GEOLOGICAL RECONNAISSANCE REPORT

COLVILLE LAKE EXPLORERS LIMITED B. & N. C. HOLDINGS

AUBRY LAKE AREA, NORTH-WEST TERRITORIES

Prepared for

Colville Lake Explorers Limited

February, 1959

J. C. SPROULE & ASSOCIATES
GEOLOGICAL & EXPLORATION CONSULTANTS

901 EIGHTH AVENUE WEST
CALGARY — ALBERTA

TELEPHONES
AMHERST 2-4128
AMHERST 2-4374

TABLE OF CONTENTS

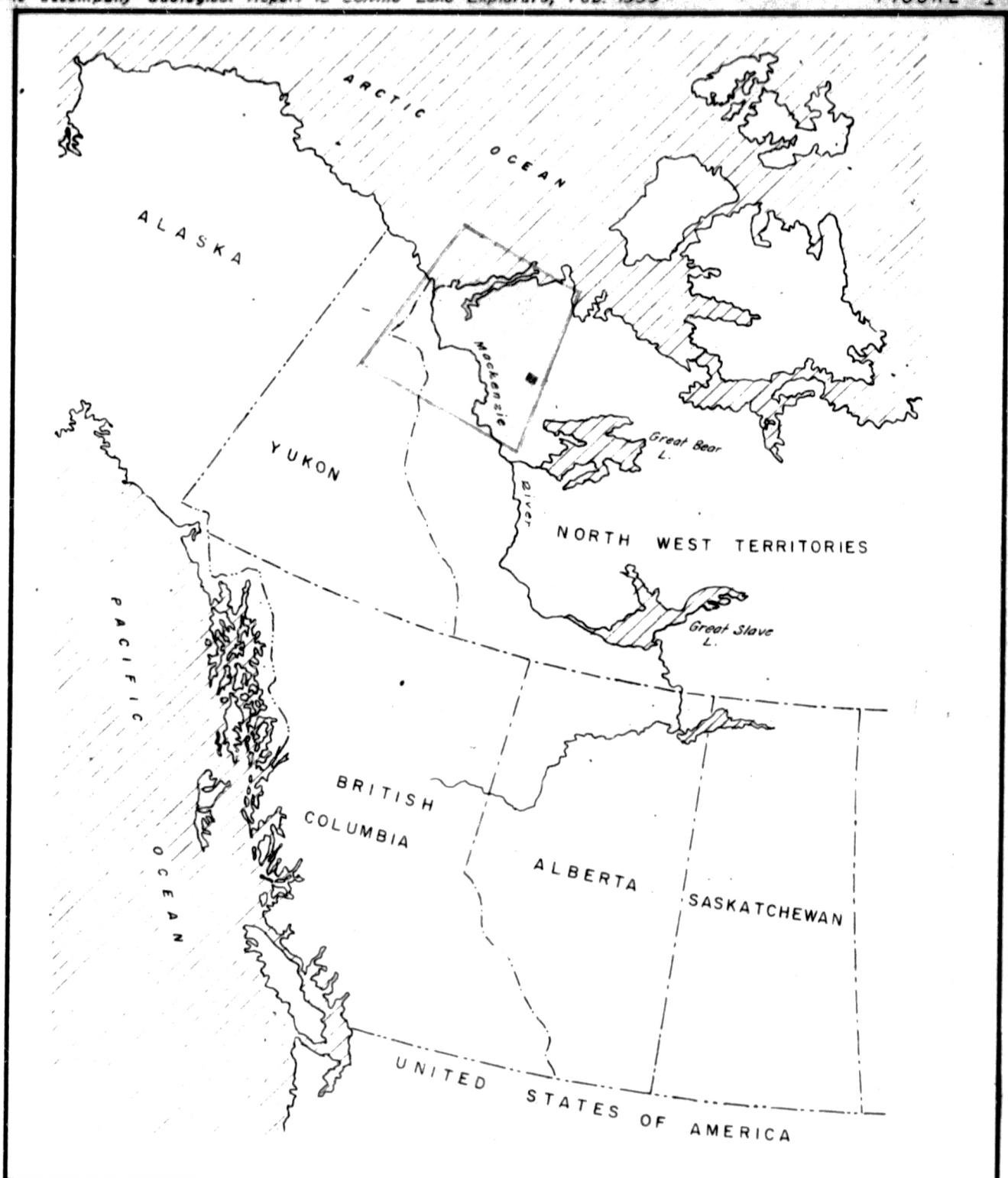
PLATES

Plate	I-A	Aerial view of Port Good Hope
	-B	Aerial view of Richardson Mountains
Plate	II-A	Aerial view in the first range of the Mackenzie Mountains
	-B	Aerial view of Belot Lake structure
Plate	III-A	Rolling, lake-dotted topography, typical of Permit area
	-B	Base camp on shore of Carcajou Lake
Plate	IV-A	Company owned model G-1 Bell helicopter
	-B	Massive-bedded Siluro-Ordovician dolomites exposed at Jaccmet Lake
Plate	V-A	Close-up of Siluro-Ordovician dolomite exposed on Hare Indian River
	-B	Siluro-Ordovician dolomites overlain by the Bear Rock formation
Plate	VI-A	Bear Rock breccia exposed at Sam McRae Lake
	-B	Aerial view of sink holes in Bear Rock formation
Plate	VII-A	Bear Rock formation equivalent at upper canyon on the Anderson River
	-B	Close-up of unbrecciated, laminated limestone (Bear Rock formation)
Plate	VIII-A	Small bioherm developed in Lower Ramparts member on Carnwath River
	-B	Oil stained basal Cretaceous sandstone exposed on west side of Lake Belot
Plate	IX-A	Close-up of the Basal Cretaceous sandstone on the west side of Belot Ridge
	-B	Oil seep at Rond Lake

LIST OF ILLUSTRATIONS

To accompany Geological Report to Colville Lake Explorers, Feb. 1959

FIGURE - I



INDEX MAP

WESTERN CANADA

Project Area

Area covered by report

J.C SPROULE & ASSOCIATES, CALGARY

GEOLOGICAL RECONNAISSANCE REPORT

COLVILLE LAKE EXPLORERS LIMITED P. & N. G. HOLDINGS

AUBRY LAKE AREA, NORTHWEST TERRITORIES

INTRODUCTION

During the summer of 1958 a geological survey was conducted in the Northwest Territories on the Petroleum and Natural Gas Permits held by Colville Lake Explorers Limited. The Permits, which are numbered 2068, 2069 and 2070, total 98,554 acres, more or less. These holdings are located in the Aubry Lake area, 80 miles northeast of Fort Good Hope (Plate IA) and 55 miles north of the Arctic Circle.

The work was done by J. C. Sproule & Associates at the request of Mr. Paul Penna, acting for Colville Lake Explorers Limited. Mapping was conducted within the Permits and also in the adjacent areas where the information obtained might have a bearing on the prospects of the Permit acreage. For transportation within the area a helicopter and a float equipped Beaver were used. The Beaver was used in scouting, caching gas and in supplying the camp.

The field party consisted of senior geologists G.K. Williams and N.N. Peterson and assistants A. Sankeralli and J. Burton, together with a cook and the crews for the aircraft. For work in and near the Permits, the camp was based at Carcajou Lake, 30 miles west of the Permit bounlary (Plate IIIB). In addition to the work done by the above field party, other crews did stratigraphic studies in the Mackenzie and Franklin Mountains, this work was a regional study for the benefit of several clients. Essential parts of this regional study are incorporated in the present report.

Physiography

The Permit area is a low-lying plain, studded with small, rounded but irregular hills of low relief (Plate IIIA), and many fairly large lakes. Some of the lakes are located in steep-sided linear valleys. The elevation of the plain is between 1,000 and 1,100 feet above sea level. The small hills

dotting the plain have in general a relief under 100 feet. Many small ponds or swampy areas lie among the hills. There are no large streams; most of the lakes are connected by a network of minor streams which drain into Aubry Lake or into the Carmsath River, which lies northwest of the area.

The country is covered with a growth of small spruce; alders and other shrubs grow along the streams.

Accessibility

At the present time the Permit area is relatively difficult to reach. The Federal Government is, however, planning to construct a highway connecting Whitehorse in the Yukon with Fort McPherson on the Peel River. Fort McPherson is 195 miles west of the Permit area.

Fort Good Hope (Plate IA), which is about 80 miles southwest of the area, is serviced by Canadian Pacific Airlines Ltd. There are two flights a week from Edmonton to Norman Wells by C-46, and one flight weekly by Otter from Norman Wells north, except for short periods during the spring break-up and the fall freeze-up.

At present the only means of access to the Permit area is by helicopter or ski- or float-equipped planes. Any of the larger lakes in the area are suitable for seaplane bases. In addition many of the smaller lakes are large enough for a Beaver to land and take off. Commercial aircraft available in the vicinity are a Beaver at Aklavik, 210 miles from the area, and a number of Otters and smaller planes based at Yellowknife, 530 miles southeast of the area.

The Mackenzie River is the only highway into this part of the north. Equipment can be sent from Edmonton by rail to Grimshaw or to Waterways, in Alberta. From Grimshaw material is trucked 380 miles north to Hay River, N.W.T., on Great Slave Lake. From Hay River barges go down the Mackenzie. Hay River is 650 river miles from Fort Good Hope. From Waterways, Alberta, which is at the end of the railroad, equipment goes by means of the Athabasca and Slave Rivers to Great Slave Lake. The distance by water from Waterways to Fort Good Hope is about 1,150 miles.

The main rivers are navigable for a period of about three months. The Northern Transportation Company runs boats from Waterways, Alberta, and the Yellowknife Transportation Company operates from Hay River, N.W.T.

Aside from the long supply line, once heavy equipment is delivered to Fort Good Hope, or some other locality on the Mackenzie River, there will be no serious difficulties encountered in building winter roads into and within the Permit area. The trees are small and the area well-drained, so trails will be easy to bulldose. In planning roads it would, for the most part, be advisable to follow the main drainage lines as much as possible. Cutting across the drainage pattern would involve crossing many small, steep-sided stream valleys and gullies. The construction of summer roads over perma-frost involves special techniques which should be investigated before such a project is undertaken.

Previous Work

A great deal of geological material has been published pertaining to the Lower Mackenzie area; most of the work was done along the Mackenzie River or in the mountain areas. The several reports of the Canol geologists on the Norman Wells area are available. Pertinent publications are listed in the accompanying bibliography. In Geological Survey of Canada Memoir No. 273, Hume (1954) has compiled the results of a study of the literature into a single volume. This is the most useful reference for the general area.

Of special interest from a regional point of view is the Doctorate thesis of Martin (1957). This report will probably be published in a more available form in either the Bulletin of the American Association of Petroleum Geologists or the Journal of the Alberta Society of Petroleum Geologists.

There has been nothing published to date for the map-area itself. Geologists from several oil companies have, however, visited the main rivers.

GENERAL GEOLOGY

Geological Setting

The subject Permits are located in what has been named the Interior Plains of the Lower Mackenzie area. Throughout its sedimentary history this Interior Plains area was apparently a stable shelf lying west of the Canadian Shield. Basins having varying degrees of subsidence flanked this stable shelf to the southwest, west, and probably to the northwest.

The shelf and basin areas differ principally in that the basin sediments are thicker and the section more complete. Large areas of the basin have been folded and faulted, forming the Franklin, Mackenzie and Richardson mountains (Plates IB, IIA).

Bedrock of the Permit area is formed by the Bear Rock formation and the lower member of the Ramparts formation. The area is covered with a layer of unconsolidated sand which appears to be an old glacial lake deposit of reworked Basal Cretaceous Sandstone. Although no outcrops of Basal Cretaceous Sandstone were found, there may be a thin layer of this rock over parts of the area.

The following table of formations gives approximate thicknesses and brief lithologic descriptions of the rocks expected to underlie the project area.

Table of Formations

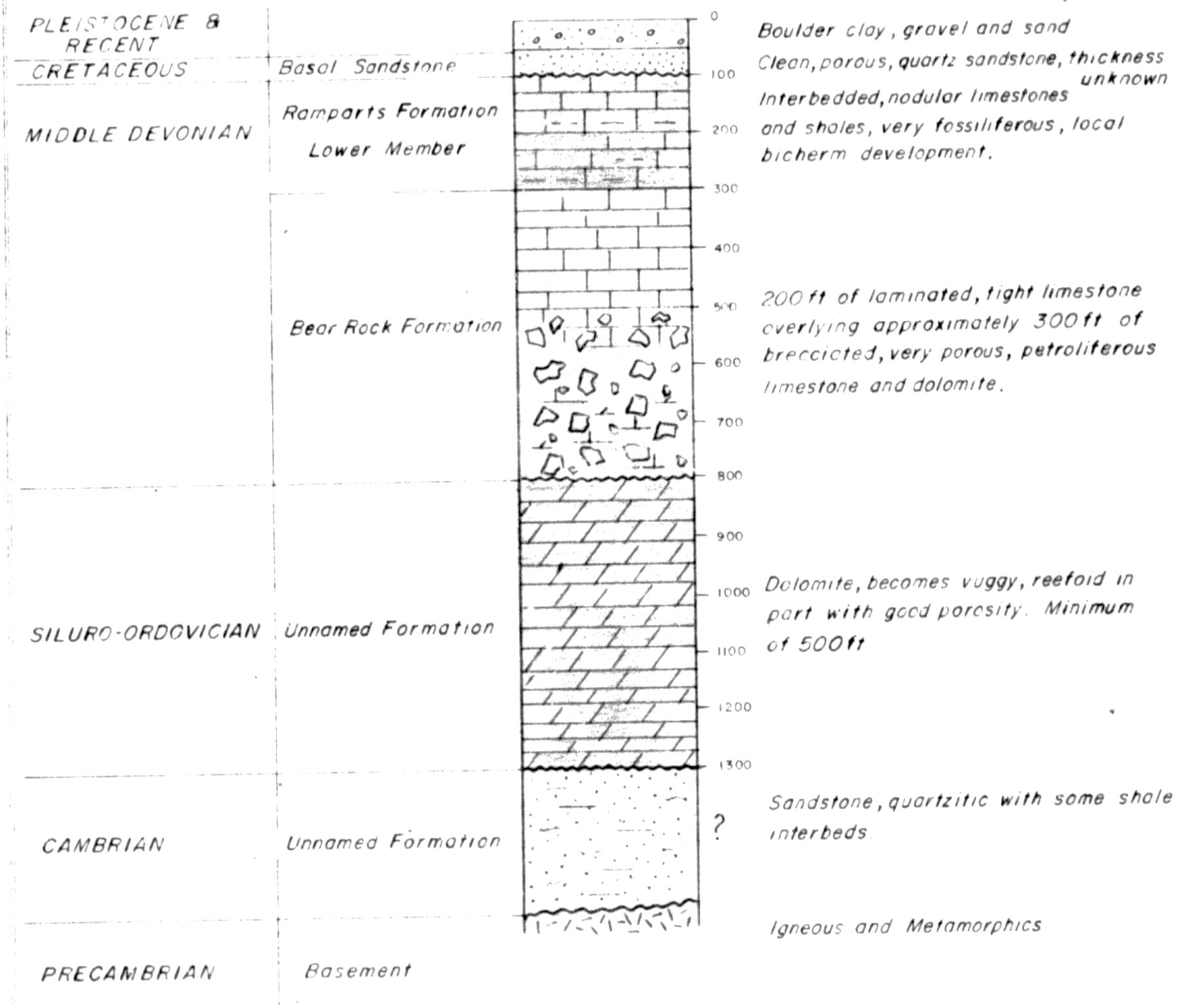
Age	Formation or Member	Lithology	Approximate Thickness Feet
PLEISTOCENE AND RECENT		Boulder clay, gravel and sand.	0-100?
CRETACEOUS	Basal Sandstone	Poorly consolidated, white weathering quartz sand; interbedded carbonaceous and bituminous matter.	50±?
		- UNCONFORMITY -	
MIDDLE DEVONIAN	Ramparts		
	*Upper Member	Grey limestone, in part reefal, in places becomes argillaceous.	150
	*Middle Member	Upper part green shale; middle part grey shale with abundant spores; lower 15 feet black bituminous shale.	600
	Lower Member	Variable lithology, bedded limestone, bioherms, interbedded nodular limestone and shale.	200
	Bear Rock	Massive tight limestone and porous dolomite beds which are oil stained, rare brecciation.	500
		- UNCONFORMITY -	
SILURO-ORDOVICIAN	Unnamed	Massive, vuggy reef dolomite, white chert.	500+
CAMBRIAN		If Cambrian beds are present they will probable be sandstone or quartzite.	Unknown

*Not present in Permit area.

FIGURE - II

GENERALIZED STRATIGRAPHIC COLUMN

AUBRY LAKE AREA, N.W.T.



Note Cambrian sandstones may or may not be present in the area, beneath an unknown thickness of Siluro - Ordovician strata.

Description of Formations

Cambrian

A thick section of Cambrian sediments is present in the Richardson Mountains, the Mackenzie Mountains and the Norman Wells area. The beds of Cambrian age are divided into the Macdougal group and the underlying Katherine group.

The Macdougal group includes shales, siltstones, sandstones, bypsum, salt, and some limestones and dolomites. This group is absent in several localities in the northern Mackenzie Mountains, southwest of Fort Good Hope. On the basis of this control we consider it unlikely that the Macdougal group is present in the Permit area.

The Katherine group is a predominantly quartzitic assemblage of rocks underlying the Macdougal group. Some sandstone beds of this group may be present in the area of the subject Permits.

Siluro-Ordovician

The Siluro-Ordovician beds are characterized by regional facies changes (see Figure V). In general the change is from black shales and limestones in the deeper basin areas to the south and west to dolomites in the shelf areas. Reef developments were observed in both the Richardson and Mackenzie Mountains and in the Norman Wells area. These coralline beds are generally in the upper part of the section, but may locally occur in lower zones.

Rocks of this age do not outcrop within the Permit area. The nearest exposure is along the Lac Belot Ridge about 15 miles south of the Permits. Two lithologic types of the Siluro-Ordovician are recognised, a cherty, vuggy dolomite and a fossiliferous, tight dolomite. The relationship of the two types is not clear; the vuggy zone may underlie the tight dolomite or it may be a reef facies not everywhere developed. The vuggy zone constitutes one of the main potential reservoirs of the area.

The cherty dolomite facies (Plate IVB) was seen on Jacomet Lake (Latitude 66° 01' N., Longitude 125° 25' W.), near the west end of Smith Arm of Great Bear Lake, about 100 miles southeast of the Permits; it was also seen on a small unnamed lake east of Lac Des Bois, 40 miles east of the Permits, (about Latitude 67° 06' N., Longitude 125° W.). Both of these locations are east of the limits of the regional map, Figure IV. The exposures form cliffs about 300 feet high; neither the upper nor lower contacts are exposed. The rock consists of dolomite, light grey to buff, fine- to medium-crystalline, massive with some thin bedding and laminations and minor brecciation. There are thin layers and lenses of white chert and also irregular outlines of chert which appear to be altered fossils. Vugs average one inch in diameter but some are larger. The vugs are usually arranged in layers but some occur at random. There are great irregular masses of what were once corals, now

partially turned to chert. No recognisable fossils were observed, but the dolomite is obviously reefal. Vuggy porosity is good, but intercrystalline porosity appears poor. The permeable nature of the dolomite is demonstrated at the unnamed lake by the manner in which it has been invaded by mineralizing water which has colored large portions of the dolomite a brilliant red.

Dolomite seen on the ridge northwest of Lac Belot, 25 miles southeast of the Permits is of the same type. One hundred and forty feet of dolomite of similar character, with fewer vugs but better intercrystalline porosity, and with chert bands as much as three feet thick, are overlain by the Bear Rock formation at this location.

Outcrops of the fossiliferous dolomite of the Siluro-Ordovician were seen on the Hare Indian River (Plate VA), 60 miles south of the Permits, and at Sam McRae Lake (Plate VB), 100 miles south of the Permits. On the Hare Indian River (Latitude 66° 18' N., Longitude 126° 16' W.) 170 feet were measured. The dolomite is light mottled grey, very finely crystalline with a finely granular texture. The bedding is generally massive, but some thin beds are present. A very minor amount of chert and a number of tiny vugs are found and corals are common in some beds. Further downstream this unit is overlain by the Bear Rock formation; the contact is not exposed.

At Sam McRae Lake the following section was seen:

Thickness Feet	
	Overlying beds - limestone of Bear Rock formation.
	- UNCONFORMITY -
72	Dolomite - light grey, very finely crystalline, thin-bedded at top, massive to medium-bedded at base. A few corals near the base.
273	Covered.
433	Dolomite - light grey, very finely to finely crystalline, uniform granular texture, generally massive with a few thin-bedded zones. A few corals, both solitary and colonial.
778	Total exposed section.

Although the contact with the overlying Bear Rock formation is not well exposed, it can be seen that there was an erosion surface with about 200 feet of relief on top of the Siluro-Ordovician prior to Bear Rock deposition.

Middle Devonian

Bear Rock Formation

Underlying the fossiliferous Lower Ramparts limestone member and overlying the Siluro-Ordovician dolomite is about 500 feet of section belonging

to the Bear Rock formation. Exposures within the Permit area and to the north are only of the upper part of the formation. This zone is dense limestone whose characteristics are a fine granular texture and fine laminae. South of the Permits the Bear Rock consists of both limestone and dolomite with some brecciation (Plate VIA). The dolomites are often porous and petroliferous.

The Bear Rock is fairly well exposed on the Anderson and Hare Indian Rivers, and forms bedrock in a broad belt between the above rivers, which includes the eastern part of the Permit area. We believe that the lower part of the formation contains porosity in this area and is the rock from which the oil seeps originate. The oil probably seeps to the surface through fractures or faults.

The following section of Bear Rock was measured on the Anderson River approximately at 127° 00' W. longitude.

Overlying beds - fossiliferous limestone of Ramparts formation.

Gradational Contact

Thickness Feet	
6.5	Limestone - brown, fine granular texture, in part oolitic, irregular brown argillaceous films, massive.
2	Limestone - thinly interbedded with dark grey shale laminae, nodular in appearance.
3.5	Limestone - brown, fine, granular.
11	Limestone - dark brown, dense to microcrystalline, slightly argillaceous, interbedded shale laminae, several fossil fragments, thin regular bedding.
13	Partly covered. Limestone - brown, microcrystalline, very thin-bedded, laminae of dark grey shale.
10	Limestone - brown, dense, trace of fragmental texture, hackly fracture, shale break at top.
16	Limestone - dark brown, microcrystalline, only faint traces of pelletoid texture, hackly fracture, three-inch shale break at top.
1	Shale - thin stringers of limestone.
2	Limestone - as above.

Thickness Feet	
16	Limestone - brown, fine-grained, composed of tiny oval pellets, massive.
5	Covered.
4	Limestone - brown, fine- to coarse-grained, fragmental, partly recrystallized, very finely crystalline, hard, massive, laminated. Rare brachiopods and corals.
90	Thickness of exposed section.

Thirty-five miles upstream, at the Anderson River Canyon (Latitude 68° 25' N., Longitude 126° W.), just off the edge of the regional map, Figure IV, an incomplete section of 106 feet, which may underlie the above 90-foot section, was measured (Plate VIIA) and described as follows:

> Limestone - brown to grey-brown, cryptocrystalline, finely granular texture, many tiny oolites; on smooth-weathered vertical faces there are faint, fine, wavy laminae; thick bedding is well developed in units of three to five feet; upper surfaces of bedding planes have a hummocky character; stylolites are numerous; the rock weathers grey. Nine feet from the base is a two- to six-inch irregular band of yellow weathering dolomitic limestone (Plate VIIB). No fossils were found. Neither the upper nor lower contacts are present in this canyon.

As the lower contact of the limestone was not seen in the Anderson River region, it is not known if the lithology is typical of the entire Bear Rock or whether a zone with porous beds, such as is present on the Hare Indian River, occurs below the limestone.

On the Hare Indian River there are several exposures, but no complete sections, of the Bear Rock formation. In this region the Bear Rock consists of limestone and dolomite, often brecciated. Porosity, which often reeks of petroleum, is common in the brecciated dolomitic zones.

Approximately 20 miles northeast of Lac a Jacques on the Hare Indian River the following section was seen.

Thickness Feet	
37	Dolomite - brown to grey, very finely crystalline, fine granular texture, laminated, massive, some pin-point porosity, petroliferous odor.
98	Covered. Talus as above.

Thickness Feet	
75	Limestone breccia - angular chunks of tan, laminated limestone of all sizes, in a limestone matrix.
98	Covered.
65	Calcareous dolomite breccia - fragments from one inch to ten feet.
52	Covered.
429	Thickness of exposed section.

- UNCONFORMITY -

Dolomite of Siluro-Ordovician.

At Echo Bend, four miles north of Lac a Jacques, similar rocks are exposed, separated by a covered interval from the overlying fossiliferous Ramparts limestone. A small exposure of gypsum was seen at this locality.

In the Mackenzie and Franklin mountains the Bear Rock formation is commonly a highly brecciated limestone associated in places with evaporites. Non-brecciated, bedded limestones in some exposures overlie and/or underlie a brecciated zone. These bedded limestones are similar to those north of the Permit area, which have been assigned to the Bear Rock. The formation lies on a rough erosion surface of older rocks and underlies the Ramparts formation. We correlate the unbrecciated limestones found north of the Permits on the Anderson River with the Bear Rock formation, on the basis of stratigraphic position and on the textural similarities of the carbonates.

The regional isopach and facies map, Figure VI, shows an interpretation of facies changes in the Bear Rock formation. The prominently brecciated and porous facies occurs in a northwest-trending belt along the Mackenzie River. East of this belt the formation thins and is predominantly tight limestone. The limit of brecciation shown on the map is conjectural; it does not necessarily coincide with the limit of porosity. In view of the indications of oil seeps within the Permit area it is believed that porosity in Bear Rock beds occurs within the Permits.

The age of the Bear Rock formation has not been determined by fossils. It is assumed to be Devonian because of the unconformity at the base and the usually gradational contact with the overlying Middle Devonian Ramparts formation. Also, the Bear Rock formation is correlated with the Middle Devonian Lone Mountain formation farther south.

Geologists have suggested various origins for the breccias in the Bear Rock formation. The breccias have been considered to be conglomerates, tectonic breccias, solution breccias or breccias produced by the alteration of anhydrite to gypsum. R. deWit of J. C. Sproule & Associates adheres to the theory that the breccias have resulted primarily from the development of karst topography (Plate VIB) during temporary pre-Ramparts uplift, when at least a portion of the Bear Rock limestone beds was exposed to subaerial erosion.

Ramparts Formation

The Ramparts forms the bedrock over the western part of the Permit area. The formation is divisible into three members, as described in the Table of Formations. Only the lower member is present within the Permits.

The Ramparts formation was named from the geographical "Ramparts" located on the Mackenzie River, a few miles upstream from Fort Good Hope, and approximately 85 miles northwest of Norman Wells. At this location the Mackenzie River narrows rapidly and flows for several miles between vertical walls of limestone known as "the Ramparts." These limestone beds constitute the Upper Ramparts member and, on the basis of regional studies, are now correlated with the Kee Scarp limestone and the producing limestone at Norman Wells. The type locality for the Middle and Lower Ramparts members has been placed by Hume (1954) on the Mountain River at the front of the Mackenzie Mountains.

Lower Ramparts Member

A complete section of the Lower Ramparts member is exposed north of the Permits in the Anderson River area. The section is as follows:

Thickness Feet	
	Overlying beds are black shale of the Middle Ramparts member. Contact very sharp.
1	Limestone - brown, bituminous.
10	Covered.
73	Limestone - grey to brown, tight, fine-grained, fragmental texture, fossil fragments, including large coral heads, give bedding a nodular appearance, thin-bedded, interbedded with thin shale layers.
10	Covered.
20	Limestone - as above.

Thickness Feet	
16	Shale - green, calcareous, minor limestone in thin beds.
15	Limestone - brown, fine-grained, fragmental in part, thin nodular bedding, in part thick, massive beds rich in corals.
10	Limestone - grey, fairly dark, dense, abundant brachiopods, thin bedding, nodular to evenly-bedded, interbedded with grey calcareous shales.
6	Limestone - light grey, dense, silty, thin regular bedding, shale partings and layers.
12	Shale - green, calcareous, one-inch limestone beds.
3	Limestone - brownish grey, fragmental, nodular bedding, shale partings.
5	Shale and limestone - interbedded.
9	Covered.
7	Limestone - brown, very dense, sublithographic, a few fossil fragments, pyrite, upper part very fossiliferous with nodular bedding.
	Gradational contact with underlying Bear Rock limestone.
197	Total thickness of Lower Ramparts member.

Exposures of the Lower Ramparts member on the Carnwath River are of similar lithology. On the upper part of the Carnwath River several small bioherms are present (Plate VIIIA), these are flanked by interbedded shale and limestone. The Ramparts exposure in the Permits is a small bioherm.

South of the Permit area the Lower Ramparts member is partially exposed along the Hare Indian River, at which location the limestone contains much less interbedded shale than on the Carnwath or Anderson rivers.

The Lower Ramparts member is easily recognized by its thin nodular bedding and the great abundance and large variety of fossils. The fossils are mainly responsible for the nodular bedding.

Middle Ramparts Member

The Middle Ramparts member is exposed west of the Permit area. It consists of about 600 feet of green and grey shale with a basal zone 15 to 30 feet thick of black bituminous shale which is similar to the bituminous Fort Creek formation.

Cretaceous

Basal Cretaceous Sandstone

West of the Permit area much of the country is underlain by a layer of light colored quartz sandstone up to 200 feet thick. The sandstone unconformably overlies the Paleozoic and underlies shale of Upper Cretaceous age. Although no fossils were found the sand is presumed to be of Cretaceous age.

The sandstone is light grey, very fine- to coarse-grained, with pebbles common near the base. The grains and pebbles consist entirely of quartz except for scattered pebbles of the underlying bedrock near the base of the unit. The sandstone is cross-bedded; torrential type cross-bedding is common. Carbonaceous layers often mark the bedding planes. The sandstone is very poorly consolidated and weathers as light grey to white, loose piles of sand. Coaly layers and laminae of carbonaceous and bituminous material occur in the sandstone. At Lac Belot over 60 feet of oil saturated sands are present overlying the Bear Rock formation.

Although no exposures of the Basal Cretaceous sandstone were found in the Permit area, it may be present as a thin layer over parts of the area. The sands of the post-glacial lake deposits appear to be reworked Basal Cretaceous sandstone.

Pleistocene and Recent

Surface deposits within and adjacent to the Permits consist of two types, glacial till and unconsolidated sand. Till exposures are rare. About 10 feet was the maximum exposure seen. The total thickness of the till sheet is unknown but it is relatively thin, probably less than 50 feet.

The unconsolidated sand is composed mainly of quartz grains of the type found in the Basal Cretaceous sandstone, with a small admixture of igneous grains. The sand is found on lake shores and also on higher ground. It would appear that ancestral Aubry and Colville Lakes were much larger in early post-glacial time than at present and covered most of the Permit area. The lack of evidence in the vicinity of these lakes of glacial lineations so common in most of the plains area is attributed to the existence of these large post-glacial lakes.

Structural Geology

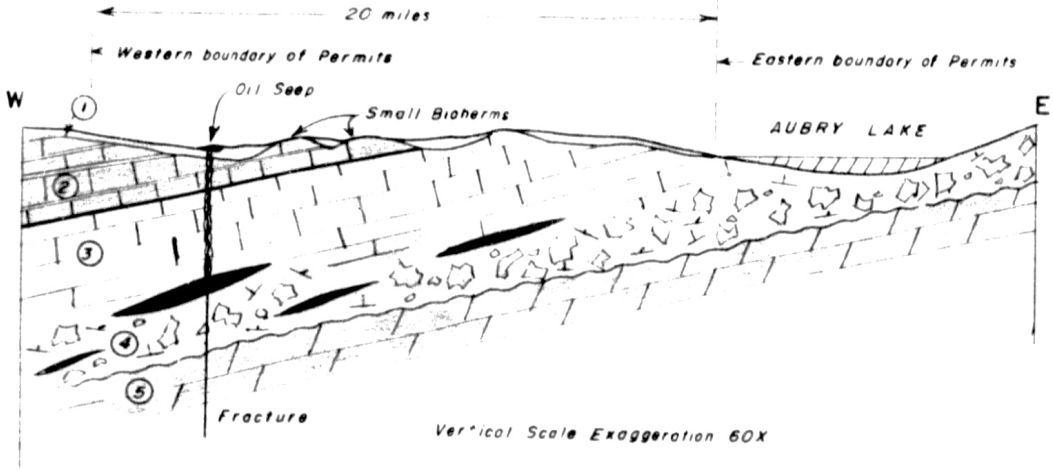
The Permits are located in what Martin (1957) designated as the Interior Plains or stable craton. The structure of the Interior Plains is of quite low relief with the regional dip to the west or southwest at approximately 20 feet per mile. The general area near the Permits is criss-crossed by a rectilinear system of faults with varying degrees of intensity, some with probably hardly any movement but still sufficient to cause alignment of lakes;

FIGURE -III

DIAGRAMMATIC CROSS SECTION

SHOWING

Position of Permit Area Relative to Truncation of Underlying Sediments



(1) Unstratified glacial sands with possible basal Cretaceous sandstones.

(2) Lower Ramparts member, nodular, limestones and shales with small bioherms.

(3) Bear Rock formation, unbrecciated, laminated, tight limestone.

(4) Bear Rock formation, brecciated, very porous, oil stained limestone and dolomite.

(5) Siluro-Ordovician, dolomite, reefoid, porous in part.

Note: Regional dip is to the west at approximately 20 feet per mile. This is so nearly flat that local reversals of dip could easily result in a closed structure.

others of greater intensity give rise to narrow tight uplifts. Two examples of the latter occur south of the Permits. One is the anticlinal structure trending northwest from Lac Belot towards the Permits. This structure causes a topographic ridge which rises 1,000 feet above the plains level near Lac Belot (Plate 11B), plunges northwest and disappears near the southern boundary of the Permit area. The other fault feature strikes northeast and makes the ridge along the southern boundary of Aubry Lake.

Within the Permit area several topographic alignments, generally indicated by a line of lakes, shown on the photomosaic are probably faults. Some of these faults may be a part of the Lac Belot uplift. The oil seep found on the western Permit occurs on one of these lineations.

The limited amount of bedrock exposure in the general area does not permit detailed structural mapping. Some generalization can be made, however, from the regional features and topography. Arguing from the premise that topography in general is controlled by structure, the large lakes, Aubry and Colville Lakes and their much larger post-glacial ancestors, mark a very large and very broad, northeast-trending synclinal area. The eastern half of the Permits lies on the western flank of this structurally low area. The Lac Belot anticlinal uplift continues on a northwestern trend through the western part of the Permit area. This feature has much less pronounced relief here than further south. West of the Lac Belot uplift bedrock appears to resume a regional dip to the southwest at about 20 feet per mile.

Our photo-interpretation work has located a structurally high area in the western part of the Permit area, along the extension of the Belot Lake anticline. It is of significance that the only oil seep in the immediate vicinity is located on this structurally high feature, close to the trace of an apparent fault. Photo studies of the eastern part of the area failed to disclose the position of strong structural relief, although there are a number of faults that may represent, or reflect, strong structural relief.

OIL AND GAS POSSIBILITIES

The P. & N. G. Permits of Colville Lake Explorers Limited are known to be prospective for oil and/or gas in two rock groups, the Siluro-Ordovician and the Middle Devonian Bear Rock formation.

The distribution and facies variation of Siluro-Ordovician strata in the Lower Mackenzie area, as outlined on Figure V, represent a very favorable set of conditions for the generation and entrapment of oil. In the west, in the deepest part of the basin, there are thick sections of dark shales of a type commonly considered as source beds. These shales interfinger updip with carbonates. In the shelf area Siluro-Ordovician rocks contain a dolomitized reef facies in which vuggy porosity is developed. Pre-Devonian erosion removed an unknown thickness of Siluro-Ordovician strata from the shelf area, which includes the Permit area. We do not know whether or not an impermeable layer occurs above the reef beds and below the unconformity.

The Bear Rock formation overlies the Siluro-Ordovician. Porosity is found in this formation south of the map-area. The nature of the Bear Rock facies beneath the Permit area can only be surmised. Porous beds in the Bear Rock formation very often show some evidence of petroleum.

Convincing evidence of the presence of oil is found within and near the Permit area. At Bond Lake, 30 miles southwest of the Permits, there is an active oil seep (Plate IXB). The seep is located a short way up the side of the hill on the east side of the lake. The oil issues from the glacial clay and sand which overlies Ramparts shale. The seep covers an area of about one-quarter of an acre.

On the west shore of Lac Belot, 25 miles southeast of the Permits, there are about 60 feet of Basal Cretaceous Sandstone (Plates VIIIB, IXA) stained dark brown by oil. These sands overlie the Bear Rock formation.

In the western Permit one oil seep was found. This is a small accumulation of only a few square feet which has saturated the surface sand and clay. A pit was dug in the sand; as no fresh oil entered the pit in the course of a week it appears that the seep is no longer active. This seep is, however, evidence that the Bear Rock formation is probably porous in this area or that, alternatively, oil has escaped through fractures from the deeper Siluro-Ordovician beds.

In the central part of the Permit area a tarry layer was found in a deposit of loose post-glacial sand (see photogeological mosaic). Small tarry layers in Basal Cretaceous Sandstone are common in exposures west of the Permit area.

There are two factors which might be considered as unfavorable for large oil accumulation. One is the relatively thin section indicated by the various isopach maps (Figures V and VI). The other factor is the very shallow depth of the potential reservoir rocks. Concerning the isopach maps, it must be emphasized that these maps represent only a minimum thickness. The Company Permits are situated about 120 miles west of the Canadian Shield; if the slope of the basement is only 20 feet per mile, the thickness of sedimentary rocks beneath the Permits would be in the order of 2,400 feet.

The Bear Rock formation, which is the uppermost potential reservoir rock, occurs beneath the Permits at shallow depths. In this regard it should be mentioned that many million barrels of oil have been produced in Ontario from depths of between 100 and 500 feet.

SUMMARY AND RECOMMENDATIONS

The Colville Lake Explorer's Permits, totalling 98,554 acres are located within the Arctic Circle, approximately 85 miles northeast of Fort Good Hope, N.W.T. To reach the area with heavy equipment for drilling or geophysical operations one would proceed from Grimshaw, the end of steel, 380 miles by the Mackenzie Highway to Hay River, N.W.T., thence 650 miles by river

barge on the Mackenzie River to Fort Good Hope. Physiographically the Permits and surrounding areas are covered with small evergreen trees, are fairly well drained and have low relief. There would be no serious difficulties in constructing temporary winter roads. The most serious problem in the construction of all-weather roads would be the perma-frost. Looking forward to the days of marketing problems, the area is roughly 600 miles from open water at Skagway, Alaska.

The Permits are located in the northern part of the Mackenzie Sedimentary Basin. Within this basin there is one known oil field, the Norman Wells pool. At Norman Wells, located about 150 miles south of Colville Lake Explorers' Permits, oil is produced from a reef in the upper member of the Middle Devonian Ramparts formation. A few unsuccessful wildcats were drilled near the field. Apart from the Norman Wells area and the Eagle Plains area in the Yukon, where a wildcat was drilled approximately 300 miles west of the Permits, the basin is unexplored by the drill. Even geological mapping of the Lower Mackenzie area is far from complete.

Bedrock over the Permit area is the lower member of the Ramparts formation or the upper part of the Bear Rock formation. Potential reservoir rocks are the lower portion of the Bear Rock formation, which in nearby exposures shows porosity with oil staining, and the underlying dolomites of the Siluro-Ordovician. Exposures of these latter rocks indicate that the zone is partly reefal with good vuggy porosity.

Because the potential reservoir rocks are so shallow under the Permits and are exposed at the surface in nearby areas, there is a possibility that any oil once in these beds has already escaped to the surface through fractures and that the porous beds are now flushed with fresh water. A porous zone only 100 feet below the surface is, however, still a potential reservoir, providing the overlying beds are impervious. The cap rock in this case is a dense limestone which would be prone to fracturing. The position of the porous reef, relative to the total Siluro-Ordovician sequence, is unknown. Whether or not impermeable layers are present above the Siluro-Ordovician reefs and below the upper part of the Bear Rock formation is unknown.

To evaluate the potential of this acreage it is suggested that a portable diamond drill be flown in and a hole drilled on the indicated structurally high area near the oil seep. The rig should be capable of drilling to a depth of 1,000 feet. If porous beds are encountered with no sign of fresh water, the chances of finding oil within at least that part of the Permit area overlain by the Lower Ramparts member might be regarded as favorable.

If the initial test hole shows a favorable reservoir rock at depth, a form of exploration to determine structure and a more accurate distribution

of the formations should be undertaken. A small coring rig capable of going 100 feet and light enough to be moved by Beaver or helicopter can be obtained and this method of exploration is recommended for the area.

G. K. Williams

G. K. Williams, P. Eng.

J. C. Sproule

J. C. Sproule, P. Eng.

901 Eighth Avenue S. W.,
Calgary, Alberta.
February 13, 1959.

BIBLIOGRAPHY

Beggs, O.D., 1944: The Subsurface Geology of the Norman Wells Pool; Canol Report

Bostock, H.S., 1948: Physiography of the Canadian Cordillera, with Special Reference to the Area North of the Fifty-Fifth Parallel; Geol. Surv., Canada, Memoir 247

Crickmay, C.H., 1953: New Spiriferidae from the Devonian of Western Canada; Published by the author

Crickmay, C.H., 1957: Elucidation of some Western Canada Devonian Formations; Imperial Oil Limited, Calgary

Dowling, D.B., 1922: Geological Structure of the Mackenzie River Region; Geol. Surv., Canada, Sum. Rept. 1921, pt. B, pp. 79-90

Foley, E.J., 1944: The Donnelly River Area, Northwest Territories, Canada; Canol Report, Assignment No. 26

Goodman, A.J., 1951: Tectonics of East Side of Cordillera in Western Canada; Bull. Am. Assoc. Petrol. Geol., Vol. 35, No. 2

Geological Survey of Canada, 1957: Map No. 1048A, Geological Map of the Yukon Territory

Geological Survey of Canada, 1958: Map No. 1055A, Geological Map of the District of Mackenzie, Northwest Territories

Hume, G.S., 1954: The Lower Mackenzie River Area, Northwest Territories and Yukon; Geol. Surv., Canada, Memoir 273

Kindle, E.M. and Bosworth, T.O., 1921: Oil Bearing Rocks of Lower Mackenzie River Valley; Geol. Surv., Canada, Summary Report 1920, Pt. B.

Martin, L.J., 1957: Stratigraphy and Depositional Tectonics of the North Yukon Lower Mackenzie Area; Doctorate Thesis, Northwestern University, Evanston, Illinois.

McConnell, R.G., 1890: Report on an Exploration in the Yukon and Mackenzie Basins, Northwest Territories; Geol. Surv., Canada, Ann. Rept. 1888-89, Vol. IV, pt. D

Mauss, A.W., 1944: The Lower Mackenzie River Area, Northwest Territories, Canada; Canol Report, Assignment No. 32

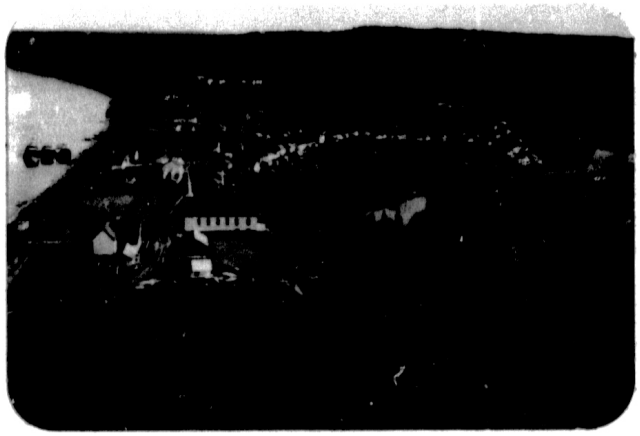
O'Neill, J.J., 1924: Report of the Canadian Arctic Expedition 1913-18, pt. A.

Stewart, J.S., 1944: Petroleum Possibilities in Mackenzie River Valley, Northwest Territories, Trans. Can. Inst. Min. and Met., Vol. 47, pp. 152-171

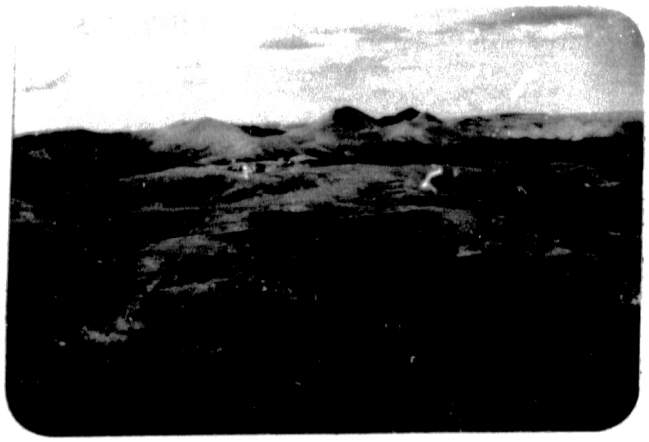
Stewart, J.S., 1945: Recent Exploratory Deep Well Drilling in Mackenzie River Valley, Northwest Territories; Geol. Surv., Canada, Paper 45-29

Stewart, J.S., 1947: Exploration for Petroleum, Northwest Territories, 1946, Geol. Surv., Canada, Paper 47-2

Warren, P.S., 1944: Index Brachiopods of the Mackenzie River Devonian; Trans. Roy. Soc., Canada, Vol. 38, Sec. IV



A. Aerial view of Fort Good Hope, the nearest transportation terminal.



B. Aerial view, looking north, of the central portion of the Richardson Mountains. These mountains are approximately 200 miles west of the Permit acreage.

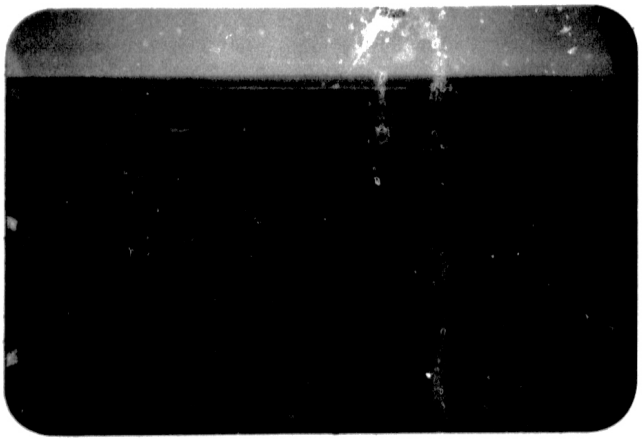
Photos by D.L. Campbell

A. Aerial view, looking east, of the Siluro-Ordovician overlying the Cambrian (?) in the first range of the Mackenzie Mountains just east of the Arctic Red River.

B. Aerial view of Belot Lake structure which lies south of Permit acreage. Bear Rock and Siluro-Ordovician strata are exposed in the core of the structure overlain by basal Cretaceous sandstones.

Photos by D.L. Campbell

PLATE III



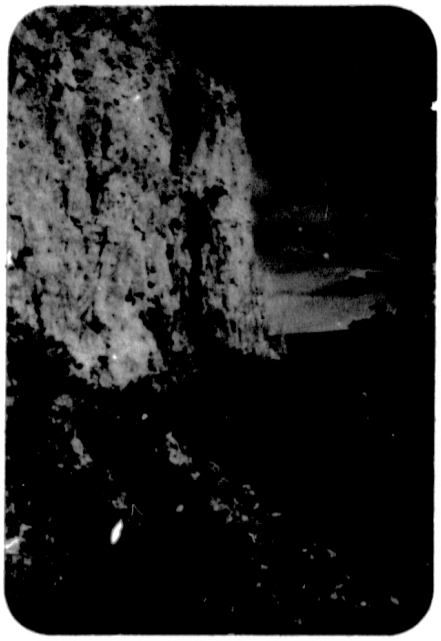
A. Rolling, lake dotted, topography typical of Permit area. Most of the lake shores are sandy and areas of extensive muskeg are uncommon.

B. Base camp on shore of Carcajou Lake, west of Permit area.

Photos by G.K. Williams and J.C. Sproule

PLATE IV

A. Company owned model G-1 Bell helicopter used extensively for short range reconnaissance mapping and checking of scattered outcroppings.



B. Massive bedded Siluro-Ordovician dolomites exposed at Jacomet Lake, near Great Bear Lake. The dolomite has good vuggy porosity.

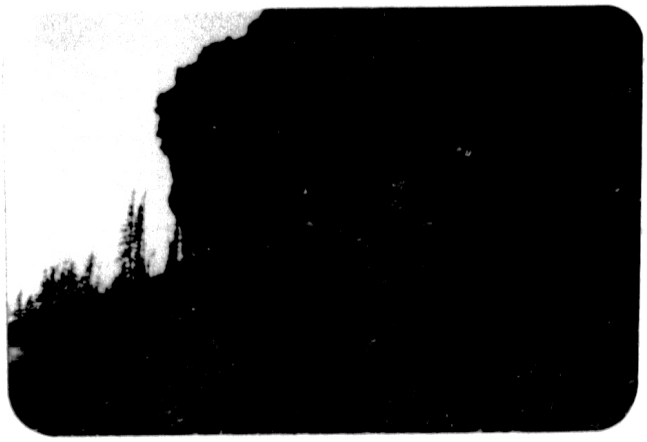
Photos by J.C. Sproule and G.K. Williams

PLATE V

A. Close-up of Siluro-Ordovician dolomite exposed on Hare Indian River. The vuggy porosity will often occur in layers as shown.

B. Siluro-Ordovician dolomites overlain by the Bear Rock formation, 8 miles southeast of Jacques Ridge, on Sam McRae Lake.

Photos by D.L. Campbell

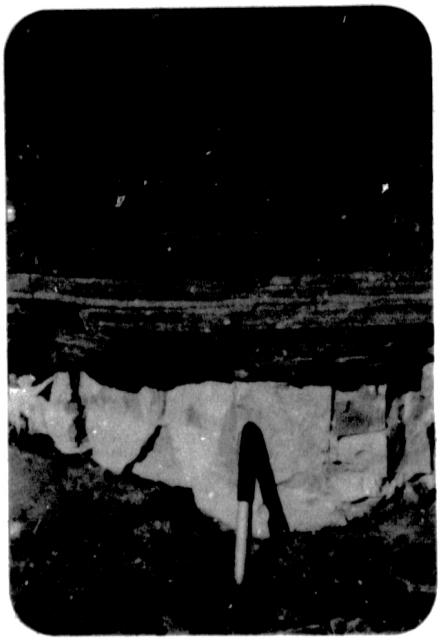


A. Bear Rock breccia exposed at Sam McRae Lake, southeast of Lac à Jacques. This is typical of the brecciated Bear Rock formation and is very porous.

B. Aerial view of sink-holes in Bear Rock formation 15 miles southwest of Lake Belot. These sink-holes are common from here south to Lac à Jacques.

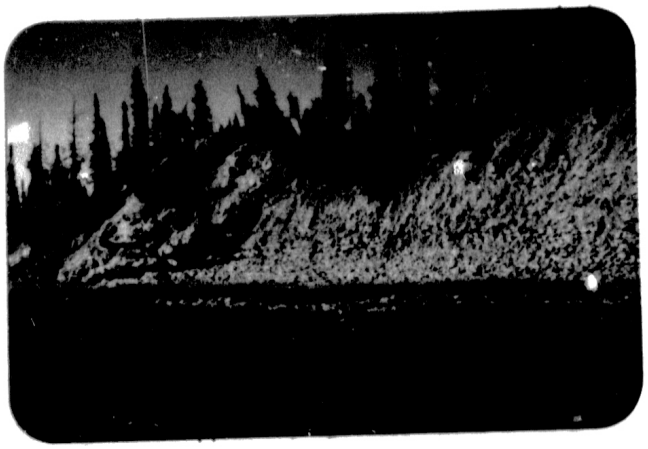
Photos by S.R.L. Harding and D L. Campbell

A. Bear Rock formation equivalent at upper canyon on the Anderson River. The strata consist of unbrecciated, laminated, bedded limestones with an absence of fossils.

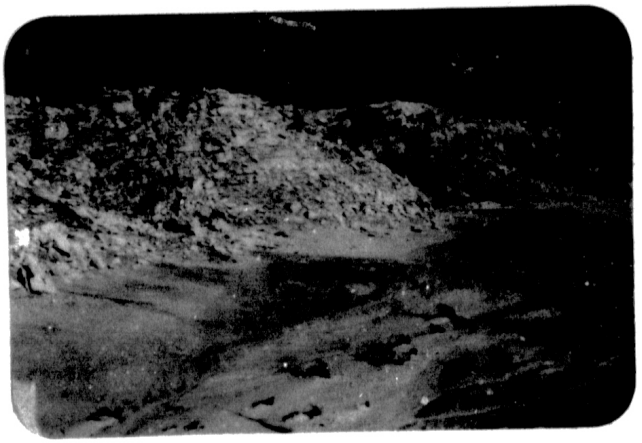


B. Close-up of unbrecciated, laminated limestone exposed at upper canyon on Anderson River. The laminae are gently distorted. The white zone is a thin band of dense dolomitic limestone.

Photos by G.K. Williams and N.N. Peterson

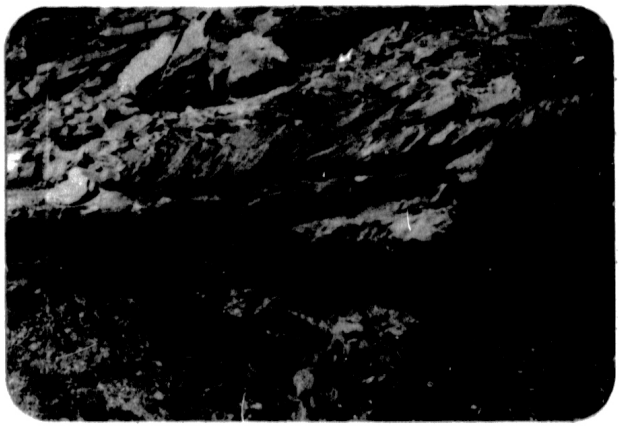


A. Small bioherm developed in Lower Ramparts member on Carnwath River. The off-reef facies is fossiliferous nodular limestone and shales.

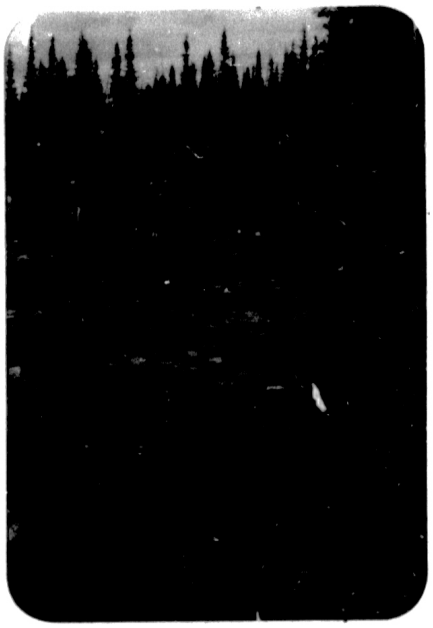


B. Oil stained basal Cretaceous sandstone exposed on west side of Lake Belot. No sandstone exposures were seen east of this point.

Photos by N.N. Peterson and G.K. Williams



A. Close-up of the Bas[illegible]taceous sandstone on the west side of Belot Ridge. The sandstone is highly cross-bedded and is impregnated with oil.



B. Oil seep at Rond Lake. A smaller, less active seep occurs within the Permit area.

Photos by D.L. Campbell and N.N. Peterson

GEOLOGICAL LEGEND

TERTIARY-RECENT
- T-R Undivided

CRETACEOUS
- K Undivided
- Kss Basal Cretaceous Sandstone

JURASSIC
- J Undivided

PERMO-PENNSYLVANIAN
- PP Undivided

MISSISSIPPIAN
- M Undivided

DEVONIAN UPPER
- UD Undivided
- Di Imperial Fm.
- Df Fort Creek Fm.

MIDDLE DEVONIAN
- Dr Ramparts Fm (Undivided)
- Dru Upper Ramparts Member
- Drm Middle Ramparts Member
- Drl Lower Ramparts Member
- Db-Dlm Bear Rock-Lone Mountain Fms

SILURIAN
- S Undivided

ORDOVICIAN-SILURIAN
- O-S Undivided

ORDOVICIAN
- O Undivided

CAMBRIAN-ORDOVICIAN
- €-O Undivided

CAMBRIAN
- € Undivided
- €m Macdougal Group
- €k Katherine Group

PROTEROZOIC OR (?) EARLY CAMBRIAN
- P-€ Undivided

NOTE - Geology in the area 130° to 135° W. Long. & 66° to 68° N. Lat. is adapted from Geological Survey of Canada Map 1055A published 1958.

REGIONAL GEOLOGICAL MAP
LOWER MACKENZIE BASIN AREA
YUKON & NORTHWEST TERRITORIES

PREPARED FOR

COLVILLE LAKE EXPLORERS

8 0 8 16 24 32 40

SCALE:- 1 INCH = 8 MILES

COMPILED FROM GEOLOGICAL SURVEY OF CANADA MAPS & FIELDWORK BY J.C. SPROULE & ASSOCIATES

516-1-7-1

LEGENDS

GEOLOGICAL
- Geological Boundary (Ascertained)
- Geological Boundary (Conjectural)
- Synclinal Axis
- Anticlinal Axis
- Fault
- Bedrock or Near Bedrock (Observed)
- Photogeological Dip

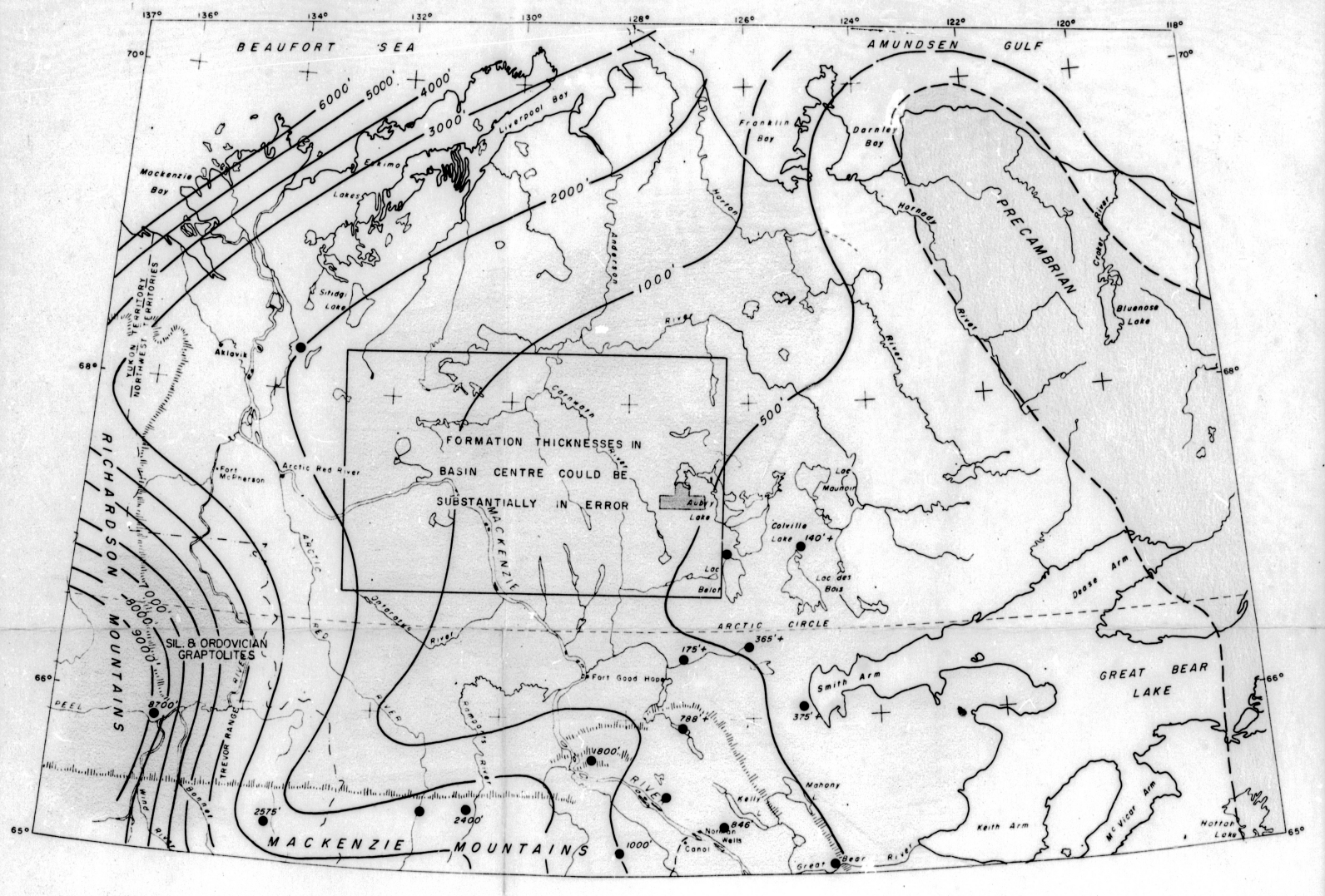
GENERAL
- Abandoned Well
- Outline of Mosaics
- Outline of P.& N.G. Permits
- 2A Kodachrome Print No. & Direction Taken

WELL
1. Sans Sault No. 1
2. Whirlpool No. 2
3. Canyon No. 2
4. Canyon No. 1
5. Loon Creek No. 2
6. Loon Creek No. 1
7. Loonex No. 1
8. Mac No. 1
9. Mac No. 2
10. Ray No. 1
11. "C" Location
12. Ft. Norman No. 1
13. Seepage Lake No. 1
14. Raider Island No. 1
15. Morrow Creek No. 1
16. Hoosier Ridge No. 1
17. Hoosier Ridge No. 2
18. Judile No. 1
19. Vermilion Ridge No. 1

J.C. SPROULE & ASSOCIATES, CALGARY

FIGURE - IV


BEAUFORT SEA
MACKENZIE BAY
KUGMALLIT BAY
FRANKLIN BAY
WHITE MTNS
RICHARDSON MOUNTAINS
MACKENZIE
Measured Section-Bear Rock Fm.



ISOPACH AND FACIES MAP

LOWER MACKENZIE BASIN AREA

YUKON AND NORTHWEST TERRITORIES

Ordovician - Silurian

Eastern Limits of Mountain Belts

Point or Area of Control

2575' Thickness of Ordovician - Silurian

Mainly Dolomite

Mainly Black Shale

Precambrian

Project Acreage

40 0 40 80

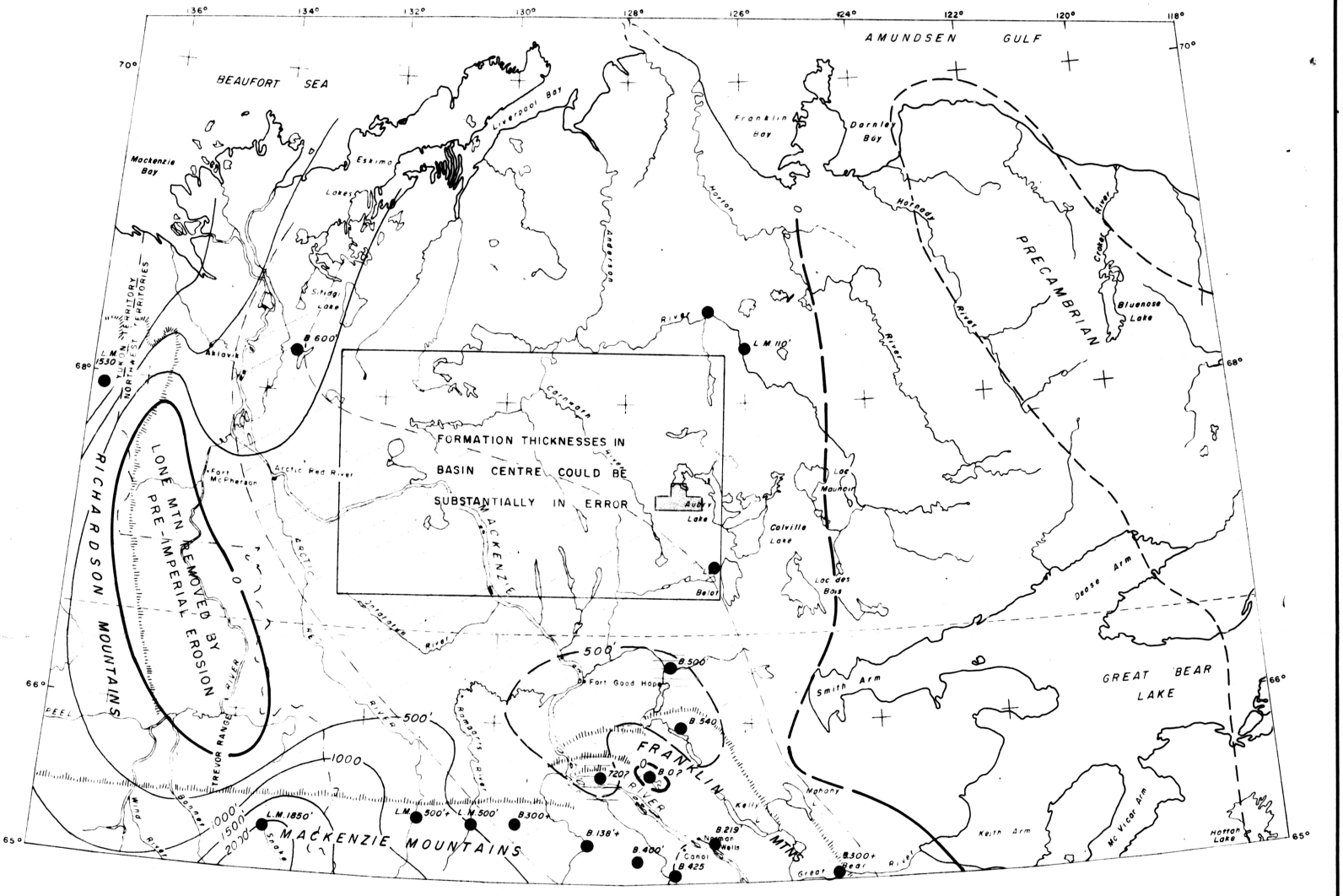
SCALE: 1"=40 MILES

Interpretation by R. de Wit, Dec. 1958

516-1-9-1

J. C. SPROULE & ASSOCIATES, CALGARY

FIGURE-V



ISOPACH AND FACIES MAP

LOWER MACKENZIE BASIN AREA

YUKON AND NORTHWEST TERRITORIES

Lone Mountain - Bear Rock Interval

Eastern Limits of Mountain Belts

Point of Area of Control

B 500' Thickness of Bear Rock

LM 500' Thickness of Lone Mountain

Mainly Limestone

Mainly Dolomite

Evaporites Present

Prominent Brecciation

Project Acreage

40 0 40 80

SCALE 1" = 40 MILES

516-1-7-1

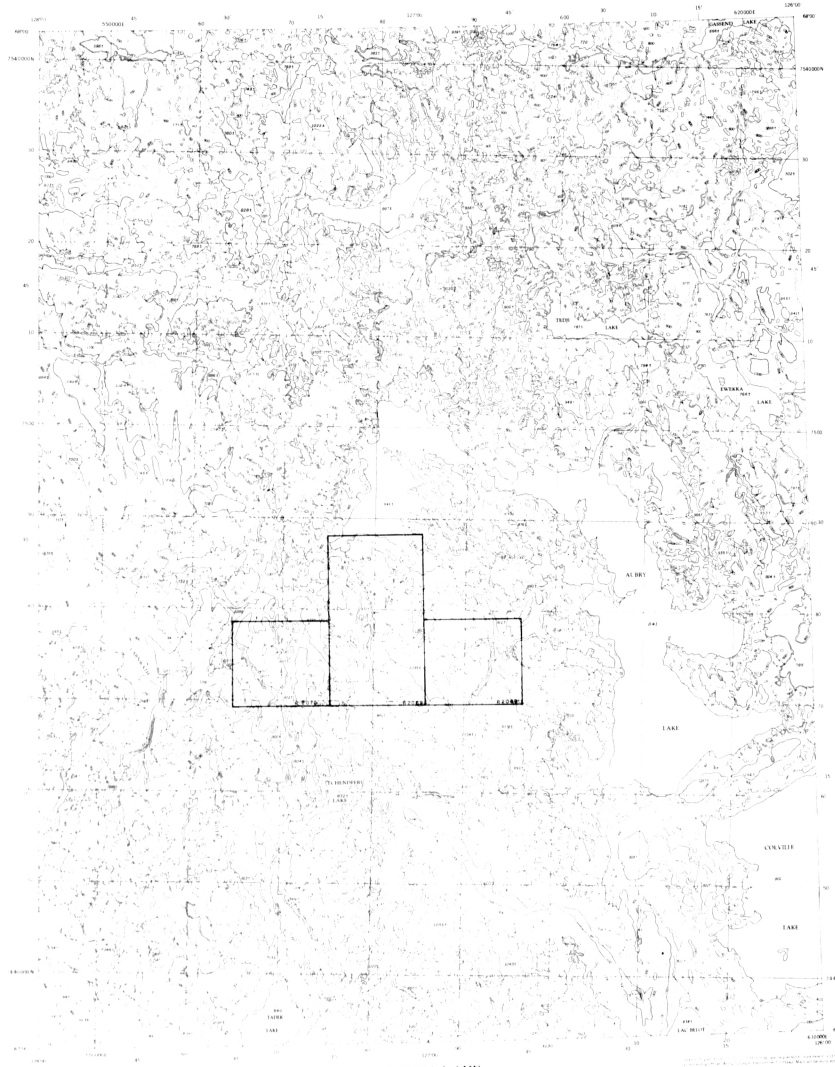
Interpretation by R. de Wit, Dec. 1958.

J.C. SPROULE & ASSOCIATES, CALGARY

To accompany Geological Report to Colville Lake Explorers, February 1959

DEPARTMENT OF NATIONAL DEFENCE
ARMY SURVEY ESTABLISHMENT

First Edition 96M



AUBRY LAKE 96M
NORTHWEST TERRITORIES

Scale 1:250,000

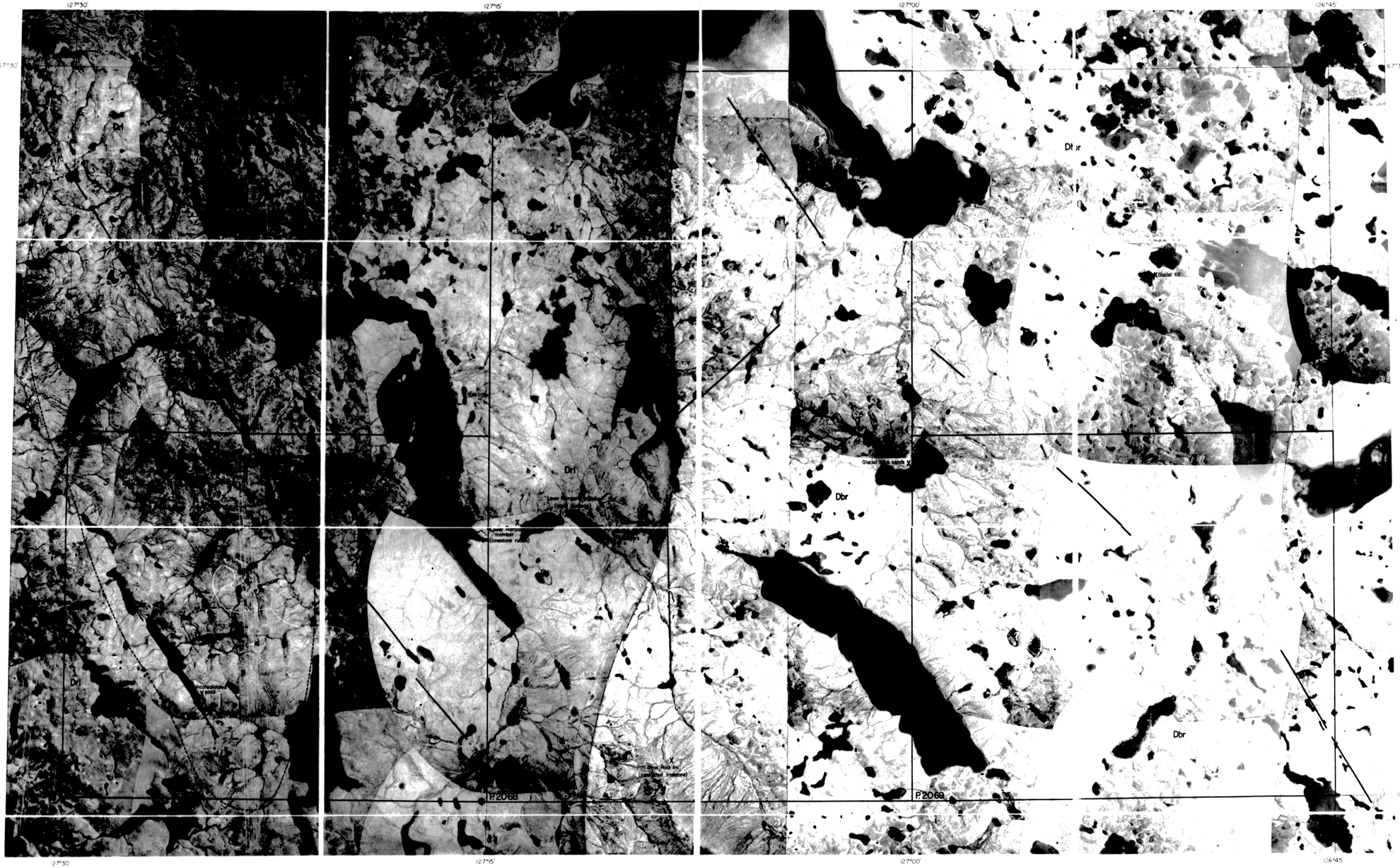
REFERENCE

CONTOUR INTERVAL 100 FEET

PROVISIONAL MAP
Subject to Correction

P & N G Permits

FIGURE - VII



INDEX MAP

LEGEND

TOPOGRAPHICAL & GENERAL

1. Bluff
2. Lake
3. Muskeg
4. River

P.2068 P.R.N.G. Permit Number and Outline

GEOLOGICAL

MIDDLE DEVONIAN

Nonparts Formation

Dfl Lower Nonparts Member

Dbr Bear Rock Formation

? ? Geological Boundary (Suggested)

X Rock Outcrop and Description

PHOTO INTERPRETATION

Fault Line

Outline of Structurally High Area

PHOTOGEOLOGICAL MOSAIC

AUBRY LAKE AREA

NORTHWEST TERRITORIES

COLVILLE LAKE EXPLORERS LIMITED

Note: The topographic information is rough and should not be taken as accurate geographic base.