PRELIMINARY GEOLOGICAL REPORT

GREAT SLAVE LAKE - LIARD RIVER AREA, N. W. T.

(with particular reference to the Permit Holdings of Kelcam Oils Ltd.)

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INTRODUCTION

The present report is written as a preliminary geological evaluation of a large spread of acreage, held in permit form by Kelcam Oils Limited, in the southern portion of the MacKenzie Sedimentary Basin, N.W.T. There are 42 permits involved, totalling in all 2,503,061 acres. As is shown on the accompanying map, Figure 1, these permits are all located a short distance north of the N.W.T. boundary, between Great Slave Lake and the Liard river.

The easiest means of access to the area between the Liard river and Great Slave lake is by commercial plane, any one of a number of which are available for charter trips to the area. Local travel within the area is generally done by canoe. The eastern end of the area is also serviced by an automobile road which runs from Grimshaw in the Peace River area to Hay River Post on the south shore of Great Slave lake. The Hay River Post is about thirty miles east of the most easterly of the permits. The western permit areas can be reached by boat from Fort Nelson on the Alaska Highway. Fort Nelson is about one hundred miles southeast of Fort Liard, the location of which is given on Figure 1.

In general the area between Liard river and Great Slave lake is marked by low relief. Elevations above sea-level are from about 800 feet to 1,000 feet. There are, however, several escarpments which rise as high as 400 feet above the general level.

The Mackenzie mountains are just west of Liard river, about 5 miles west of the Fort Liard permits. These mountains rise to heights as great as 4,000 feet above sea-level.

The area is fairly well drained, with numerous streams and lakes draining northwards into Great Slave lake and as well as into the Mackenzie river.

A number of geological surveys within the area were carried out by the early explorers. One of the earliest systematic exclusively geological surveys was conducted by R. G. McConnell in 1888. He was followed from time to time by other geologists on the staff of the Geological Survey of Canada, and some for private interests, the most active of whom has been the Imperial Oil Company. These surveys had in mind the principal objective of determining the oil and gas prospects of the area, attention to it having been drawn by the numerous seepages of oil along the Mackenzie river between Great Slave lake and downstream from Fort Norman, and on Great Slave lake. The most thorough survey in the area was conducted by the Imperial Oil Company, under the sponsorship of the Canol project, in 1942 and 1943. Previous to these surveys most of the geological work was of a reconnaissance nature. Within the last year or two there has been a revival of interest in this area and a number of surveys have been made by private interests. A number of relatively shallow wells have been drilled.

Further details on the general geology of the area can be obtained from the reports referred to in the accompanying selected bibliography.

From the standpoint of detailed geological knowledge of the subject area, it is relatively unknown. We have, however, a sufficient amount of regional data to enable us to generalize on the general occurrence of the principal geological formations over the area. The most significant unknowns are local geological structure and those local facies changes that are related to the origin and occurrence of petroleum and natural gas. What general data we do have places the area in a highly favourable light from the standpoint of potential occurrences of petroleum and natural gas.

A compilation of the presently known geology of the map area is of necessity presented herein in two parts because of the lack of detailed work necessary to correlate the geology of the Liard River area with that of the Great Slave Lake-Mackenzie River area. Our stratigraphic geological summary, therefore, falls into two parts, as follows:

1. Stratigraphy of the Liard River Area
2. Stratigraphy of the Great Slave Lake Area

STRATIGRAPHY OF THE LIARD RIVER AREA

The following rock formations are exposed in the Liard River area:

Table of Formations

Era and Period or Epoch	Formation and Thickness (feet)	Character
CENOZOIC Recent and Pleistocene	0 - 100	Soil, alluvium, boulder clay.
	Unconformity	
MESOZOIC Upper Cretaceous	(Unnamed) 50±	Grey sandstone & pebble conglomerates; non-marine.
	Kotaneelee 500±	Dark grey shale, thin sandstone beds; marine.
	Fort Nelson 500 - 800	Dark grey, chunky shale & banded grey sandstone; conglomerate; non-marine.
Lower Cretaceous	Fort St. John Group 2250±	Sandstone & shale; ironstone concretions; marine and non-marine.
	Unconformity	
PALEOZOIC Pennsylvanian and/or Mississippian	(Unnamed) 1000±	Sandstone, shale, chert; marine.
Mississippian	(Unnamed) 1000±	Limestone, cherty limestone & shale; marine.
Upper Devonian	(Unnamed) 2000±	Dark grey shale & concretions; marine.
Middle Devonian	Nahanni 450	Dolomite and limestone; marine.
	Disconformity	
Silurian	(Unnamed)	Banded siliceous limestone and dolomite; marine.

Descriptions of Formations

Silurian - The oldest rocks thus far observed in the Liard River area consist of siliceous limestone and dolomite in alternating light and dark grey bands. The rock is, for the most part, fine-grained, hard and dense and has been indurated by a circulation of siliceous and carbonate solutions. Veins of quartz and calcite up to two inches in thickness are very common in these rocks. The thickness of the Silurian in this area is at least 500 feet. The bottom of the formation is not exposed.

Nahanni Formation - The Nahanni formation consists of light grey and dark grey weathering, dense dolomitic limestone and finally crystalline dense limestone. Fossil content places the age as Middle Devonian. The thickness of these rocks as exposed in the Mackenzie mountains and along the Liard river is 450 feet. The formation is the probable correlative of the Slave Point, Presqu'ile and Pine Point formations of the Great Slave Lake area. Since the combined thickness of those three formations near Great Slave is about 1200 feet there is considerable thinning (700 feet or more) towards Fort Liard.

Upper Devonian - A complete section of Upper Devonian beds is not exposed in the Liard River area but a thickness of 2000 feet and more is estimated. The rocks consist of dark grey shales, usually thinly bedded, with beds and concretions of ironstone in places. The shales are bituminous in places. Fossils are rare but indicate an Upper Devonian age for the containing rocks.

The Upper Devonian shales in this area are the equivalent of the Hay River limestones and shales and the Simpson shales of the Great Slave Lake area.

The geological reports describing the geology of the Fort Liard area make no mention of the Devonian reefs that have in recent years become the principal objective in this general area. This is probably due to non-recognition of strata, the true potential of which has only recently been recognized.

Mississippian - The strata included in this group consist of limestone, cherty limestone and some interbedded shale which is particularly abundant in the lower part of the formation. No continuous section of these rocks is anywhere exposed, but an estimated thickness of 2,000 feet has been put forth. The limestones are coarsely crystalline in places and in other places are very fossiliferous. No porosity has been observed in these beds.

Pennsylvanian and/or Mississippian - Pennsylvanian and/or Mississippian strata are made up of sandstones interbedded with dark shales and a chert member at the top. No complete section of these beds was observed but thicknesses as great as 640 feet were measured. A total thinkness of 1,000 feet has been assigned to this group of strata. The chert bed at the top at one locality was found to be 75 feet in thickness.

Fort St. John Group - This group of strata is made up of several formations which were not studied in detail and hence accurate subdivisions are not possible at this time. These rocks are made up of dark grey marine shales and ironstone concretions, grey sandstone beds and sandy shale. The group is roughly divisible into two parts, an upper and lower. The lower is sandy and is about 625 feet thick, whereas the upper consists essentially of shale and is about 1625 feet thick.

Fort Nelson Formation - The strata of this formation consist of grey banded sandstones interbedded with dark grey chalky shale which is transitional from the marine shale of the Fort St. John group. Conglomerates are also present in the Fort Nelson formation. This formation is considered to be the equivalent of the Dunvegan formation of the Peace River area.

Kotaneelee Formation - This formation is made up of dark grey shale, thin sandstone beds and a conglomerate bed. The conglomerate bed is located in the middle of the formation and consists of chert pebbles. This formation is the possible equivalent of the Big Horn and Blackstone formations of the Alberta foothills.

Late Upper Cretaceous - Beds considered to be correlatives of the Wapiti group of the Peace River overlie the Kotaneelee formation. These Late Upper Cretaceous beds consist of medium grain grey sandstone and fine pebbled conglomerate beds. Some coal also appears to be present in this formation. The formation is poorly exposed in the area.

Tertiary (?) - Gravels of possible Tertiary age and certainly pre-glacial age are found at a few points within the area.

STRATIGRAPHY OF THE GREAT SLAVE LAKE AREA

The rock formations which outcrop in this area are shown in the following table:

Era and Period or Epoch	Formation	Character	Thickness (feet)
CENOZOIC			
Recent and Pleistocene		Soil, alluvium, boulder clay	0 - 250
MESOZOIC			
Cretaceous	Unnamed	Greenish shales and sandstone	-
PLAEOZOIC			
Upper Devonian	Hay River Series	Dolomite, limestone and shale, marine	700
	Simpson	Shale, marine	150 - 200

Era and Period or Epoch	Formation	Character	Thickness (feet)
Paleozoic (con't)			
Middle Devonian	Slave Point	Grey, shaly limestone, marine	200
	Presqu'ile	Dolomite, limestone & shale, marine	375
	Pine Point	Limestone and shaly limestone, marine	100 - 595
	Horn River	Shale	100
Silurian	Fitzgerald	Dolomitic limestone with gypsum & anhydrite, marine	275
Ordovician (?)	Unnamed	Red shale, gypsum, shale, marine	595

Description of Formations

Ordovician - The Ordovician is represented by red calcareous shale, gypsum, salt and red argillaceous shale. These rocks lie directly on Precambrian sandstones and granite. They are placed in the Ordovician with some reservations. It is possible that they have a Devonian age.

Fitzgerald Formation - The strata ascribed to this formation consist of dolomite, limestone, gypsum and anhydrite. Similar strata are found in north-eastern Alberta and have been placed in the Devonian. It is possible that the Fitzgerald formation is also Devonian.

Horn River Formation - The Horn River formation is Middle Devonian in age. It is exposed along Horn River which flows southward into Mills Lake. Mills Lake is located in the northeast portion of the present map area, at the outlet to Great Slave lake. No outcrops of Horn River rocks are known within the map area. The formation consists of black and brownish-black fissile shales, some of which are bituminous.

Pine Point Formation - This formation is made up of thin-bedded grey limestone which is fine to medium-grained. In places thin-bedded bituminous limestone, grey to black in color, is present. The beds are richly fossiliferous in places.

Presqu'ile Formation - The Presqu'ile formation consists of hard fine-grained bituminous dolomitic limestones, in part biohermal reef, and interbeds of thin-bedded grey limestone. The dolomite weathers to a white or very light grey. In places the dolomite is quite porous and cavernous, particularly in the reefal facies, where oil seepages commonly occur. This formation carries the diagnostic Middle Devonian brachiopod, Stringocephalus burtini.

Slave Point Formation - The Slave Point formation consists of grey

weathering, light grey, fine-grained thin-bedded limestone, slightly bituminous in places.

Simpson Formation - The Simpson formation consists entirely of a greyish-green shale that weathers for the most part to small flakes of fissile shale. Due to the non-resistant character of the beds outcrops of this formation are rather scarce.

The formation is of potential importance in the present area in that it is the equivalent of the Fort Creek formation of the Fort Norman area, where the oil source limestone reefs of the Fort Norman Field occur. The Simpson shales are the approximate equivalent of the Green Shale and D-3 zone of central Alberta.

Hay River Series - This series can be divided into two members, an upper limestone member, some 300 feet thick, and a lower shaly member about 400 feet thick. The upper limestone member consists of dark grey limestones that weather to yellow and reddish-brown colours. Some sandy limestone and thin sandstone beds, as well as some shaly limestone, are present in this section. The lower member, which may be called the Hay River shales, consists of bluish-green, soft, fissile shales that weather readily to a clay. Some sandy beds and shaly limestone beds are present.

The Hay River limestone forms a prominent escarpment some 400 feet high in the southern part of the map sheet.

Cretaceous - The greater part of the southern Mackenzie basin is underlain by Cretaceous strata. Soft dark-grey, fissile, marine shales, with numerous large ironstone concretions and occasionally thin bands of ironstone predominate. These shales are correlated with the Loon River formation of north-western Alberta. Overlying the marine shales in places are thin-bedded and poorly indurated sandstones that may represent the Peace River formation of northwestern Alberta. The Cretaceous rocks are not well exposed, and have not, to date, been subjected to much study.

Pleistocene and Recent - As a result of Pleistocene glaciation widespread deposits of boulder clay and outwash sands and gravels cover much of the area. The glacial drift varies in thickness up to 250 feet. Recent deposits consist of stream silts, sands and gravels and soil.

DISTRIBUTION OF GEOLOGICAL FORMATIONS

The distribution of the Paleozoic and Mesozoic formations described above are shown in the accompanying map (Figure 1). It will be observed on this map that the exposed formations become progressively younger from the northeastern corner in the Great Slave Lake area to the Fort Liard area in the southwestern corner of the map sheet. In the northeast corner Middle Devonian formations are exposed, and in the southwest corner the Upper Cretaceous is at the surface. Off the map sheet about fifty miles northeast of the map-area, Silurian and Precambrian rocks are exposed.

The above regional structural and surface relationship of the stratigraphic section in the MacKenzie River Basin is the same as the relationship that exists in the Alberta Basin, except that in the Alberta Basin the Cretaceous overlaps most of the Paleozoic and some of the Precambrian, leaving only occasional small windows of Paleozoic, whereas in the Mackenzie Basin the erosionally truncated surface of the Paleozoic has been stripped back for some distance from the basin margin, by post-Cretaceous erosion.

The total thickness of the stratigraphic column in the northeastern corner is about 1600 feet. A well drilled at Windy Point penetrated the Precambrian at a depth of about 1640 feet. In the Fort Liard area the combined stratigraphic thickness of post-Silurian strata alone is about 8,000 feet, and it is estimated that when the dip of the strata is considered along with any additional sedimentary formations not exposed at the surface the total drilling thickness of the sedimentary section in the Fort Liard area is well in excess of 10,000 feet.

Most of the known strata in the Fort Liard area are marine in origin. Non-marine beds constitute but a small fraction of the total section, and such beds are found only in the immediate vicinity of Fort Liard.

STRUCTURAL GEOLOGY

Structurally, the area in which the permits are located is a regional homocline, dipping gently to the southwest. This homocline forms the east flank of the Mackenzie River basin. The dip ranges up to six degrees, the overall average, however, amounting to only 50 to 100 feet per mile. The homocline is terminated on the southwest in the vicinity of the Liard river, by the Liard, Nahanni and other ranges of the southern Mackenzie mountains, along the theoretical axis of the Mackenzie River basin.

Local structures are evident in several places. The best known is a low, broad anticline which occurs in the vicinity of Windy Point on the northwestern shore of Great Slave lake. The axis of the anticline strikes about sixty degrees west of north. It is also evident on the south shore of Great Slave lake in the vicinity of Pine Point, just off the eastern edge of the map sheet. At Windy Point the core of this anticline exposes Presqu'ile dolomite, from which there are numerous seepages of heavy oil. This structure was tested by a well drilled to the Precambrian in 1921 by the Northwest Company. Oil in commercial quantities was not obtained. The reservoir beds in this structure are obviously too close to the surface to have an effective cap-rock. Although this structure has long been known as an anticline, it is undoubtedly caused by a reef deposit.

Another small dome, about fifteen miles upstream from the mouth of Hay river, has been known for many years. Nine wells have been drilled on it. The first well, drilled in 1922, obtained a strong flow of salt water from the Presqu'ile dolomite at a depth of slightly over 700 feet. The other eight wells were drilled in the 1930 to 1947 period in an attempt to define the structure and to test the commercial prospects.

These also were unsuccessful and indications are that the closure, if present, is too small for the accumulation of commercial quantities of gas or oil. In the drilling of these wells, however, oil-saturated cores were obtained. It is possible that this dome is also a reefal structure.

In the vicinity of Great Slave lake there are numerous small domes from 100 to 200 feet in diameter and having dips as great as six degrees. These structures are too small to serve as traps for oil or gas and, furthermore, their origin does not favor the accumulation of oil or gas. It is thought that these small domes have been formed by the expansion of anhydrite in altering to gypsum.

Northeast of the map-area the Paleozoic-Precambrian contact has been observed in several places. Near the contact the Precambrian surface is gently undulating, and the Paleozoic strata parallel the Precambrian surface. Large and widespread faulting in the Precambrian of the area is certain to affect the overlying beds in places.

In the Fort Liard area, in the southwest corner of the map sheet, very little is known regarding those structures lying east of Liard river. West of the Liard river are the Mackenzie mountain ranges. These ranges are largely anticlinal in structure, but since the principal objective horizons namely the Paleozoic formations, are exposed at the surface, the structures do not hold much prospect of large oil or gas accumulations. East of the Liard river and in the vicinity of the westerly block of permits folded and faulted structures such as are found in northeastern British Columbia and in the foothills of Alberta are probably present. However, the thick covering of glacial drift, that covers the bedrock in these parts, has obscured local structure to a large extent.

It should be pointed out at this time that the governmental surveys made in this area have been of a reconnaissance nature, and very little detailed structure has been mapped. It is certain that detailed surface geological surveys of this area will reveal much of the structure, presently unknown.

OIL AND GAS OCCURRENCES AND PROSPECTS

No oil or gas seepages have been recorded in the Fort Liard area, but bituminous shales have been observed in the Upper Devonian formations. It is possible that these bituminous shales are associated with reefs which have not yet been identified as such, for it should be remembered that when surveys were made in this area very little was knows about reef occurrences and structure. Source beds of oil and gas are present in the area, since there are great thicknesses of marine shale. Potential sands, dolomites and limestones are also present.

In the Great Slave Lake area and along the Mackenzie river, downstream to and beyond Fort Norman, there are numerous oil seepages. These seepages occur in the Presqu'ile dolomite and also in the overlying and underlying shales. At Windy Point on Great Slave lake there are numerous seepages in the Presqu'ile dolomite. The reefal character of the Presqu'ile

at this place has already been noted. It is of interest to note that the discovery of the Fort Norman oil field was due to oil seepages from the Fort Creek shale along the shores of the Mackenzie river.

It is possible that there are reefs of two different ages in the area. The Presqu'ile dolomite is known to contain reefs, and the Simpson shale probably does also. The Simpson is the equivalent of the Fort Creek shale of the Fort Norman area and the Green Shale of the central Alberta area, both of which contain oil-bearing reefs.

Within the Great Slave Lake area the prospects of finding oil-bearing reefs are good. Furthermore, the reef facies are known to be associated with shale cap-rock.

A number of wells have been drilled in the vicinity of Great Slave lake within the last year or two by Punch Petroleums and by the New Superior Oils of Canada group. The location of these wells is shown in Figure 1. Some of the wells obtained shows of oil and gas, but not in commercial quantities. It appears likely that these wells were drilled in areas in which there was insufficient cover to hold the oil and gas.

If drilling is carried out on structural or reef prospects in the general vicinity of the subject reservations, southwest of Great Slave lake and south of the Mackenzie river where a thick cover is still in place, the prospects of finding oil and gas pools are excellent.

CONCLUSIONS AND RECOMMENDATIONS

The Liard River - Great Slave Lake area lies in the southern portion of the Mackenzie River sedimentary basin, in territory where the sequence of geological formations is known to be favorable for the occurrence of petroleum and natural gas. Oil seepages are known in similar strata immediately outside the report area, and the occurrences of oil in commercial quantities in equivalent formations at Fort Norman has already been proven.

In view of the above, prospects for the occurrence of petroleum and natural gas in commercial quantities within the map area, are excellent. The degree to which discoveries made are commercial will depend of course on the development of markets.

Although the area is a long distance from what we now regard as civilization, it is not difficult of access, since it can be reached by air, water, and by land. There is considerable muskeg within the area, but since it is fairly well drained sufficient canoe traffic arteries are present to enable ground parties to cover much of the area by surface geological methods without much difficulty.

With respect to future exploration work, it is recommended that the airborne magnetometer survey being conducted currently be studied in its

relation to the presently known geology and to what additional interpretations can be made from airphoto mosaics, following which such airphoto mosica studies should be supplemented by field geological ground control, with particular respect to geological interpretations made from the air photographs. The advisability or non-advisability of conducting seismic work should remain for a decision until the geological field work has been completed.

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March 21, 1953

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CERTIFICATE

I, John Campbell Sproule, consulting geologist, of 901 - 8th Avenue West, Calgary, Alberta, do declare:

1. That I agraduated as a geologist from the University of Alberta with the degree of Bachelor of Science in the year 1930; I obtained the degree of Master of Arts at the University of Toronto in the year 1931; and I obtained the degree of Doctor of Philosophy in Geology from the University of Toronto in the year 1935.

2. That I am a Fellow of the Geological Society of America and a Member of the American Association of Petroleum Geologists, the Society of Exploration Geophysicists and the Society of Economic Paleontologists and Mineralogists, and that I am a registered Professional Engineer for the Province of Alberta.

3. That I have no interest, direct or indirect, nor do I expect to receive any interest, direct or indirect, in the properties described in the attached report on the Great Slave Lake-Liard River Area, N.W.T., written for Kelcam Oils Limited. Nor have I any interest, present or expected, in the securities of the Company.

4. The above report is based on my geological and other general knowledge of the area described above and upon a consideration of all available data on what few wells have been drilled in adjacent areas.

"J.C. Sproule"

SEAL

J.C. Sproule
R.P.E., Alberta

901 - 8th Avenue West,
Calgary, Alberta,
March 21, 1953.