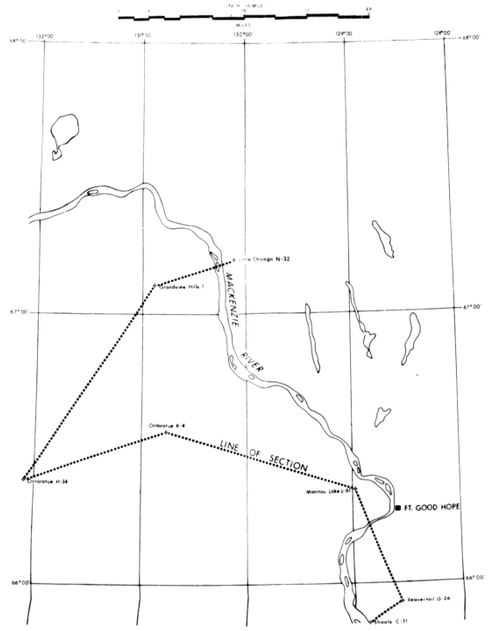
INDEX MAP



ONTARATUE H-34

ONTARATUE K-4

GRANDVIEW HILLS 1

LITTLE CHICAGO N-32

MANITOU L-61

SHOALS C-31

BEAVERTAIL G-26

ORDOVICIAN & SILURIAN — LOWER & MIDDLE DEVONIAN — MIDDLE DEVONIAN

RONNING FORMATION — BEAR ROCK FORMATION — HUME FORMATION

FRANKLIN MT. FM. & MT. KINDLE FM. ? SECURITY UNDETERMINED

LIMESTONE FACIES

DOLOMITE FACIES

EVAPORITIC FACIES

UNCONFORMITY ?

SILTY & SHALY MARKER

TOP OF RONNING ?

MARKER "Q"

MARKER "Z"

MARKER "A" (CHERT)

MARKER "F"

MARKER "E" (CHERT)

LIMESTONE FACIES

DELORME FORMATION

1871 TO 3460', GRANDVIEW HILLS No 1 IS THE TYPE SECTION OF GOSSAGE FORMATION (E.J. TASSONYI, 1967)

DOLOMITE FACIES, VARIABLE AMOUNTS OF INTERBEDDED LIMESTONE AND SHALE

THREE MISRUNS

107

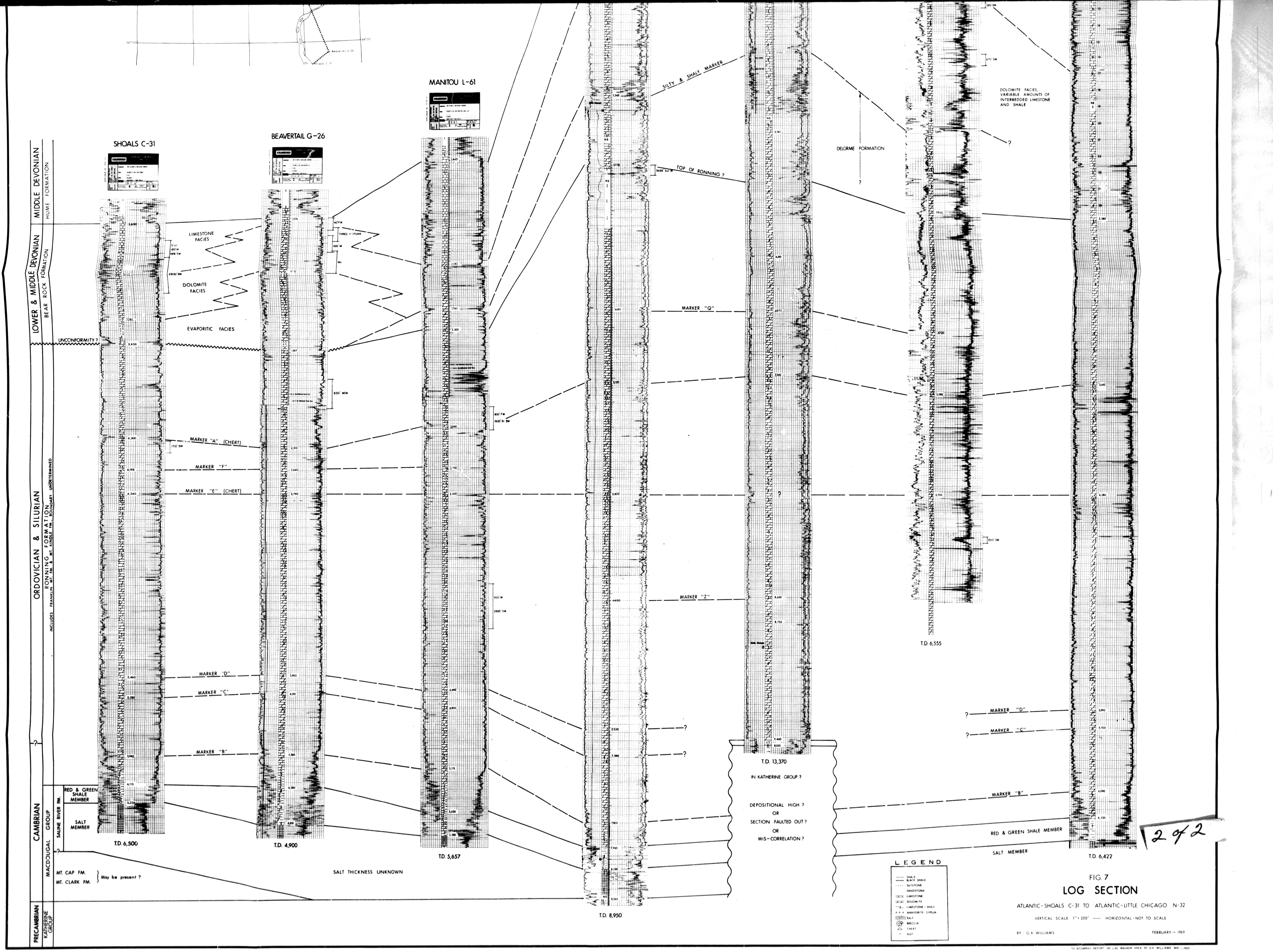
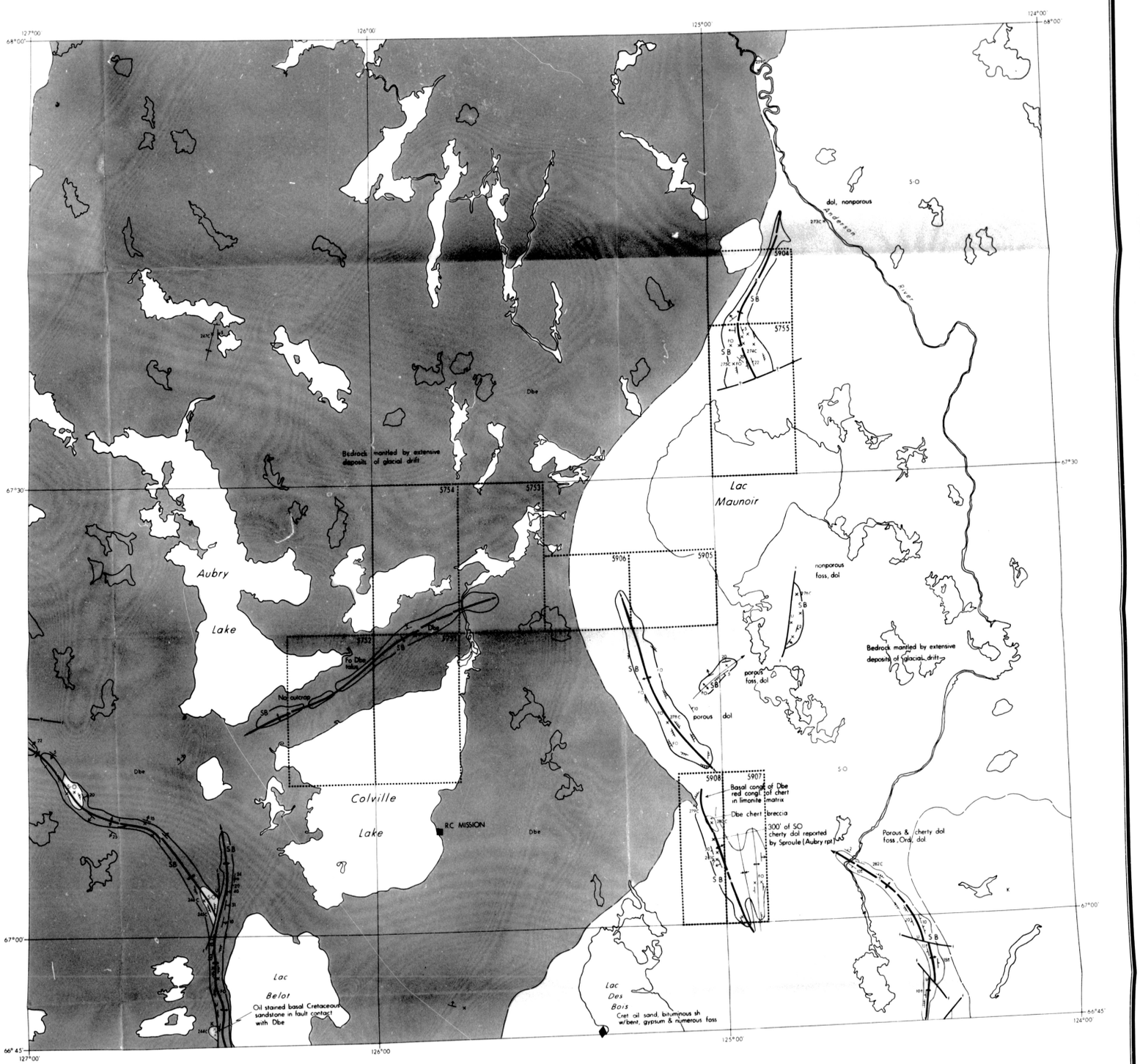


FIG. 7
LOG SECTION
ATLANTIC - SHOALS C-31 TO ATLANTIC - LITTLE CHICAGO N-32
VERTICAL SCALE 1" = 200' — HORIZONTAL - NOT TO SCALE
BY: G.K. WILLIAMS
FEBRUARY — 1969



LEGEND

- K — CRETACEOUS
- Dbe — DEVONIAN, BEAR ROCK FORMATION
- S-O — ORDOVICIAN–SILURIAN, RONNING GROUP

- Dip group 1, 1° to 3°
- Dip group 2, 3° to 10°
- Dip group 3, 10° to 25°
- Dip group 4, 25° to 45°
- Field observed dip (this report)
- Field observed, published dip
- Fault, dotted where extended through Quaternary deposits
- Thrust fault, triangles on thrust sheet
- Anticline, arrow denotes plunge, diamond denotes approx. position of apex
- Syncline, arrow denotes plunge, break and crossbars denote approx. position of high point
- SB — Stratigraphic break
- FOP — Field observed, published
- FO — Field observed, Summer 1967
- × — Outcrop area
- 267C — Field station number
- Oil, gas or sulphur seep

Information taken from Areal Geology and Structural Interpretation Map, 96 NW, of the Great Bear Lake-Horton River-Norman Wells area, Northwest Territories by V. Zay Smith Associates Ltd. 1968

UNITED CANSO OIL & GAS LTD.

DRAWN BY: G. K. WILLIAMS
DATE: MAY - 1969
REVISED:

FIGURE 8

GEOLOGIC MAP LAC MAUNOIR AREA

1 INCH = 4 MILES
0 MILES

TO ACCOMPANY REPORT ON LAC MAUNOIR AREA BY G.K. WILLIAMS MAY 1, 1969

352-4-1-6

Gault

A STUDY OF EARLY PALEOZOIC ROCKS IN THE NORTHERN PART OF THE MACKENZIE RIVER BASIN AND THEIR PETROLEUM POTENTIAL IN THE LAC MAUNOIR AREA

G.K.Williams May, 1969


OIL & GAS OPERATIONS UNIT
Oil and Mineral Division
OTTAWA, CANADA
Dept. of Indian Affairs & Northern Development

A STUDY OF EARLY PALEOZOIC ROCKS IN THE NORTHERN PART OF THE MACKENZIE RIVER BASIN AND THEIR PETROLEUM POTENTIAL IN THE LAC MAUNOIR AREA

For

UNITED CANSO OIL & GAS LTD.

By

G.K. Williams, P. Geol.

May, 1969

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INTRODUCTION

United Canso Oil & Gas Ltd. holds permits 5751 to 5755 inclusive, and 5904 to 5908 inclusive, totalling 370,070 acres. The permit area is herein called the 'Lac Maunoir' area, the general area is also sometimes known as the 'Colville Lake' area and the 'Colville Uplift'.

The nearest settlement is a community of Indians and a Roman Catholic Mission on the east shore of Colville Lake. Rev. B. Brown operates a fishing lodge with accommodation for up to ten people.

The permit area lies about 110 miles northeast of Fort Good Hope, which is situated on the Mackenzie River. Fort Good Hope is serviced by river boats along the Mackenzie River; scheduled flights by Pacific Western Airlines service Norman Wells, 85 miles southeast of Fort Good Hope.

In the general area of the permits there are five large lakes: Aubry Lake, Colville Lake, Lac Belot, Lac Des Bois and Lac Maunoir. Most of the area is a relatively flat plain at an elevation of about 1,000 feet above sea level, covered with a light growth of small trees, and dotted with small lakes. What makes the Lac Maunoir area distinctive, is the presence of several large anticlines or faulted anticlines which form prominent ridges of considerable relief. These structures are conspicuous in an area otherwise devoid of significant structure or topographic relief.

Bedrock in the Lac Maunoir area is early Paleozoic carbonate rocks, for the most part Upper Ordovician-Silurian in age, although a thin cover of Lower to Middle Devonian carbonates (Bear Rock formation) is present in the western part of the area.

Since rocks as old as Upper Ordovician are present at or near the surface, the petroleum prospects are limited to early Paleozoic, i.e. Cambrian to Middle Ordovician strata. (Also possibly from Cretaceous tar sands if present). From what is known regionally of the early Paleozoic rocks, there is no compelling reason to expect other than a fairly thin section, perhaps in the order of 2,000 to 3,000 feet. Although these rocks are marine, and contain potential reservoir,

source and cap rocks, the prospect of a thin section, to all appearances breached in the large structures, has rendered this area unattractive.

The large structures, lying far to the northeast of the Mackenzie and Franklin Mountains, are difficult to explain. One theory of their origin postulates that these structures could be a result of local overthickening of the sedimentary section - i.e. a sub-basin in which growth structures developed near the center of subsidence. It was partly on the basis of this theory that the permits were taken out.

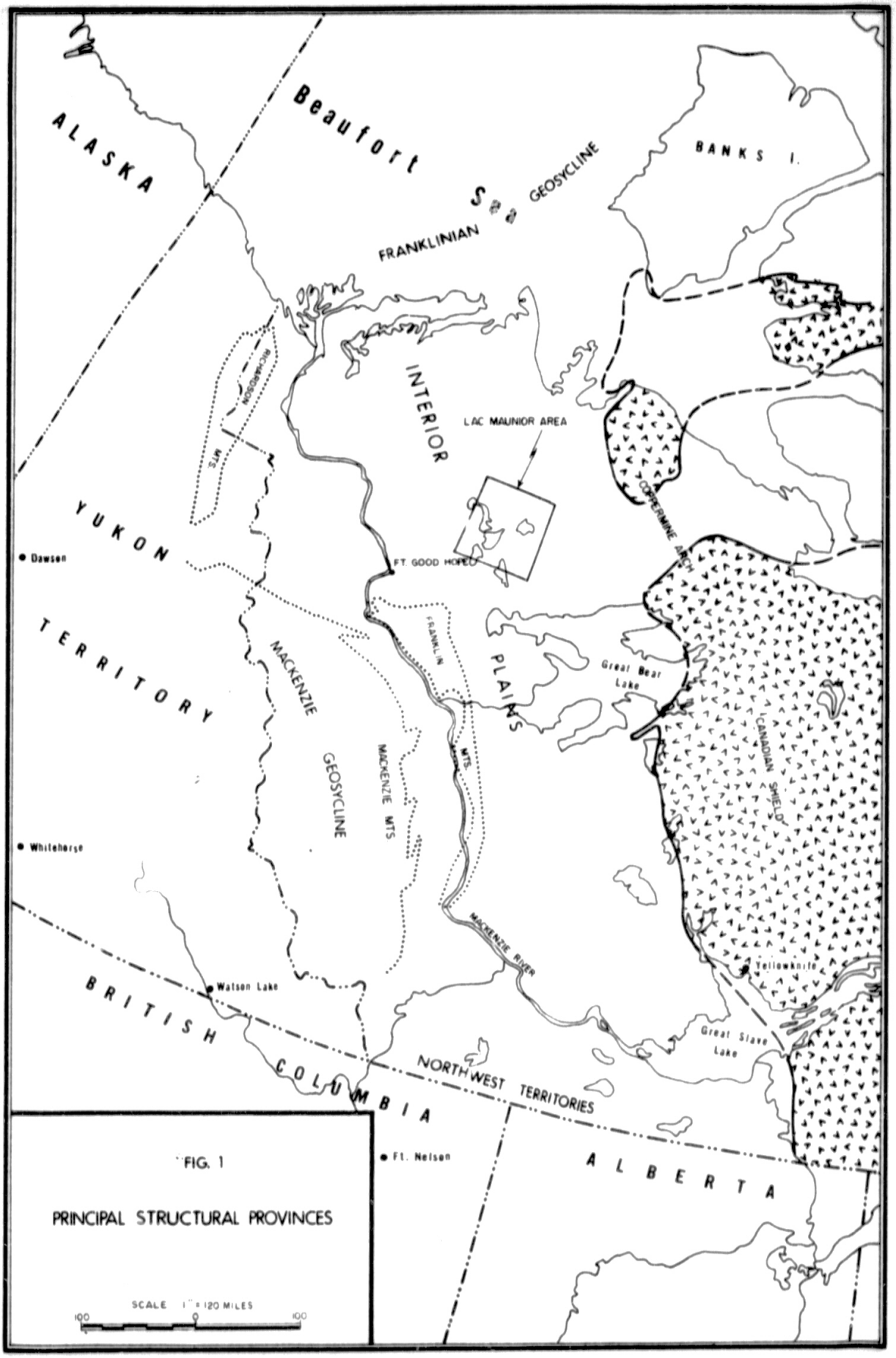
In the following report a synthesis of known geological data pertinent to early Paleozoic history is presented. From this regional material the subsurface possibilities of the Lac Maunoir area are discussed.

REGIONAL GEOLOGY

GENERAL STATEMENT

The principal tectonic provinces of the Mackenzie River basin are, from east to west, the Canadian Shield, the Interior Plains, and the Mackenzie Geosyncline (Fig. 1). Lying along the northwestern part of the mainland, and extending off-shore is the Franklinian Geosyncline. The early Paleozoic history of the Franklinian Geosyncline is essentially unknown as far as the Canadian mainland is concerned; it must be kept in mind however, that north-south facies changes could be at least as pronounced as the well documented east-west facies changes.

The tectonic pattern was established during the Proterozoic when great thicknesses of shallow water sediments, chiefly clastic but including carbonates, evaporites and volcanics, accumulated over the Interior Plains and the Mackenzie Geosyncline. A widespread unconformity separates Proterozoic and Paleozoic rocks; the unconformity erodes deeper down section from west to east. Nearly all of the map area (Figs. 3 and 4) is underlain by Proterozoic sediments except for the southeast corner of the maps, where Paleozoic strata overlie crystalline basement.


ALASKA
Beaufort Sea GEOSYCLINE
FRANKLINIAN
BANKS I.
INTERIOR
LAC MAUNIOR AREA
RICHARDSON MTS.
COPPERMINE ARCH
YUKON TERRITORY
Dawson
FT. GOOD HOPE
FRANKLIN MTS.
PLAINS
Great Bear Lake
MACKENZIE GEOSYCLINE
MACKENZIE MTS.
CANADIAN SHIELD
Whitehorse
MACKENZIE RIVER
Yellowknife
Watson Lake
Great Slave Lake
BRITISH COLUMBIA
NORTHWEST TERRITORIES
Ft. Nelson
ALBERTA
FIG. 1
PRINCIPAL STRUCTURAL PROVINCES
SCALE 1" = 120 MILES
100
0
100

Early Cambrian sediments consist of a thin shoreline facies in the east, an evaporite basin immediately to the west whose axis coincides approximately with the Franklin Mountains, a carbonate facies and, in the central part of the Mackenzie Geosyncline, a shale facies. A large tectonic uplift or arch (Redstone Arch) was present in late Cambrian time in the central Mackenzie Mountains, between the Mackenzie Geosyncline and the Interior Plains. It is possible that this arch developed early in the Cambrian period and divided the western open marine facies from the eastern evaporitic facies.

In the Interior Plains the Upper Cambrian to Silurian sediments consist almost entirely of dolomite. These rocks are normal marine shallow water sediments deposited with remarkably uniform thickness and facies over a very large area. Their eastern extent is unknown, having been eroded, however these rocks once extended well to the east of the present limit of the Canadian Shield. These sediments thicken across the shelf from east to west and near the center of the Mackenzie Geosyncline change from a carbonate to a shale facies.

A late Silurian-early Devonian uplift resulted in a widespread sub-Devonian unconformity which affected most of the Interior Plains. Erosion cuts progressively deeper from west to east and in the eastern part of the Interior Plains, Middle Devonian strata lie on rocks as old as Upper Cambrian. In the central part of the Mackenzie Geosyncline however, deposition may have been continuous. Late Silurian-early Devonian rocks are present only within the central part of the geosyncline. Devonian seas transgressed eastward from the geosyncline and progressively younger sediments extended farther and farther to the east. Middle Devonian sediments covered the entire Interior Plains area. These Devonian rocks show a gradual facies change from shale in the west, through normal marine carbonates, to an evaporitic section in the east.

Some late Paleozoic and early Mesozoic sedimentation occurred within part of the Mackenzie Geosyncline, however these rocks are of no concern in this study. Post-Devonian to pre-Cretaceous erosion affected the entire area. As with earlier erosion intervals, the unconformity cuts deeper into the section from west to east. Cretaceous rocks

probably covered most of the Interior Plains, the eastern shore line coinciding approximately with the present limit of the shield. Post-Cretaceous erosion has since stripped most of the Cretaceous cover from the eastern part of the Interior Plains, leaving only patches.

Most earth movements prior to late Mesozoic-early Tertiary time were of epirogenic origin. Within the Franklinian Geosyncline there were orogenic episodes during the middle and late Paleozoic, these however affect mainland rocks only in the northern Yukon Territory and possibly in the Mackenzie River Delta area, and are not pertinent to this study. The main episode of folding was the Laramide orogeny, late Mesozoic-early Tertiary, during which the Mackenzie and Richardson Mountains were formed. The Laramide earth movements were predominantly vertical, with only a moderate amount of crustal shortening. The structure consists of relatively symmetrical and fairly broad folds. In the eastern Mackenzie Mountains anticlines are often fairly sharp and cut by high angle reverse faults, whereas the synclines are broad and flat. In the Richardson Mountains, there are several large lateral faults. Low angle thrust faults are a rarity in both mountain belts.

The Franklin Mountains occupy a broad arcuate belt parallel to the Mackenzie Mountains, but separated from them by a low-lying area of moderate structure. The Franklins resemble the eastern Mackenzies structurally, but appear more complex. The Franklin Mountains consist of a series of high angle faults, faulted anticlines and scissor faults with a somewhat erratic orientation.

PROTEROZOIC

Crystalline rocks of the Canadian Shield outcrop on the eastern shores of Great Bear and Great Slave Lakes, and immediately to the west these crystalline rocks are overlain by the Paleozoic. Elsewhere in the map area (Figs. 3 and 4) a westward thickening wedge of Proterozoic sedimentary rocks lies with approximate structural conformity below Paleozoic rocks.

In the northeastern part of the map area, the Coppermine series consists of 11,000 feet of basalts overlain by up to 15,000 feet of sandstone, quartzite, shale, dolomite and limestone. Numerous diabase dykes and sills cut the Proterozoic strata but do not cut Paleozoic rocks.

In the northern Mackenzie Mountains, Proterozoic strata are known as the Katherine group. The name 'Katherine group' was originally applied by Link in 1921 to a series of interbedded quartzites and black platy shales in the upper Carcajou River area. The group was inadequately defined and probably included some strata now placed in the overlying Cambrian section. The name is now loosely applied to a thick sandstone or quartzite, in the order of 1,000 feet, and an unknown thickness of siltstone, shale and carbonates. At least one, and possibly three diabase sills up to 100 feet thick occur in the basal section. Several near vertical dykes are associated with the sills.

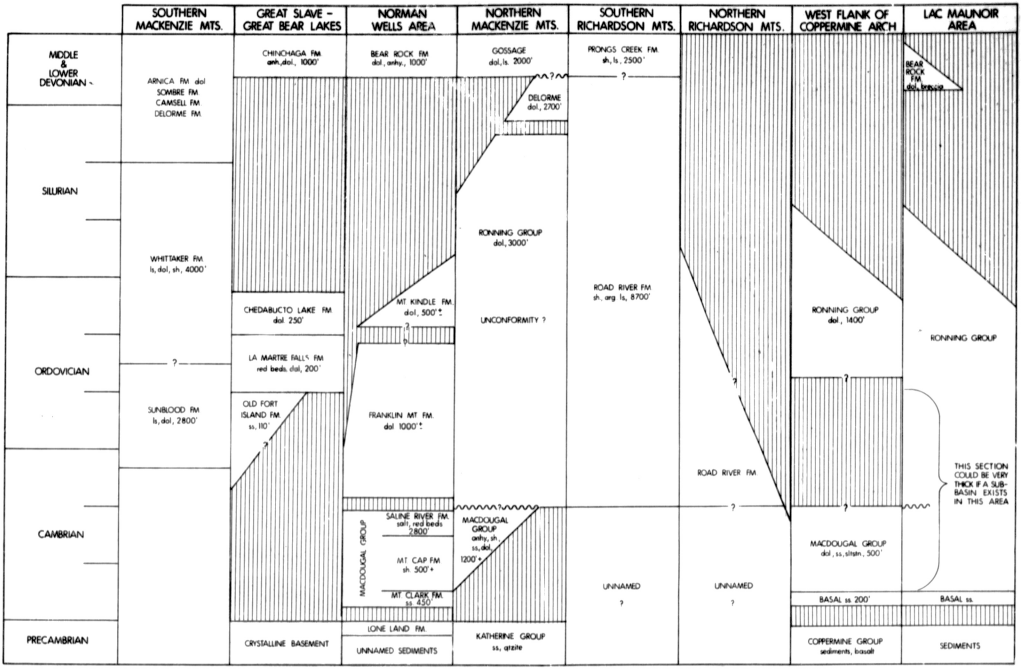
Near the headwaters of the Snake River, (Fig. 3) there is a local area of dolomite, red and green shale, and gypsum. These beds have been included in the Cambrian section by the Geological Survey of Canada and others. Ziegler, 1967, p. 49 however, indicates that this section is Precambrian.

In the subsurface Atlantic Ontaratue H-34 drilled 3,860 feet of clastics which are in part at least Precambrian. The upper 900 feet consist of fine grained sandstone, in part glauconitic, and interbedded red and green siltstone and shale. The remainder of the section is predominantly dark grey shale with minor sandstone and siltstone.

It is reported that a radioactive age determination from a cored section yielded a Precambrian age.

In the core of the Richardson Mountains some Precambrian sedimentary rocks are indicated on G.S.C. Map 10-1963.

FIG. 2 NOMENCLATURE & CORRELATION CHART



MIDDLE AND LOWER CAMBRIAN

General

Rocks of Cambrian age outcrop in the Mackenzie, Franklin and Richardson Mountains. Rocks of uncertain age, but probably equivalent to the mountain outcrops, are found north of Great Bear Lake to the Arctic coast, over the Coppermine Arch. Several wells have drilled into Cambrian strata.

Nomenclature

The nomenclature in use is illustrated on Fig. 2, page 7. The boundaries of the Cambrian system, especially the top of the Cambrian, are not well established in published literature. Most of the formation or group names are not well defined and there is disagreement as to the age ranges of some of the units. The Franklin Mountain formation is in part, or in some areas in total, of Upper Cambrian age, however this formation belongs, lithologically, with the Ordovician-Silurian carbonate sequence. A group term is desirable to refer to the pre-Franklin Mountain Cambrian section. The term 'Macdougal group' will be used in that sense in this report. It must be pointed out however that as originally defined, the term Macdougal group did not include all of the basal Cambrian section and probably did include part of the Franklin Mountain formation.

Northern Mackenzie Mountains

Macdougal Group

The type area of the Macdougal group is in Dodo Canyon, a tributary of the Carcajou River, which cuts through the front range of the Mackenzie Mountains about 25 miles south of Norman Wells.

The section was first described by Nauss, and is quoted in Hume, 1954, p. 10. Nauss described 997 feet of varicolored shales, minor limestone and sandstone; in the upper part of the section is a zone of gypsum from 200 to 500 feet thick. Fossils collected by the Canol geologists indicated a Middle and Upper Cambrian age. The section described by Nauss included 50 feet of limestone at the top

which would now probably be placed in the Franklin Mountain formation. In Hume, 1954, it is implied, but not expressly stated, that the Macdougal group as described directly overlies the Katherine group which consists of a series of interbedded quartzites and black shales. The Katherine group was considered to be probably Precambrian, possibly in part Lower Cambrian.

Recent re-examination of the type section by geologists of the Geological Survey of Canada established the presence of Lower Cambrian fossils. In addition they report that there are at least 200 feet of additional section, consisting of shale, dolomite, etc. below the base of Nauss' section and above the Katherine group.

In summary, the Macdougal group in the type area consists of a sequence of varicolored shales with interbedded limestone, dolomite and sandstone and, in the upper part, a zone of gypsum. The total thickness is not known but appears to be in the neighborhood of 1,200 feet or more. It is uncertain whether or not a basal sandstone, correlative with the Mount Clark formation is present, or whether the latter formation is equivalent to the upper part of the Katherine group. The age of the Macdougal group is Lower and Middle Cambrian.

Franklin Mountains

Mount Clark Formation

The Mount Clark formation was named by Williams, 1923. The type section is on Cap Mountain in the Franklin Mountains, about 160 miles southeast of Norman Wells. The formation is discussed by Douglas, 1962.

The Mount Clark formation consists of 450 feet of fine grained sandstone. The base of the section is marked by a strong angular unconformity, taken by Douglas to mark the base of the Paleozoic. Williams found Lower Cambrian fossils near the top of the formation from an outcrop on Mount Clark, north of the type section.

Mount Cap Formation

The Mount Cap formation was also named by Williams, 1923, on Cap Mountain. Only a few feet are exposed, these consist of soft, light olive-green, fissile shale. Middle Cambrian fossils according to Williams as well as A.W. Norris (Douglas, 1963)are present. Ziegler, 1967, p. 45, shows the Mount Cap formation to be 500+ feet thick and to be of Lower Cambrian age.

Saline River Formation

The Saline River formation is not well described in the literature. The formation was named by Williams, 1923. The type area is on Saline River, which is a small tributary of the Mackenzie River, about 50 miles southeast of Fort Norman. The section, which is poorly exposed in all outcrops, consists of red and green shale and gypsum, with minor dolomite. Salt springs are commonly associated with outcrops of the formation. The age of the formation is not discussed in Hume, 1954, or in Douglas, 1963.

Ziegler, 1967, p. 45, shows the Saline River formation to be divisible into two zones:- the upper zone is 500 to 2,000 feet thick, consists of red and green shale, minor dolomite and anhydrite or gypsum; a lower zone is 2,000 feet thick and consists of salt. The thickness for the salt section is probably taken from the interval in Imperial Vermilion Ridge No. 1. It is not obvious how Ziegler arrived at the thickness of the upper zone, possibly from the shale drilled in Shell Keele River L-4. The formation, according to Ziegler, is Middle Cambrian in age.

Southern Richardson Mountains

In the southern Richardson Mountains we have no adequate description of the pre-Road River beds. The Road River formation is described by Norford, 1964. The basal part of the Road River formation consists of limestone and argillaceous limestone and ranges in age from Upper Cambrian to Ordovician. As a working hypothesis it is convenient to assume that the Road River formation is equivalent to the Mount Kindle and Franklin Mountain formations, and that the

base of the Road River and the base of the Franklin Mountain formations are approximately equivalent. The pre-Road River rocks then are equivalent to the Macdougal group.

Concerning the beds underlying the Road River formation, Norford 1964, p. 3, states as follows:-

> ".... at Trail River the boundary (base of Road River formation) seems gradational with a thick sequence of shales and siltstones of Cambrian age .... ".

Marginal notes for G.S.C. Map 10-1963 indicate a 1,200-foot thick limestone succession with Lower Cambrian fossils overlain by a thick platy siltstone succession; these beds are assumed to be equivalent to the Macdougal group. Sproule 1961, measured a much faulted section on the Peel River consisting of argillite, siltstone and shaly limestone with a thickness estimated at between 4,000 and 7,000 feet.

Northern Richardson Mountains

In the northern Richardson Mountains there are a few scattered occurrences of Cambrian rocks exposed in the cores of deeply eroded anticlines. These exposures are all of only partial sections, measuring a few hundred feet of section, mostly carbonates. Early Paleozoic rocks of this area suffered one or more episodes of folding and erosion during the late Paleozoic.

Possible Cambrian Rocks Near Inuvik

Near the Inuvik airport are a few hundred feet of interbedded red and green shale or argillite and dolomite. No fossils have been found. These beds are overlain, apparently conformably, by Ordovician-Silurian dolomite. In several reports these rocks have been tentatively included in the Macdougal group. Recently Norris and Black, 1964, have given evidence, based on paleomagnetic analysis, that these beds are late Precambrian.

Probable Cambrian Rocks, Coppermine Arch

On the western flank of the Coppermine Arch rocks of probable Cambrian age are mapped by Craig et al, 1960 and by Macqueen, 1969. This section overlies the Proterozoic section and underlies carbonates correlated with the Mount Kindle and Franklin Mountain formations. No fossils other than worm-tubes were found. Macqueen, p. 239, states as follows:-

> "A similar (to the type section) three-fold division of Macdougal strata is evident within the eastern broad belt of lower Paleozoic outcrop. In this eastern area, however, the lower unit is largely composed of siltstone and dolomite (200 feet); the middle glauconitic sandstone unit is in part an orthoquartzite (100-150 feet); and the upper gypsiferous and argillaceous dolomite unit is much reduced in thickness (100-150 feet)."

These units are all considerably thinner than in the Franklin Mountains. Although no fossils were found, Aitken (personal communication) is confident that these beds are continuous across the plains with the three formations of the Franklin Mountain area, however he would expect them to be younger in age, in other words the formations would be diachronous, becoming younger from west to east.

Cambrian Rocks in the Subsurface

Several wells have drilled into the Macdougal group. The thickest drilled section is in Imperial Vermilion Ridge No. 1. Here the upper 560 feet consist of red shale and anhydrite. Below are over 2,200 feet of salt. Four hundred plus feet of fossiliferous green shale occurs below the salt. It is presumably from this well that Ziegler arrives at a thickness of 2,000 feet for the salt section of the Saline River formation. As this well is situated

within the Franklin Mountain disturbed belt, it is unsafe to assume that the drilled section of salt is the true stratigraphic thickness - it could be thicker or thinner.

North and northwest of Norman Wells several wells drilled by Atlantic drilled into Cambrian salt. Typically the salt is overlain by 50 to 125 feet of red and green shale. The top of this shale is picked as the top of the Cambrian on well cards. Most of the Atlantic wells drilled a few feet into the salt and stopped so the thickness is unknown. Only Atlantic Ontaratue K-4 drilled through the salt, which was 140 feet thick; green, grey and red shale and siltstone underlie the salt; this clastic section may belong in the Katherine group.

Atlantic Ontaratue H-34 drilled several thousand feet of Precambrian sediments (a radioactive date was obtained from a metamorphic layer). No salt was encountered. Immediately below the Ronning dolomite are about 40 feet of red and green shale with anhydrite. This shale section overlies quartzitic sandstone, probably the upper part of the Katherine group. The 40 feet of red and green shale may be a remnant of the Macdougal group.

Regional Distribution of Middle and Lower Cambrian Rocks

From outcrop and subsurface data it is possible to arrive at only a very tentative interpretation regarding distribution, thickness and facies of the Middle and Lower Cambrian beds. Fig. 3 is a map which summarizes most of the known data and presents an interpretation of the Macdougal group and equivalent strata.

Along the northern front of the Mackenzie Mountains, between Mountain River and Snake River, the Macdougal group is missing, and the Ronning carbonates overlie a thick quartzite or sandstone unit, believed to be the Precambrian Katherine group. A fairly large area of the Yukon was apparently uplifted late in the Cambrian period resulting in the removal, thinning, or perhaps non-deposition of the Macdougal group. This uplifted area has been termed the 'Redstone Arch' (see Gabrielse 1964 and 1967, and Ziegler, 1967, p. 7).

On Fig. 3 the Redstone Arch is interpreted as extending northward below part of the Peel Plateau. This interpretation is based on the section drilled in Atlantic Ontaratue H-34. The arch may very well have extended farther north than shown, perhaps paralleling the Richardson Mountains. Unfortunately we don't know whether the Redstone Arch acted as a barrier during deposition of the Macdougal group or if it is merely a late Cambrian uplift from which the Cambrian strata were eroded. From the brief comments in Gabrielse, 1967, it might appear that both conditions prevailed. Perhaps a continuation of the Redstone Arch does extend northward, lying east of the Richardson Mountains, and acted as a barrier separating the evaporitic facies of the Mackenzie basin from the dark-colored, thicker, and deeper water facies of the Richardson trough.

In the northern Mackenzie Mountains, near the headwaters of the Snake River, there is a sequence of dolomite, shale, sandstone and gypsum which Sproule 1961, equates with the Macdougal group. The Geological Survey of Canada (Map 10-1963) also, it appears, has mapped this section as Cambrian. On the other hand, Ziegler 1967, p. 49, places this evaporitic sequence in the Precambrian.

Fig. 3 illustrates the presence of a Cambrian salt basin. The mapped limits of the salt basin are extended far beyond the known occurrences of salt on the basis of an assumed relationship between salt and structure. The long salt trough extending southeast from Norman Wells includes all of the Franklin Mountain structural province. East and northeast of Fort Good Hope the boundary of the salt basin is drawn to include all of the Franklin Mountain-like structures which occur west of the Smith arm of Great Bear Lake and the folds of the Lac Maunoir area. The northwestern boundary of the salt basin is drawn along a line of less pronounced structures which include a fault on the Iroquois River, a small tight syncline east of the Carnwath River, and a thrust fault near Little Chicago. All of these structures are anomalous in an otherwise structurally dull area, and all occur approximately along the same trend.

This large area of salt is of course highly speculative. It is assumed that there is a genetic relationship between the Franklin Mountain-type structures and a thick salt section.

The situation at Shell Keele River L-4 deserves special mention. This well is located within the Mackenzie Plain, i.e. the structural and topographic low between the Mackenzie and Franklin Mountains. The well spudded in the Tertiary and drilled through Cretaceous into Middle Cambrian green shale. The Devonian to Ordovician section is missing. There is no discussion of this phenomenon in the well report. Presumably the well indicates the presence of a profound pre-Cretaceous structure, not a Laramide or later normal fault. The well drilled 2,000 feet into the Cambrian shales; these shales are stated to be Middle Cambrian in the well report (evidence is not discussed). On this basis these shales would belong to the Saline River formation which Shell (Ziegler 1967) consideres to be Middle Cambrian. On the basis of lithology however, these green shales appear to belong in the Mount Cap formation (pre-salt) and not in the variegated section which overlies the salt. At any rate, the interesting and anomalous structure revealed at Shell Keele River L-4 may in some way, be related to a Cambrian salt structure.

UPPER CAMBRIAN-ORDOVICIAN-SILURIAN

General

Rocks of this age outcrop in the Mackenzie, Richardson and Franklin Mountains, along the flanks of the Coppermine Arch, and in the large structures of the Lac Maunoir area. In the eastern part of the Interior Plains rocks of this age are found in small widely scattered exposures. Several wells have drilled the entire section.

Nomenclature

Terminology in use is illustrated in Fig. 2, page 7. In general the term Ronning group is used to refer to the carbonate facies in the area north of Norman Wells and in the northern Mackenzie Mountains. The western shaly facies exposed in the Richardson Mountains is known as the Road River formation.

In the Franklin Mountains the Ronning group consists of two formations, the upper Mount Kindle formation and the lower Franklin Mountain formation, both are chiefly dolomite. Although a regional unconformity separates these two formations, there is not sufficient information available to subdivide the Ronning group in most areas.

It should be noted that due to the confusion that exists regarding the meaning of the terms 'Mount Kindle', 'Franklin Mountain' and 'Ronning', many reports of this area simply use the term 'Ordovician-Silurian'. This latter usage is unsatisfactory because it is now known that the basal beds of this sequence are Upper Cambrian.

Franklin Mountains

Franklin Mountain Formation

The name was originally applied by M.Y. Williams, 1922, for several hundred feet of red and green shales on Mount Kindle in the Franklin Mountains. The shales are overlain by dolomite of the Mount Kindle formation. The base was not described and thickness was estimated at 500 feet or more. No fossils were found, but the formation was provisionally placed in the Lower Silurian.

The next year Williams, 1923, elaborated on the formation on Mount Kindle, and stated that the formation consisted of grey shales with red interbeds grading upward into buff limestone. He also identified a 865-foot thick section of limestone and magnesian limestone on Mount Charles as belonging to the formation.

Subsequently Hume (1954) and Tassonyi (1967) have avoided the term using instead the term 'Ronning group' or 'Ronning formation' for all strata above the Cambrian and below the Bear Rock.

Douglas (1963) restudied the formation on Mount Kindle and his more complete description should probably be considered the type section. The formation on Mount Kindle is 1,265 feet thick and consists predominantly of fine grained dolomite and minor chert and some stromatoporoid structures. In the basal 520 feet there is a considerable

amount of interbedded red, green and grey shale, some limestone and minor sandstone. The contact with the underlying Saline River formation (Cambrian) is not exposed. The upper contact with the Mount Kindle formation appears conformable.

Ziegler 1967 uses the term Franklin Mountain formation. Unfortunately no text accompanies his publication, so his application is not entirely clear. With his diagrams as a guide his use of the term 'Franklin Mountain formation' appears to be as follows:-

The formation is widespread over the Mackenzie River basin, from the shield into the Mackenzie Mountains. The formation is chiefly dolomite with intercalations, near the base, of sandstone and shale. The dolomite is mostly very fine to fine grained, fossils are rare. The formation is 1,000 to 1,500 feet thick over much of the plains area, but thickens to over 5,000 feet in the interior of the Mackenzie Mountains. Both upper and lower contacts are widespread unconformities. The age is Upper Cambrian to Middle Ordovician. In the plains, due to the overlying pre-Upper Ordovician unconformity, only beds of Cambrian age are present.

Mount Kindle Formation

The name 'Mount Kindle' was first proposed by M.Y. Williams, 1922, for about 500 feet of fossiliferous dolomite of Middle Silurian age. These dolomite beds were named for their exposure on Mount Kindle in the Franklin Mountains. The formation overlies a section of dolomite and shale, which Williams named the Franklin Mountain formation, and was overlain by cavernous dolomite, at that time known as the Bear Mountain formation, now known as the Bear Rock formation.

The name was apparently not widely used by Canol geologists. Hume (1954) refers to the Mount Kindle formation of Williams, but does not use the term, instead he applied the name 'Ronning group' to all beds above the Cambrian and below the Bear Rock.

Douglas, 1963, restudied the section on and near Mount Kindle and his description, though brief, is more complete than that of Williams, and should probably be taken as the type section. The formation is 900 feet thick and consists entirely of dolomite. The lower half is medium grained, reefy, and contains Upper Ordovician corals (considered by Williams, 1922, 1923 and 1963, to be Middle Silurian). The upper half is fine to micrograined, and contains early Silurian fossils. Douglas makes no mention of chert in this section, however Upper Ordovician rocks north of the type area are characterized by an abundance of chert.

The age of the Mount Kindle was formerly considered to be Middle Silurian. Recently Bell (1959) dated the formation as Upper Ordovician. This conclusion has been rebutted by Williams, 1963.

Ziegler (1967) uses both 'Mount Kindle' and 'Franklin Mountain'. Unfortunately his publication contains no text so his application is not entirely clear. With Ziegler's diagrams as a guide, his use of the term Mount Kindle formation appears to be as follows:-

The formation consists of a widespread carbonate, mostly dolomite, 500 to 2,500 feet thick, which extends from the Mackenzie Mountains to the shield and over the entire area north of Great Slave Lake. The formation is characterized by an abundance of chert as thin layers, nodules and replaced fossils. Corals are abundant, often forming biostromes which weather to vuggy, sometimes cavernous dolomite. The age is Upper Ordovician to Lower Silurian. The formation unconformably overlies the Franklin Mountain formation (Upper Cambrian to Lower Ordovician) and is unconformably overlain by Lower or Middle Devonian rocks. The formation is not present, having been stripped by pre-Devonian erosion over part of the Franklin Range in the vicinity of Norman Wells.

Ronning Group

The term 'Ronning' has a long controversial history. Canol geologists working in the Norman Wells area used the term 'Mount Ronning formation' for all beds below

the brecciated dolomite and limestone (Bear Rock formation) and above probable Cambrian strata. Hume (1954) proposed the term 'Ronning group' for the same stratigraphic interval. He introduced the term 'group' because he felt that the various Canol geologists had included different beds from different areas in the Mount Ronning formation without sufficient evidence for correlation. Hume, as well as the Canol geologists, considered that this interval was Silurian in age; in fact Hume states "No rocks of Ordovician age have been identified in the vicinity of Norman Wells nor in the Franklin Mountains". Subsequently the fossils from this interval have been re-examined and reclassified and it appears that most of what was termed the Mount Ronning formation in the Norman Wells area is of Ordovician and Cambrian age.

It would appear that Hume intended the 'Ronning group' to include and be equivalent to the Mount Kindle and Franklin Mountain formations. This situation is confused by the inadequate definition given by Williams, 1922, to these two formations. For example, the Franklin Mountain formation as originally described on Mount Kindle, i.e. 500 feet+ of red and green shale, is almost certainly the upper part of the Saline River formation as that term is now used. The term 'Franklin Mountain formation' subsequently evolved to mean the lower part of the Cambrian-Silurian carbonate section. Unfortunately it is not certain from published literature how the Mount Kindle and Franklin Mountain formations are to be separated.

In many of the industry reports, the name is avoided and the term 'Ordovician-Silurian' used instead.

Tassonyi has reviewed the problem in detail and has temporarily solved it by ignoring the Mount Kindle and Franklin Mountain formations, and re-introducing the term 'Ronning formation' for the Ordovician-Silurian carbonate sequence. This seems unfortunate because the above carbonate sequence is divisible into units, at least in some areas, and furthermore the age of the sequence apparently ranges from Upper Cambrian to Lower Silurian (see Ziegler, 1967, pp. 43-53 re Franklin Mountain and Mount Kindle formations).

Northern Mackenzie Mountains

The Upper Cambrian to Silurian of this area is illustrated on cross sections, Figs. 5 and 6, which extend across the Northern Mackenzie Mountains and tie into the subsurface in the Norman Wells area. Correlation lines for the western section are fairly certain, on the eastern section however, correlation is uncertain.

In this area the Upper Cambrian to Silurian section, or Ronning group, is fairly consistent in thickness and lithology all along the mountain front. The thickness ranges from 2,000 to 3,000 feet, and the unit is principally dolomite with minor limestone. The Ronning is unconformably overlain by dolomite of the Bear Rock formation or, in the west, by the 'Delorme' formation. The basal contact is also an unconformity. In the Norman Wells area and easternmost Mackenzie Mountains, the Ronning lies on the Macdougal group (Cambrian). Farther west the Macdougal beds are missing and the Ronning overlies the Katherine sandstone (Proterozoic).

Three distinct units are evident:-

- upper fossiliferous cherty dolomite,
- middle dolomite,
- lower algal dolomite.

The basal unit, 200 to 500 feet thick, consists of fine crystalline silty dolomite characterized by algal laminations or stromatolites. This unit is identified by Norford, 1963 (Section No. 2 in his report) as Upper Cambrian in age. It is uncertain whether Ziegler, 1967, considers the basal unit to constitute the Franklin Mountain formation, or only the basal part of that formation.

The middle unit is 1,500 to 1,800 feet thick. It consists of dolomite in the east, grading to platy, slightly argillaceous limestone in the west. This facies change is apparently the initial phase in the east to west transition from the Ronning carbonate facies to the Road River shaly facies. The dolomite of the middle unit is generally fairly dark, fine crystalline and well bedded. Siliceous material in the form of laminae of quartz crystals, nodules and irregular networks of chert and quartz is fairly common

throughout the unit but more so in the upper part. In the area of Fig. 5 and the western part of Fig. 6, there are several lenses from 10 feet to over 100 feet thick of fine to coarse crystalline dolomite which appear to be massive organic accumulations or biostromal lenses, although few fossils are preserved. The middle dolomite unit is of Ordovician age.

The upper unit consists of 600 to 1,100 feet of dolomite with an abundance of silicified fossils. In part this unit is a coral biostrome, fine to coarse crystalline, thick bedded to massive and weathers vuggy and porous. Silica, both chert and quartz, is very abundant and has replaced all of the fossils. In some beds, the silica is so abundant that the weathered rock resembles a bed of cinders. The best biostromal development occurs in the basal 100 to 300 feet.

The top of this unit is a regional unconformity; where overlain by the 'Delorme' formation the contact is marked by a prominent yellow-orange weathering marker. Farther east where the 'Delorme' has pinched out the Ronning is unconformably overlain by the Bear Rock formation. In the subsurface of the Norman Wells area this fossiliferous upper unit, plus part or perhaps all of the underlying middle unit has been truncated by pre-Devonian erosion.

The base of the upper unit may also be an unconformity, the break is usually sharp and marked by an abundance of chert. In most sections, the base of the upper unit marks the lowest occurrence of very abundant chert. In some locations, thin lenses of quartzite occur at this contact.

The fossils of this unit indicate an Upper Ordovician to Silurian age. This upper unit is undoubtedly equivalent to the Mount Kindle formation. It is uncertain whether Ziegler, 1967, considers this upper unit to constitute the entire Mount Kindle formation or only the upper portion of the formation.

Southern Richardson Mountains

Road River Formation

In the southern Richardson Mountains, most of the Paleozoic section up to the top of the Devonian consists of a shaly facies. That part of the sequence ranging from late Upper Cambrian to the Lower Devonian (and probably including some Lower Devonian) is known as the Road River formation. The formation was named by Jackson and Lenz, 1961.

The Road River formation consists of a thick series of alternating dark colored graptolitic shales, argillaceous limestone and subordinate amounts of chert, dolomite, siltstone and sandstone. The thickness of the formation is difficult to determine because of faulting in all exposed sections. Furthermore, the thickness is variable. Probably this variation is partly depositional but it is in part because of an unconformity at the top. The maximum thickness appears to be in the order of 10,000 feet.

The lower boundary of the formation is not well defined. In the type section the lower contact is a fault with older beds. Nearby the formation appears to conformably overlie a thick section of shale, siltstone and sandstone of Cambrian age. The upper contact at the type section and in most areas is an unconformity; the formation is overlain by the Upper Devonian Canol formation. In the southern part of the Richardson Mountains however, the upper part of the Road River formation contains graptolitic shales which are apparently of Lower Devonian age and these are overlain, apparently conformably, by Middle Devonian shales and argillaceous limestone of the Prongs Creek formation.

Northern Richardson Mountains

In the northern Richardson Mountains, there are several small incomplete exposures of the early Paleozoic section. These exposures occur in the eroded cores of anticlines, and are unconformably overlain by rocks ranging from Upper Devonian to Permian. These rocks are mapped as the Road River facies by the Geological Survey of Canada (Map

10-1963). Section 66 near the western side of Fig. 4 consists of 1,620 feet of dark-colored siltstone, silty cherty dolomite and bedded chert of probable Ordovician age.

East of the Richardson Mountains, near the Inuvik airport, are 600± feet of clean carbonates the lower part of which is reported to be of Upper Ordovician age (Norris and Black, 1964). These beds overlie rocks which are probably Precambrian in age. It would appear therefore that near Inuvik only the upper part of the Ronning group, i.e. the Mount Kindle formation, is present, and that the Franklin Mountain formation as well as earlier Paleozoic strata is missing. It is also apparent from this outcrop that the boundary between the carbonate and shale facies lies somewhere between Inuvik and the northern Richardson Mountains.

Eastern Interior Plains

The strata which outcrop along the western flank of the Coppermine Arch as well as in the eastern Interior Plains have been described by several geologists, most recently by Macqueen, 1969. These beds consist entirely of dolomite up to 1,400 feet thick (1,825± feet according to Smith, 1968), and are assigned to the Ronning group.

According to Macqueen the section is divisible into three units as follows:-

Upper unit - 500 feet to 700 feet - light grey weathering, thick bedded, fine to coarse crystalline dolomite, abundant chert, locally containing corals.

Middle unit - 500 feet - grey weathering, thick bedded, banded, slightly porous dolomite with little chert.

Lower unit - 200 feet - pale yellow-orange weathering, thin bedded, cyclic dolomite, in part argillaceous.

The age of the Ronning in this area ranges from Middle Ordovician to Middle Silurian. The uppermost unit is missing in the eastern part of the area due to erosion.

Macqueen does not discuss the relationship of these units to the Mount Kindle and Franklin Mountain formations. Presumably the upper cherty unit is the Mount Kindle equivalent and the lower two units are equivalent to the Franklin Mountain formation. Macqueen notes that these shelf sediments, like the underlying Cambrian beds, are characterized by a high degree of uniformity across the entire area from the Franklin Mountains to the Coppermine Arch.

Subsurface

Several wells have drilled the total Ronning section, most of these wells are presented graphically on Figs. 6 and 7.

In the Norman Wells area, Fig. 6, the sub-Devonian unconformity has cut fairly deeply into the Ronning, the upper fossiliferous, cherty beds of the Mount Kindle formation are missing and the Devonian lies on the eroded surface of the Franklin Mountain formation. The formation here consists of from 900 to 1,300 feet of brown to light-colored microcrystalline dolomite. No reservoir beds are logged.

The other wells all lie to the northwest of Norman Wells and these are presented in Fig. 7. In Appendix I the problems of correlation are discussed and it will be noted that, among other problems, the top of the Ronning group is uncertain. Of this thick carbonate section from the top of the Bear Rock formation to the base of the Ronning group, only two markers can be carried with assurance, these are the top and base of the section.

Assuming that the top of the Ronning has been correctly picked, this unit thickens from about 2,700 feet in the Fort Good Hope area to over 4,000 feet in Ontaratue H-34, to the northwest. The entire section is dolomite. Very roughly, and with no clear cut definable contacts, the

Ronning is divisible into three units, based on grain size and the amount of chert:-

Upper unit - from the top of the Ronning down to within 0 to 400 feet above marker A (a chert marker). In the deep portion of the basin the basal contact approximates Marker Q (Fig. 7). This unit varies from 600 to 900 feet in thickness. Typically it consists of microcrystalline dolomite, in part slightly limy and with very few limestone layers. There is very little chert.

There is only a small proportion of dolomite coarser than microcrystalline and very little intercrystalline porosity. This unit appears unpromising as a reservoir rock, however a test of the top of the unit in Ontaratue K-4, a zone of lost circulation, recovered a lot of salt water.

Middle unit - the top of this unit was discussed above; the base is even more vague, however it coincides very roughly with Marker D (Fig. 7). Lithologically this middle unit is characterized by an abundance of chert, especially in the upper half. In addition the crystal size is coarser than the upper or lower units. The dolomite is mostly micro to fine crystalline, however there are abundant interbeds of medium or coarse crystalline dolomite, some of these beds are up to 200 feet thick. Most of the dolomite, including the coarse crystalline layers, is tight, however there is some intercrystalline porosity. The middle unit ranges in thickness from 1,500 feet in the Fort Good Hope area to 2,600 feet in the northwest.

Lower unit - although the top of this unit is vague, the lithology is distinct, being microcrystalline grading downward to cryptocrystalline dolomite with very little coarser material. Chert is scarce. Towards the base of the unit the dolomite becomes argillaceous and the lower 200 feet contain interbedded dark shale. The basal contact, which is the top of the Macdougal group, is taken at the highest occurrence of red and green shale. The thickness of the lower unit is fairly constant in all wells, in the order of 700 feet.

In comparing the subsurface section with Macqueen's descriptions of outcrops in the eastern Interior Plains, it is apparent that the three units of each area do not correlate. The most logical correlation would appear to be as follows:-

Subsurface	Eastern Interior Plains
Upper unit, 600-900'	Not present
Middle Cherty unit, 1500' - 2600'	Upper Cherty unit, 500' - 700'
Lower unit, 700'	Middle and Lower units, 700'

If the above correlation is correct the lower subsurface unit is remarkably consistent in thickness and character over a very long distance, being about 700 feet thick. The cherty unit on the other hand, is much thicker than its outcrop equivalent, both in the eastern Interior Plains (500 to 700 feet) and the northern Mackenzie Mountains (600 to 1,100 feet).

It is reasonable to assume that the subsurface middle cherty unit is equivalent to at least part of the Mount Kindle formation. It is uncertain whether this cherty

unit constitutes the entire Mount Kindle formation or just a part of it. As the subsurface markers are so vague, it is premature to attempt to carry the terms Franklin Mountains and Mount Kindle.

It is difficult to decide where to place the top of the Ronning group in the subsurface. It must be remembered that the top of the Ronning where defined in outcrops in the Franklin Mountains is the sub-Devonian unconformity - an unknown amount of section has been eroded.

As most formations thicken in the subsurface northwest from the Franklin Mountains, it would not be surprising if younger Ronning strata are encountered than occur in outcrop. This appears to be the case -- the upper subsurface unit of non-cherty dolomite appears to be younger than any Ronning strata seen in outcrop in the Mackenzie and Franklin Mountains or the Interior Plains. The problem of picking the top of the Ronning group is discussed further under the heading 'Devonian-Silurian, Subsurface' and it must be pointed out here that all or part of the upper subsurface unit could be a part of the 'Delorme' formation.

Regional Distribution of Upper Cambrian-Silurian Rocks

Rocks of this long time interval are treated as one unit on Fig. 4 in spite of the fact that there is at least one regional unconformity, i.e. at the base of the Upper Ordovician. There is just not sufficient data to subdivide these rocks in most areas, either in outcrop or in the subsurface.

The carbonate facies, i.e. the Ronning group, is very widespread, extending from the shield in the east to near the Richardson Mountains in the west, a distance of over 300 miles. Probably the carbonate once extended well to the east of the present boundary of the shield as, although the section thins, there is no evidence of a shoreline facies in the outcrops fringing the shield. Thickness changes are gradual, in general the unit thickens from east to west. To the west, in the Richardson trough, the carbonates give way to a thick shale facies, the Road River formation.

Although there is insufficient information to construct a meaningful isopach map, the distribution and thickness of the Ronning group as recorded on Fig. 4 lead to several generalizations:-

1. A positive area is indicated in the vicinity of Norman Wells. The southwestern bulge of the Canadian Shield is reflected in the line marking the eastern eroded edge of the 'Delorme' formation. Within this bulge are the areas wherein pre-Devonian erosion has truncated the Mount Kindle formation and possibly (at Shell Keele River L-4) has truncated the entire Ronning. Of course these limited areas of deepest pre-Devonian erosion might be a result of growth structures related to Cambrian salt, rather than to the existence of a regional high, nevertheless the evidence suggests a broad positive arch which has existed since late Silurian time.

2. The Ronning equivalent is very thin in the Inuvik area (northwestern part of the map). Furthermore, it is probable that only the upper part, or Mount Kindle formation is represented, and overlies Precambrian rocks. It is apparent that another positive feature lies in this area. The trend of this feature is unknown, but it is reasonable to postulate a northeast trend, in line with the predominant Franklinian geosyncline structures.

3. Subsurface data indicate a pronounced thickening of the Ronning group in the vicinity of the Ontaratue wells. It is apparent that there is a sub-basin or trough in this area, but its size, extent and orientation are unknown. There is no evidence to indicate that the Road River shale facies extended into this negative area, however there is plenty of room in the undrilled area for this to happen. It is tempting to postulate an east-northeast trending trough extending from the southern Richardson Mountains to the structural saddle where old Paleozoic rocks cross the Coppermine Arch.

DEVONIAN-SILURIAN

Southern Mackenzie Mountains

In the easternmost Mackenzie Mountains, the Franklin Mountains and in the eastern Interior Plains, the sub-Devonian unconformity represents a time gap from Middle Silurian to late Lower Devonian or longer. Sediments of this age, if ever deposited in these areas, have been removed prior to deposition of the Bear Rock formation. West of the front ranges of the Mackenzie Mountains however, the sedimentary record is more complete and several formations are present representing this time interval. These beds are very thick in the central part of the geosyncline but thin rapidly eastward and pinch out due to both depositional thinning and unconformities.

In the southern Mackenzie Mountains, several formations have been recognized, from late Silurian to lower Middle Devonian. These are the Delorme, Camsell and Sombre formations.

Northern Mackenzie Mountains

In the western part of the Northern Mackenzie Mountains, Fig. 5, there is a westward thickening wedge of dolomite above the Ronning group and below the Bear Rock equivalent (i.e. the Gossage formation). This dolomite is termed the 'Delorme' formation in Ziegler, 1967. The 'Delorme' thickens from zero near the Arctic Red River to over 2,500 feet near the Snake River. Farther west the relationships are obscure, but the formation apparently shales out rapidly and is equivalent to the upper part of the Road River formation. The unit consists of dolomite, minor limestone, mostly micro to fine crystalline, in part sublithographic, with only rare beds coarser than fine crystalline. The dolomite is brown, thin bedded, often laminated with thin layers or laminae of microbreccia, and is pyritic. Prominent yellow-orange weathering zones mark the base and top of the formation - these zones also consist of thin bedded dolomite which is siltier and more pyritic than the rest of the formation. These orange markers probably mark regional unconformities, although there is no noticeable discordance in the bedding across the contacts.

It should be noted that the wedge of dolomite is not evident in the Geological Survey of Canada reports by Norford, 1964, or Norris, 1967. These authors apparently did not recognize the 'Delorme' as a distinct unit because in some Geological Survey of Canada field sections parts of this unit are lumped with the Gossage and in others with the Ordovician-Silurian. For this reason the 'Delorme' is written in quotation marks to indicate that it is not officially recognized or named.

Subsurface

Fig. 7 illustrates how the carbonate section between the top of the Bear Rock and the base of the Ronning group thickens considerably in the subsurface northwest of Fort Good Hope. All stratigraphic units appear to thicken, however it is virtually certain that part of the increased thickness is due to the presence of the 'Delorme' formation. In Appendix I, the problem of correlation is discussed, and it will be noted that none of the markers, other than the top of the Bear Rock and the base of the Ronning are reliable. Neither the base of the Bear Rock nor the top of the Ronning (which coincide and are fairly obvious in Atlantic Shoals C-31 and Beavertail G-26) can be identified with confidence in the deeper part of the basin. The problem of defining the top of the Ronning group in the subsurface was discussed previously under the heading "Upper Cambrian-Ordovician-Silurian, Subsurface". The problem of recognizing the top of the Ronning and of identifying the presence of the 'Delorme' are related.

In outcrop in the northern Mackenzie Mountains the 'Delorme' formation is bracketed by prominent orange weathering markers and is therefore easily mapped. Perhaps for this reason there is little attention paid in published reports to the nature of these contacts. It has been noted however, that there is an abundance of silt and pyrite in the orange weathering dolomite.

In the subsurface of course, these beds do not weather orange. Unfortunately nearly all of the thick Cambrian to Devonian carbonates are silty and pyritic to

some extent. Ordinary sample logging methods do not seem to be adequate to detect the markers at the top and base of the 'Delorme'. Presumably a detailed analysis with a quantitative measurement of insoluble residue would solve the problem.

As picked on Fig. 7, the 'Delorme' formation consists of dolomite with subordinate limestone, micro- to cryptocrystalline. A silty-shaly zone overlies the formation. The base is picked on a slight increase in grain size. An increase in the amount of silt and pyrite can be noted in two of the wells. As noted previously, the base of the 'Delorme' (top of the Ronning) is far from certain. In several respects the 'Delorme' in outcrop resembles the upper unit of the Ronning group as picked in the subsurface:-

- mainly micro to fine crystalline dolomite, rarely coarser,
- very little chert,
- presence of a minor percentage of limestone,
- overlies highly siliceous or cherty, up to coarse crystalline dolomite.

It is quite possible therefore, that the base of the 'Delorme' may be lower than is indicated on Fig. 7.

Regional Distribution of the Devonian-Silurian Rocks

There is insufficient information available from published reports to present a regional picture of these rocks. Note however, that Ziegler 1967, p. 10, does present such an interpretation. The eastern edge of the 'Delorme' formation shown on Fig. 4 is taken from Ziegler's map. The rocks consist of carbonates in the eastern flank of the Mackenzie Geosyncline grading to a shale facies in the center of the geosyncline. The section is rapidly truncated from west to east by a sub-Devonian unconformity.

LOWER-MIDDLE DEVONIAN

Rocks of this age are only briefly treated in this report. Names involved in this group are the Bear Rock, Gossage and Prongs Creek formations.

It is convenient to regard these names as rock facies. The Bear Rock is an evaporitic facies - interbedded dolomite and anhydrite or, in outcrop, a brecciated rock. The Bear Rock evaporitic facies grades to the west and northwest into a normal marine carbonate which has been named the Gossage formation (Tassonyi, 1967).

The Gossage consists of an upper cryptocrystalline limestone characterized by an abundance of pellets and a lower part consisting of dolomite with subordinate limestone. The Gossage facies is the most widespread, extending across most of the Interior Plains.

To the west the Gossage carbonate grades to a shale facies named the Prongs Creek formation (Norris, 1967). The carbonate to shale gradation occurs west of the Snake River (Fig. 5) and there is evidence to indicate the presence of a reef complex along this facies front.

A widespread unconformity marks the base of this group of rocks. In the eastern Interior Plains, the Bear Rock formation lies on beds of Ordovician to Middle Silurian age; locally, as in parts of the Franklin Mountains, the Bear Rock lies on beds as old as Upper Cambrian. To the west, this unconformity is less pronounced and in the Richardson trough the Prongs Creek shale lies with apparent conformity on the Road River formation.

GEOLOGY OF THE LAC MAUNOIR AREA

The information on outcrop geology, presented on Fig. 8, is taken from a map purchased by United Canso from V. Zay Smith Associates Ltd., a part of a larger mapping project carried out in 1967.

Most of the area is mantled by glacial drift, therefore the distribution of formations is only approximate. No Cretaceous beds are mapped within or near any of the permits. Thin patches of Cretaceous may be present, nevertheless, and hidden by the drift.

The eastern eroded edge of the Bear Rock formation runs roughly north-south through the area. Approximately one-half of the area under permit is overlain by the Bear Rock formation; in the remainder of the area the Ronning formation forms bedrock.

STRUCTURE

In the Lac Maunoir area there are several long, narrow, sinuous ridges. The orientation of these ridges is somewhat erratic, however they roughly fit into two sets:- north-northwest and east-northeast. In spite of the sharp relief there is very little outcrop. From the few dips available and from air photographs, these ridges all appear to be anticlines or faulted anticlines. Most of the structures are somewhat assymetrical and show some indication of faulting. With minor exceptions, the upthrown side is on the east.

The folds occur in carbonate rocks of from Ordovician to basal Devonian age (Ronning group and Bear Rock formation). The only Cretaceous rocks involved are a patch of steeply-dipping sandstones west of the Belot structure; these are in fault contact with the underlying Bear Rock formation. The age of the structures is post-early Devonian and in part at least, post-Cretaceous.

The Lac Belot fold is the longest continuous ridge. For nearly forty miles this ridge follows a sinuous north-northwest course. Near its northern end the ridge

bifurcates and a branch strikes to the northeast for a distance of thirty miles. The fault at the junction of this bifurcation is one of the few in which the west side is upthrown. For the most part the fold appears approximately symmetrical with flank dips [illegible] to [illegible], however segments of both flanks appear to be faulted. Near the mid-point of the west flank of the Beloc, the west flank is in fault contact with west-dipping basal [illegible] saturated sandstone. For most of its length the ridge has a vertical relief of 400 to 500 feet. At the [illegible] which expose Ordovician-Silurian rocks the relief is over 1,000 feet.

The Beloc anticline is the most westerly ridge. Other structures are smaller and shorter and are generally lower in relief. Following are descriptions of ridges which occur within United Canso permits.-

[illegible] Lake - This ridge trends east-northeast. It is twenty-two miles long and one to one and one-half miles wide. The ridge rises up to 400 feet above the lakes on either side. The southeast slope appears to be a gentle dip slope, under ten degrees. The northwest side of the ridge is steeper and may be a fault scarp. Nearly all of this structure is covered by permits 5751 to 5754.

Northeast of [illegible] - This is a short broad uplift about five miles wide covered by permits 5907 and 5908. It appears to be composed of two anticlines separated by a shallow syncline. The eastern anticline is seven miles long and has very gentle flanks. The western fold is longer and appears to be en-echelon with a large fold north of these permits. Along the west flank there are canyons or deep lake valleys which expose up to 300 feet of cherty dolomite of the Ronning group. Dips up to 30 degrees west occur on the west flank, these high dips and the steep west facing scarp may indicate a fault, east side upthrown. This structure has a topographic relief of about 700 feet.

Southeast of [illegible] - This is a 20 mile long anticline with flank dips estimated up to 25 degrees. The eastern slope of the ridge is probably a dip

slope, the western face is steeper and may be a weathered fault scarp. The culmination lies south of permits 5905 and 5906, however the structure continues through these two permits with a north-northwest trend. There is a suggestion of a transverse structure immediately south of these permits which divides the northern part from the main structure. This anticline is formed in the Ronning dolomite. Vertical relief in the permit area is about 600 feet, the culmination to the south rises another 300 feet.

North of Lac Maunoir - This hill, with 800 feet of relief, appears to be the northern half of an elongate dome. There is no topographic expression of a southern half. To the north the dome tails off into a northeast-trending narrow ridge. The flank dips of the dome are up to 25 degrees. The northeastern tail has a fairly steep northwest slope suggesting a fault scarp. To the south the topography flattens abruptly, suggesting the structure is terminated by a cross-fault, but this is only one possibility; the structure probably continues to the south below Lac Maunoir.

POSSIBILITY OF A SUB-BASIN

The idea that there could be a sub-basin in the Lac Maunoir area is based entirely on the presence of the enigmatic structures. In a paper on basin evolution by K.F. Dallmus, 1958, the relationship between subsidence and the growth of intra-basin structures is discussed. In essence the theory is as follows:- The floor of any basin, regardless of its size, is an arc which is convex upwards. With subsidence this arc flattens, moving towards the chord formed by a line joining opposite points on the rim of the basin. As subsidence proceeds the sediments accumulating within the basin will be subject to a decrease in volume, hence compression. One result of compression will be the growth of folds within the central part of the basin.

The structures of the Lac Maunoir area are difficult to explain. They were obviously caused by compression, however they are so distant from the main area of Laramide mountain building that it is difficult to conceive of

horizontal pressures being transmitted from the mountain area. Nevertheless the prevailing opinion seems to be that these structures were formed by compressive forces originating in the Mackenzie Mountains. The force was transmitted by the competent carbonate rocks which slid eastward over a decollement in the Cambrian salt. The Lac Maunoir structures formed over lines of weakness which probably coincide with basement faults. This theory would be strengthened by supposing a relatively thin Paleozoic section in the Lac Maunoir area - the effect of basement faults would be more pronounced.

There are elements in the foregoing theory which are undoubtedly true. The folds were caused by compression. There is probably a decollement at depth - such structures can hardly be explained without one of at least local extent. There is very likely salt, or at least a plastic layer, at depth. Furthermore, at least some of the folding occurred roughly during the Laramide orogeny.

Nevertheless a case can be made against this theory and in favor of an overthickened sedimentary section. First of all, there is no great crustal shortening involved in the Mackenzie Mountain uplift, nothing like that of the Canadian Rockies. Secondly, there is the variable orientation of the Lac Maunoir folds, a situation hard to reconcile with a push from the southwest. On the other hand, forces originating within a subsiding basin would be directed radially, which is nearer the actual case. Furthermore most of the structures appear to be assymetrical with their steepest limb on the northwest side, this is not what would be expected from a push from the southwest. Finally, the Lac Maunoir and Franklin Mountain structures are quite similar in form and in their lack of definite orientation. There is evidence of a thick Cambrian section in the Franklin Mountain belt, therefore by analogy, it is not unreasonable to expect the same in the Lac Maunoir area.

Regarding the age of the folding, it can only be said that the Lac Maunoir folds were formed, in part at least, after Cretaceous time. The Franklin Mountains likewise were affected by the Laramide orogeny. In the Franklin Mountain belt there is evidence for earlier structure growth. The most dramatic evidence is the occurrence of Cretaceous over

Middle Cambrian in Shell Keele River L-4. Other evidence is the pre-Devonian erosion which cuts out the Mount Kindle formation in the Norman Wells area.

As Dallmus points out it is unnecessary to invoke compressive forces transmitted over long distances through undeformed sediments to explain folding within a basin. Folding is a necessary outgrowth of subsidence. At any rate, the possibility of a sub-basin in the Lac Maunoir area, although in the realm of geofantasy, is defensible.

There is no outcrop evidence (very little outcrop of any kind) to suggest that the Ronning formation is unusually thick in the Lac Maunoir area. The anticipated thickening would therefore be confined to Cambrian (or older!) beds.

THEORETICAL PETROLEUM PROSPECTS

In the general area oil stained porous Bear Rock beds are common and several occurrences of oil stained or oil saturated basal Cretaceous sandstone are known. The oil sands nearest the permits are situated on the west side of the Belot structure and on the west shore of Lac Des Bois. It is often assumed that this oil has migrated through the Bear Rock formation because the concentration of oil sands seems to bear some relation to the beveled edge of that formation. This idea is logical but not necessarily the only explanation. Bitumen has been reported in the Ronning dolomite at several locations in the Interior Plains, therefore petroleum has been generated in these or older rocks.

Where the Bear Rock formation is preserved in the permit area, it is too shallow to contain oil pools, however there is a remote possibility of finding mineable residual oil. This is not a completely ridiculous possibility - a great deal of oil has probably escaped from breached Devonian reservoirs. This is indicated by the presence in the subsurface farther southwest of thick oil stained fresh water-bearing porous zones. A somewhat comparable situation exists on the shore of Great Slave Lake where near surface Presquile dolomite beds contain an appreciable amount of residual oil.

Also, the possibility of extensive Cretaceous oil sands must be kept in mind. Considering the paucity of outcrops and the relatively unexplored state of the area there are a remarkable number of shows. Although no Cretaceous beds are mapped in the permit area, bedrock in the low-lying areas is almost entirely masked by glacial drift. Structurally low areas could contain oil sands.

Unless the Ronning formation is much thicker than outcrops suggest, and contains plastic layers at present unknown and unsuspected, this formation is probably effectively breached by fractures, especially over the large structures. For conventional oil production the main hope lies in the rocks of the Macdougal group.

In assessing the petroleum potential of the Macdougal group, it is necessary to examine the pre-salt section. Presumably the salt, which is near the top of the group can be considered as the cap rock. The only known widespread bed with good potential reservoir characteristics is the basal Paleozoic sandstone. In Shell Blackwater Lake G-52 (admittedly a long distance away), porosity is logged in several sands within the Cambrian section. Sandstones occur within the Macdougal group in outcrop along the Coppermine Arch and also in the Mackenzie Mountain type section. For source rocks, there is a thick shale section in the Franklin Mountain area. The shale cored in Shell Keele River L-4 looks just like a piece of Ireton formation. Nauss (in Hume, 1954, p. 10) describes petroliferous shale from below the gypsum section in the Macdougal beds.

In summary, we have in the Lac Maunoir area, several large structures in a very large untested area of marine rocks of unknown thickness. The presence of petroleum is attested by several oil stained dolomite outcrops as well as oil saturated sands in the immediate vicinity. What more is needed to commend the area for further investigation? The fact that the potential section is in Cambrian beds is a minus factor, but cannot condemn the area. A good deal of oil has been found in Cambrian beds (Becker and Patton, 1968).

RECOMMENDATIONS FOR FURTHER WORK

The most important question is the thickness and nature of the Paleozoic section. This question should be answered before any costly geophysical program is undertaken. The only satisfactory way to answer the question is to drill a hole to the base of the Paleozoic. To accomplish this, it will be necessary for United Canso to act together with one or more other permit holders in the area. It makes little difference where the test is located, anywhere in the general area would be satisfactory. From the standpoint of acquiring information, it would probably be preferable to locate the test in a structurally undisturbed area - if the large structures are underlain by a significant decollement, then the deep potentially oil-bearing structures would not directly underlie the surface structures.

In programming a well, the difficulty will be to estimate total depth. Rather than move in a large rig, a modified diamond drilling rig (such as used by Canadian Pacific Oil & Gas in an area farther north) might be advisable. This rig is said to be capable of drilling to 8,000 feet. If 8,000 feet of favorable sediments are proven to be present, then further exploration will be justified.

In the event that a joint venture deep test proves difficult to arrange, some form of geophysical exploration would be justified. In the Lac Maunoir area, a thick unmetamorphosed sequence of sedimentary rocks is anticipated below the Paleozoic. As these Proterozoic sediments will differ little in density, velocity and magnetic susceptibility from the Paleozoic section, it is doubtful that any geophysical method will give a reliable estimate of the thickness of the Paleozoic section.

An aeromagnetic survey would probably yield useful data only if the survey was conducted over a large area -- from the edge of the Precambrian to the Mackenzie River area where there is some subsurface control. United Canso should consider the method only if it is possible to participate in such a regional survey.

If salt is present in the subsurface and has played a roll, either active or passive, in the evolution of the structures, a gravity survey should give useful information. If it is necessary for United Canso to act alone, a gravity survey over the large structures should be a first step. Such a survey might best be carried out in winter using snowmobiles for transport.

Costly conventional seismic work should not be done without prior assurance of a thick, favorable stratigraphic section. It is doubtful if reflection seismic methods could differentiate between Paleozoic and Proterozoic sediments, unless the program were to cover a large area, in which case the basal Paleozoic unconformity should show up. Refraction seismic methods would probably fail to determine depth to the Proterozoic for two reasons:- the similarity of the Paleozoic and Proterozoic sections and also because a thick high velocity carbonate is present at the surface.

Some useful structural information might be obtained by employing water-borne seismic equipment in the large lakes within the permits. Equipment is available which should be adaptable to use on these lakes using boats or rafts small enough to be transported by air. Theoretically at least this method should yield low cost results. This idea should be thoroughly researched to determine its feasibility and approximate cost.

G. K. Williams, P. Geol.

GKW/mk
May, 1969

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APPENDIX I

Discussion of markers, Fig. 7, Log Section Atlantic Shoals C-31 to Atlantic Little Chicago N-32

List of Markers

	Shoals	Beaver-tail	Manitou	Ontaratue K-4	Ontaratue H-34	Grandview Hills	Little Chicago
Top of Ronning	3430'	1917'	2500'	3775'	6035'	3960'	2580'
Marker Q	-	-	-	4680	6850	4720	-
A	4000	2510	3090	5120	7240	5090	3610
F	4195	2640	3335	-	-	-	-
E	4340	2790	3500	5800	7965?	5700	4280
Z	-	-	-	6450	8600	-	-
D	5460	3900	4690	7230	-	-	5590
C	5580	4010	4800	7390	-	-	5700
B	5940	4380	5175	7800	-	-	6090
Top Macdougal Group	6115	4580	5430	7945	9460	-	6250
Salt	6226	4810	5580	8080	-	-	6385
Top Katherine Group	-	-	-	8265?	9500	-	-

General

Correlation by lithology and by gamma-sonic logs is fairly good between the Shoals, Beavertail and Manitou Lake wells. Correlation of the other wells is less certain.

From Manitou Lake to Little Chicago the only reliable markers are the top of the Bear Rock (or Gossage) and the top of the Macdougal group. Other markers, including the top of the Ronning, are open to question. Ontaratue H-34 is especially troublesome.

Top of Ronning

In outcrops along the northern Mackenzie Mountains, the top of the Ronning is marked in most places by a recessive zone of yellow-orange weathering dolomite. The weathered color is due to an increased amount of silt and pyrite in this zone compared to overlying and underlying beds. Although this contact is obvious from a distance, it would be difficult to pick this contact in fresh hand specimens. In outcrops in the Franklin Mountains, the Bear Rock is usually brecciated and lies with a marked erosional contact on the Ronning. Here also the lithological change across the contact may be slight, often being dolomite upon dolomite with little change in appearance.

In attempting to locate the top of the Ronning in the subsurface, I have been guided by varying criteria, however in general I have assumed that the change from Ronning to basal Bear Rock or 'Delorme' will be marked by an increase of terrigenous material, sand, silt or shale.

In Shoals and Beavertail a layer of anhydrite occurs near the base of the Bear Rock. In Shoals there is a shaly zone with a trace of sandstone below the anhydrite and the contact is picked below this clastic layer. In Beavertail the clastic layer is not present.

In Manitou the company marker (2385') is picked on a shale kick on the gamma-log. I have moved the contact down (2500') to the base of a fine fragmental dolomite with faint pellet texture (a Bear Rock characteristic). Traces of sandstone occur at and above this contact.

In the Ontaratue wells, there is no lithological basis for the contact as picked. In Ontaratue H-34 there is a slight increase in the crystal size across the contact. In Ontaratue K-4 the samples below the contact are missing or are fouled by lost circulation material. Note however the similarity in the gamma-logs between the Ontaratue wells and Grandview Hills and Little Chicago.

In Grandview Hills, the contact was picked by E.J. Tassonyi and Atlantic at 3470 feet, near the base of a shaly-silty limestone. I have moved the contact down to

3960 feet, which is a change from microcrystalline very silty dolomite (nearly a siltstone) to a clean fine crystalline dolomite. By lowering the contact to 3960 feet, I place all of the shaly-silty dolomite, limy dolomite and all of the section with high radioactivity within the Bear Rock and 'Delorme' formations. This correlation is weakened however by the traces of chert which occur above 3960 feet. Chert is not characteristic of the Bear Rock or 'Delorme' sections.

In Little Chicago the top of the Ronning (2580') is picked at a change from microcrystalline dolomite with minor layers of limestone to fine crystalline dolomite. The main criterion for this contact is the occurrence of pellets, both in the dolomite and limestone above the 2580-foot mark. This point coincides with a change in the radioactivity; the lower section contains practically no radioactive breaks. No clastic material was noted in the samples of this well. Note that the map of the 'Delorme' by Ziegler, 1967, p. 10, indicates the presence of 'Delorme' formation in this well.

Marker Q

This is a faint color change which can be detected when the samples are viewed with the naked eye -- lighter above, darker below. Marker Q is not in itself a reliable marker, however it brings several changes into juxtaposition in the two Ontaratue wells:-

1. The highest abundant chert (Marker A) occurs about 400 feet lower.

2. The highest fine to medium crystalline dolomite in the Ronning section occurs below Q - about 50 feet lower in H-34, about 150 feet lower in K-4.

3. The dolomite section down to Q in both wells is slightly limy and contains very minor amounts of interbedded limestone.

Marker A

In Shoals, Beavertail and Manitou, this marker shows fair gamma-log correlation, being marked by a shaly kick. In addition there are the following lithological changes:-

1. A marked change in color tone from brownish-grey to light grey.

2. Increase in crystal size.

3. The highest occurrence of abundant chert.

Traces of sand, silt and shale occur at or below this marker in these three wells.

In all of the other wells the only criterion for Marker A is the highest occurrence of abundant chert.

Marker F

This is a vague radioactive kick picked only in Shoals, Beavertail and Manitou.

Marker E

Like Marker A, this is a horizon marked by abundant chert, in most wells probably a zone of solid chert. Chert is fairly abundant between Markers A and E, and also occurs below Marker E. With one exception, Marker E marks the most cherty zone in the wells.

The one exception is Ontaratue H-34 where no chert is logged over this interval. This raises the possibility that in this well Markers A and E have been confused.

Marker Z

Marker Z marks a change from micro to fine crystalline dolomite above, to fine to medium or coarse dolomite below.

Markers C and D

These are gamma-log markers, with good correlation from Shoals to Manitou but with forced correlation to the other wells. No lithologic change was detected.

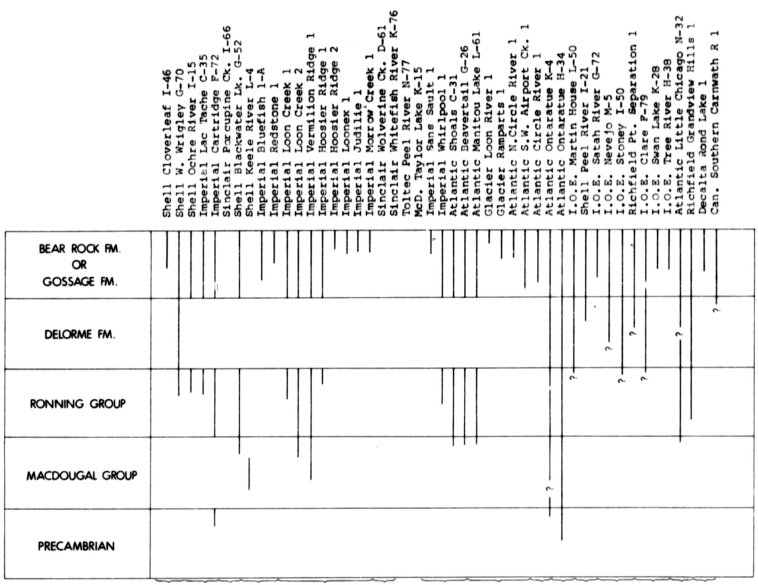
Marker B

This is a gamma-log pick from Shoals to Manitou, with only a vague lithological change detected. Crypto- to microcrystalline dolomite above B changes to a microgranular or very fine, sugary, very silty dolomite below. Correlation to other wells is forced via slight gamma-log similarities, however, in Little Chicago an increased siltiness and increase in grain size was noted.

Top of the Macdougal Group

This marker is picked at the highest occurrence of red and green shale. There is a gradual increase in radioactivity of the basal Ronning formation due to the occurrence of interbedded grey shale in the dolomite. The change to interbedded red shale and dolomite is marked by a further increase of radioactivity.

GRAPHIC SUMMARY OF NORTHERN WELLS WHICH PENETRATE EARLY PALEOZOIC



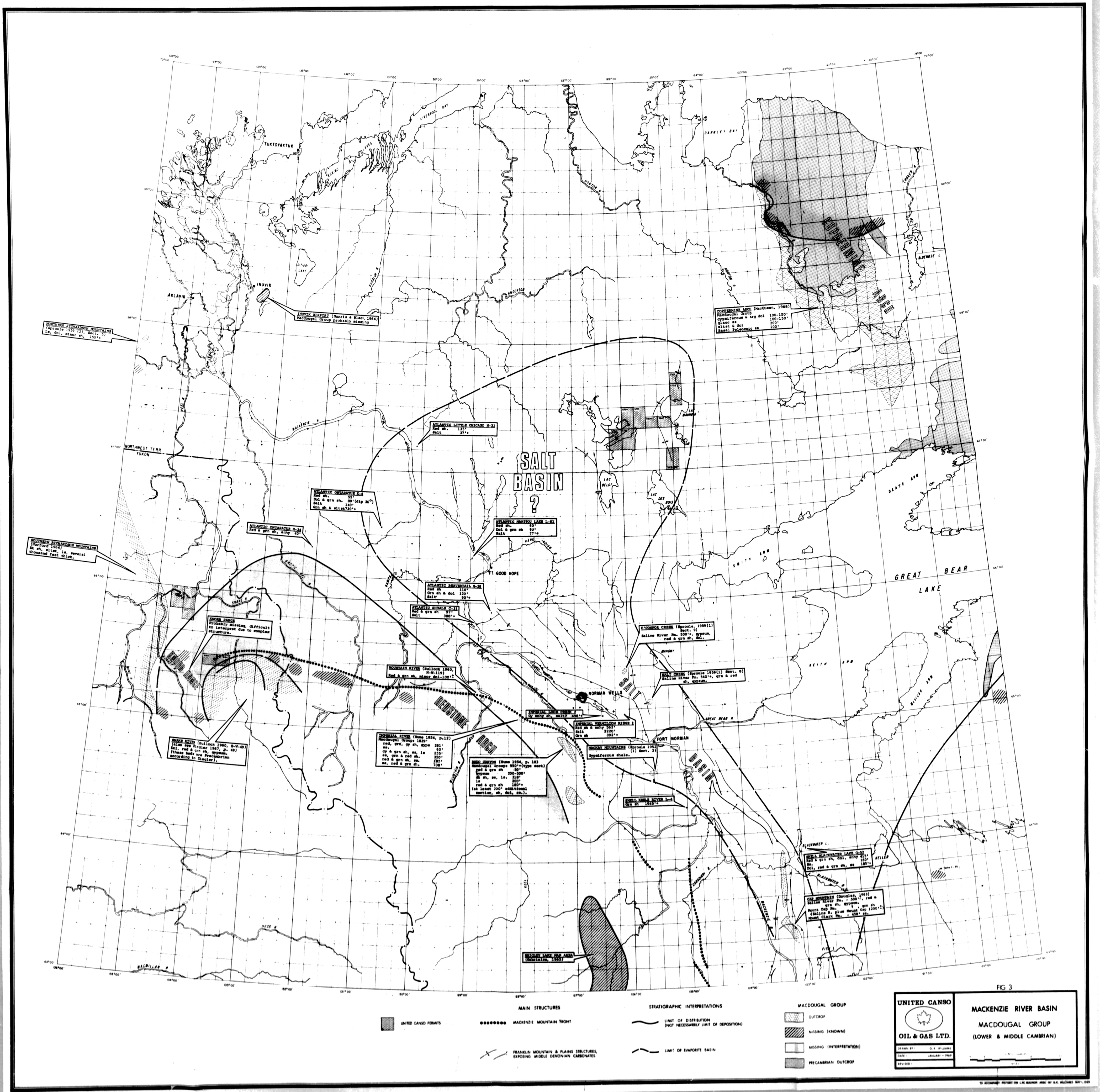
APPENDIX III

United Canso Permits, Lac Maunoir Area

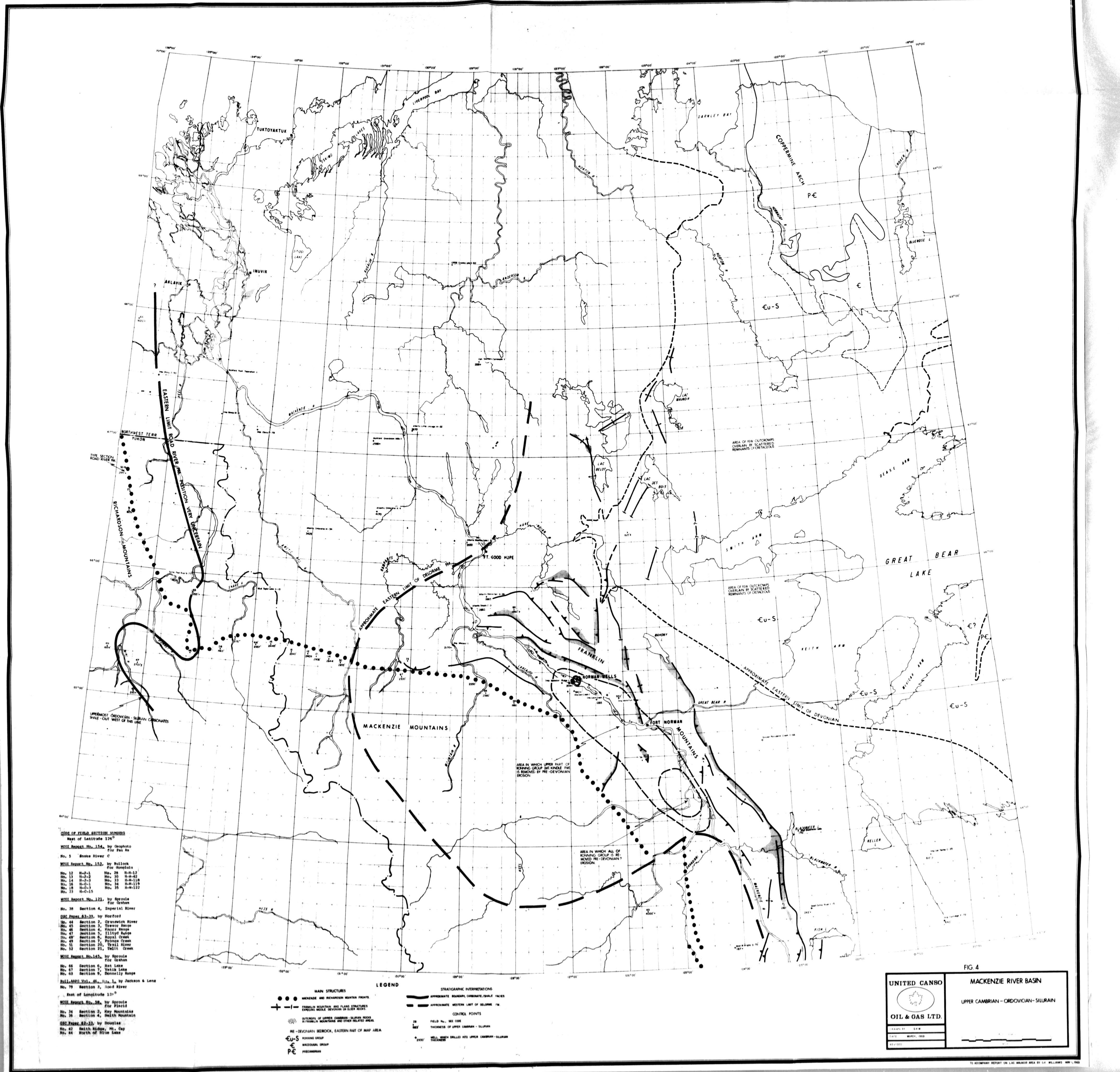
Permit No.	Area	Date	Acreage
5751	67° 20', 125° 45'	27-5-68	49,578
5752	67° 20', 126° 00'	27-5-68	49,578
5753	67° 30', 125° 30'	27-5-68	49,234
5754	67° 30', 125° 45'	27-5-68	49,234
5755	67° 40', 124° 45'	27-5-68	48,890
5904	67° 50', 124° 45'S	29-7-68	24,316
5905	67° 30', 125° 00'S	29-7-68	24,660
5906	67° 30', 125° 15'S	29-7-68	24,660
5907	67° 10', 124° 45'W	29-7-68	24,960
5908	67° 10', 125° 00'E	29-7-68	24,960
		Total	370,070 acres

Work Obligations

1st 18 months	to	27-11-69	5¢/acre	$ 18,503.50
next 30 months	to	27- 5-72	15¢/acre	55,510.50
1st Renewal	to	27- 5-73	30¢/acre	111,021.00
2nd "	to	27- 5-74	40¢/acre	148,028.00
3rd "	to	27- 5-75	50¢/acre	185,035.00
4th "	to	27- 5-76	50¢/acre	185,035.00
5th "	to	27- 5-77	50¢/acre	185,035.00
6th "	to	27- 5-78	50¢/acre	185,035.00



TO ACCOMPANY REPORT ON LAC MAUNOIR AREA BY G.K. WILLIAMS MAY 1, 1969


TUKTOYAKTUK
LIVERPOOL BAY
DARNLEY BAY
COPPERMINE ARCH
P€
INUVIK
AKLAVIK
€u-S
€
LAC MAUNOIR
NORTHWEST TERR
YUKON
EASTERN LIMIT ROAD RIVER FM. POSITION VERY UNCERTAIN
TYPE SECTION ROAD RIVER FM.
RICHARDSON MOUNTAINS
AREA OF FEW OUTCROPS OVERLAIN BY SCATTERED REMNANTS OF CRETACEOUS
LAC BELOT
LAC DES BOIS
FT. GOOD HOPE
APPROXIMATE EASTERN LIMIT OF DELORME FM.
SMITH ARM
GREAT BEAR LAKE
DEASE ARM
KEITH ARM
MAHONY
FRANKLIN
NORMAN WELLS
FORT NORMAN
MOUNTAINS
GREAT BEAR R
APPROXIMATE EASTERN LIMIT OF DEVONIAN
MACKENZIE MOUNTAINS
UPPERMOST ORDOVICIAN - SILURIAN CARBONATES SHALE - OUT WEST OF THIS LINE
AREA IN WHICH UPPER PART OF RONNING GROUP (MT. KINDLE FM) IS REMOVED BY PRE-DEVONIAN EROSION
AREA IN WHICH ALL OF RONNING GROUP IS REMOVED PRE-DEVONIAN ? EROSION.
BLACKWATER L
KELLER L
HESS R
FIG. 4
CODE OF FIELD SECTION NUMBERS
West of Latitude 126°
WCGI Report No. 154, by Geophoto for Pan Am
No. 5 Snake River C
WCGI Report No. 153, by Bullock for Honolulu
No. 12 H-J-1 No. 28 H-H-12
No. 13 H-J-2 No. 30 H-W-42
No. 14 H-J-3 No. 33 H-W-118
No. 16 H-C-1 No. 34 H-W-119
No. 18 H-C-3 No. 35 H-W-122
No. 23 H-C-15
WCGI Report No. 121, by Sproule for Graham
No. 38 Section 4, Imperial River
GSC Paper 63-39, by Norford
No. 44 Section 2, Cranswick River
No. 45 Section 3, Trevor Range
No. 46 Section 4, Knorr Range
No. 47 Section 5, Illtyd Range
No. 48 Section 6, Royal Creek
No. 49 Section 7, Pronge Creek
No. 51 Section 20, Trail River
No. 52 Section 21, Telit Creek
WCGI Report No.145, by Sproule for Graham
No. 66 Section 6, Rat Lake
No. 67 Section 7, Yatik Lake
No. 68 Section 9, Donnelly Range
Bull.AAPG Vol. 46, No. 1, by Jackson & Lenz
No. 79 Section 3, Road River
East of Longitude 126°
WCGI Report No. 58, by Sproule for Placid
No. 34 Section 2, Kay Mountains
No. 36 Section 4, Smith Mountain
GSC Paper 62-33, by Douglas
No. 42 Smith Ridge, Mt. Cap
No. 44 North of Blue Lake
LEGEND
MAIN STRUCTURES
MACKENZIE AND RICHARDSON MOUNTAIN FRONTS.
FRANKLIN MOUNTAIN AND PLAINS STRUCTURES EXPOSING MIDDLE DEVONIAN ON OLDER ROCKS.
OUTCROPS OF UPPER CAMBRIAN - SILURIAN ROCKS IN FRANKLIN MOUNTAINS AND OTHER ISOLATED AREAS.
PRE-DEVONIAN BEDROCK, EASTERN PART OF MAP AREA
€u-S RONNING GROUP
€ MACDOUGAL GROUP
P€ PRECAMBRIAN
STRATIGRAPHIC INTERPRETATIONS
APPROXIMATE BOUNDARY, CARBONATE/SHALE FACIES
APPROXIMATE WESTERN LIMIT OF DELORME FM.
CONTROL POINTS
28 FIELD No., SEE CODE
1963' THICKNESS OF UPPER CAMBRIAN - SILURIAN
2930' WELL WHICH DRILLED INTO UPPER CAMBRIAN - SILURIAN THICKNESS
UNITED CANSO
OIL & GAS LTD.
DRAWN BY G.K.W.
DATE MARCH, 1969
REVISED
MACKENZIE RIVER BASIN
UPPER CAMBRIAN – ORDOVICIAN – SILURAIN
TO ACCOMPANY REPORT ON LAC MAUNOIR AREA BY G.K. WILLIAMS MAY 1, 1969

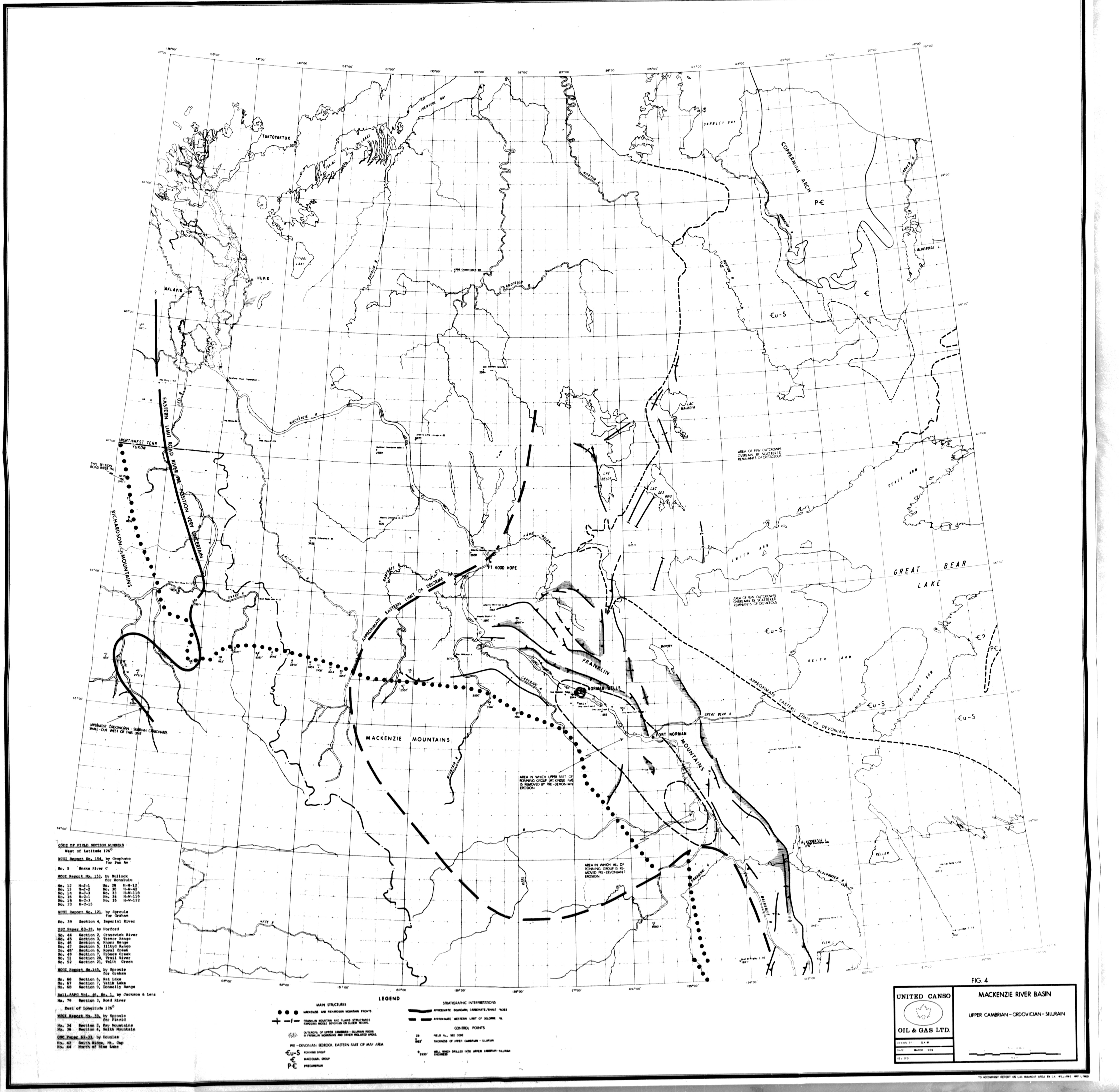
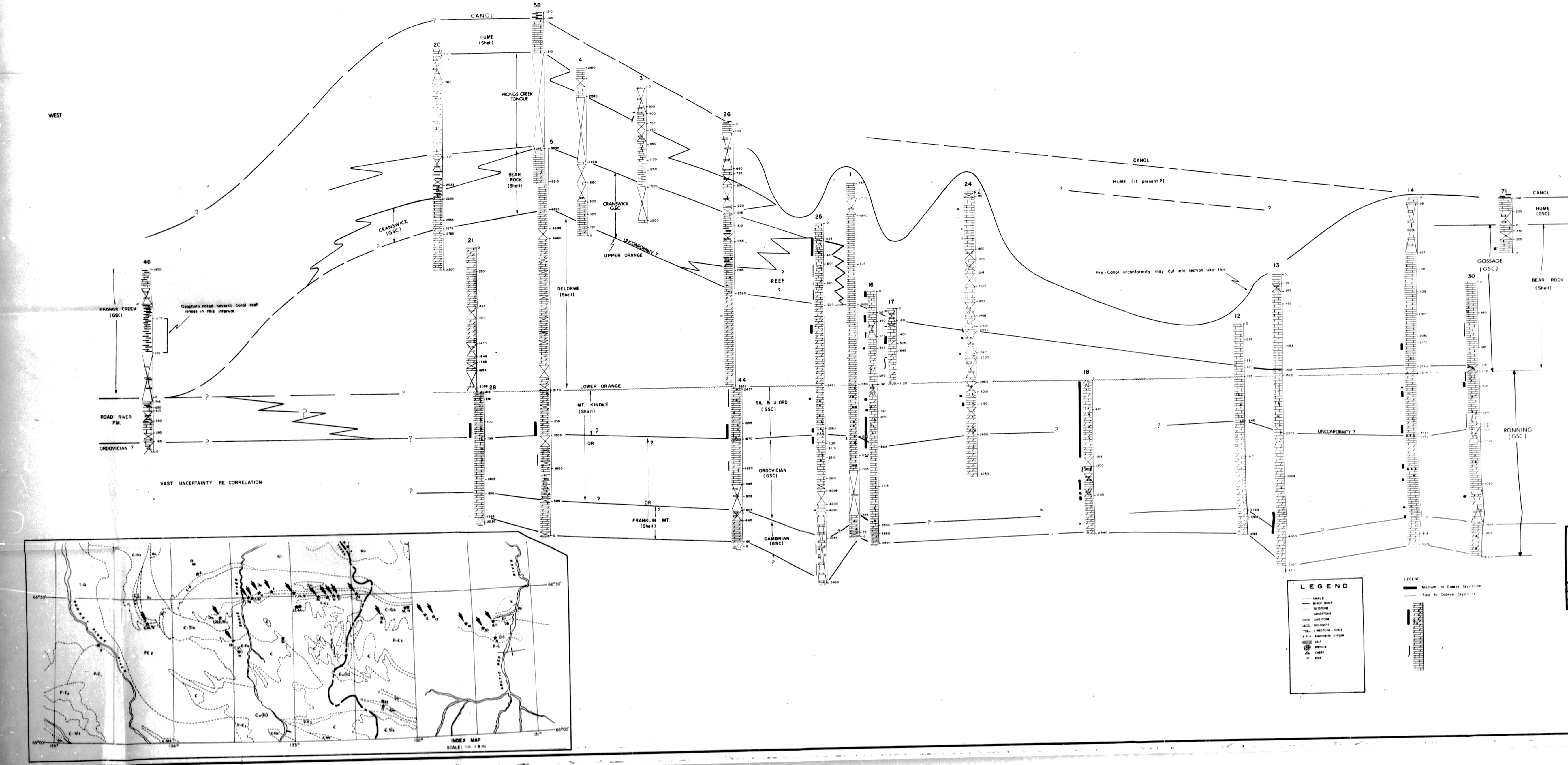

TUKTOYAKTUK
INUVIK
AKLAVIK
LIVERPOOL BAY
DARNLEY BAY
COPPERMINE ARCH
P€
€
€u-S
ANDERSON
MACKENZIE R.
NORTHWEST TERR
YUKON
TYPE SECTION ROAD RIVER FM.
EASTERN LIMIT ROAD RIVER FM. POSITION VERY UNCERTAIN
RICHARDSON MOUNTAINS
FT. GOOD HOPE
APPROXIMATE EASTERN LIMIT OF DELORME FM.
LAC MAUNOIR
LAC BELOT
LAC DES BOIS
AREA OF FEW OUTCROPS OVERLAIN BY SCATTERED REMNANTS OF CRETACEOUS
SMITH ARM
GREAT BEAR LAKE
DEASE ARM
KEITH ARM
MCVICAR ARM
FRANKLIN
NORMAN WELLS
FORT NORMAN
MOUNTAINS
GREAT BEAR R.
APPROXIMATE EASTERN LIMIT OF DEVONIAN
MACKENZIE MOUNTAINS
UPPERMOST ORDOVICIAN - SILURIAN CARBONATES SHALE OUT WEST OF THIS LINE
AREA IN WHICH UPPER PART OF RONNING GROUP (MT. KINDLE FM.) IS REMOVED BY PRE-DEVONIAN EROSION.
AREA IN WHICH ALL OF RONNING GROUP IS REMOVED PRE-DEVONIAN ? EROSION.
HESS R.
KEELE
DAHADINNI R.
MACKENZIE
BLACKWATER L.
BLACKWATER R.
KELLER L.
FISH L.
CODE OF FIELD SECTION NUMBERS
West of Latitude 126°
WCGI Report No. 154, by Geophoto for Pan Am
No. 5 Snake River C
WCGI Report No. 153, by Bullock for Honolulu
No. 12 H-J-1 No. 28 H-H-12
No. 13 H-J-2 No. 30 H-W-42
No. 14 H-J-3 No. 33 H-W-118
No. 16 H-C-1 No. 34 H-W-119
No. 18 H-C-3 No. 35 H-W-122
No. 23 H-C-15
WCGI Report No. 121, by Sproule for Graham
No. 38 Section 4, Imperial River
GSC Paper 63-39, by Norford
No. 44 Section 2, Cranswick River
No. 45 Section 3, Trevor Range
No. 46 Section 4, Knorr Range
No. 47 Section 5, Illtyd Range
No. 48 Section 6, Royal Creek
No. 49 Section 7, Prongs Creek
No. 51 Section 20, Trail River
No. 52 Section 21, Telit Creek
WCGI Report No.145, by Sproule for Graham
No. 66 Section 6, Rat Lake
No. 67 Section 7, Yatik Lake
No. 68 Section 9, Donnelly Range
Bull.AAPG Vol. 46, No. 1, by Jackson & Lenz
No. 79 Section 3, Road River
East of Longitude 126°
WCGI Report No. 58, by Sproule for Placid
No. 34 Section 2, Kay Mountains
No. 36 Section 4, Smith Mountain
GSC Paper 62-33, by Douglas
No. 42 Smith Ridge, Mt. Cap
No. 44 North of Blue Lake
LEGEND
MAIN STRUCTURES
MACKENZIE AND RICHARDSON MOUNTAIN FRONTS.
FRANKLIN MOUNTAIN AND PLAINS STRUCTURES EXPOSING MIDDLE DEVONIAN ON OLDER ROCKS.
OUTCROPS OF UPPER CAMBRIAN - SILURIAN ROCKS IN FRANKLIN MOUNTAINS AND OTHER ISOLATED AREAS.
PRE-DEVONIAN BEDROCK, EASTERN PART OF MAP AREA
€u-S RONNING GROUP
€ MACDOUGAL GROUP
P€ PRECAMBRIAN
STRATIGRAPHIC INTERPRETATIONS
APPROXIMATE BOUNDARY, CARBONATE/SHALE FACIES
APPROXIMATE WESTERN LIMIT OF DELORME FM.
CONTROL POINTS
FIELD No., SEE CODE
THICKNESS OF UPPER CAMBRIAN - SILURIAN
WELL WHICH DRILLED INTO UPPER CAMBRIAN - SILURIAN THICKNESS
UNITED CANSO OIL & GAS LTD.
DRAWN BY: G.K.W.
DATE: MARCH, 1969
REVISED:
MACKENZIE RIVER BASIN
UPPER CAMBRIAN - ORDOVICIAN - SILURAIN
MILES
TO ACCOMPANY REPORT ON LAC MAUNOIR AREA BY G.K. WILLIAMS MAY 1, 1969

FIG. 4



WEST
EAST
CANOL
HUME (Shell)
PRONGS CREEK TONGUE
BEAR ROCK (Shell)
CRANSWICK (GSC)
CRANSWICK GSC
UNCONFORMITY ?
UPPER ORANGE
DELORME (Shell)
REEF
LOWER ORANGE
MT. KINDLE (Shell)
OR
SIL. & U. ORD. (GSC)
ORDOVICIAN (GSC)
FRANKLIN MT. (Shell)
CAMBRIAN (GSC)
PRONGS CREEK (GSC)
Geophoto noted several coral reef lenses in this interval.
ROAD RIVER FM.
ORDOVICIAN ?
VAST UNCERTAINTY RE CORRELATION
HUME (if present ?)
Pre-Canol unconformity may cut into section like this
UNCONFORMITY ?
HUME (GSC)
GOSSAGE (GSC)
BEAR ROCK (Shell)
RONNING (GSC)
LEGEND
INDEX MAP
SCALE: 1 in. = 8 mi.

CODE TO FIELD SECTION NUMBERS

WCGI Report No. 154, by Geophoto for Pan Am

No. 1 Moose Ridge
No. 3 Unconformity Ridge
No. 4 Snake River A
No. 5 Snake River C

WCGI Report No. 153, by Bullock for Honolulu

No. 12 H-J-1
No. 13 H-J-2
No. 14 H-J-4
No. 16 H-C-1
No. 19 H-C-3
No. 20 H-C-5
No. 21 H-C-10
No. 24 H-H-6
No. 25 H-H-7
No. 26 H-H-8
No. 27 H-H-9
No. 28 H-H-12
No. 30 H-W-42

WCGI Report No. 171, Sinclair

No. 58

GSC Paper 63-39, by Norford

No. 44 Section 2, Cranswick River
No. 46 Section 4, Knorr Range

GSC Paper 66-39, by Norris

No. 71 Section 2, Arctic Red River

FIGURE 5

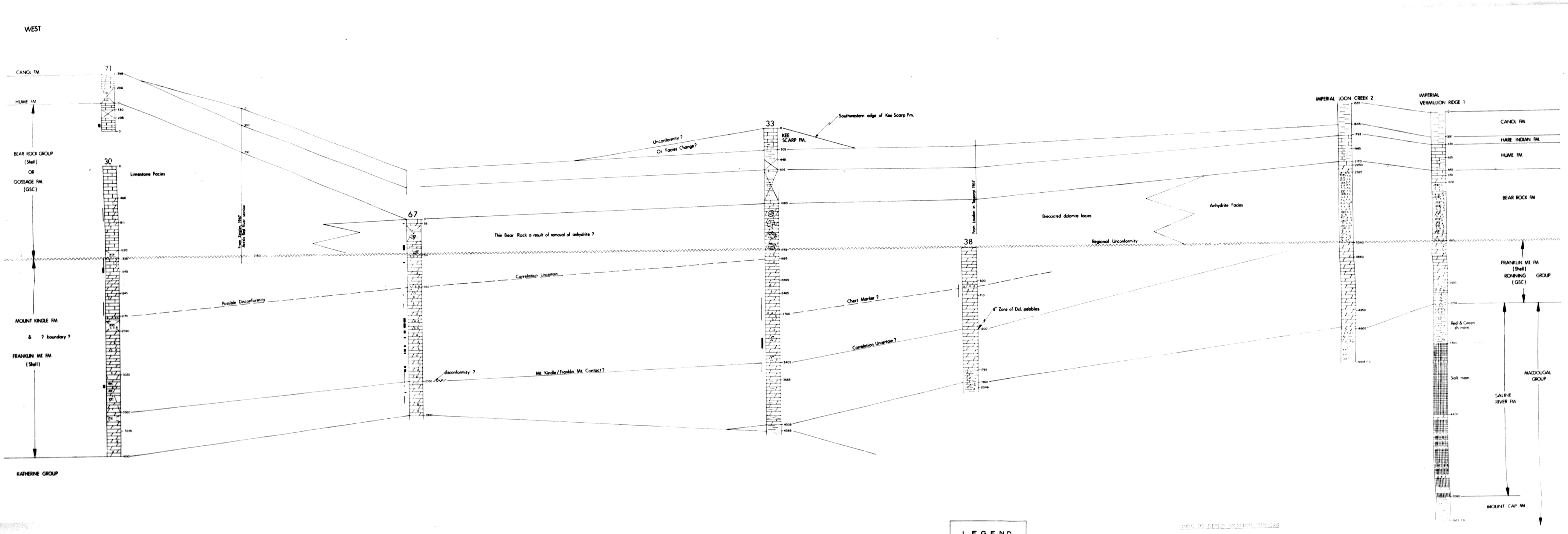
UNITED CANSO OIL & GAS LTD.

DRAWN BY: G K W
DATE: MARCH 19, 1969
REVISED

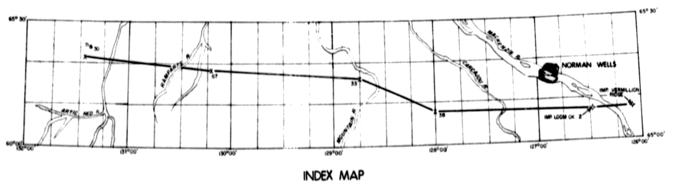
CROSS SECTION

CANYON RANGES, MACKENZIE MOUNTAINS
KNORR RANGE to ARCTIC RED RIVER

HORIZ SCALE 1 inch = 2 miles
VERT SCALE 1 inch = 500 feet


WEST
EAST
CANOL FM
HUME FM
BEAR ROCK GROUP
(Shell)
OR
GOSSAGE FM
(GSC)
MOUNT KINDLE FM
& ? boundary ?
FRANKLIN MT FM
(Shell)
KATHERINE GROUP
71
30
Limestone Facies
67
33
KEE SCARP FM.
Southwestern edge of Kee Scarp Fm.
Unconformity ?
Or Facies Change ?
38
Thin Bear Rock a result of removal of anhydrite ?
Brecciated dolomite facies
Anhydrite Facies
Regional Unconformity
Correlation Uncertain
Possible Disconformity
Chert Marker ?
4" Zone of Dol. pebbles
Correlation Uncertain ?
disconformity ?
Mt. Kindle/Franklin Mt. Contact ?
IMPERIAL LOON CREEK 2
IMPERIAL VERMILLION RIDGE 1
CANOL FM
HARE INDIAN FM
HUME FM
BEAR ROCK FM
FRANKLIN MT FM
(Shell)
RONNING GROUP
(GSC)
Red & Green sh mem
Salt mem
SALINE RIVER FM
MACDOUGAL GROUP
MOUNT CAP FM

LEGEND



INDEX MAP

UNITED CANSO OIL & GAS LTD.

FIG 6

CROSS SECTION

ARCTIC RED RIVER TO IMPERIAL VERMILLION RIDGE 1

DRAWN BY	GEOLOGY BY	SCALE	DATE
CHECKED BY	TRACED BY	FILE	REVISED