorer variety. Since the oil company reasons there may only be ten to fifteen feet of shale, they must assume that only five to ten feet at most is of the oil-rich variety because most of the shale float found was of the oil-lean type.

The drilling attempts by the oil company proved rather frustrating. The poor results both of footage and core recovery was probably caused by the use of too small and light a machine and by inexperienced personnel. The location of the holes are all on Bell Peninsula and are shown on the map. The drilling is described in the field notes, Appendix I, pp. 46-48. It would seem to this writer that the lack of limestone recoveries while drilling predominately shale sections possibly indicates the shale may well be in the order of ten feet thick and relatively free of limestone stringers.

Dr. S. J. Nelson's Report

Dr. Nelson left Calgary for Coral Harbour on July 20 and returned to Churchill on August 10. Nelson stayed at the Hudson Bay Post rather than at the air base because of the availability of eskimos and boats.

Nelson travelled by canoe east of Coral Harbour to the Ford River and west as far south as Renny Point. He spent about a week at the shale occurrence at Sixteen Mile Brook, and visited the Gore Point area with the oil company helicopter. His observations, conclusions and recommendations are clearly put forth in his report. It should be noted that while he had many discussions with the field party, he did not have free access to their notes until late in the preparation of his report. His report, therefore, is based on his own observations and his opinions of the observations of the field party as reported to him in the field.

Essentially, Nelson's findings are the same as the field party's. He identified the shale unit as probably the uppermost Ordovician present and found the shale both at Sixteen Mile Brook and at Gore Point limited to an approximate fifty-foot interval. Nelson, however, makes the point that the shale is really known by rubble only and the exact nature of the interval unknown. The rubble suggested to Nelson interbedding of shale with limestone and an apparent increase in the number and thickness of shale beds towards the base of the unit. He also developed a feeling that the shale occurred in much thicker beds at

Gore Point than at Sixteen Mile Brook. Therefore, Nelson has a more hopeful attitude towards the shale than the field party, both in possible amount of shale and possibility of a single thicker unit.

Analyses

During the course of the Sogepet studies detailed analysis of the shale samples has been made by two separate and knowledgeable companies with laboratories to carry out the work. In both cases the samples analyzed were collected from the Sixteen Mile Brook area. Without mentioning the companies who kindly carried out the analyses, the results are shown on pages 1 and 2 of Appendix III. Samples A and B of the second company's analysis were specimens of blocky material similar to analysis "1" of the first company. Sample C was of the small exfoliating type. It is interesting that the exfoliated type was the richer in one set of samples and poorer in the other. In any case, the assays ranged from 26.4 to 37 gallons/ton and the API of the oil is in the order of 17.5 degrees. The reported 4.5% sulphur content is noteworthy.

Spectroscopic analysis of five representative samples of the shale (64-11-2, 64-11-3, 64-8-A, R, S) was made by Sogepet and is reported on pages 3 and 4 of Appendix III. This analysis was primarily performed to check for interesting mineral contents of such metals as copper, uranium, vanadium, etc., which are sometimes found concentrated in black shale deposits. The analysis showed no interesting amounts of metal contents but reported traces of copper, iron, lead, molybdenum, nickel, titanium, vanadium and manganese.

Geological Map

The enclosed map which indicates the oil company geological stations and the relative abundance of shale rubble, also presents Sogepet's geological thinking about the island. The geology, as shown, is the result of the geological work of Nelson and Johnson in 1963, and Nelson in 1964 and includes the data from the field notes of the oil company. No structural geology is shown. However, with only a few exceptions, the attitude of the Silurian and Ordovician strata is very low with dips generally too small to measure. The impression is that in the southern parts of the island the strata dips seaward at one or two degrees.

Summary and Conclusions

The original "burning rock" of the early reports was found to be an oil shale. This shale is Upper Ordovician in age and occurs in the uppermost fifty feet of Ordovician section. The areal distribution of the shale in outcrop or "near outcrop" is known mainly in the south-central area and on Bell Peninsula, between the Silurian-covered lowlands and the Precambrian highlands. The subsurface distribution of the shale is unknown but it is suggested that the unit may thicken southward towards the axis of the Hudson Bay basin. The shale interval is always rubble-covered in the field and has never been fully seen in outcrop. Where observed, the shale is thinly interbedded with limestones with the shale beds at most a few inches thick. The grade of the shale apparently varies widely. In general it runs either about twenty-two gallons per ton or about twelve gallons per ton with the maximum value found to date of thirty-seven gallons per ton. The incompleteness of our knowledge of the section in outcrop, and our total lack of knowledge of the unit in the subsurface leaves it entirely possible that thick and rich oil shale strata do occur on Southampton Island.

Future exploration of the oil shale requires further geological reconnaissance of parts of the island, particularly in the west and north. Detailed geological mapping is needed along the known Ordovician outcrop areas. Mechanical trenching of the known shale outcrops and drilling down-dip from the outcrops is essential before a clear understanding is possible of the nature and thickness of the shale beds and their oil content.

In performing the work outlined in this and other related reports, Sogepet Limited has made several important contributions to the economic geology of Southampton Island and of the Hudson Bay area. It has (1) identified the Paleozoic strata present with sound paleontological data, (2) made possible a geological reconnaissance map of the area indicating the distribution of Paleozoic stratigraphic divisions, (3) illustrated the presence of reservoir rocks, and (4) established the presence of highly petroliferous shales. The petroleum prospects of Hudson Bay are considerably brightened as a result of this work. In addition, further exploration may prove the presence of oil shale thick enough and of sufficient quality to provide the basis for an oil shale industry.

HALLADAY PHOTOGRAPHS April 1964

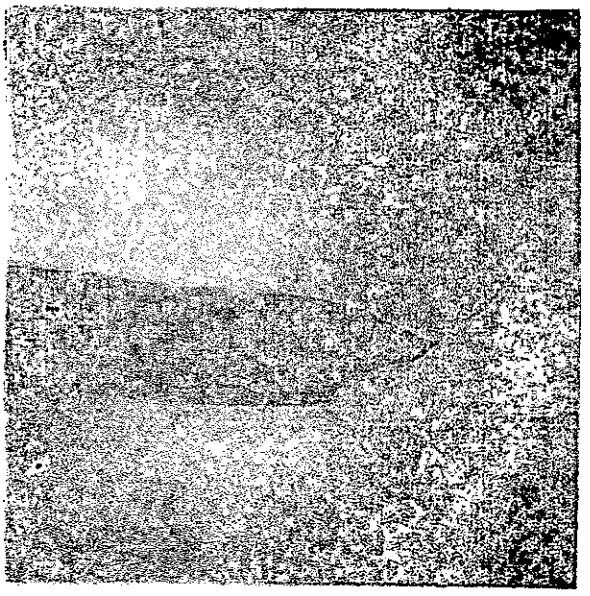


Photo 1

Photo 2

Photo 3

N.B. Descriptions on reverse side.

PHOTO 1

Sixteen Mile Brook about one mile from coast. Note complete snow cover and heavy drifts. Exposed rock in left-centre marks diggings for shale.

PHOTO 2

Halladay in diggings collecting shale sample from below massive Silurian limestone. Eskimo holds oil specimen and torch.

PHOTO 3

General photo of beach and travel conditions along Bell Peninsula near Leyson Point.

A P P E N D I X I

FIELD NOTES

The following are the field notes of the oil company surface party as submitted to Sogepet Limited and read by R. D. Johnson. The geological stations referred to are shown on the accompanying map.

July 11, 1964
Cloudy and sunny

Sixteen Mile Brook
Air Photo #A15430-86

CM-1-N64 (walking down stratigraphically)

15' Limestone, very light grey brown-buff, with light grey brown-buff laminae, microcrystalline, algal with scattered oolites.

2' Limestone, microcrystalline, banded and mottled light and medium grey brown-buff, bands ¼", with mottled light and medium grey brown.

4' Limestone, pelletal, light medium grey brown with light medium grey brown-buff.

15' Limestone (?) shaly, cryptogranular-microgranular, light yellow grey-cream laminated, soft, with light yellow grey-yellow brown.

samples 1-3, no gallons/ton

2' Limestone, micro-cryptocrystalline banded as in other 2' bed above Sample #4.

CM-2-N64

Limestone with light grey slabby-flaggy interbed, microcrystalline, slightly fossiliferous, slightly carbonaceous. One sample.

CM-3-N64

Bituminous black shale, (float). Two samples 12.2 gals/ton.

CM-4-N64

Limestone, light grey, thin-bedded, microcrystalline, weathering light grey. One sample.

CM-5-N64

(Marl) Limestone light grey, thin-bedded, microcrystalline with light grey-buff platy 2" bed of black bituminous shale lying at top of marls. Two samples of oil shale gave 10 gals/ton and 6.8 gals/ton. One talus sample.

CM-6-N64

Marl, buff light yellow grey, with buff finely crystalline green platy trace interbed, cliff fragment (?), dips very slightly east. May overlie black bituminous shale of CM-5-N64. Sample #1 five feet above #2. Total over a 15' interval, 0.4 gals/ton and 0.06 gals/ton.

CM-7-N64

Shale, black platy, in an 18" interval at top of a 20' cliff (?) Marls of CM-6-N64. Black shales are interbedded with some marls. Total thickness of black shale interval is 18" of which half is black shale. Four samples 12.7 gals/ton. Sample is composite of shale stringers only within the 18" marl bed. Rerun gave 15 gals/ton.

July 12, 1964

Traverse to Mount Minto from D.O.T.
Plotting 1" to 4 mile map, 1" to 16,000 mosaic, RE 20820-2

CM-8

Area 1 mile by $\frac{1}{2}$ mile weathers brown by air, composed of fine limestone rubble lying in thicknesses of up to 4' on Precambrian gneiss, obvious remnant of original limestone cover. Limestone on close view weathers grey and comprises medium-grained calcarenite with crinoid ossicles and other unrecognizable debris in very fine (?) cement. No macrofauna. Sample.

CM-9

Limestone as before disposed in patches over an area of a few square miles. Maximum thickness of limestone on Precambrian not more than ten feet. At landing point, some five to six feet are present on stream flowing southeast to Ford River. This is in beds 1' to 2' with slabby partings at 1" intervals between the beds. Found one 2" fragment of a straight cephalopod and/or cone gastropod.

CM-10

Precambrian gneiss forms rapids in river, rubbly-bedded limestone about twenty feet thick, lying above it in river bank.

CM-11

West branch of north fork of Ford River. River valley 200 yards across with fifty-foot banks. Top twenty-five feet (+ or -) exposed. Limestone as before. This limestone is reefy with a specially abundant crinoid varying from 2 mm. to 3 mm. From the air weathers brownish and is due to a yellowish-brown mottling which affects about one-third of the rock on weathered surface. On fresh surface this mottling can be seen to be due to an impalpably fine material (dolomite ?) which is shot through the rock. Rock is quite massive with bedding planes at 1 to 5 feet and a fine slabby parting at 1" intervals. Collected poor gastropod fragments and pieces of crinoids.

CM-12

Brown with mottled Precambrian granitic slough but just ¼ mile is similar brown weak rubble which is mostly limestone veneer on Precambrian.

July 13, 1964
Sunny, high wind

Traverse toward Mount Minto
Plotting 1" to 4 mile map, mosaic, RE 20820-2

CM-14

Outcrop on bank of Ford River exposes 5 feet along 600 yards.

Limestone light brown, grey with yellow-brown anastomosing splotches of dolomite (?). Limestone is fragmental material in ground mass of fine mud. Slabby parting parallel to bedding. Attitude about flat. Collected orthocones, coiled cephalopods, gastropod and piece of coral.

CM-15

At south end of large (several square miles) carbonate outlier. At mouth of small south flowing stream is light brown with dense mealy dolomite which weathers into angular plates averaging many square miles in area and ¼ to 1" thick. Quite porous (dries

tongue readily). Some 400 yards upstream and 50 feet (approx.) stratigraphically higher is limestone, very finely crystalline to finely sucrosic. Rubbly bedded and attitude approx. flat. This is quite a distinct unit from the reefy limestone around Post River. Only fossils are some poor remnants of smooth shelled, chitinous?, brachiopods.

CM-16

Limestone fragma. No shale.

CM-17

North edge of carbonate rubble plateau dolomitic limestone and reefy limestone fragma. No shale.

CM-18

Landing on west side of carbonate plateau. Grey weathering limestone in well-sized chunks ½ to 2" pale brown pelletal and mud limestone.

CM-19

Fine to medium grained calcarenite rubble.

CM-20

Fine to medium grained calcarenite and lesser dolomite rubble. Ridge shown on map on southwest edge of lake is formed of this material and is of glacial or moraine construction.

CM-21

South side of carbonate plateau. Small creek with very abundant finely sucrosic dolomite boulders which weather yellow brown common brachs with Devonian aspect, one graptolite. This material is not in place but is of very local derivation.

July 14, 1964
Sunny, windy

Traverse to Gore Point and vicinity with Eskimo Pameoolik to look for oil shale.
Plotting mosaic.

CM-24

Small gully on east side of Pameoolik River. Fairly abundant flags of oil shale. Smooth planar surfaces, light grey, looks like limestone until broken. Frags are angular, some blocks as much as 4" thick. Confined. to immediate vicinity of small gully. Very rare in glacial drift. Occasional fragments in gravels of main river are small and rounded--suggests stuff is fairly common. Angular fragments imply a near surface subcrop in vicinity of gully. This will be hard to drill because of gravel and gully bottom. Thin pieces 10.5 gals/ton. Thick pieces 1.6 gals./ton.

CM-25

A few small worn fragments of oil shale.

CM-26

Flat-lying slabby bedded bioclastic limestone. About twenty feet exposed in side-hill. Lower ten feet covered in talus. The level plain at the base of the slope is underlain by Precambrian although the exact contact is not exposed.

CM-27

Drift. No oil shale.

CM-28

Station on north side of very extensive carbonate plateau. Platy limestone to limy shale much of which is petroliferous. Most of the material is not in place but is of very local derivation. Small stream flows down side and this has an outcrop at base. From inner part of piece 23.2 gals/ton rerun 20.1 gals/ton. Generally 18 gals/ton.

Also collected series of samples from base of hill upwards at about 10 feet vertical intervals. These are only selected shale fragments. The limestone is ignored. (7.1 gals/ton, 3.2 gals/ton, marly limestone, etc. 0.5 gals/ton)

The first bench rises to about 35 feet above the general base. Oil shale is scattered through this talus but above this point on the sides of the hill there is only bioclastic and mealy limestone. Near top of hill is outcrop of limestone. Should probably try to drill from lowest of the terrace levels. Fragments of oil shale can be seen all through the base of the hill for half-mile east of the original landing point (marked by orange tag). There are two or three eskimo stone houses on the second terrace about ¼ mile east. Sample from bench ½ mile east of original location 4.6 gals/ton rerun 5.1 gals/ton. 0 to 10 feet equals 3.3 gals/ton and 10 to 25 feet equals 2.8 gals/ton. Second general sample of float fragments equal 22.6 gals/ton. Thickest single piece of oil shale found was about three inches. This is about the size of the largest limestone and shaly limestone fragments. Also took one unsorted sample which is a random sample of the limestone and shale area taken about ¼ mile east of landing point.

The thicker pieces always have a stronger smell and I suspect that analysis of the thin piece will considerably underestimate the true oil content.

August 5, 1964
Cold and windy

Trip to carbonate mesa near Gore Point to look for fossils in rocks associated with oil shale.

CM-28

Site of second drill camp.
Photos 7 & 8 looking south towards bench. Cameraman is at level of outcrop below oil shale horizon. Nelson stands on first bench 10 to 15' high back of helicopter can be seen rise east of bench. Near top of the rise an outcrop of limestone is exposed. This outcrop is some 50 to 55' above the outcrop at camera level and is believed to overlie the oil shale horizon.

Note that the section is quite reminiscent of CM-328 - CM-331. The shaly limestone at camera level is equal to the limestone along shore at Cm-328. The limestone 50 to 55' higher is equal to the limestone at CM-329. See sample CM-28X. Some 30' (+ or -) higher there is a cream weathering mealy dolomite (CM-28Y) which corresponds to the dolomite of CM-330.

July 16, 1964
Cool and windy

Traverse around perimeter of Bell Peninsula
Plotting 1" equals 4 mile map and mosaic

CM-29

Dolomite, pale yellow brown, marly and limestone, bioclastic medium grey light brown as float in creek. No oil shale fragments seen.

CM-30

As above.

CM-31

Limestone and dolomite float. No oil shale.

CM-32

Light grey weathering, very fine crystalline, buff limestone. Abundant angular float. No oil shale.

CM-33

Limestone, grey with buff limestone float, finely crystalline with good fine vuggy and pinpoint porosity. Lesser fine sucrose and fine vuggy porosity. Some coralline material in the limestone, collected one fragment. No oil shale.

CM-34

Carbonate float in river. No oil shale.

CM-35

Near outcrop of dolomite, light grey weathering, finely sucrosic, vuggy. Collected one coral. No oil shale in river gravel.

CM-36

Checked river gravel, mostly dolomite with vuggy porosity. No oil shale.

CM-37

Fine carbonate gravel. No oil shale.

CM-38

Dolomite outcrop about 5 feet high and exposes several hundred yards along river. Very light grey with buff fine crystalline vuggy porosity interbedded. Weathered surface with many large weathered out fossil pits. Poor coral remains and pentameroid looking molds, dolomitized biostrom, essentially flat. No oil shale in gravel.

CM-39

River gravel. No oil shale.

CM-40

River gravel. No oil shale.

CM-41

River gravel. No oil shale.

CM-42

River gravel. No oil shale.

CM-43

Few feet dolomite exposed for few hundred feet along low scarp. Dolomite is finely sucrosic, vuggy, buff creamy weathering, well bedded. Not macrovuggy on weathered surface. No reefal material or fossils noted. Approx. dip 3 to 5° West.

CM-44

River gravel. No oil shale. Flat-lying dolomite outcrops along bank.

CM-45

River gravel. No oil shale.

CM-46

Dolomite, finely sucrosic, a few small vugs plus apparent good pinpoint porosity, creamy weathering light buff. Abundant brachiopods at places (see collection). No oil shale in river gravel.

CM-47

Stop in river which conducts water from several tributaries draining across Precambrian-Paleozoic contact. Found one small piece oil shale in gravel. Outcrop in bank of cavernous dolomite.

CM-48

Small stream crossing Precambrian-Paleozoic contact. On one side of creek a fifty-foot covered interval separates gneiss and limestones. On the other side only 30 feet of covered interval in terraces. The Precambrian and limestone creeks are about at same height and the contact would be a fault, however the following suggest the contact is not a fault:

(1) The degree of fracturing does not increase significantly as the covered interval is approached.

(2) Absence of drape in the beds.

(3) The limestone, which is bioclastic with dolomite patches and contains quartz and chert grains as if it were shoreline facies developed on Precambrian island.

Collected one poorly preserved coiled cephalopod and lithological samples.

CM-49

Precambrian and Paleozoic contact obscured by 30 feet of covered interval. Precambrian is quartz feldspar biotite gneiss. Paleozoic is limestone very finely crystalline with 20% bioclastic material in grains up to 2 mm. Light grey weathering grey nubbly weathering with bedding planes up to 2 to 8". Attitude 090, dip 10 to 25° South. Steepest dips are nearest contact and are correct for an assumed fault to downthrow to the south side. The limestone outcrop continues for 500 feet east of contact, then 800 feet of covered interval, poorly exposed. Then two poorly exposed outcrops of Precambrian gneiss strongly brecciated and shot with calcite.

CM-50

Rubble of very fine creamy weathering dolomite and grey weathering limestone both with good, very fine, porosity. No oil shale.

July 17, 1964
Sunny and cold

Trip to Bell Peninsula
Plotting 1 to 4" mile map, mosaic RE 20820-2

CM-51

Limestone flat-lying, clotted textures with 15 - 20% fragmental material, ramifying yellowish weathering dolomitic patches, grey weathering, moderate bedded. No oil shale in stream gravel.

CM-52

Stream gravel, no oil shale. Gravel is mostly mealy dolomite.

CM-53

Fragmental limestone stream gravel. No oil shale.

CM-54

Stream gravel. No oil shale.

CM-55

Stream gravel. No oil shale.

CM-56

Rubbly dolomite, cream brown weathering, medium buff, finely mealy porosity. In part in blocks and cobbles to small boulder size, in part in thin (½") plates. No oil shale.

CM-57

Oil shale in river gravel. Oil shale makes up to 5-10% of gravel and occurs in platy pieces averaging 3" diameter and ¼" thick. Maximum thickness seen was 3/4" and maximum diameter about 6". In order to attempt to determine from relatively lean oil shales, I made up two samples from pieces of float pebbles. All pebbles around ¼ - ½" thickness and generally 2 - 4" diameter. One sample is labelled "rich" and the other "lean". The criteria used for selecting the lean sample are given below. The criteria for rich samples are the opposite. (Also took one large fragment as sample)

(1) Weak oil smell
(2) Harder (less fissile)
(3) Lighter colour and streak
(4) Presence of silt in streaks
(5) Has metallic clinky ring when struck

Values run 5.3 gals/ton, 2.9 gals/ton, 6.6 gals/ton, large pieces.

CM-58

Oil shale as before makes up 10% of river gravel.

CM-59

Gravel on inner side of bend in river, fairly fine oil shale 10% but particles quite small (less than 2").

CM-60

Very small gully in minor stream coming into river from north. No oil shale in gravel.

CM-61

Oil shale in fine pieces making up to 8% of river gravel.

CM-62

Stream flowing slowly through grassy area just downstream from headwater slough. Rubble of bioclastic limestone, no oil shale.

CM-63

Carbonate stream gravel. No oil shale.

CM-64

Forks of river. West fork has essentially no oil shale. East fork has 15% (+ or -) of gravel composed of oil shale pieces up to 8" and 1½" thick. Shale generally quite lean and silty. Found one piece with trilobite impression. 5.6 gals/ton

CM-65

Oil shale makes 15% of river gravel.

CM-66

River gravels. No oil shale.

CM-67

Stream flowing on grassy upland surface. Gravel is quite fine and is composed of 30 - 40% oil shale.

CM-68

Large swampy area from which stream emerges, composed of fine carbonate gravel in marly ooze. No oil shale.

CM-69

Oil shale making up 30% of river gravel in quite small pieces ¼" to 3" diameter. 8.3 gals/ton

CM-70

Clean carbonate river gravels. No oil shale.

CM-71

Clean fairly fine stream gravel with 5% oil shale.

CM-72

Fragmental limestone with 20% quartz grains and rock fragments reflecting deposition on Precambrian surface which outcrops ¼ mile to northeast. No outcrop only carbonate rubble. No oil shale.

CM-73

Clean stream gravels. No oil shale.

CM-74

Stream flowing south from Precambrian onto carbonate. Landing is almost on contact. River gravel is mostly 2% small oil shale fragments. Gravel must come from old beach deposits as there can hardly be enough carbonate cover in the Precambrian to produce this much carbonate gravel.

CM-75

Rubble of grey weathering, chalky, limy dolomite. Very elegant patterned ground with polygonal rings averaging 6 feet in diameter, very fine material inside surrounded by rims 10" thick of coarse blocks.

CM-76

Rubble of grey weathering, very fine crystalline, sucrosic limestone with fine vugs and good water absorbing capacity. Buff weathering surface. No oil shale.

CM-77

Carbonate river gravel. No oil shale.

CM-78

Coarse rubble of creamy weathering dolomite. No oil shale.

CM-79

Point between two fairly large forks of streams. Can't find exact place on photo because of snow, etc. One small oil shale fragment in gravel of east fork, none in gravel of west fork. West fork has abundant clam shell fragments which are presumably derived from old beach gravels. If this is so, the oil shale in some creek gravels could also come from reworked beach deposits.

CM-80

Clean stream gravel. No oil shale.

CM-81

River forks, clean gravel, no oil shale in either fork.

July 19, 1964
Overcast, cool

Trip to visit Drill Camp #8. Geology of Terror Point, etc.
Plotting 1" = 4 mile map and 1" = 3 mile mosaic

CM-82

Small stream emerging from Paleozoic remnant landing point about at base of mesa. Clean fine gravel, all carbonate. No oil shale. Outcrops can be seen along the south edge of this mesa proving that it is a genuine limestone outcropping, not merely a very old beach gravel.

CM-83

Clean stream gravel. No oil shale.

CM-84

Clean stream gravel. No oil shale.

CM-85

Dolomite, dense, creamy with creamy fresh surface. Beds 2" thick. Minor white chert. About flat-lying. Clean river gravel. Found one small piece of slightly bituminous shale.

CM-86

Gully running 345° debouching into swampy flatland at base of carbonate area. Common fragments of silty calcareous oil shale like that at Fukamukluk Creek (CM-57 and CM-71). This makes up perhaps 20% of the river gravel bottom and is in smooth rounded pieces $\frac{1}{4}$" thick and 3" diameter. Smell is weak and yield will probably only be 5 (+ or -) gals/ton. Also lesser smaller piece of thinly fissile dark brown oil shale similar to DB 18A which yielded around 25 gals/ton. These are mostly 1/8" thick and 1" diameter. Lean oil shale 3.5 gals/ton.

CM-86A

The fragments of fissile oil-rich shale following stream upstream (165°) quickly become larger and more numerous while the fragment of silty oil lean shale diminishes in quantity. Specimens of fissile oil-rich shale up to 1" and 10" diameter found. (25.2 gals/ton)

CM-86B

Collected several pieces along stream course. Proportion of fissile shale float rises to perhaps 50%. Throughout its course the stream flows through banks of limestone and lesser shale fragments, banks being 3 to 5 feet high. Some 1400 feet south of its mouth, the stream peters out and the ground level slopes up 4 or 5 feet. The water emerging from the gravel at the base of this rise. Continuing in a direction 165° there is a poorly developed dry wash where the stream flows on surface at high water. There is no oil shale only in this dry wash. 525' from the point where the stream first disappears there is a small trickle of water from the base of another upward slope which is the beginning of the gravel rise to the mesa surface. This point marked CM-88 on photo. CM-86 is about 30 feet below head of creek and this is some 35 (feet?) below CM-88. Cairn built 200 feet below head of creek. From these observations it can be surmised that:

(1) the lower part of the mesa is composed of flat-lying beds comprising limestone finely crystalline to calcarenite overlying a thin section of fissile dark brown oil-rich shale in turn overlying harder silty calcareous oil lean brown shale.

(2) the fissile oil-rich shale fragments are very poor travellers and would disintegrate along a stream course 1,000 to 2,000 feet below this source.

(3) the calcareous, non-fissile shales with slight oil smell are guides to the richer oil shales. CM-86B yields 24.5 gals/ton

CM-87

Very small gully 100 feet long with mouth at point 300 feet east of CM-86. Gravel contains about __? of shale and minor oil-rich shale (in total 25% + or -) in very fine fragments. Collected sample oil-rich shale. 19.0 gals/ton

CM-88

No record.

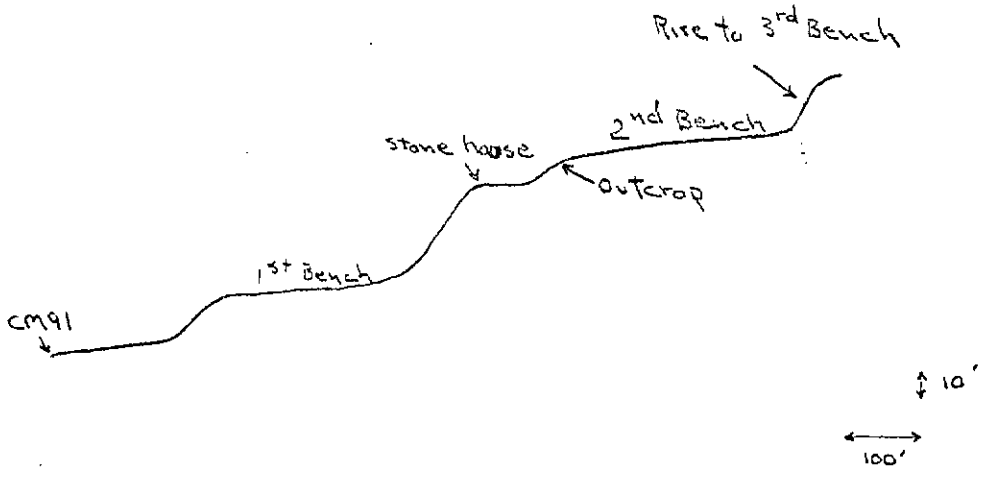
CM-89

Larger northflowing gully with mouth 200 feet east of CM-87. Gravel has 15% silty oil shale and 2% fissile oil-rich shale.

CM-90

Minute trickle of water over lowermost 5 feet of carbonate mesa. Gravel 10 to 20% oil shale in smooth thin fragments, mainly of harder oil-lean shale type. Collected sample of thinnest pieces in an attempt to get mainly the oil-rich material. 18.7 gals/ton

CM-91



The situation here appears basically the same as at CM-86 to CM-88 except that the oil-rich shales are not prominent in the float. One small outcrop two-thirds of the way along the slope to third bench. Sugary limestone with good micro-vuggy porosity. About one foot of thick sandy limestone contained within the 20 foot exposure.

Abundance of water all along the north part of this mesa is questionable. There are innumerable lakes lying in the coastal plain but all but one are very shallow (two to three feet). On the mesa itself, lakes are fewer but deeper.

CM-92

Dolomite yellow weathering, light buff, finely sucrosic and finely vuggy. One chert horizon is very oddly shattered but looks to be about flat. I speculate this dolomite is faulted in contact with the Precambrian and that the shattering is due to faulting. No oil shale in this stream gravel.

CM-93

Clean river gravel mostly carbonate. No oil shale.

CM-94

Clean dolomite stream gravel. No oil shale.
Drill site visited at 3:30 p.m. Rig had been moved to new location after trouble with first hole at 17 feet.

July 20, 1964
Sunny, warm

Traverse to Munn Hills and vicinity
Plotting 1" to 4-mile map, mosaic RE 20820-2 and 3

CM-95

Fine stream gravel, half granitic and half carbonate. No oil shale.

CM-96

Limestone, moderately coarse, clean river gravel 75% of which is carbonate, most of which in turn is finely crystalline, buff limestone. No oil shale.

CM-97

From CM-96 to here, the east slope of hill is floored by Precambrian outcrop. Just north of stream Paleozoic drift is seen and here in the stream gravel is 80% Paleozoic carbonate (mostly very fine crystalline limestone). No oil shale.

CM-98

Clean river gravel, mostly dolomite, buff, and limestone, grey-brown, both finely crystalline and dense. No oil shale.

CM-99

Clean carbonate river gravel, mainly finely crystalline limestone with lesser dolomite. No oil shale.

CM-100

As above.

CM-101

Seven feet of limestone, finely crystalline, brown-grey, nubbly grey weathering, contains up to 15% bioclastic material including crinoid ossicles, medium bedded. Top of section is thinly bedded, softer weathering material and the upland surface away from and above the outcrop is composed of this material. One 3" horizon of abundant well preserved brachs. No oil shale in river gravel, attitude of outcrop as near as can be distinguished by the eye is flat.

CM-102

Clean limestone, stream gravels. No outcrop.

CM-103

Small stream trickling across Precambrian-Paleozoic contact which lies 200 yards northeast of here. Fine clean gravel. No oil shale.

CM-104

Area which looks like limestone-cover from air actually is lime mud and boulders and Precambrian rubble resting on Precambrian outcrop.

CM-105

Limestone bioclastic with abundant organic detritus. No inorganic detritus despite the fact that the Paleozoic-Precambrian contact is 200 yards east and the limestone is probably only a few feet above basement. Clean gravel in stream flowing across contact. No oil shale.

CM-106

Small stream crossing Precambrian-Paleozoic contact. No oil shale.

CM-107

Limestone, pale grey finely crystalline with abundant organic detritus. Pyrite blebs up to 2 mm. and fine veinlets. No porosity, weathers blue-grey. Beds 2" and somewhat slabby. Attitude 045/3N. Clean coarse limestone river gravel in both forks of stream. No oil shale.

CM-108

Limestone as at CM-207. Attitude 030/2W.

CM-109

Clean stream gravel with 2% (?) oil shale mostly the harder silty, calcareous, non-fissile, lower yield variety.

CM-110

Limestone finely crystalline with 30% bioclastic material, light grey, blue-grey weathering, well bedded. Attitude 110/35S at south end with dip being more gentle to north end at northernmost end of outcrop 900' downstream being 15S.

CM-111

Rare, small well worn fragments of lean oil shale.

CM-112

Clean carbonate gravel. No oil shale.

CM-113

Clean river gravel some 200 feet upstream from south end of outcrop at CM-210. No oil shale.

CM-114
Clean beach gravel at lake edge. No oil shale.

CM-115
Clean stream gravel. No oil shale. On shore is coarse rubble of calcareous dolomite, yellow-buff, finely sucrosic with microvuggy porosity.

CM-116
Clean stream gravel. No oil shale.

CM-117
Clean stream gravel. No oil shale.

CM-118
Fairly clean fine river gravel. No oil shale.

CM-119
Large pavement of very fine, sucrosic, buff dolomite. Good micro to fine vuggy porosity. Common macro vugs or solution pits on weathered surface. (These up to 2" in diameter, average 3/4" tend to be elongate parallel to bedding. Possibly brach. molds.) Attitude 000/3W.

CM-120
Limestone, very finely crystalline to pelletal lime mud with 10 to 20% bioclastic material, brown grey with blue-grey weathering, well bedded 6". Attitude 160/2W. No oil shale in stream gravel.

CM-121
Clean stream gravel. No oil shale.

CM-122
Clean stream gravel. No oil shale.

CM-123
Dolomite, light buff, creamy-yellow weathering, finely crystalline, dense. Beds 3 to 6". Attitude 110/15N. River gravel mostly coarse angular blocks. No oil shale found.

CM-124

Clean stream gravel. No oil shale.

CM-125

Clean stream gravel. No oil shale.

CM-126

Moderately clean stream gravel. No oil shale.

July 22, 1964
Sunny and windy

Traverse around whole southwest perimeter of Southampton
Plotting 1" = 4 miles

CM-127

Clean river gravel. In ten minute search found two small holes of shale. Can't tell if petroliferous or not. See sample.
7.6 gals/ton

CM-128

Limestone, lower 3 to 4 feet exposed of sublithographic grey limestone intermixed with finely sugary yellow-weathering limestone. The areas of the different types are in order of several square inches. The general appearance is of a dolomite replacing limestone but the yellow weathering material is not dolomite. Could also be calcirudite with the yellow material being cement but the intimate association and complex boundaries of the two types preclude this unless there has been some replacement of the sublithographic class by the sugary cement. Common coarse coralines bryozoan. There is also 5 to 10% chert which is in many corals partly or completely converted to chalk. Above this there are two or three feet of finely pelletal limestone. Bedding rather crude throughout but appears basically flat-lying. No oil shale in clean river gravel.

CM-129

Clean river gravel. No oil shale.

CM-130

Muddy stream gravel and clean beach gravel. No oil shale found. If any is present it can be present only in very small amounts.

CM-131

Clean stream gravel. No oil shale.

CM-132

Limestone biostrom, grey weathering, poorly bedded. Limestone stuffed with coral heads, lesser horn corals and algal material, also beds with abundant small brachiopods and lesser large smooth-shelled brachs. Non-fossiliferous material is a very finely pelletal limestone. Attitude flat. Clean stream gravel. No oil shale.

CM-133

Clean stream gravel. No oil shale.

CM-134

Clean stream gravel. No oil shale.

CM-135

Limestone as CM-132. Essentially flat. Collected poor collection of horn corals and brachs. No oil shale in river gravel.

CM-136

Clean stream gravel. No oil shale.

CM-137

Clean stream gravel. No oil shale.

CM-138

Several feet of dolomite, very finely sucrosic with micro-vuggy porosity. Abundant coral and brach material. Below this is several feet of coarse calcarenite also with abundant organic material. Attitude 155/15E. Clean river gravel. No oil shale.

CM-139

Limestone, sublithographic. Abundant fossil material similar to last two outcrops, grey, yellowish weathering. Clean river gravel. No oil shale.

CM-140

Stream flowing through rocky gorge for about 2 miles above mouth as it descends to sea level from outcrop 300 feet plus plateau level. Rock is limestone, medium crystalline, with abundant bioclastic detritus varying from fine to whole corals and brachs. Beds thick but incipient bedding planes at few inch intervals. Attitude 165/4W.

No oil shale in stream gravels.

CM-141

Clean stream gravel. No oil shale.

CM-142

Clean stream gravel. One small worn fragment of brown shale like hard oil shale but with no detectable odor.

CM-143

Clean stream gravel. Found only two small worn pebbles of shale resembling hard oil shale and with slight petroliferous smell. 2.6 gals/ton.

CM-144

Swampy stream with muddy gravel. No oil shale.

*** No record CM-145, 146

July 24, 1964
Sunny and windy

Local geology between Little Corner Cliff and Kirchoffer River
Plotting 1" = 4 mile map

CM-147

Dolomite, light buff, light grey weathering, finely sugary, micro

to fine vuggy porosity. Outcrop somewhat jumbled, hard to estimate attitude but probably flat or nearly flat.

CM-148

Clean river gravel, 5% oil shale of the harder silty variety. Collected sample taking thinner smaller pieces in the hope that these may be fragments of the fissile oil-rich variety but in actual fact they are merely worn fragments of hard shale. 15.3 gals/ton.

CM-149

As above except percentage of oil shale in river gravel is lower (about 3%). 11.8 gals/ton.

CM-150

Clean gravel. Mostly coarse dolomite. No oil shale.

CM-151

Clean stream gravel. No oil shale.

CM-152

Clean stream gravel. About 1% hard oil shale. 8.8 gals/ton.

CM-153

Limestone, light grey, hard, dense, strongly bioclastic with 30% fine to medium detritus, thick bedded but close spaced slabby bedding planes, brownish weathering, flat. Contains large cephalopod, gastropods and corals. Red River assemblage. No oil shale in clean stream gravels.

CM-154

Landing on stream just above where Ordovician limestone laps onto Precambrian (probably 20 feet stratigraphically above Precambrian). Clean river gravel. No oil shale. Limestone outcrops. . . of last station.

CM-155

Limestones as at CM-153. Collected sunflower corals and gastropods. No oil shale. Flat-lying.

CM-156

Clean stream gravel. No oil shale.

CM-157

Limestone gravel resting on Precambrian, quite fine, mostly less than 2". Presumably this derived from thin skin of limestone beds on Precambrian. Limestone is of same type as CM-153.

CM-158

Clean stream gravel. No oil shale.

July 25, 1964
Sunny, high winds

Traverse between Kirchoffer River and Rocky Brook
Plotting 1" = 4 mile map

CM-159

Limestone, light grey, dense, bioclastic, weathers grey (brownish from air), thick bedded, rubbly weathering. Identical with other limestones in the area which contain Red River fauna. Flat. No oil shale in creek wash.

CM-160

Clean stream gravel. No shale in either fork. Precambrian at surface.

CM-161

Clean stream gravel. No oil shale. Red River limestone type outcrops 200 yards east.

CM-162

Limestone, dense, grey, bioclastic, typical of other limestone outcrops in this area. Contains Red River assemblage, large cephalopods, Receptaculites, etc. Attitude flat. Various outcrops along creek banks, largest exposes some 40 feet of strata. No oil shale in river gravel.

CM-163

Limestone as before. Essentially flat-lying. Same fauna. No oil shale in river gravel.

CM-164

Limestone as before with Red River type fauna. About flat-lying. Collection includes Ordovician chain corals. No oil shale in stream gravel.

CM-165

A half to one per cent oil shale in clean river gravel. Looks quite lean. 10.9 gals/ton.

CM-166

Limestone as before. Similar fauna including chain corals, Receptaculites, cephalopods, gastropods. Attitude flat. River bottom mostly limestone beds clear of gravel or coarse limestone blocks. Few areas of fine gravel seen yielded no oil shale. Red River assemblage.

*** No record for CM-167, 168.

July 26, 1964
Sunny and windy

Traverse . . . Paleozoic-Precambrian contact from Salmon Pond north
Plotting 1" = 4 mile map

CM-169

In spite of the fact that a long Ordovician carbonate section is exposed 5 miles upstream, the river gravel here is 98% Precambrian. Of the Paleozoic material, oil shale makes up 20%, mostly in very fine plates sized from a dime to a quarter. 13.6 gals/ton.

CM-170

West end of Ordovician section measured by Nelson and Johnson. Formation light grey, grey weathering limestone with yellow weathering dolomite tracery running through. 20% bioclastic material. Well bedded master beds several feet, with thinner intermediate bedding plane. In general, resembles the Red River

type beds elsewhere in the area but no macrofossils were seen. Attitude 180/10W.

River gra vels here are mostly coarse Precambrian cobbles and boulders less coarse angular limestone. Found a few oil shale pebbles mostly of hard silty variety. Well below 1% of gravel is oil shale. 7.2 gals/ton.

CM-171

Small stream with fine stream gravel. 20% oil shale in plates up to 6" diameter. Maximum thickness seen 2", mostly of the harder silty oil-poor variety. Collected analysis sample, mostly finer pieces, and litho-sample both fine and coarse pieces. This part is probably stratigraphically above the last part. 10.gals/ton.

CM-172

From last point, walked 125' through rubble of buff very finely crystalline creamy weathering dolomite to area of coarse rubble with limestone which consists of fine (1 mm.) pellets in a lime paste. Limestone has 15 to 20% porosity in fine vugs which are evenly distributed. This part is possibly 50 to 100 feet stratigraphically above last station.

CM-173

Wash swampy creek gravel is coarse Precambrian boulders with scummy algal covering. Traces of fine gravel of Precambrian material. No oil shale. Observation not very good.

CM-174

Clean stream gravel. No oil shale.

CM-175

Limestone, sublithographic with 10% fine organic detritus, medium grey, bluish-grey weathering (brown from distance). Some chalk and cherty areas. Fossils include chain and colonial corals, gastropods and stromatopora. Surface of the limestone is covered with the ramifying white splotchiness in a pattern similar to the brown weathering dolomite splotchiness on the Red River type limestone but these are probably chalkified cherty or siliceous areas rather than dolomite. This limestone is somewhat similar to Red River types elsewhere but is darker grey and has a little less organic material. Clean stream gravels and no oil shale.

CM-176

Clean fine stream gravel with 5% oil shale in pieces up to 3" (average 1") and up to ½" thick. Mostly hard silty variety. 10.5 gals/ton.

CM-177

Clean stream gravel. Oil shale 3% in fragments up to 6 inches by ½ inch (average 1½ inches). 10.1 gals/ton.

CM-178

Stream gravel mostly covered with Algal scum but some clean areas. No oil shale.

CM-179

Clean gravel, no oil shale.

CM-180

Clean stream gravel, 10% oil shale. Walked 200 yards east to where low stream bank 15 feet high occurs. At base of abundant rubble of platy silty limestone and lesser dolomite and oil shale, collected a complete unsorted grab sample. 9.6 gals/ton. CM-180A (unsorted?) equal 2.1 gals/ton.

CM-181

Nearly dry wash with medium sized gravel of light grey limestone like typical Red River type. One Ordovician gastropod in float. No oil shale.

CM-182

Clean stream gravel. Only one fragment oil shale.

CM-183

Clean stream gravel. Two fragments oil shale.

CM-184

Clean stream gravel. No oil shale.

CM-185

Clean stream gravel, 85% Precambrian, 15% Paleozoic carbonate,

less than ½% oil shale in small well worn fragments. N.B. South fork is swampy and insignificant. 11.6 gals/ton.

CM-186

Clean stream gravel. No oil shale found. Limestone, sublithographic with more or less organic detritus, hard, grey weathering, light grey well-bedded bedding planes 3" (+ or -), slightly dimpled on surface. Attitude flat.

CM-187

Limestone as before, approximately flat-lying. Collected fragments of cephalopod. Upstream from outcrop and away from coarse outcrop rubble, the stream gravel has 1% oil shale in small well rounded pebbles. Small tributary on south has no oil shale in gravel. 2.4 gals/ton.

CM-188

Clean stream gravel. 1% (+) oil shale. Fragments look a little larger than at last stop. Collected two large fragments (½" thick for analysis). 10.2 gals/ton.

CM-189

Clean stream gravels. Rare small oil shale fragments.

CM-190

Clean stream gravel. ½% oil shale. 11.8 gals/ton.

CM-191

Large areas of very clean fine river gravel. Only three small fragments of oil shale found.

July 27, 1964
Cold, windy

Traversing between Rocky and Sixteen Mile Brooks
Plotting 1" = 4-mile map

CM-192 Clean stream gravel. No oil shale.

CM-193

Red River type limestone with typical faunal assemblage. Attitude flat. Only one oil shale fragment in large area of clean stream gravel.

CM-194

Clean stream gravel. No oil shale. Flat-lying Red River type limestone.

CM-195

Clean river gravel. No oil shale. Flat-lying Red River type limestone. Outcrops around stream valley.

CM-196

Clean stream gravel. No oil shale.

CM-197

Low east bank of Sixteen Mile Brook here appears to be composed of carbonate as estimated from scree and rubble. West bank is fairly sharp scarp and exposes Precambrian to an elevation of 100 feet above stream level. Therefore, west bank is scarp of fault involving basement, or the Precambrian represents an old barely exhumed ridge. Clean river gravels. No oil shale. 60% carbonate, 40% Precambrian.

CM-198

Clean stream gravel. No oil shale.

CM-199

Clean stream gravel. Found 3 fragments of oil shale.

CM-200

Flat-lying limestone of Red River type. Clean stream gravel. No oil shale.

CM-201

Precambrian gneisses exposed to height of 5 to 10 feet above east bank of stream.

CM-202

Red River type, finely crystalline limestone with much bioclastic detritus in flat-lying beds exposed all along west bank. Almost

15 feet covered by talus. However, if the Precambrian extends on west side of creek at same elevation, the beds seen here are no more than 15 feet above the Precambrian. Creek is 400 feet wide and east side of bed is lower by 5 or 10 feet than west side. No rock fragments or sand grains in the limestone here. Clean river gravel. No oil shale.

CM-203

Clean stream gravel. No oil shale.

July 28, 1964
Sunny, windy and cold

Traverse along west side . . . between Salmon Pond and Duke of York Bay
Plotting 1" = 4-mile map

CM-204 Clean stream gravel. No oil shale.
CM-205 Clean stream gravel. No oil shale.
CM-206 Clean stream gravel. No oil shale.
CM-207 Clean stream gravel. No oil shale.

CM-208

Large area of clean stream gravel. Long search found one very small oil shale gravel.

CM-209

Limestone, sublithographic, hard, medium grey, grey weathering with white patchiness on weathered surfaces in part, with very abundant fossil fragments both finely broken and whole brachs. Some bedding planes are surfaced with poorly preserved brachs, lesser horned corals and Favosites? corals, rare gastropods and trilobites, one bryozoan. Attitude 120/2W. Locally steepens to 10° west but this is probably slumping. No oil shale found in stream although good normal stream gravel is pretty well flooded but by coarse detritus from this outcrop. Column notes possible Devonian?.

CM-210

Clean stream gravel. No oil shale except one piece 3" by 1". Sudden influx of Precambrian boulders implies near-surface Precambrian subcrop.

CM-211 Clean gravel, 90% Precambrian. No oil shale.

CM-212 Clean gravel, 90% Precambrian. No oil shale.

CM-213 Somewhat swampy gravel. No oil shale.

CM-214 Clean gravel. No oil shale.

CM-215 Clean stream gravel. No oil shale.
CM-216 Clean stream gravel. No oil shale.
CM-217 Clean stream gravel. No oil shale.
CM-218 Clean stream gravel. No oil shale.
CM-219 Clean stream gravel. No oil shale.
CM-220 Clean stream gravel. No oil shale.
CM-221 Clean stream gravel. No oil shale.
CM-222 Clean stream gravel. No oil shale.

CM-223 Fairly clean stream gravel. No oil shale.

CM-224 Clean stream gravel. No oil shale.

CM-225 Clean stream gravel. No oil shale.

CM-226 Edge of large carbonate nose. Very finely crystalline, buff, blue-grey weathering limestone, fragmental, mostly very thin. No outcrop. Only fossil found was one poorly preserved coral.

CM-227 Clean fine stream gravel. No oil shale.
CM-228 Clean fine stream gravel. No oil shale.
CM-229 Clean fine stream gravel. No oil shale.

July 29, 1964
No weather indicated

Traversing along Paleozoic-Precambrian contact from Salmon Pond to Duke of York Bay.
Plotting 1" = 4-mile map

CM-230

River gravel here discounting large Precambrian boulders is 30% Precambrian, 50% carbonate and 20% oil shale. Oil shale in places averaging 4" by ½". Thickest seen is 1½". Most all of harder

variety, non-fissile yielding 10 to 15 gals/ton. Collected two samples one in thin pieces, one in thicker pieces.

CM-230A = thin pieces 12.5 gals/ton
CM-230B = thick pieces 11.5 gals/ton

Some fragments of interbedded silky shaly limestone and oil shale interbeds found. The passage from one type to another is gradational, interbeds are 1" (+ or -). Also found single graptolite, traces on both sides of graptolite.

N.B. By collecting sample of both the thick and thin types some bias should be introduced into assays. However, the thin pieces could give a higher assay since they may be derived from fissile oil-rich shale or a lower assay since they may be merely the breakdown of the non-fissile shale and thus more highly weathered.

CM-231

Clean stream gravel. No oil shale.

CM-232

Gravel 20% Paleozoic carbonate. No oil shale. Limestone outcrops on both sides of river. Typical of Red River type elsewhere with many gastropods, cephalopods, Receptaculites, some brachs and Stromatopora. Attitude 045/3S.

CM-233

Outcrop of limestone, very finely crystalline, with 30% bioclastic fragments, medium grey, blue-grey weathering, much thicker bedding and harder weathering than previous outcrop. Generally contains pyrite in streaks up to 2 to 4 mm. long as small bedding blebs. Few macrofossils, saw some cephalopods. Attitude about 090/2S. Steeper at one end of outcrop but probably due to slumping. Gravel above outcrop is 90% Precambrian. No oil shale.

CM-234

Limestone, light grey to buff, sublithographic, generally less than 10% fossil detritus, pyrite veinlets, rare horn corals, gastropods, pelecypods, well bedded. Attitude 070/3S. No oil shale in stream gravel.

CM-235

Landing at south end of outcrop of limestone similar to the previous station. No oil shale in river gravel.

CM-236 Limestone, very finely crystalline with common organic detritus. Attitude about flat. Oil shale as at CM-230 makes up 20% of gravel. Going upstream it quickly tails off and in the elbow to the west has tailed to less than a ½%. Presumably the source is very near this location. The tailing off upstream is peculiar but may be due to thin beds in this section or to being moved by glaciers into till then from till into stream gravel. The limestone horizons outcropping here must be very near the oil shale horizon. Unfortunately, no fossils except cephlopods and horned corals.

CM-237 Minute ditch-like creek flowing through swamp. No oil shale in stream gravel.

CM-238 Fine clean stream gravel with 1% oil shale in very fine flakes.

CM-239 Clean stream gravel. No oil shale.

CM-240 Clean coarse stream gravel. No oil shale.

CM-241 Clean stream gravel, 3/4 Precambrian, 1/4 carbonate. No oil shale.

CM-242 Clean coarse stream gravel. No oil shale in either fork.

CM-243 Clean stream gravel. No oil shale.
CM-244 Clean stream gravel. No oil shale.
CM-245 Clean stream gravel. No oil shale.

CM-246

Large outcrop of white-weathering pale buff, dense dolomite. This material is strongly brecciated although its original horizontal bedding is still discerible, particularly from a distance. This will be faulted by adjacent to boundary fault between Paleozoic and Precambrian while 300 yards east there are exposures of even more strongly brecciated calcarenites which are very near contact.

Thus, here the Paleozoic carbonate contact is very probably a fault whereas the suggestion from 30 miles farther south where Ordovician Red River type beds are adjacent to the Precambrian the contact appears to be an unconformity. Probably these

dolomites are higher in the section than the Red River type limestones which may explain the absence of oil shale in the part of the area north of the Red River.

CM-247 Clean stream gravel. No oil shale.

CM-248 Clean stream gravel. Found four or five fragments of oil shale. 9.5 gals/ton.

CM-249 Clean stream gravel. Three fragments of oil shale. 6 gals/ton.

CM-250 Clean stream gravel. One piece silty oil shale.

CM-251 Precambrian-Paleozoic gneiss exposed in stream bed, then a covered interval of fifty feet laterally. Then two feet exposed of coarse poorly sorted, soft, very porous, quartzose. Attitude 005/11W. Then covered interval for 200 feet laterally in direction 230°. Then mudstone, 20 feet, soft, greenish, thinly but poorly bedded, common gastropods. Then five feet stratigraphically covered interval. Then a peculiar thin but rubbly-bedded, greenish, fine crystalline, shaly limestone with bioclastic fragments, much pyrite and a fauna including common Ordovician-type gastropods and cephalopods and rare brachiopods. This grades up to a harder, more normal thicker bedded limestone, over twenty to thirty foot section, then continues for sixty feet plus. Attitude at start of normal limestone 345/11W.

Section works out as follows, going stratigraphically upward:

Precambrian	
5'	Covered interval
2'	Basal sandstone
25'	Covered interval
20'	Mudstone
5'	Covered interval
20' - 30'	Limestone, very finely crystalline, shaly, greenish, soft, poor bedded, becoming more calcareous, harder and better bedded upwards.
60' (+/-)	Limestone, slightly shaly, finely crystalline with bioclastic detritus and pyritic veinlets and flecks.

July 30, 1964
No weather reported

Traverse from Cleveland River north around Duke of York Bay
Plotting 1" = 4 mile map

CM-252 Clean stream gravel. Few fragments of fissile oil shale. 10.3 gals /ton.

CM-253 Clean stream gravel. No oil shale.
CM-254 Clean stream gravel. No oil shale.
CM-255 Clean stream gravel. No oil shale.
CM-256 Clean stream gravel. No oil shale.

CM-257 Clean stream gravel. One pebble slightly bituminous silty shale.

CM-258 Clean stream gravel. No oil shale.

CM-259 Clean stream gravel. No oil shale.

CM-260 Clean stream gravel. No oil shale in Cleveland River or in gravel of fork.

CM-261 Clean stream gravel. No oil shale.

CM-262 Moderately clean stream gravel. No oil shale.

CM-263 Moderately clean stream gravel. No oil shale.

CM-264 Clean stream gravel. No oil shale.

CM-265 Clean stream gravel. Very finely crystalline dolomite. No oil shale.

July 31, 1964
Sunny, warm

Traverse an area between Sixteen-Mile Brook and Sutton River
Plotting 1" = 4 mile

CM-266 Clean stream gravel. No oil shale.

CM-267 Clean stream gravel. No oil shale.

CM-268 Clean stream gravel. No oil shale.

CM-269

Clean stream gravel. One-half to one per cent hard oil shale in pebbles, averaging 2" by 1/4". Outcrop of limestone, very finely crystalline, with 5 to 25% fine to medium grain bioclastic detritus. Light grey, grey weathering, beds 6" to 2". Common cephalopods. Typical of other Red River limestones in area. Attitude 170/10W. 8.3 gals/ton.

CM-270

Clean river gravel. No oil shale. Outcrop from here to previous station is essentially continuous and no shale beds seen. Therefore, the material seen in the gravel at the last station probably comes from thin interval in the limestone not apparent from fly past. Here outcrop missing for about 50 feet stratigraphic then reoccurs and continues to the Precambrian contact. At contact, some 130 feet of covered interval intervenes.

CM-271

Limestone, finely crystalline with 20% organic detritus, grey, grey weathering. This is the last outcrop before Precambrian. No sand in limestone which is a typical Red River type in appearance. Attitude 165/8W

CM-272

Clean stream gravel. No oil shale. Gravel mostly of local derivation. This creek is so swampy and slow flowing that it probably does not drain any very large area.

CM-273

Clean gravel with less than $\frac{1}{2}$% oil shale in pieces averaging 2" by $\frac{1}{2}$". 12.2 gals/ton

CM-274

Clean stream gravel. No oil shale.

CM-275

Clean stream gravel with less than $\frac{1}{2}$% oil shale of hard variety. 11.6 gals/ton.

CM-276

Outcrop of carbonate with beds 2" to 8". Mostly limestone, grey sublithographic to limestone, light buff, fine crystalline, some fine organic detritus, generally splotchy weathering dolomite, fuccoidal marks going up to 50% of rock volume, occasional thin

dolomite beds. Abundant brachiopods mostly present along bedding plane. One 6" bed has a brachiopod coquina, lesser colonial coral and occasional horned corals. Generally this outcrop has a gentle dip but it is variable in direction and the true dip, if any, can not be distinguished from dips caused by slumpage down stream bank.

CM-277 Clean stream gravel. Less than $\frac{1}{2}$% oil shale in fine pebbles.

CM-278 Clean stream gravel. Trace oil shale.

CM-279 Clean stream gravel. Five per cent hard oil shale. 9.8 gals/ton.

CM-280 Clean stream gravel. Seven per cent hard oil shale. Two poorly preserved trilobite fragments in pieces of oil shale. 9.8 gals/ton.

CM-281 Clean stream gravel. Five per cent oil shale. 10.5 gals/ton.

CM-282 Clean stream gravel. One-half per cent hard oil shale. 12.3 gals/ton.

CM-283 Fairly clean stream gravel with about 5% hard oil shale.

CM-284 Stream flowing 210° forms wide nearly dry gravel wash. At station point is outcrop of hard, light grey, well bedded, finely crystalline limestone with bioclastic material and pyrite veinlets flecks and nodules. To the north there is a 300 foot covered interval. Then continuous outcrop of Red River type limestone for about 2 miles upstream. Between the first outcrop and the start of the continuous outcrop 5 to 10% oil shale can be seen in a pool of water. The gravels show continuous outcrop has no shale therefore the shale must come from beds in the covered interval in the two outcrops. Since the outcrops are 4 to 5 feet high and close to flat lying it is hard to see how there can be much stratigraphical thickness in the covered interval. Certainly it must be very thin. Hence the oil shale beds must have an insignificant thickness. The oil shale fragments show abundant trilobite pygidium and some graptolite markings. Attitude about 050/?S (2°) 8.2 gals/ton.

CM-285 Clean gravel. Three per cent hard oil shale. 7.6 gals/ton.

CM-286 Clean gravel with 20% oil shale. Two samples thicker pieces give 8.4 gals/ton. Thinner pieces give 8.7 gals/ton.

CM-287 Fairly clean gravel in slow flowing stream. No oil shale.

CM-288 Clean stream gravel. Trace oil shale.

CM-289 Clean stream gravel. No oil shale.

CM-290 Clean stream gravel. One-half per cent hard oil shale.

CM-291 Clean stream gravel. One per cent hard oil shale. 8.9 gals/ton.

August 1, 1964
High winds, cool

Traversing west of Duke of York Bay
Plotting 1" = 4 mile map

CM-292 Clean stream gravel. One small flake fissile oil shale.

CM-293 Clean stream gravel. One piece fissile oil shale.

CM-294 Clean stream gravel. No oil shale.

CM-295 Clean stream gravel. No oil shale.

CM-296 Clean stream gravel. One piece hard oil shale.

CM-297 Clean stream gravel. Trace hard oil shale.

CM-298 Clean stream gravel. No oil shale.
CM-299 Clean stream gravel. No oil shale.
CM-300 Clean stream gravel. No oil shale.

CM-301 Some 100 feet of carbonates exposed on north shore of lake. Massive limestone with dolomitic splotches near top of section. There are several feet of buff weathering dolomite.

In hand specimen, the limestone is finely crystalline to sub-lithographic, contains little fossil fragma. Colour is medium grey to buff. White chalky chert nodules and splotchy markings common at certain horizons. Abundant honeycomb corals, lesser horn corals, small brachs, some large smooth brachs resembling Pentamerids particularly one with a large spondilium. Found one chain coral which looks Ordovician. This sequence is fairly distinct lithologically from the Red River type beds but resembles other beds I have seen around Sutton River, particularly in the white cherty patches and dolomite splotches. Attitude 140/7N

CM-302 Dolomite, very finely crystalline, sugary, buff, creamy weathering well bedded, only 2' exposed. Fair micro-vuggy porosity. Attitude 135/2E.

CM-303 Landing in a large dolomite area. Dolomite as at last point. Thin (1" to 6") typically has vertical round solution holes 2" to 4" in diameter. Attitude hard to determine except that it is close to flat.

CM-304 Clean stream gravel, of locally derived dolomite. No oil shale.

CM-305 Clean stream gravel. Trace hard oil shale.

CM-306 Clean stream gravel. No oil shale.

August 4, 1964
Windy, cold

Traversing between Sixteen-Mile Brook and Sutton River
Plotting 1" = 4 mile map

CM-307 Clean stream gravel. About ½% hard oil shale.

CM-308 Clean stream gravel. One per cent hard oil shale.

CM-309 Clean stream gravel. Oil shale in comparatively large flakes makes up about ½ %.

CM-310 Gravel at stream mouth too covered with calcareous deposits for proper determination although a few oil shale flakes could be seen.

CM-311 Clean river gravel. About ½% hard oil shale.

CM-312 Clean stream gravel. One-half per cent hard oil shale.

CM-313 Clean stream gravel. One-half per cent oil shale mostly hard variety with occasional fissile plates. Average fragment size 2" by 3/8".

CM-314 Clean stream gravel. About 1% oil shale mainly hard and silty.

CM-315 Limestone, about 12 feet exposed along 300 feet of stream bank mostly finely pelletal, thin bedded. Lower part of the exposed section has some mounds several feet across and a few feet high composed of poorly bedded limestone stuffed with coral heads (Favosites?). These coral heads are about the size of cabbages cut in half. Overlying these mounds are thinly bedded finely crystalline limestone which is about 50% dolomitized, the dolomite being present in buff weathering and anastomosing patches. Other fauna includes common Strophomenid brachiopods and occasionally

horned corals. No gastropods or cephalopods. Probably this is in the upper Ordovician, Stoney Mountain equivalent interval. Trace oil shale in stream gravels. No oil shale in beach gravels. Outcrop attitude about flat. Note that the beds immediately overlying the coral mounds are draped with very local dips up to 15°.

CM-316 Clean stream gravel. Oil shale in fine flakes, percentage hard to estimate, probably 2 to 5%. No significant quantity of oil shale in beach gravel.

CM-317 Rock-defended ridge 25' high with outcrops in the upper 10 feet of poor bedded limestone sublithographic with little bioclastic material to sub-coquina with abundant assorted brachiopods, etc. A clean carbonate through the ridge exposes 4' of yellow weathering, platy, finely sucrosic dolomite with good pinpoint porosity and occasional macro brachs. Limestone beds have at places common well preserved brachiopods. Attitude about flat. This ridge runs down to the sea and outcrops along shore. No oil shale in beach gravel here.

CM-318 Clean stream gravel. Trace oil shale.

CM-319 Clean stream gravel. Trace oil shale.

CM-320 Clean stream gravel. 3% oil shale.

CM-321 Stream distributary area. Clean gravel with about 1% oil shale.

CM-322 Clean stream gravel. 8% oil shale being about 7% hard variety and 1% fissile variety. Collected a few large badly weathered chunks of fissile oil shale labelled CM-322A N64. This is for analysis to try to find out the effect of weathering on the oil content of fissile oil rich shale.

Along the coast there is a storm ridge some 30 to 40 feet above high tide and 6 feet above high tide level. This contains coarse dolomite, limestone, etc. fragments and about 20% hard shale, commonly in pieces several inches across and $\frac{1}{8}$" thickness. The finer beach gravel in front and back of the storm ridge also contain oil shale but due to its platy nature it is probably being concentrated in the storm ridge.

Shovelled up an unsorted sample from the landward edge of the storm ridge where grain-size quite fine (2") (labelled CM-322 B N64A). This is for analysis to permit an estimate of oil shale content in beach gravel.

Also took a lithological sample of several large (6" x 3/8") plates of oil shale lying on the storm ridge. This is mostly the

hard variety but there is some fissile plates. Labelled CM-322 CN64 L.

CM-323 First bench of rock-defended ridge. Rock is dolomite, very fine sucrosic with good pinpoint porosity, buff, creamy weathering, thin bedded, probably Silurian. No oil shale on ridge. This bench is 105 feet above CM-322. The base of the rise to this bench is 35 feet below (i.e. 70 feet above CM-322). From that point back to CM-322 there is a fairly steady decline in elevation. Oil shale at base of bench, but it does not become common until only some 200 feet inland from CM-322. Point CM-322 was not exactly at sea level but probably less than 15 feet above.

N.B. Total of about 50 feet exposed in this bench and stream gorge. Lower part is dolomite as above but upper part is pelletal lime mud and less sublithographic limestone, light buff, grey weathering. Attitude flat.

CM-324 Hard oil shale. It appears fissile oil shale makes up 15 to 20% of bench gravel, there being about 9 : 1 ratio of hard to fissile shale.

CM-325 Massive, mealy dolomite exposed along here. Attitude 024/4E. No oil shale and rubble away from modern beach. In modern beach gravel some 5% oil shale. Flat.

CM-326 Clean tide-washed outcrop of massive yellow weathering dolomite, chalky and micro-porous. About 20% of this rock is grey, sub-lithographic limestone mostly in layers parallel to what is thought to be bedding but also as formless crosscutting masses. The scale of the inter-growth textures is large, that is, measured in feet. Attitude 115/35S (not certain this is bedding but probably is). Since last point, outcrop almost continuous along the shore and all close to flat to this point.

Oil shale in beach gravel here to extent of 5%. Less present in rubble inland beyond beach gravel.

CM-327 Sixteen-Mile Creek mouth about 10% oil shale, mainly hard variety. Beach gravel is similar.

CM-328 Coarse rubble and dense, shaly, grey limestone, apparently reflecting immediate subcrop. Just at high tide.

CM-329 Base of limestone-defended ridge. Elevation 40 feet. Limestone is buff, grey weathering, has close spaced bedding planes, chalky-looking, either very finely pelletal or finely crystalline with microvuggy porosity. The ridge is about 20 feet high and this limestone is exposed as flat lying beds in upper ten feet. No fauna, no bioclastic material. At base of ridge extending 100 yards toward CM-328 is a rubble of thin platy limestone and 30 to 40% hard oil shale. Took unsorted sample of this for analysis. Elevation at top of ridge is 68 feet. 5.9 gals/ton.

CM-330 Base of dolomite-defended ridge (no outcrop, only rubble). Elevation 90 feet.

CM-331 Landing to creek for oil shale. Rubble of grey weathering to grey nubbly thin weathering limestone. No oil shale.

CM-332 Rubble of mealy buff, creamy weathering dolomite with good microvuggy porosity. This rubble reflects subcrop and occurs on bank of Sixteen-Mile Creek some 40 feet above bed. Apparently same horizon as CM-330 and CM-323.

CM-333 Clean stream gravel. Less than 1% composed of hard, silty, calcareous shale which forms thick, well-rounded pebbles. Can't tell whether or not this is bituminous. The river bed here is some 25 feet below the level at which the rubble of the dolomite horizon can be seen on the bank. About one mile upstream from this point the dolomite horizon crosses the stream and from that point onward, as deducted from the drift seen during the flypast, the section comprises interbedded dolomites and limestones.

July 13, 1964
Sunny and warm

Traverse Sixteen-Mile Creek and Vicinity

DB-1 0 - 15' limestone, thin to medium bedded, platy, argillaceous?, laminated in part (contains beds with oolites leached out), microgranular, finely crystalline, very light grey-brown, weathers buff. Directly underlies sample CM-7. Composite samples taken 0-5', 5-10', 10-15'.

DB-2 200 feet east of DB-1
0 - 10' limestone and probably overlies CM-1
10- 11' limestone as above with $\frac{1}{4}$" bed of black bituminous shale and a 2 - 4" bed of black bituminous shale at the top. 4" bed of oil shale overlain by 4" bed of limestone medium grey, pelletal, vuggy, massive, weathering buff to light grey. Shales appear to be somewhat lenticular.

DB-3 Bituminous shale rubble in limestone rubble. 1 sample.

DB-4 Bituminous shale rubble. Shale black, weathering very light grey, platy. 1 sample.

DB-5 Bituminous black shale, weathering very light grey. One-quarter mile from high water mark of Bay. Rubble interval 20 feet wide. No dip. 1 sample.

DB-6 Bituminous shale rubble.

DB-7 Bituminous shale rubble.

DB-8 Limestone, medium light grey, weathering light grey, nodular, bioclastic fragments throughout, microcrystalline, argillaceous, thin to medium bedded, total thickness exposed is 10 feet.

July 15, 1964
Sunny and windy

Trip to Sixteen-Mile Brook to see oil shale locality previously reported

Plotting Air Photo

DB-2 Section of carbonate exposed along west bank of brook forming cliffs 10 to 20 feet high. Below oil shale is creamy weathering

platy, to brownish dolomitic limestone with impalpably fine texture. Above oil shale is thick bedded limestone of clotted texture and containing vugs partly filled with calcite incrustations.

Oil shale bed is exposed for 100 feet. At south end it pinches out at 0. Going north it rapidly thickens to its maxium of 5 or 6 inches and continues at this thickness for 95 feet, to covered interval. After a 300 foot covered interval, the section continues and the bed can be seen at the top of a 15 foot cliff where it apparently is still 6 inches (+ or -) thick but it is inaccessible. Continues for 200 feet (?) where it runs out of the top of the section.

The shale is basically the same age as the underlying dolomitic limestone, since the two are gradational and interbedded. The overlying massive vuggy limestone may however be separated by a hiatus of some significance since there is a sharp transition and at places a very thin ($\frac{1}{4}$") red mud layer at the base of the massive limestone. However, the contact is a planar surface and the disappearance of the shale bed at the south end appears to be due to wedge out rather than erosion.

Collected three burlap sacks of oil shale for tests. Collected one plate of oil shale with brachiopod. Collected sample of limestone above oil shale and dolomitic limestone below oil shale.

July 15, 1964
Clear and warm

Traverse along north edge of carbonate plateau south of Gore Point

DB-8 Dolomite, finely crystalline, mottled light grey and buff, weathers light medium grey, algal, medium bedded, strong petroliferous odor on surface, approximately 5 feet of outcrop. Proportion of algal material varies but is 70% in places. Trace of microvuggy porosity and some intercrystalline porosity. Some of the hemispherical shaped "algal balls" could be corals. Forms small waterfall.

DB-9 Dolomite, microcrystalline, buff, with buff weathering, very light brown grey, medium bedded, flaggy, original texture appears to have been pelletal lime mud. Trace vuggy porosity, slight petroliferous odor. Approximately 10 feet of outcrop. Underlies DB-8.

DB-10 Dolomite as above forms creek bottom on east side. Outcrop very poor. Still no sign of black shale.

DB-11 Limestone, algal, medium grey to medium dark grey brown, micro-crystalline, weathers light medium grey, oil stain?, petroliferous odor on fresh surface, five to ten per cent vuggy porosity. Outcrop about 10 feet high. Resistant, forms waterfall. Probably same unit as DB-8. 40 to 70% is algal material.

DB-12 Shale, black bituminous. One piece found in rubble.

DB-13 Shale, black bituminous (rubble) with soft dark grey with rusty splotches. Between DB-12 and DB-13 six pieces of black shale were seen.

DB-14 Limestone, finely crystalline, light brown, weathering light grey, massive, 5 to 10% vuggy porosity, outcrop only 3 inches (?) thick in side of rubble-covered hill.

DB-15 Limestone as above in DB-14. Three outcrops of limestone close together.

DB-15A Shale, rubble, black bituminous. Black shale probably underlies the limestone of DB-14 and 15. Five pieces of black shale rubble were collected from 14 and 15 and were put in one bag. i.e DB-15A

DB-16 Described from top down:
0 - 5' Limestone, light grey-brown, weathering light grey, massive brecciated, vuggy porosity.

5 - 9' Limestone, finely crystalline, light brown, weathers light grey, medium bedded, 10% (+) micro-vuggy porosity.

DB-16A Nine pieces of black shale, rubble, collected between DB-15 and 16.

DB-17 Describing from top down:
0 - 8' Limestone, light medium brown-grey, micro to very finely crystalline, massive, weathers medium light grey, mottled.

8 - 12' Limestone, light brown, very fine to finely crystalline, weathers light grey, sucrosic, micro-vuggy porosity 5 to 10%, medium thick bedded.

DB-17A Eight pieces black bituminous shale rubble collected between DB-16 and DB-17.

DB-18 Describing from top down:
0 - 1' Limestone, massive, wavy bedded, light brown weathering very light grey, 5% microvugular porosity, lenticular appearance (i.e. varies in thickness along plane 1 - 2") fine to very finely crystalline.

1 - 4' Limestone, banded light brown and light medium grey, appears laminated, thin medium bedding, weathers yellow brown, fine to very finely crystalline. 10% microvugular porosity.

Massive limestone of 0 - 1 foot DB-17 caps a series of small isolated outcrops exactly like that described above between DB-17 and 18. Have lost black shale rubble ! None found between DB-17 and 18.

DB-18A Sample mark DB-18A came from ridge between DB-18 and CM-28.

* * * * *

DRILL RECORDS

Sogepet Fukamukaluk Lake #1

July 18, 1964

Casing 0 - 5 feet
Coring 5 - 9 feet
Core Recovery ?

This hole was just a test hole to uncover possible problems. There will be caving problems in this type of country because water melts permafrost and rock particularly shale will cave. This results in inconclusive core results and much time spent stuck in the hole, especially when pulling out.

Sogepet Fukamukaluk Lake #1A

July 19, 1964

Casing 0" - 36"
Coring 3' 3" - 6' 9"
Core Recovery 3" to 4" of black shale, slightly silty.

Coring 6' 9" - 9' 6"
Core Recovery 3" to 4" of black shale, slightly silty.

Coring 9' 6" - 11' 6"
Core Recovery 4" black, slightly silty shale.

Coring 11' 6" - 13' 6"
Core Recovery 1" black shale, 4" limestone.

Limestone top at 13' below surface and T.D. is 13' 6". Hole terminated on reaching limestone. Oil seam intermittent between 5' and 13'. Many problems with cavings of shale into hole, particularly in lower part. Poor recovery of shale probably due to its breaking up and being washed out of core barrel by water. Good recovery in the more resistant limestone.

Sogepet Big Island #1

July 20, 1964

Casing 0 - 5'
Coring 4' - 7'
Core Recovery 5" silty bituminous shale, 1" limestone

Casing 5' - 7' (added two feet casing)
Coring 7' - 11'
Core Recovery 10" black shale.

Casing 7' - 11' (added 4 feet casing)
Coring 11' - 16' 6"
Core Recovery 1" black shale, 38" limestone.

Total depth at 16' 6". Terminated drilling on finding limestone as at Fukamukaluk Lake #1. Drilled into limestone to make sure it was not just a thin stringer. Limestone top at approximately 12' 10" below surface. Oil seam intermittent between 4' and 13'. Problems similar to Fukamukaluk Lake. Good recovery of limestone core and very poor recovery of shale core. Will try using less water in next hole and pulling out more often to see if shale recovery improves.

Sogepet Pameoolak Creek #1

July 21, 1964

Casing 0 - 2'
Coring 0 - 2'
Core Recovery 3" limestone

Most of this interval is still probably rubble, therefore no coring just picking up pieces of rubble. One piece of granite very tough going, at four feet could make no further progress. Change bits, tried again, still could not get below four feet, abandoned hole.

Sogepet Pameoolak Creek #1A

July 21, 1964

Casing 0 - 1'

Could not get casing in at all. Spent two hours in attempt to run casing. No success. Pulled out of hole. Tried again. No success. Dug out of hole with shovel. Nothing but fine gravel 1" to 1/16" expected to have granitic boulder but problem must be just fine material clogging and stalling drill. Abandoned hole. Waiting for orders.

A P P E N D I X I I

FIELD ANALYSES OF THE OIL SHALE

The following are the results of analyses performed in the field by the oil company using simple retort procedures. The stations referred to are shown on the accompanying map.

SAMPLE LOCATION	ASSAY RESULTS (IMPERIAL GAL. PER TON)
Mukluk Lake No. 1	
3' - 3" - 6' 9" rec. 5" core	6.6
5' - 9'	7.2
Mukluk Lake No. 1A	
9' - 11' 6" rec. 4"	4.6
11' - 12' rec. 3"	7.3
Big Island	
4' - 8' rec. 6"	6.6
8' - 11" rec. 10"	6.8
13' 3" - 13' 4" rec. 1"	4.9
CM-322A-N64	27.8
CM-322C-N64	8.6
CM-252-N64	10.3
CM-248-N64	9.5
CM-249-N64	6.0
CM-230A-N64	12.5
CM-230B-N64	11.5
CM-86-N64	3.5
CM-86A-N64	25.2
CM-86B-N64	24.5
CM-87-N64	19.0
CM-90-N64	18.7
CM-308-N64	8.9
CM-313-N64	9.7
CM-314-N64	10.3
CM-322B-N64	0.13
CM-329-N64	5.9
CM-282-N64	12.3
CM-284-N64	8.2
CM-285-N64	7.6
CM-286A-N64	8.7
CM-286B-N64	8.4
CM-291-N64	8.9
CM-269-N64	8.3
CM-273-N64	12.2
CM-275-N64	11.6
CM-279-N64	9.8
CM-280-N64	8.9
CM-281-N64	10.5
CM-180A-N64	2.1
CM-185-N64	11.6
CM-187-N64	12.4
CM-188-N64	10.2
CM-190-N64	11.8

SAMPLE LOCATION		ASSAY RESULTS (IMPERIAL GAL. PER TON)
CM-64-N64		5.6
CM-69-N64		8.3
CM-57-N64	(Rich)	5.3
CM-57-N64	(Lean)	2.9
CM-57-N64		6.6
CM-180-N64		9.6
CM-177-N64		10.1
CM-176-N64		10.5
CM-171-N64		10.0
CM-170-N64		7.2
CM-169-N64		13.6
CM-24-N64	(Using thin pieces)	10.5
CM-24-N64	(Using thick piece)	1.6
CM-28-N64	(Using inner part of thick piece)	23.2
CM-28A-N64	(Composite from various pieces)	18.1
CM-28-N64	(Unsorted sample from bench)	7.1
CM-28-N64	(Otc L composite)	0.5
DB-12-N64		24.4
DB-15A-N64		24.9
DB-16A-N64		22.8
DB-17A-N64		23.2
DB-18A-N64		21.6
CM-7-N64	(Composite sample) of four undivided bags	12.7
CM-5-N64	"Otc"	6.8
CM-6-N64	Sample #1 (15' above base)	0.4
CM-6-N64	(Sample #2)	0.06
CM-3-N64		12.2
CM-1-N64	(#1)	0
CM-1-N64	(4)	0
CM-5-N64	(Sample #2) Large bag	10.01
CM-7-N64	Composite sample bags #1 - #4 incl.	15
DB-2-N64	(Large bag) Shale from 2" - 4" bed & $\frac{1}{4}$"bed	32.5
DB-2-N64	(Small bag)Composite across 10'-11' interval	18.7
DB-2-N64	Shale from 2" to 4" bed & $\frac{1}{4}$" bed	28.0
DB-5-N64		9.7
DB-7-N64		6.9
DB-6-N64		5.2
DB-4-N64		9.1
DB-3-N64		18.3
DB-1-N64		0
CM-109-N64		15.0
CM-127-N64		7.6
CM-143-N64		2.6
CM-28-N64	(Sample $\frac{1}{2}$ mi. E of Original)	4.6
CM-28-N64	(0-10')	3.3
CM-28-N64	(10'-25')	2.8
CM-28-N64	(Sample bag marked "Same as CM-28-N64")	22.6

SAMPLE LOCATION	ASSAY RESULTS (IMPERIAL GAL. PER TON)
CM-165-N64	10.9
DB-13-N64	28.2
DB-19-N64	22.1
DB-19-N64	24.8
DB-20-N64	23.6
DB-20-N64	25.1
DB-21-N64	23.4
CM-148-N64	15.3
CM-149-N64	11.8
CM-152-N64	8.8

A P P E N D I X I I I

LABORATORY ANALYSES OF THE OIL SHALE

Analysis "A" and "B" were performed for Sogepet Limited by separate oil company laboratories on similar specimens from the Sixteen Mile Brook locality. The spectroscopic analyses are of representative samples from five widely scattered localities.

ANALYSIS "A"

Oil Shale - N. Canada

2 samples: 1. Large
2. Small, exfoliated

	1. Large	2. Small, exfoliated
Oil, gallons/ton (Fisher Assay)	29.	37.
Water, gallons/ton (Fisher Assay)	6.	13.
Insolubles in 6N HCl, gm/gm* (Gravimetric)	0.5110	0.6895
Density of Oil, gm/ml (IP 59/55)		
60°F	0.9595 0.9596	0.9581 0.9574
100°F	0.9437 0.9431	0.9410 0.9409
Viscosity of Oil, cp (ASTM D445-53)		
60°F	24.90	24.10
100°F	9.62	9.36
Carbon, %** (Combustion-Gravimetric)	43.08	39.77
Hydrogen, %** (Combustion-Gravimetric)	4.73	4.44
Ash at 800°C, %** (Combustion-Gravimetric)	39.5	43.8

*Sample dried at 105°C before analysis

**Results apply to HCl leached portion of sample

Nitrogen	1.25%
Sulphur	4.5 %

ANALYSIS "B"

SAMPLES			Yield GPT		Oil Gravity @60°F		Oil	Water	Spent Shale	Gas +Loss	
Number	Hour	Date	Oil	Water	SP. GR.	°API	Wt.%	Wt.%	Wt.%	Wt.%	Remarks
A		11-17-64	33.8	3.6	.941	18.9	13.25	1.50	80.98	4.27	2.56 Wt. loss
Duplicate		11-17-64	33.4	3.8	.947	18.0	13.21	1.60	81.06	4.13	0.85% Moisture
B		11-17-64	33.7	4.6	.946	18.1	13.29	1.90	80.41	4.40	2.70 Wt. loss
Duplicate		11-17-64	33.9	4.8	.949	17.7	13.40	2.00	80.32	4.28	0.90% Moisture
C		11-17-64	26.9	10.2	.959	16.1	10.75	4.25	79.88	5.12	3.24 Wt. loss
Duplicate		11-17-64	26.4	10.3	.962	15.6	10.72	4.30	79.83	5.15	1.08% Moisture

X-RAY ASSAY LABORATORIES LIMITED

28 EGLINTON AVENUE WEST — TORONTO, ONTARIO — HUDSON 5-8907

Certificate of Analysis

NO. 3868-A

TO. Franc. R. Joubin & Associates,
170 Bloor St. W. Park Plaza, 511,
TORONTO 5, Ontario.

RECEIVED Janaury 14, 1965 INVOICE NO. 7187

SAMPLE(S) OF rock SUBMITTED TO US SHOW RESULTS AS FOLLOWS:

Element	Sens*	Concentration 64-11-2	64-11-3	64-8-A	Element	Sens*	Concentration 64-11-2	64-11-3	64-8-A
Antimony	(4)	N D	ND	ND	Manganese	(1)	ND	FT	FT
Arsenic	(4)	ND	ND	ND	Mercury	(4)	ND	ND	ND
Beryllium	(2)	ND	ND	ND	Molybdenum	(3)	FT	FT	ND
Bismuth	(2)	ND	ND	ND	Nickel	(1)	FT	FT	FT
Cadmium	(4)	ND	ND	ND	Silver	(1)	ND	ND	ND
Cerium	(5)	ND	ND	ND	Tantalum	(5)	ND	ND	ND
Columbium	(4)	ND	ND	ND	Thorium	(3)	ND	ND	ND
Chromium	(4)	ND	ND	ND	Tin	(2)	ND	ND	ND
Cobalt	(3)	ND	ND	ND	Titanium	(2)	FT	FT	FT
Copper	(1)	FT	FT	FT	Tungsten	(4)	ND	ND	ND
Gallium	(2)	ND	ND	ND	Uranium	(3)	ND	ND	ND
Germanium	(1)	ND	ND	ND	Vanadium	(2)	T	T	FT
Iron	(2)	LM	LM	LM	Yttrium	(3)	ND	ND	ND
Lead	(2)	FT	FT	FT	Zinc	(4)	ND	ND	ND
Lithium	(4)	ND	ND	ND	Zirconium	(4)	ND	ND	ND

LEGEND

Key To Symbols

H - 10% plus	L - 0.1-1%	* Sensitivity (limit of detection)
MH - 5-15%	TL - 0.05-0.5%	1- 0.0005-0.001%
M - 1-10%	T - 0.01-0.1%	2- 0.001-0.005%
LM - 0.5-5%	FT - 0.01% or less	3- 0.005- 0.01%
	ND - Not detected	4- 0.01 - 0.05%
		5- 0.05 - 0.1%

Note: Better sensitivities can be obtained with special techniques, if and when required.

X-RAY ASSAY LABORATORIES LIMITED

CERTIFIED BY A. E. Cameron MANAGER

DATE Janaury 14, 1965.

X-RAY ASSAY LABORATORIES LIMITED

28 EGLINTON AVENUE WEST – TORONTO. ONTARIO – HUDSON 5-8907

Certificate of Analysis

NO. 3668-B

TO. Franc. R. Joubin & Associates,
170 Bloor St. W. Park Plaza, 511,
TORONTO 5, Ontario.

RECEIVED Janaury 14, 1965 INVOICE NO. 7187

SAMPLE(S) OF rock SUBMITTED TO US SHOW RESULTS AS FOLLOWS:

Element	Sens*	Concentration #R	#S
Antimony	(4)	ND	ND
Arsenic	(4)	ND	ND
Beryllium	(2)	ND	ND
Bismuth	(2)	ND	ND
Cadmium	(4)	ND	ND
Cerium	(5)	ND	ND
Columbium	(4)	ND	ND
Chromium	(4)	ND	ND
Cobalt	(3)	ND	ND
Copper	(1)	FT	FT
Gallium	(2)	ND	ND
Germanium	(1)	ND	ND
Iron	(2)	LM	LM
Lead	(2)	FT	FT
Lithium	(4)	ND	ND

Element	Sens*	Concentration #R	#S
Manganese	(1)	ND	ND
Mercury	(4)	ND	ND
Molybdenum	(3)	FT	FT
Nickel	(1)	FT	FT
Silver	(1)	ND	ND
Tantalum	(5)	ND	ND
Thorium	(3)	ND	ND
Tin	(2)	ND	ND
Titanium	(2)	T	T
Tungsten	(4)	ND	ND
Uranium	(3)	ND	ND
Vanadium	(2)	FT	T
Yttrium	(3)	ND	ND
Zinc	(4)	ND	ND
Zirconium	(4)	ND	ND

LEGEND

Key To Symbols

H - 10% plus	L - 0.1-1%
MH - 5-15%	TL - 0.05-0.5%
M - 1-10%	T - 0.01-0.1%
LM - 0.5-5%	FT - 0.01% or less
	ND - Not detected

* Sensitivity (limit of detection)

1- 0.0005-0.001%
2- 0.001-0.005%
3- 0.005- 0.01%
4- 0.01 - 0.05%
5- 0.05 - 0.1%

Note: Better sensitivities can be obtained with special techniques, if and when required.

X-RAY ASSAY LABORATORIES LIMITED

DATE January 14, 1965 CERTIFIED BY _____ MANAGER