Subcrop pattern of Miss. strata and thinning of Upper Devonian section (1000'-1500') suggest the Liard Uplift is a positive element, whose flanks may be fault controlled. It was uplifted and eroded during the post-Miss., pre-Cretaceous interval. Uplift occurred during the Laramide orogeny.

Reefoid carbonate build ups on top of Middle Devonian carbonate anticipated in this area.

The West Tathlina High is a structural element, which may be partly fault controlled, that probably originated early in the Paleozoic Era and persisted as a positive feature through Middle Devonian time when it became submerged.

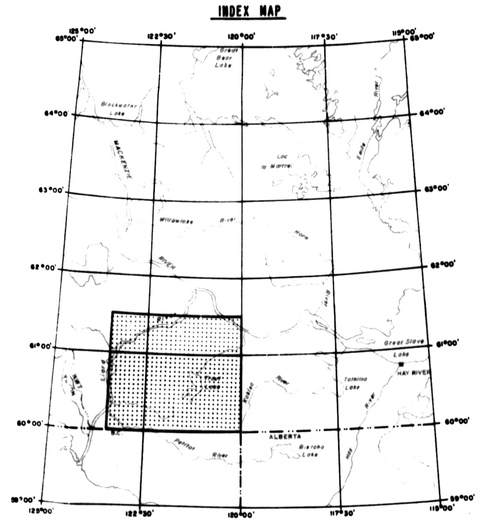
Northeasterly trending faults anticipated in this area.

Northeasterly trending faults anticipated in this area.

In this area the Slave Point front is positioned after published accounts by McCamis & Griffith (1967), Bassett & Stout (1967) and Ziegler (1969). Confirming well control is lacking in N.W.T.

Miss. strata thin markedly (1500-2000') over the crest of the Celibeta Uplift. It is a positive element whose flanks may be fault controlled. Structural relief on the base of Cretaceous is subdued (500') compared to relief on the Middle Devonian carbonate (2500-3000'). Thus, the structure apparently was uplifted and eroded in the post-Miss, pre-Cretaceous interval and subsequently uplifted during the Laramide orogeny.

INDEX MAP



LEGEND

◇ -2930	Elevation of structural datum in well
X -3375	Elevation of structural datum based on projection from topographic elevation of surface geology to the datum.
NR	Structural datum not penetrated by well.
DNR	Well data not released.
-5500	Structural contour.

Note: Other structural symbols as shown in Areal Geology Map.

WELL SYMBOLS

○	Well location or drilling location.
◇	Dry and abandoned test.
●	Oil well
◈	Capped oil well.
✱	Oil and gas well.
✱	Capped oil and gas well.
✲	Gas well.
✱	Capped gas well.

REGIONAL STRUCTURAL CONTOUR MAP OF THE TROUT LAKE ~ CELIBETA AREA NORTHWEST TERRITORIES

SCALE: 1 INCH TO 4 MILES

4 2 0 4 8 12 MILES

Structural Datum: Top of Middle Devonian carbonate
Contour Interval: 500 feet

— Prepared by —
V. ZAY SMITH ASSOCIATES LTD.
CALGARY, ALBERTA.

Approximate outline of weak basement high derived from magnetic survey

Mineralized (chalcopyrite) discordant carbonatized dikes, which strike N. 18° W., and dip 84° W., occur in silicified fracture zone 900' long and up to 80' wide in Upper Devonian shale. An igneous source of sulphide mineralization is possible, and dikes may have been intruded cataclysmically and metasomatized according to Read (1970).

Outcrops along scarp face

Approximate outline of southwesterly plunging basement high derived from magnetic survey

Approximate outline of closed basement high derived from magnetic survey

Approximate outline of basement high derived from magnetic survey

Bedrock mantled by glacial drift

P6441

P6432

P6439

RAMPARTS

FAULT

PETITOT RIVER

SWAN LINE

FAULT

LIARD FAULT

RIVER

Mantled

Qal

Dfs

Dm

PC

Kj

Dr

Dk

Dtr

Kfn

Kk

Kw

Mr

RADA III

RDA III

TADA

DCA

Dtf

ADA II

RADA III

PADA III

RDA II

ADA III

RADA II

TRDA II

RDA III

TRDA III

ARDA

Mantled

165'/mile

850'/mile

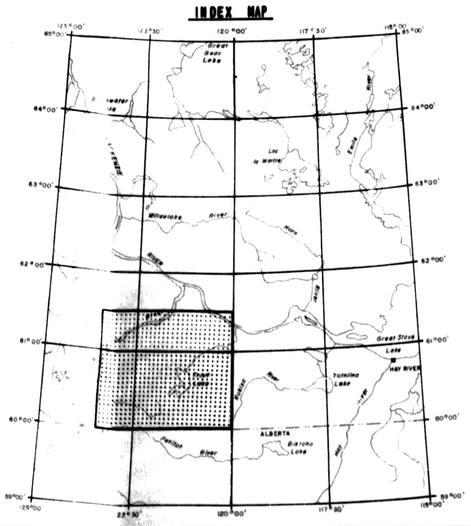
650'/mile

500'/mile

150'/mile

50'/mile

INDEX MAP



GEOLOGICAL FORMATIONS

QUATERNARY	Qal	Mainly Recent alluvium
UPPER CRETACEOUS	Kw	Wapiti Group mainly ss
	Kk	Kotaneelee Fm shale
	Kfn	Fort Nelson Fm ss, cgl, sh
LOWER CRETACEOUS	Kj	Fort St John Gp mainly shale
PERMIAN AND CARBONIFEROUS	PC	Permian and Carboniferous rocks undivided Includes Fantasque (chert, ss), Kindle (ss, sh, ls), Fratt (ls), Cleveland (sh) and Yahniah (ss) Fms.
MISSISSIPPIAN	Mr	Rundle Gp limestone
MISSISSIPPIAN AND DEVONIAN	MDv	Besa River Fm shale
UPPER DEVONIAN	Dt	Tetcho Fm ls, sh
	Dtr	Trout River Fm ls, ss
	Db	Kakisa Fm ls (+shale)
	Dr	Redknife Fm ls, ls
	Dh	Hahnina Fm sh, silts, ls
	Dfs	Fort Simpson Fm sh, silts, ss Map unit includes early Upper Devonian clastics, most base is marked by — DBr — and underlying Middle Dev. Hare River shale, where present
MIDDLE DEVONIAN	Dm	Middle Dev rocks undivided: Sb= marks base of Nahoon (ls) which is underlain by Headless (sh), Manetoe (dol) or Landry (ls) and Jenina (dol) Fms

LEGEND

GEOLOGICAL SYMBOLS

- Bedding appears horizontal on air photographs
- Dip group 1, 1° to 3°
- Dip group 2, 3° to 10°
- Dip group 3, 10° to 25°
- Dip group 4, 25° to 45°
- Dip group 5, 45° to nearly vertical
- Dip and strike. Amount of dip cannot be estimated on air photographs
- Dip component
- FOP Field observed published information
- Distinctive alignment, possible structural significance
- Fault, dotted where extended through Quaternary deposits
- Anticlines, arrow denotes plunge, diamond denotes approximate position of apex
- Synclines, arrow denotes plunge, break and cross bars denote approximate position of high point
- Glacial striation indicating direction of ice movement
- Contact, dashed where indefinite
- Stratigraphic break, subtended letter or number indicates local correlation
- Indicates correlative beds or formations
- Outcrop area
- Possible outcrop area
- Anticlines and synclines based on geomorphic evidence
- Arrow indicates direction of plunge
- Outline of magnetic basement anomaly interpreted from depth estimates to basement from open file magnetic survey by Gravity Motor Exploration Co. in 1968
- M Location of basement fault interpreted from open file magnetic survey by Gravity Motor Exploration Co. in 1968.
- 150'/mile Regional dip of basement interpreted from magnetic depth estimates to basement by Gravity Motor Exploration Co. in 1968 open file report

- Strike and dip interpreted from geomorphic evidence
- Geomorphic Anomaly a surface feature defined by geomorphic analysis and interpreted to have possible structural and/or stratigraphic significance
- RDA III — Radar Drainage Anomaly
- ADA — Annular Drainage Anomaly
- T — Topographic Anomaly
- P — Photographic Tonal Anomaly
- I, II, III — Very well defined by geomorphic evidence
- II — Well defined by geomorphic evidence
- III — Moderately defined by geomorphic evidence
- DCA — Drainage Course Anomaly a meaningful change in the nature and character of a stream or its valley which may have structural and/or stratigraphic significance
- Stream segment interpreted as structurally controlled

WELL SYMBOLS

- Well location or drilling well
- Dry and abandoned test
- Oil well
- Capped oil well
- Gas well
- Capped gas well
- Oil and gas well
- Capped oil and gas well

AREAL GEOLOGY AND STRUCTURAL INTERPRETATION MAP OF THE

TROUT LAKE — CELIBETA AREA

NORTHWEST TERRITORIES

SCALE 1 INCH TO 4 MILES

0 1 2 3 4 5 6 7 MILES

— Prepared by —

V. ZAY SMITH ASSOCIATES LTD.

CALGARY, ALBERTA.

1970

SURFICIAL GEOLOGY AND TERRAIN ANALYSIS
OF
PERMITS 6432, 6439 AND 6441

TROUT LAKE AREA

NORTHWEST TERRITORIES

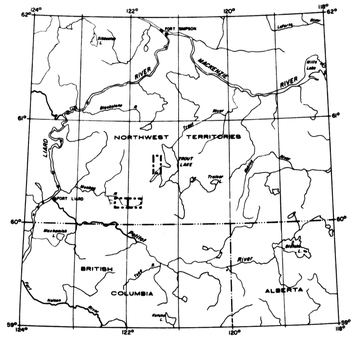
SCALE : 1 INCH TO 1/2 MILE

1/2 0 1/2 1 1/2 MILES

— Prepared by —

V. ZAY SMITH ASSOCIATES LTD.
CALGARY, ALBERTA
1970

INDEX MAP



LEGEND

FORMATIONS

QUATERNARY
- Qm — Muskeg and areas of poorly drained bogs and marshes
- Qd — Undifferentiated glacial drift

GEOLOGICAL SYMBOLS

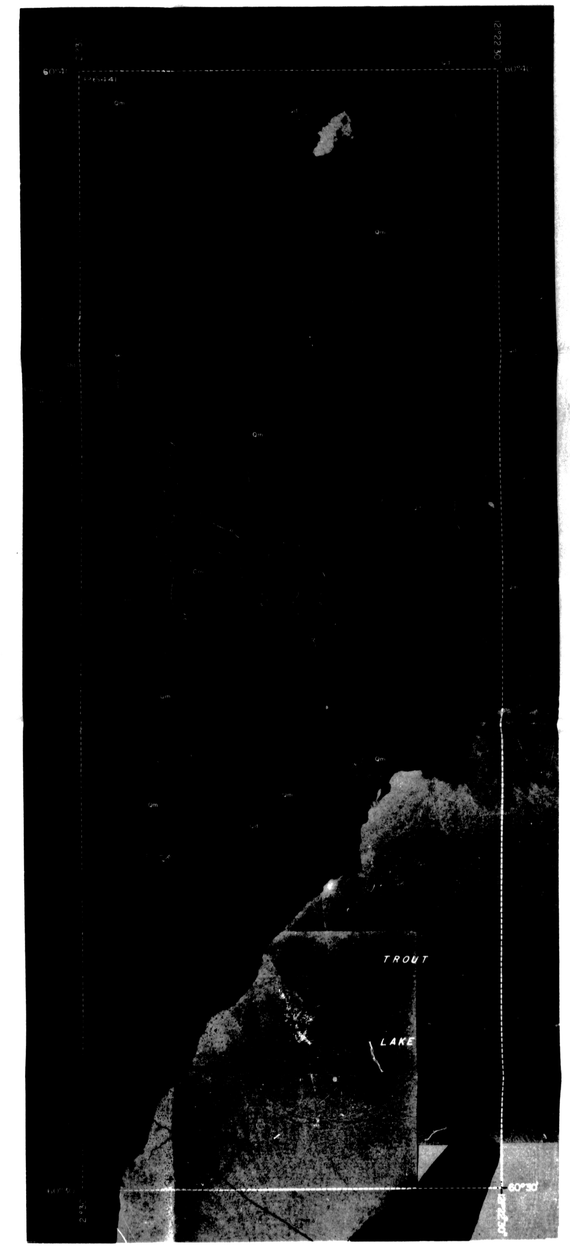
- Steep scarp or slope
- Moderate scarp or slope
- Gentle scarp or break in slope
- Sand dunes
- Esker ridge
- Distinctive alignment, probably indicates fracture trend, fault or joint
- Strandline of former lake
- XT — Possible outcrop area

Explanatory Note

Terrain in Permit 6441 is comparatively level and slopes gradually from elevations of 1,800' in the west toward Trout Lake (1,623'). Local topographic relief seldom exceeds 25' except in southwest.

Terrain in Permits 6432 and 6439 is relatively level at most places and local topographic relief seldom exceeds 25' to 50'. Land surface slopes gradually from 1,800' level in northeastern Permit 6432 toward Muskeg River and major tributaries which are incised 100' to 250'± into the plain and flanked by steep to moderate scarps.

Land surface in each permit is dominated by extensive muskeg areas supporting light to dense bush cover. Remaining area is underlain by thick deposits of undifferentiated glacial drift of probable lacustrine origin in part. Surficial deposits completely mantle bedrock.



TROUT LAKE AREA

NORTHWEST TERRITORIES

J. RAY SMITH ASSOCIATES LTD.

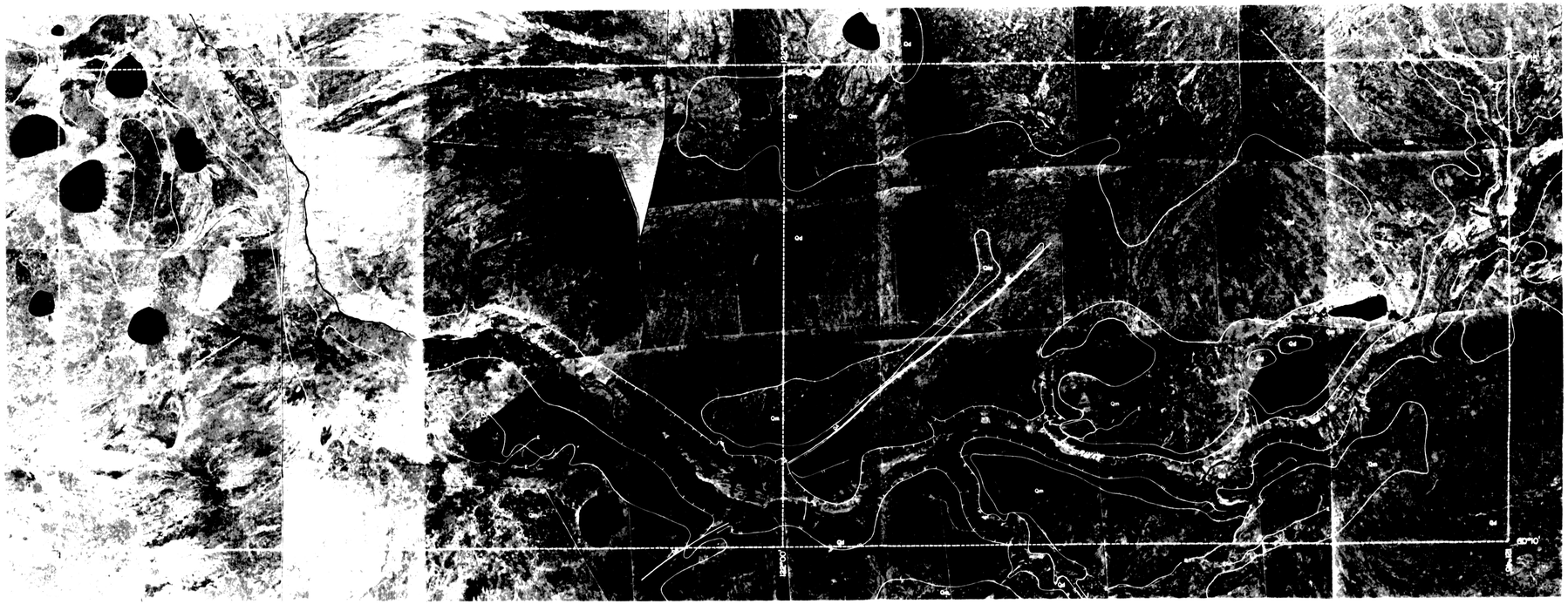
INDEX MAP

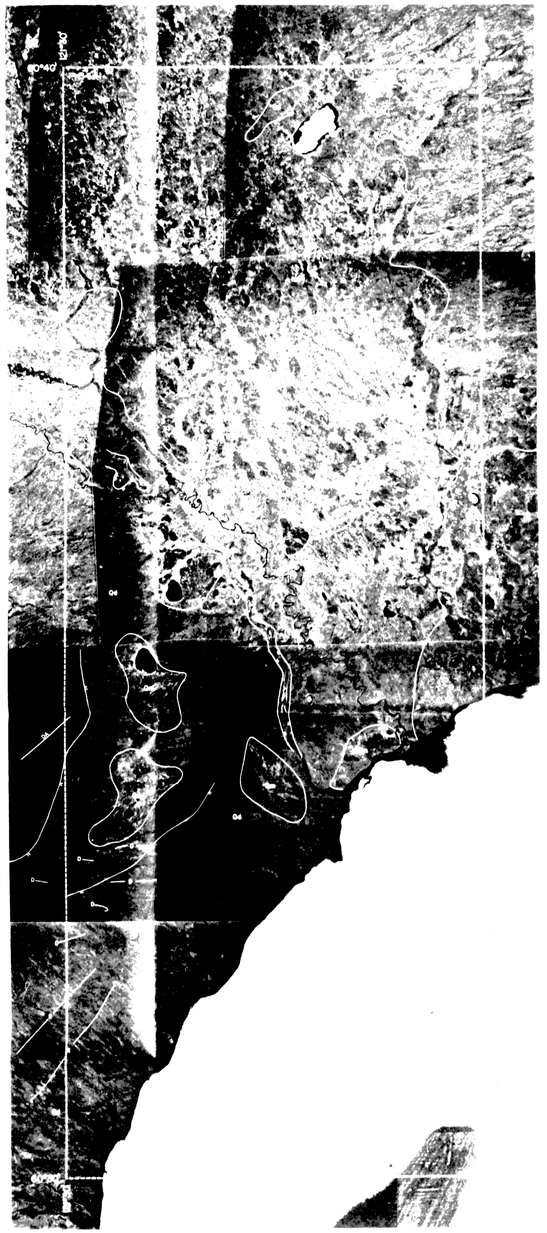
LEGEND

FORMATIONS

QUATERNARY

GEOLOGICAL SYMBOLS





802-1-4-1

GEOLOGIC REPORT

on the

TROUT LAKE - CELIBETA AREA,

NORTHWEST TERRITORIES

Prepared For

PENNZOIL UNITED, INC.

by

V. ZAY SMITH ASSOCIATES LTD.

1970

TABLE of CONTENTS

ILLUSTRATIONS

GEOLOGIC REPORT

on the

TROUT LAKE-CELIBETA AREA,

NORTHWEST TERRITORIES

INTRODUCTION

The geologic evaluation was undertaken to provide geologic data and interpretations to aid in the understanding of the geologic framework and oil and gas potential of the area centered about Permits 6432, 6439 and 6441 in the Trout Lake-Celibeta area. The work consisted of several parts: areal geology and structural mapping and integration, and terrain analysis and accessibility survey.

A photogeologic analysis was done to cover approximately 12,000 square miles centered about the permit acreage and bounded by latitudes 60° and 61° 30' N. and longitude 120° W. and 123° 30' W. This area centers about the permit acreage and includes the Interior Plains geologic province and the eastern fringe of the Cordilleran Region. The interpretation is presented on a map prepared at a scale of 1 inch to 4 miles. The work was based on photogeologic mapping and incorporated all published and open file data.

The subsurface structural mapping and integration involved preparation of a structural contour map on the top of the "Middle Devonian carbonate". The regional structural contour map covered the project area and was based on the co-ordination of surface data and well control.

The terrain analysis and accessibility survey involved stereoscopic examination of vertical air photographs covering the permit acreage. An air photomosaic was prepared at a scale of 1 inch to 1/2 mile and the interpretation was superimposed on it. Thus, the work can be used as an aid in laying out and planning a geophysical or drilling program in the future.

References to published information and other material in the report are indicated by the author's name followed by the year of publication. The references are listed in the Selected Bibliography at the end of this report.

REGIONAL GEOLOGIC SETTING

PHYSIOGRAPHY

The project area includes parts of two main geologic provinces: the Interior Plains and the Cordilleran Region.

The Interior Plains occupy most of the project area. The topography is gently to moderately rolling and elevations range from 700' along the Liard River to as high as 2,500' in some of the low plateaus that surmount the plain. However, in most places the topography is gently undulating and stands at elevations ranging from about 1,000' to 1,500'. Bedrock consists mainly of Cretaceous and Devonian clastics. However, the Interior Plains have been subjected to multiple continental glaciation. At most places bedrock is mantled by variable but extensive deposits of glacial drift. The Liard River forms the main drainage of the area. In some places tributary streams have incised into the plain and eroded canyons several hundred feet deep. Muskeg is plentiful and numerous lakes, both large and small, are present throughout much of the area. Outcrops are sparse. Thus, the landscape of the Interior Plains is made up of a stream-dissected plains and low plateau region that had reached the late mature stage in the erosional cycle prior to the Pleistocene Epoch. Thereupon, it was subjected to multiple continental glaciation and in places has been reverted to the youthful stage in the erosional cycle. Parts of it are now being vigorously eroded by streams.

Only a very small part of the projectcovers the Cordilleran Region. It lies in the northwest corner of the project and involves mainly a part of the Nahanni Range. This linear north-trending mountain ridge rises abruptly above the Interior Plains and crestal elevations range from 4,000' to 4,500' above sea level. Approximately 2,500' to 3,000' of local topographic relief is present. Rock exposures of the resistant Paleozoic carbonates are common in the Nahanni Range. The topography has been produced by differential erosion controlled by structure.

STRATIGRAPHY

Although a detailed discussion of stratigraphy is beyond the purpose of this report, some comments dealing with regional and local stratigraphy are presented. Details have been reported in the literature by geologists who have worked in the area in the past. Reference to pertinent publications listed in the Selected Bibliography will provide considerable detailed information and background data.

Consolidated sediments of Paleozoic, Mesozoic and Cenozoic age make up the post-Precambrian sedimentary section. The Paleozoic sequence is comprised mainly by carbonates, clastics and evaporites which are Devonian, Mississippian, Pennsylvanian and Permian in age. Some Cambrian, Ordovician and Silurian strata may be present in the subsurface in the westernmost part of the project. The Mesozoic assemblage is composed of Cretaceous sandstone and shale. A thin skim of Quaternary alluvium and Pleistocene glacial drift make up the Cenozoic section. Important gaps in the geologic record exist and recurring cycles of subsidence, deposition, uplift and erosion are evident. Strata accumulated in two main depositional environments which have developed and tended to persist since Precambrian time. A geosynclinal belt lay to the west in the Cordilleran Region whereas relatively stable shelf conditions were present in the Interior Plains. A northerly trending hinge line along long. 123° W. separates the two areas. Carbonates, clastics and evaporites were deposited under predominantly marine conditions during the Paleozoic Era and marine shale and sandstone were deposited during the Mesozoic Era. As much as 20,000' of sediments accumulated in the miogeosynclinal belt in the Cordillera to the west. The sedimentary section is much thinner in the Interior Plains and it is estimated that the section ranges in thickness from about 2,500' to 10,000'.

Consolidated rocks exposed at the surface range in age from Middle Devonian to Upper Cretaceous and are mainly sandstone and shale. However, some Paleozoic carbonates are exposed at places in the Cordilleran Region and at a few outcrop areas in the Interior Plains. The age, name, lithology and map symbol for the various geological formations are shown in the legend of the accompanying areal geology and structural interpretation map.

Examination of the stratigraphic section shows that source rocks for the generation of hydrocarbons are widespread geographically throughout the geologic section Moreover, potential reservoir rocks which are predominantly carbonates with some possible clastics, are present. Gas has been discovered in Middle Devonian carbonates to the west in the Liard Plateau by wells drilled on anticlinal structures as, for example, in the Pointed Mountain area. Significant gas reserves have been developed south of the project area in northeastern British Columbia, mainly in carbonates of Middle Devonian age. Numerous shows of gas and oil have been recorded in wells drilled within the project area. Some wells are classified as shut-in gas wells. Thus, analysis of the stratigraphy and the record of exploration to date indicates that significant oil and/or gas reserves should be developed in the map area.

STRUCTURE

The Trout Lake-Celibeta map area covers parts of two main structural provinces: the Interior Plains and the Cordilleran Region. A variety of structures are known and are expected. These include moderate to intense orogenic folds and faults and, gentle to moderate epeirogenic warping, faults and folds. Compaction folds and solution collapse structures are also expected. Structures caused by igneous activity may be present locally. Of lesser consideration and importance are structures caused by the distortion of surface bedrock during glaciation and isostatic rebound following deglaciation. Important structural movements have occurred in the Paleozoic Era during the Late Silurian and/or Lower Devonian time, early Upper Devonian time and during late Paleozoic time. Evidence beyond the limits of the map area demonstrate periods of crustal activity during the Mesozoic Era culminating in the Laramide orogeny of late Upper Cretaceous and early Tertiary age

The Interior Plains form a vast structural province lying between the Precambrian Shield on the east and the Cordilleran Region on the west. Most of the project lies within this structural province. The Trout Lake-Celibeta map area covers part of a broad gently deformed asymmetric structural basin. Although gentle to moderate structural movements have prevailed, some local

areas have been subjected to moderately intense deformation. Throughout much of the eastern half of the area Paleozoic strata dip regionally southwesterly at about 40' to 75' per mile. However, this regional dip is interrupted in the western part of the Interior Plains by several structural elements which will be discussed in more detail later in this report. These include the structures in the Liard Basin and the Celibeta and Liard Uplifts. Paleozoic strata are unconformably overlain by flat-lying to gently dipping Cretaceous shales and sandstones.

Only a small part of the Cordilleran Region is included by the project and that is in the northwestern part. The leading edge of the Cordillera is marked by a high angle thrust fault, the Nahanni Fault. It has strongly dislocated the strata along a north-trending structural zone where displacement in the order of 7,000' is evident. The Nahanni Fault is upthrown to the west and gives a sense of motion towards the Interior Plains to the east. Minor folds and auxiliary faults are present along the leading edge of the thrust fault, and they are displayed in the Nahanni Range. The structures are defined by dips ranging from about 10° to 45° or more.

AREAL GEOLOGY and STRUCTURAL MAPPING and INTERPRETATION

Two geologic maps were prepared to portray the areal geology and to present a structural evaluation. The areal geologic and structural interpretation map was based on the co-ordination of photogeologic mapping and geomorphic analysis with published and open file data. The maps show the areal distribution of bedrock formations at the surface and their structural attitude. The attitude of surface strata are indicated by dip symbols; axes of folds and faults are also shown by suitable photogeologic symbols. The mapping is based mainly on stereoscopic examination of contact prints of vertical air photographs. Rates of dip of strata are estimated and assigned to dip classification shown on the legend of the areal geology and structural interpretation map. Faults and axes of folds observed on air photographs were traced on them and transferred to the base maps. All geologic literature and open file data was reviewed and incorporated in to the interpretation.

In many parts of the Interior Plains usual photogeologic mapping techniques cannot be used effectively because of the relatively poor expression of bedding on air photographs and the cover of glacial drift. In these areas structural interpretation was aided by a geomorphic analysis which involved studies of drainage patterns and development, topography, glacial geology, photographic tone, - in fact, all elements that make up the landscape. This work lead to the delineation of structures based on geomorphic evidence and to the defining of geomorphic anomalies. A geomorphic anomaly is a surface feature delineated by geomorphic analysis and interpreted to have positive structural and/or stratigraphic significance. The anomalies are defined by a variety of evidence including radial and/or annular drainage patterns, delicate tonal and topographic patterns, etc. These anomalies have been classified into groups depending on the geomorphic evidence as shown in the legend. Several distinctive alignments are also mapped They are indicated by heavy solid lines labelled DA. Distinctive alignments are interpreted to indicate fractures, either joints or faults.

A part of the project is covered by an open file magnetic survey performed by Gravity Meter Exploration Co. in 1953. The outlines of magnetic basement anomalies interpreted from depth estimates to basement and the location of basement faults interpreted from the magnetic data are also shown on the areal geology and structural interpretation map.

A regional structural contour map of the Trout Lake - Celibeta area was also prepared. It is an attempt to integrate and co-ordinate surface geologic data with well control. The object is to portray the structure of the area quantitatively by means of structural contours which depict the size, shape and magnitude of geologic structures. The top of the "Middle Devonian carbonate" is the structural datum because it is widespread and present throughout most of the project area. Although the top of the Middle Devonian carbonate is not a time line because of lateral facies changes, the location of the most conspicuous change, which involves the Slave Point Formation, was taken into account during the interpretation.

Several local structural features and elements were delineated during the interpretation, and these are discussed in the paragraphs that follow.

Liard Basin

One of the most conspicuous structural subdivisions in the southern part of the Interior Plains is the Liard Basin; however, only a small part of it is covered by the project. The eastern flank of the Liard Basin is marked by the Bovie fault and accompanying anticlinal flexure. It is a north-trending linear structural zone comprised by an elongate closed anticline with a high angle thrust fault on the east flank. Although stratigraphic relationships indicate the Bovie fault is upthrown to the west, regional considerations indicate that the Liard Basin is warped down in comparison to the Interior Plains to the east.

Interpretation of stratigraphic data within the project and to the south in British Columbia suggests that the Bovie structural zone has been active several times in the geologic past. Some movement probably took place in late Paleozoic time, the final result being produced during the Laramide deformation. The

structural trend lies along the stratigraphic hinge line separating the more stable shelf of the Interior Plains on the east from the more mobile geosyncline to the west in the Cordilleran Region.

The Petitot River syncline, a southerly plunging moderately deformed fold defined by dips ranging from 5° to 10°, lies between the Bovie fault and another fault to the west. This fault is termed the Liard fault. It is a northerly to northwesterly trending, slightly sinuous fault upthrown to the west. Displacement appears to be in the order of 500' within the project area. Although the attitude of the fault plane is not known, it is interpreted to be a high angle reverse fault.

Celibeta Uplift

The Celibeta Uplift forms another important structural element within the project. It lies in the Interior Plains. Evidence for its presence is based on surface stratigraphic relationships in the vicinity of the Petitot River, geomorphic anomalies, several distinctive alignments and well control. However, its true structural configuration is uncertain because of the obscure nature of the evidence. It is shown as a broad positive feature which displays 2,500' - 3,000' of structural relief at the Middle Devonian level. Mississippian strata thin markedly (1,500 to 2,000') over the crest of the Celibeta Uplift. The flanks of the positive element may be fault-controlled. Structural relief on the base of the Cretaceous is subdued (500') compared to relief on top of the Middle Devonian carbonate (2,500' to 3,000'). Thus, the structure apparently was uplifted and eroded in the post-Mississippian, pre-Cretaceous interval and subsequently uplifted during the Laramide orogeny. Permits 6432 and 6439 lie on the northeast flank of this positive element.

Liard Uplift

The Liard Uplift is another positive element in the Interior Plains whose form has not been completely delineated. It is located in the vicinity of the Liard River in the northwest part of the project. The subcrop pattern of Mississippian strata and thinning of the Upper Devonian section (in the order of 1,000' to 1,500') suggest that the Liard Uplift is a positive element whose flanks may be fault-controlled. It was uplifted and eroded during

the post-Mississippian, pre-Cretaceous interval. Uplift recurred during the Laramide orogeny. Some mineralized discordant carbonatized dikes have been reported at the surface in the vicinity of the Liard Uplift (Reed, 1970). The dikes strike north 18° W. and dip 84° W. They occur in a silicified fracture zone 900' long and up to 80' wide in Upper Devonian shale. Reed (1970) postulates an igneous source for the sulphide mineralization (chalcopyrite) and states that the dikes may have been intruded cataclysmically and metasomatized.

West Tathlina High

The West Tathlina High is defined mainly by subsurface data and is part of a broad structural feature present in the region southwest of Great Slave Lake. The West Tathlina High is a structural element which may be partly fault-controlled. It probably originated early in the Paleozoic Era and persisted as a positive feature through Middle Devonian time when it became submerged. The crestal portion is defined by the depositional edge of the Chinchaga Formation. . .

TERRAIN ANALYSIS and ACCESSIBILITY SURVEY

A surficial geology and terrain analysis map covering Permits 6432, 6439 and 6441 was prepared at the scale of 1 inch to 1/2 mile. The interpretation was superimposed to an air photomosaic. The map shows the distribution of surface deposits and portrays topography and other surface physiographic and geologic features by symbols.

The terrain in Permit 6441 is comparatively level and slopes gradually from elevations of 1,800' in the west toward Trout Lake which stands at an elevation of 1,623'. Local topographic relief seldom exceeds 25' except in the southwest. The land surface is dominated by extensive deposits of glacial drift and muskeg. The undifferentiated glacial drift is probably of lacustrine origin in part. Extensive areas of muskeg are present, especially in the north and they support light to dense bush cover. Bedrock is completely mantled by surficial deposits and no outcrops are known. A few easterly trending sand dunes, which are stabilized by vegetation, are present west of Trout Lake. A few faint indications of former shore lines of Trout Lake are present in the southwest corner of the permit. At places along streams flowing into Trout Lake, they are incised slightly into the level plain; however, this local topography would provide no hindrance to access. Thus, no severe terrain problems exist to hinder conventional seismic and drilling operations although programs should probably be undertaken during the winter months when the lakes, muskeg and the ground surface are frozen.

The terrain in Permits 6432 and 6439 is relatively level at most places. Local topographic relief seldom exceeds 25' to 50'. The land surface slopes gradually from an elevation of 1,800' in the northeastern part of Permit 6432 towards the Muskeg River, where elevations of 1,300' are present. The Muskeg River traverses the permits. The river and its major tributaries are incised 100' to 250' into the plain and are flanked by steep to moderate scarps. These incised stream channels could hinder access by seismic and drilling equipment in places. The land surface is dominated by extensive and thick deposits of undifferentiated glacial drift which is probably of lacustrine origin in part.

Muskeg and areas of poorly drained bogs and marshes are abundant, especially south of the Muskeg River and in the eastern part of the permit acreage. The area supports light to dense bush cover. Several esker ridges are apparent and in places may be 50' to 75' high. Surficial deposits appear to mantle bedrock completely although one possible outcrop was detected in the central part of Permit 6432 in a stream cut of the Muskeg River.

A northeasterly trending gentle escarpment is present in the southeastern part of Permit 6439. It can be traced for a distance of 4 miles. This distinctive alignment can be extended to the southwest across the Muskeg River. Detailed examination of this feature indicates that it is not of glacial origin. It is suggested that it is a surface indication of an underlying fault along which there has been some relatively recent but very minor movement. Except in the vicinity of the Muskeg River and some of its tributaries, no serious problems of access are anticipated for conventional seismic or exploratory drilling programs; however, they can be most effectively conducted during the winter months when the muskegs, lakes and ground surface are frozen.

SUMMARY and CONCLUSIONS

Permits 6432, 6439 and 6441 lie in the Interior Plains where topographic elevations range from approximately 1,300' to 1,800'. However, local topographic relief seldom exceeds 25' to 50' except along the Muskeg River and its major tributaries which are incised 100' to 250' into a very gently undulating plain. Bedrock is formed by Cretaceous clastics but outcrops are probably nonexistant because bedrock is covered by a variable thickness of undifferentiated glacial drift. Muskeg, bogs and marshes are common over parts of the permit acreage, but no severe problems of terrain and accessibility are anticipated.

The permits lie in an area which should eventually produce significant oil and/or gas reserves. Carbonates of Middle Devonian age, which have yielded gas in adjoining regions, offer the most attractive reservoir targets. Stratigraphic and structural/stratigraphic traps could exist at drilling depths in the order of 5,000' to 7,500'. The permits lie in an area where gentle to moderate epeirogenic warping, faults and folds are anticipated. Compaction folds and solution collapse structures may also be present. Permits 6432 and 6439 lie on the northeast flank of the Celibeta Uplift. It is a broad positive feature which displays 2,500' to 3,000' of structural relief and whose flanks may be fault-controlled. Permit 6441 lies on the flank of a broad gentle asymmetric structural basin where Paleozoic beds dip regionally to the southwest at about 50' per mile. A northeasterly trending distinctive alignment, which can be traced for a distance of 4 miles in the southeastern part of Permit 6439, is interpreted to be a surface indication of an underlying fault.

Further delineation of oil and gas prospects should involve a reflection seismic survey which can best be undertaken in winter months when the muskeg, lakes and ground surface are frozen.

Respectfully submitted,

V. ZAY SMITH ASSOCIATES LTD.

George M. Collins, P. Geol.

SELECTED BIBLIOGRAPHY

ALBERTA SOCIETY of PETROLEUM GEOLOGISTS, 1960, "Lexicon of Geologic Names in the Western Canada Sedimentary Basin and the Arctic Archipelago", Symposium.

ALBERTA SOCIETY of PETROLEUM GEOLOGISTS, 1964, "Geological History of Western Canada", Atlas, edited by R.G. McCrossan and G.P. Glaister.

AMERICAN ASSOCIATION of PETROLEUM GEOLOGISTS, 1954, "Western Canada Sedimentary Basin", Symposium.

AMERICAN ASSOCIATION of PETROLEUM GEOLOGISTS, 1958, "Jurassic and Carboniferous of Western Canada", Symposium.

ANTONIUK, S.A., 1958, "Report on Surface Geology, Mackenzie River Area", Report to Minister, Dept. Northern Affairs and National Resources, by Pan American Petroleum Corp., open file, Calgary.

BELYEA, H.R., and McLAREN, D.J., 1961, "Upper Devonian Formations, Southern Part of Northwest Territories, Northeastern British Columbia, and Northwestern Alberta", Geol. Surv., Canada, Paper 61-29.

BELYEA, H.R., and NORRIS, A.W., 1962, "Middle Devonian and Older Palaeozoic Formations of Southern District of Mackenzie and Adjacent Areas. Geol. Surv., Canada, Paper 62-15.

BELYEA, Helen R., 1968, "Facies Distribution and Reactivation of a Pre-Devonian Uplift, Southern Dist. of Mackenzie", Paper presented to Alta. Soc. Petrol. Geol., luncheon meeting, May 8, 1968. (Summary in OILWEEK, May 27, 1968, pp. 9-10.

BOSTOCK, H.S., 1948, "Physiography of the Canadian Cordillera, with Special Reference to the Area North of 55th Parallel", Geol. Surv., Canada, Mem. 247.

BRADY, W.B., 1959, "Liard River Area, N.W.T., Yukon and B.C.", Report to Minister, Dept. Northern Affairs and Nat. Resources by Union Oil Co. of Calif., open file, Calgary.

BRADY, W.B., 1967, "What Rainbow Reefs May Look Like", OILWEEK, Aug. 28, 1967, p. 21 and 24.

BRADY, W.B., & WILSON, D.W.R., 1967, "Surface & Subsurface Devonian Stratigraphy of the Nahanni Region, Yukon and N.W.T., Canada", Alta. Soc. Petrol. Geol., Abstracts of Proc. of Internation Symp. Devonian System, p. 26.

BURK, C.F., 1964, "Structure Contours on Fish Scales Marker Horizon, Northeastern British Columbia, and Adjoining Alberta and Northwest Territories", Geol. Surv., Canada, Map 57-1963.

CAMERON, A.E., 1917, "Reconnaissance on Great Slave Lake, Northwest Territories", Geol. Surv., Canada, Summary Report 1916, pp. 66-76.

CAMERON, A.E., 1918, "Explorations in the Vicinity of Great Slave Lake", Geol. Surv., Canada, Summary Report 1917, pt. C, pp. 21-28.

CAMERON, A.E., 1922, "Hay and Buffalo Rivers, Great Slave Lake and Adjacent Country", Geol. Surv., Canada, Summary Report 1921, pt B, pp. 1-44

CAMPBELL, N., 1957, "Stratigraphy and Structure of Pine Point Area, N.W.T.", in Structural Geology of Canadian Ore Deposit Vol. II, 6th Commonwealth Mining and Met. Congr., Canada, pp. 161-174.

DEPARTMENT of NORTHERN AFFAIRS and NATIONAL RESOURCES, Canada, 1964, "Schedule of Wells, Northwest Territories and Yukon Territory, 1920-1963". Supplement 1962 - 1969.

DOUGLAS, R.J.W., 1959, "Great Slave and Trout River Map-Areas, N.W.T.", Geol. Surv., Canada Paper 58-11.

DOUGLAS, R.J.W., and NORRIS, D K., 1959, "Fort Liard and LaBiche Map Area, Northwest Territories and Yukon", Geol. Surv., Canada, Paper 59-6.

DOUGLAS, R.J.W., and NORRIS, D.K., 1960, "Horn River Map-Area, N W.T. and Yukon", Geol. Surv., Canada, Paper 59-11.

DOUGLAS, R.J.W., and NORRIS, D.K., 1960, "Virginia Falls & Sibbeston Lake Map-Areas, N.W.T 95F and 95G"(Report, Map 22-1960, 23-1960) Geol. Surv., Canada, Paper 60-19.

DOUGLAS, R.J.W., NORRIS, D.K., THORSTEINSSON, R., and TOZER, E.T., 1963, "Geology and Petroleum Potentialities of Northern Canada", Geol. Surv., Canada, Paper 63-31.

GEOLOGICAL SURVEY of CANADA, 1941, "Great Slave Lake to Great Bear Lake, District of Mackenzie, Northwest Territories", Prelim. Map 41-2.

GEOLOGICAL SURVEY of CANADA, 1955, "Geological Map of Canada", Map 1045A.

GEOLOGICAL SURVEY of CANADA, 1958, "Geological Map of the District of Mackenzie, Northwest Territories", - Map 1055A.

GRAVITY METER EXPLORATION COMPANY, 1953, Interpretation of Aeromagnetic Survey of Block I, N.W.T.", Report to Minister, Dept. of Northern Affairs National Resources, by Logan G., Grant, R.E. Reese, R.G ., May, O., open file, Calgary.

GRAVITY METER EXPLORATION COMPANY, 1953, Interpretation of Aeromagnetic Survey of Block II, N.W.T.", Report to Minister Northern Affairs National Resources, for KEICAM, open file, Calgary.

GRAYSTON, L.D., SHERWIN,D.F. and ALLAN,J.F., 1964, "Middle Devonian", in Geol. Hist. of Western Canada, editors: R.G. McCrossan and R.P. Glaister, Alta. Soc. Petrol. Geol., pp. 49-59.

GRIFFIN, D.L., 1965, "The Devonian Slave Point Beaverhill Lake, and Muskwa Formations of Northeastern British Columbia and Adjacent Areas", British Columbia Dept. of Mines and Petroleum Resources, Bull. No. 50.

GRIFFIN, D.L., 1967, "Devonian of Northeastern British Columbia", in, Symposium on the Devonian System, Vol. 1, Alta. Soc. Petrol. Geol., pp. 803-826.

GUSSOW, W.C., 1965, "Review of Geological History of Western Canada", in Geotimes, Vol. 10, No. 3, pp. 30.

HACQUEBARD, P.A., and BARSS, M.S., 1957, "A Carboniferous Spore Assemblage, in Coal From the South Nahanni River Area, Northwest Territories", Geol. Surv., Canada, Bull. 40.

HAGE, C.O., 1945, "Geological Reconnaissance Along Lower Liard River, Northwest Territories, Yukon and British Columbia", Geol. Surv., Canada, Paper 45-22.

HARKER, P., 1961, "Summary Account of Carboniferous and Permian Formations, Southwestern District of Mackenzie", Geol. Surv., Canada, Paper 61-1.

HARKER, P., 1963,"Carboniferous and Permian Rocks, Southwestern District of Mackenzie", Geol. Surv., Canada, Bull. 95.

HUME, G.S., 1932, "Oil Prospects of the Great Slave Lake and Mackenzie River Areas", Can. Ins. Min. Met. Trans. (March), pp. 92-103.

HUME, G.S., 1954, "The Lower Mackenzie River Area, Northwest Territories and Yukon", Geol. Surv., Canada, Mem. 273.

HUNT, C.W., 1954, "Normal Devonian Sequence of Southern Mackenzie Basin, Western Canada", Bull., Amer. Assoc. Petrol. Geol., Vol. 38, No. 11, pp. 2290-2301.

KIDD, F.A., 1962, "The Besa River Formation", Guidebook, Edmonton Geol. Soc., 1962 Field Conference, pp. 97-101.

KINDLE, E.D., 1944, "Geological Reconnaissance Along Fort Nelson, Liard, and Beaver Rivers Northeastern B.C. and Southeastern Yukon. Geol. Surv., Canada, Paper 44-16

KINGSTON, D.E., 1951, "Stratigraphic Reconnaissance Along Upper South Nahanni River, N.W.T., Canada", Bull. Amer. Assoc. Petrol. Geol., Vol. 35, No. 11, pp. 2409-2426.

KOCH, N.G., 1958, "Report on Surface Geology Mackenzie River Area", Report to Minister, Dept. of Northern Affairs and National Resources, by Pan American Petroleum Corporation, open file, Calgary.

LAW, J., 1955, "Geology of Northwestern Alberta and Adjacent Areas", Bull. Amer. Assoc. Petrol. Geol., Vol. 39, pp. 1927-1975.

MCLAREN, D.J., and NORRIS, A.W., 1964, "Fauna of the Devonian Horn Plateau Formation, District of Mackenzie", Geol. Surv., Canada, Bull. 114.

MCLEARN, F.H., 1945, "The Lower Triassic of Liard River, B.C.", Geol. Surv., Canada, Paper 45-28.

MEEK, F. B., 1868, "Remarks on the Geology of the Mackenzie River with Figures and Descriptions of Fossils from the Region, in the Smithsonian Institute, Chiefly Collected by the Late Robert Kennicott", Trans. Chicago, Acad. Sci., Vol. I.

NAUSS, A.W., 1944, "The Nelson-Liard River Area", Report to Minister, Dept. Northern Affairs and National Resources, by Imperial Oil Ltd., (Canol Project, Assignment #8), open file, Calgary.

NORRIS, A.W., 1963, "Devonian Stratigraphy of Northeastern Alberta and Northwestern Saskatchewan", Geol. Surv., Canada, Mem. 313.

NORRIS, A.W., 1965, "Stratigraphy of Middle Devonian and Older Palaeozoic Rocks of the Great Slave Lake Region, Northwest Territories", Geol. Surv., Canada, Mem. 322.

O'BERTOS, E., and JACKSON, D.E., 1963, "Age of the Whittaker Formation, Northwest Territories", Bull. Can. Petrol. Geol., Vol. II, No. I., pp. 27-32.

OILWEEK, 1966, "Guide Helpful in B.C. Slave Point Reef Gas Hunt", Vol. 17, No. 1, pp. 9-10.

PELLETIER, B.R., 1960, "Triassic Stratigraphy, Rocky Mountain Foothills, Northeastern British Columbia", Geol. Surv., Canada, Paper 60-2.

PELLETIER, B.R., 1961, "Triassic Stratigraphy of the Rocky Mountains and Foothills, Northeastern British Columbia", Geol. Surv., Canada, Paper 61-8.

SIKABONYI, L.A., and RODGERS, W.J., 1959, "Palaeozoic Tectonics and Sedimentation in the Northern Half of the West Canadian Basin", Jour., Alberta Soc. Petrol. Geol., Vol. 7, No. 9, pp. 193-216.

SPROULE, J.C., and ASSOCIATES, 1953, "Geological Report on the P. & N.G. Holdings of Merrill Petroleums Limited, Hay River Area, N.W.T.", Report to Minister, Dept. of Northern Affairs & National Resources by Merrill Petroleums Limited, open file, Calgary.

SPROULE, J.C. and ASSOCIATES, 1955, "Report on Summer Geological Program, 1955", Report to Minister, Dept. Northern Affairs and National Resources, open file, Calgary.

SPROULE, J.C., and ASSOCIATES, 1958, "Geological Report, Upper Mackenzie River Area, Northwest Territories", Report to Minister, Dept. Northern Affairs & National Resources by Husky Oil & Refining Ltd., open file, Calgary.

SPROULE, J.C. and ASSOCIATES, 1961, "Geological Reconnaissance Report P. & N.G. Permits Nos. 3002 to 3005, inclusive, Caen Lake Area, Northwest Territories", Report to Minister, Dept. Northern Affairs & National Resources, by Glacier Explorers Ltd., open file, Calgary.

SPROULE, J.C., and ASSOCIATES, 1961, "Geological Reconnaissance Report P. & N.G.Permits Nos. 3054, 3055, 3056, Fort Providence Area, N.W.T.", Report to Minister, Dept. of Northern Affairs & National Resources by T. J. Rubeo and W. R. Sheeky, open file, Calgary.

STOTT, D.F., 1960, "Cretaceous Rocks in the Region of Liard and Mackenzie Rivers, Northwest Territories", Geol. Surv., Canada, Bull. 63.

STOTT, D.F., 1965, "Operation Liard", Geol. Surv., Canada, (in press).

SUSKA, M.M., 1960, "Subsurface Geology and Oil and Gas Prospects of Cameron Hills Area, N.W.T.", Report to Minister, Dept. of Northern Affairs and National Resources, by Western Decalta Petroleum Co., open file, Calgary.

WALCOTT, C.D., 1928, "Pre-Devonian Palaeozoic Formations of the Cordilleran Provinces of Canada", Smith. Inst. Misc. Coll., Vol. 75, No. 5.

WARREN, P.S., 1944a, "Index Brachiopods of the Mackenzie River Devonian", Trans. Roy. Soc., Canada, Vol. 38, Sec. IV.

WARREN. P. S., 1947, "Cretaceous Fossil Horizons in the Mackenzie River Valley", Jour. of Pal., Vol. 21, No.2.

WARREN, P.S., 1950, "Succession of Devonian Faunas in Western Canada", Trans. Roy. Soc. Canada, Vol. 44, Ser. 3, Sec. 4, pp. 61-78.

WEBB, J.B., 1951, "Geological History of Plains of Western Canada, Bull. Am. Assoc. Petrol. Geol., Vol. 35, No. 11, pp. 2291-2315, reprinted with revisions in 1954, in Western Canada Sedimentary Basin, pp. 3-28.

WHITTAKER, E.J., 1922, "Mackenzie River District Between Great Slave Lake and Simpson", Geol. Surv., Canada, Summary Report 1921, Part B, pp.45-55.

WHITTAKER, E.J., 1923, "Mackenzie River District Between Providence and Simpson", Geol. Surv., Canada, Summary Report 1922, Part B, pp. 88-100.

ADDENDUM

ROED, Murray A. Ph.D., 1970, "An Occurrence of Chalcopyrite", Western Miner, April, 1970, Vol. 43, No. 4, pp. 24-32.