PHOTOGEOLOGY REPORT

GLACIER PROJECT

NORTHWEST TERRITORIES, CANADA

Abstracted for
Geo-Science Data Index
Date

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GLACIER PROJECT

NORTHWEST TERRITORIES, CANADA

PREPARED FOR

THE ATLANTIC REFINING COMPANY

BY

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DALLAS, TEXAS

MAY 16, 1960

CONTENTS

ILLUSTRATIONS

INTRODUCTION

The Glacier project was initiated in March, 1959, by the Photogeology Section of The Atlantic Refining Company at the request of our Calgary Exploration office. Purpose of the project was to furnish a preliminary evaluation of leaseholds held at that time by Glacier Explorers, Ltd.

Preliminary work. Upon approval of the project, Mr. K. M. Renfro, senior photogeologist, made a ten day trip to the cities Toronto, Ottawa, and Calgary to obtain materials and information necessary for completion of the project.

Aerial photography was purchased from the National Air Photographic Library, Ottawa, Ontario. The photography was flown at an average scale of 1:40,000 by the RCAF. Quality of the photography is poor.

Uncontrolled mosaics were also obtained from the National Air Photographic Library. Scale of these mosaics is 1:250,000 - 1:500,000. Duplicate negatives of these mosaics were enlarged to a scale of 1:48,000 for use in the field.

Unpublished topographic maps, scale 1:126,720 were obtained from the Surveys and Mapping Branch of the Department of Mines and Technical Surveys, Ottawa. The maps are of excellent quality. Base maps were compiled from these sheets.

The National Research Council, Ottawa, furnished information on permafrost and "muskeg" research. Geological information was supplied by the Canadian Geological Survey and company files. Miscellaneous information was furnished by the Geographic Branch of the Department of Mines and Technical Surveys, Ottawa, and the Department of Northern Affairs and Natural Resources, Ottawa.

Method of Work. Photographs, topographic maps, and other materials were received by this office in April, 1959. Since the maps are the only reliable ones available for the area, a base map was immediately made for the leaseholds upon which the photographs were indexed and interpretation results compiled.

Stereoscopic interpretation was done on the contact prints by Messrs. K. M. Renfro, J. F. Weaver, and L. F. Miller. The interpretation was made on acetate strip overlays and transferred to the base map by means of a sketchmaster. Interpretation was begun in May, 1959, and completed in June, 1959. Results of the interpretation are included as Plate VI.

In the course of interpretation, it was found that satisfactory results were not being obtained because the scale of the photography did not allow a visual continuity over large areas. The small-scale, uncontrolled mosaics were laid down, and a regional geographic interpretation was made. Results of this interpretation are included as Plate V.

A trip was made to Fort Good Hope, Northwest Territories, in July, 1959, by Mr. Renfro. Tentative conclusions reached during the interpretation were verified by field inspection and helicopter flights over portions of the leaseholds.

Previous Investigations. Little information was available relative to the geology of the area. Original surveys were of a reconnaissance nature, and are adequately summarized in Memoir 273 of the Canadian

Geological Survey. None of the original reports of the Canol project, conducted during World War II, were available at the time of interpretation. J. C. Sproule and Associates made a preliminary investigation for Glacier Explorers, Ltd., in 1958. The report was made available during part of the interpretation.

Most of the background material for photointerpretation was based on the numerous research reports and published articles on muskeg and permafrost. Reprints of this material is available from the National Research Council of Canada.

The conclusions reached in this report should be considered tentative, pending further field investigations. The results should be useful as a guide to more detailed study.

GEOGRAPHY

Location. The Glacier Explorers, Ltd., leaseholds lie between 66°00' and 66°50' North Latitude and 120°00' and 132°15' West Longitude. It is in the Lower Mackenzie River Valley. The only settlement in the vicinity is the village of Fort Good Hope near the eastern extremity.

Accessibility is by river barge on the Mackenzie River, or by chartered aircraft from the Pacific Western Airline Terminal at Norman Wells, 85 air line miles southeast of Fort Good Hope.

Topography and Physiography. The mapped area lies 40 miles north of the Mackenzie Mountain front and 50 miles east of the Richardson Mountain. It includes a portion of the Peel Plateau in the southwestern half and the Interior Plains in the northeastern portion. The Mackenzie River Valley Plain was not discernible in the area. The regional physiographic position is shown in Plates II and IV.

The Mackenzie Mountains rise abruptly to elevations of 5000' at latitude 65°20'. Elevations become greater southward.

Adjacent to the mountain front on the north is the Peel Plateau. The plateau is broad and flat and is composed of three steps or terraces: (1) the upper terrace with an elevation of 2500'; (2) the middle terrace at an elevation of 2000', forming the base of the mesas and buttes of the upper terrace; and (3) an ill defined lower terrace between the elevation of 700' and 1300'.

Trending diagonally northwest-southeast through the center of the mapped area are the lowlands of the Interior Plain province. These represent the lowermost elevations in the leaseholds, varying from 100', near the Mackenzie River, to 500' in the central portions of the area.

The zone is marked by numerous lakes and swamps and glacial deposition. It is the most difficult terrain in the leaseholds to traverse.

The terrain slopes upward to the north to the Grandview Hills in the north boundary of the area. Highest elevations are 1000-1300'.

Drainage. The entire area lies in the drainage basin of the Mackenzie River. Major tributaries to the Mackenzie flow northward from the Mackenzie Mountains, across the Peel Plateau, into the Interior Plains Province. All exhibit several stages of entrenchment, indicating a rather complex history.

The headwaters of the Arctic Red River are in the Selwyn Mountains, 100 miles to the south. It flows northerly to latitude 65°40' where it alters its course abruptly to the northwest and flows across the western portion of the permits.

The Ramparts River originates in the Canyon Ranges of the Mackenzie Mountains. It also flows north across the Peel Plateau. Upon entering the lowlands of the Interior Plains, it alters its ccurse abruptly and flows eastward to the Mackenzie River near Fort Good Hope. An abandoned channel of the Ramparts River near the latitude of 65°50' north marks a point at which the Ramparts formerly flowed westward as a tributary of the Arctic Red River.

The Ontaratue River drains the central portions of the leaseholds and enters the Mackenzie in the northeastern part of the area. The headwaters of its tributaries are in the Peel Plateau, the lowlands of the Interior Plain, and the Grandview Hills. The main direction of flow is northeast across the Grandview Hills, though its tributaries flow from all directions.

All major drainage flows on bedrock. The islands of the Mackenzie River are erosion remnants in the river channel, and not depositional bars as would normally be assumed. Only locally are the stream courses modified by glacial deposition or scour. The Arctic Red River flows in a typical glaciated valley in the Mackenzie Mountains, but shows normal stream development after entering the Peel Plateau province.

Glaciation. Little original investigation has been made of the glacial history of the area west of Fort Good Hope. A complete discourse on the Pleistocene history of the area is not attempted here. A few remarks are necessary to properly interpret the physiography and geology of the region, and to assist in planning field operations.

The entire area of the leaseholds was subjected to extensive continental glaciation of varying intensity, throughout the Pleistocene epoch. Plate IV is included to illustrate the effects of glaciation on the topography.

Glacial erosion and scour predominate in the area, except in the lowlands of the interior plains. The following evidences of glaciation serve to make possible preliminary reconstruction of the glacial history:

(1) Glacial erratics and scour at 5,000' elevation in the Norman Range, 40 miles south of Fort Good Hope.

(2) The step terraces of the Peel Plateau, at 700-1000', 2000', and 2,500' elevations.

(3) Typical U-shaped glacial valleys along the Mackenzie Mountain front in

- (a) Minor valleys above 2500' elevation
- (b) Major valleys (e.g. Arctic Red River) between 1800' and 2500' elevation

(4) Extensive glacial grooving and scour,

(a) Trending due north in the vicinity of Fort Good Hope,

(b) Trending northwest in the Grandview Hills,

(c) Trending west-northwest in the lowlands and Peel Plateau,

(d) And trending southwest in a local area south and east of Fort Good Hope.

(5) Prominent fluvio-glacial deposits (eskers, kames, etc.) in the lowlands area below an elevation of 700'-1000'.

From this evidence the following sequence of events may be deduced:

(1) The first and major advance of the continental ice sheet, with a minimum elevation of 5000', overrode the foothill ranges and the Grandview Hills of the Interior Plains. The predominant glacial movement was west across the permit area and along the Mackenzie Mountain front.

The ice sheet eroded the soft Cretaceous shales to an elevation of 2500 (±) feet, forming the Upper Terrace of the Peel Plateau. Small valley glaciers in the Mackenzie fed into the ice sheet at elevations above 2500'.

(2) The first ice sheet retreated. Stream erosion and dissection, which later destroyed all evidence of the first glaciation, began on the upper terraces of the Peel Plateau.

(3) The ice sheet advanced again across the area. Elevation of the ice surface was about 2000'. The larger stream valleys in the Mackenzie Mountains were occupied by large valley glaciers which fed into the continental glacier at the northern limits of the middle terrace of the Peel Plateau.

Movement of the continental ice sheet was west-northwest in the lowlands; northwest in the Grandview Hills; and due north north and east of Fort Good Hope. Again, the softer Cretaceous sandstones and shales were eroded away to an elevation of 1000'. This scouring action formed the lower terrace of the Peel Plateau. The Devonian limestones above 1000' elevation were subjected to strong glacial abrasion and showed evidence of deep grooving, drumlinization, roches moutonnees, etc.

(4) The continental ice mass receded from the area. The valley glaciers also abandoned the lower valleys leaving the typical U-shaped valley profiles between elevations of 1800'-2500'. A few eskers were deposited on Devonian limestones in the higher elevations of the interior plains.

Streams occupied the glacial valleys in the Mackenzie Mountains. Dissection of the upper terrace of the Peel Plateau was renewed at this time, and has continued to the present. The second terrace of the Peel Plateau coincides with the upper elevation of the second ice sheet, but is not related to it. It is a rock terrace developed on a Cretaceous sandstone below the upper terrace.

(5) A lobe of the Keewatin ice sheet advanced into the area north and east of Fort Good Hope. The elevation of the ice surface was 700'-1000'. The lobe moved in a southeasterly direction south of Fort Good Hope, then turned in an arc around the Grandview Hills. Its terminus was immediately northwest of the permit area, where terminal moraine deposits are found.

The glacial lobe eroded the Cretaceous shales and sandstones to a depth of 400' in the lowlands of the interior plains. It was stagnant most of the time and developed the numerous fluvio glacial deposits which are now found in the lowlands area.

The Arctic Red River, flowing due north from the Mackenzie Mountain front, was forced to flow around the southern and western borders of the glacial lobe. It still occupies the same valley developed during this time.

The Ramparts River, also was forced to flow westward, and was a tributary of the Arctic Red River.

(6) The glacial lobe withdrew from the area, leaving numerous fluvio glacial deposits in the lowlands. Ground moraine deposits are scattered and thin. Streams adjusted their courses upon the glacial retreat; the Ramparts River assumed its present course. The terraces of the Peel Plateau have been modified by stream erosion, so that little evidence of glaciation remains. All three are rock terraces developed on Cretaceous sandstone beds. The middle terrace is a true rock terrace, but the upper and lower are remnants of the first and second periods of glacial erosion.

The importance of the glaciation in the area should be emphasized. A few pertinent observations are noted below:

(1) From 2,000' to 5,000' of Cretaceous sediments have been stripped from the surface in the permit area by continental glaciation.

(2) The bedrock has been well scoured by glaciation. Chemical weathering is negligible. The surface is bedrock with little

or no soil or glacial mantle. Topography is controlled by the differential hardness of the surface beds. Topography also reflects the underlying structure.

(3) The numerous fluvio-glacial deposits are excellent construction material. Eskers are excellent roadbeds. Since these deposits are present in the lowlands area, which is the most difficult of access, they assume much greater importance.

In view of the foregoing, it should be quite feasible to operate the year round in the area of the leaseholds rather than confining activity to the winter months.

Selected Bibliography on Glaciation

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Canadian Geological Survey, Geology and Economic Minerals of Canada, Economic Geology Series No. 1, 1957.

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Flint, R. F., Glacial and Pleistocene Geology, J. Wiley and Sons, New York, 1957.

Muskeg (Organic Terrain). The glacial leaseholds lie in the area of organic terrain, popularly referred to as "muskeg." The entire area, both mountains and lowlands, is mantled by a variable thickness of matted vegetation. Bedrock is exposed on the steeper cliffs which are undergoing active erosion.

The term "muskeg" carries with it the suggestion of low, swampy terrain. This was, indeed, its original connotation. However, through loose usage, the term includes all varieties of organic terrain.

The Canadian National Research Council, the military forces of both the U.S. and Canada, and oil companies operating in northern Canada are doing extensive research on the engineering characteristics of "muskeg." A brief list of selected references is appended below.

Muskeg thickness in the permit area varies from a few inches to several feet or more. The base may be on bedrock, soils, or water. The surface of the muskeg reflects the nature of the base upon which it has grown. Consequently, much can be learned of the trafficability, pedology, and geology of an area by inspection of the surface vegetation.

The advantages of vegetation interpretation was emphasized during photo interpretation of the permit area. Muskeg completely covers the surface exposures of bedrock. Moss ("caribou" moss) exhibits a white to light gray tone on the photographs. Such moss has an affinity for well-drained sandy rock or soil. When the boundaries of the moss are traced from the aerial photographs, a definite pattern is noticed, which reflects the configuration of the Cretaceous sandstones under the vegetation cover.

There are, undoubtedly, several species of moss as noted on the photography by the different gray tones, geographic position, and patterns exhibited. Fundamentally, however, the presence of moss is indicative of sandstone outcrop.

In future field operations, the various vegetation types should be noted on the photography and correlated with the terrain conditions existing. This will be advantageous both for field operations and geological mapping.

The Canadian research reports are more utilitarian than those published by the U. S. government agencies. An asterisk notes the more important articles. Publications of the Canadian National Research Council should be checked for current developments.

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MacFarlane, I. C., Techniques of Road Construction over Organic Terrain, Technical Paper No. 45, Division of Building Research, Ottawa, Ontario, Canada, November, 1956.

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* Pogontcheff, R. Y., A. J. Hodgson, and D. G. Stoneman, Shell Tackles Muskeg Problems, Canadian Oil and Gas Industries, Vol. 12, No. 7, pp. 64-70, July, 1959.

* Radforth, N. W. and I. C. MacFarlane, Correlation of Palaeobotanical and Engineering Studies of Muskeg (Peat) in Canada, Research Paper No. 35, Division of Building Research, National Research Council, Ottawa, August, 1957.

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Sigafoos, Robert S., Vegetation of Northwestern North America, As an Aid in Interpretation of Geologic Data, U.S.G.S. Bulletin 1061-E, 1958.

* Skilling, G. F.,"Muskeg Research and Vehicle Development," Canadian Oil and Gas Industries, Vol. 12, No. 7, pp. 71-74, July, 1959.

Spetzman, Lloyd A., Vegetation of the Arctic Slope of Alaska, U.S.G.S. Prof. Paper 302-B, 1959.

Permafrost. The Glacier leaseholds lie well within the region of perennially frozen ground, commonly referred to as "permafrost." The thickness of the permafrost zone varies from sporadic at Hay River, to over 1000' in Resolute Bay in the Arctic Islands and Point Barrow Alaska. The surface thaw zone is from 6-8' to 2' at the same localities, respectively. In the leasehold area, the permafrost will probably vary from 150-200' in thickness, with a 2-4' thaw zone.

It is not intended to give a full discourse on permafrost here. The reader is referred to the very excellent investigations and reports of the Division of Building Research of the National Research Council of

Canada. Some of the references are listed below. The Council maintains a field research office at Norman Wells.

Suffice to note here that permafrost is extremely important in all engineering and field operations, and procedures must be adopted with the possible effects of permafrost in mind.

The presence of permafrost may be indicated on aerial photographs by various criteria. It has not been possible to predict local conditions from the photographs, however. For local construction or operations, data must be gathered by field parties.

In the Glacier permits, the permafrost should not greatly affect activity in the topographically higher portions because of the solid bedrock at shallow depths. Permafrost will have greater significance in the lowland lake country in the center of the lease.

In conclusion, the presence of permafrost has modified the normal topographic development in the following ways:

(1) Lateral erosion predominates in the stream valleys, causing broader valley profiles than is normal.

(2) Ground water circulation is modified, and chemical erosion is non-existent. Karst topography is not developed in the limestone areas.

(3) The numerous lakes had a possible glacial origin, but have been extensively modified by permafrost. They have the shallow depths (5'-8') typical of "thaw" lakes.

<u>Selected Bibliography on Permafrost</u>

Benninghoff, W. S., "Use of Aerial Photographs for Terrain Interpretation Based on Field Mapping," Photogrammetric Engineering, Vol. XIX, No. 3, pp. 417-490, June, 1953.

Black, R. F., "Permafrost," _Applied Sedimentation_, edited by P. Trask, Chapter 14, pp. 247-275, J. Wiley & Sons, New York, 1950.

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Radforth, N. W., _Paleobotanical Method in the Prediction of Subsurface Ice Conditions in Northern Organic Terrain_, Technical Memorandum No. 34, Associate Committee on Soil and Snow Mechanics, National Research Council, 1955.

Sager, R. C., "Aerial Analysis of Permanently Frozen Ground," _Photogrammetric Engineering_, Vol. XVII, No. 4, pp. 551-557, 1951.

Washburn, A. L., "Classification of Patterned Ground and Review of Suggested Origins," _Bull. Geol. Soc. Amer._, Vol. 67, pp. 823-866, 1956.

GEOLOGY

Regional Geology

The Glacier permits lie north of the Mackenzie Mountain salient and east of the Richardson Mountains. Plate I shows the general stratigraphic boundaries. The permits are on the north flank of a local Cretaceous basin, the Cretaceous lying with angular unconformity on Devonian sediments.

The Mackenzie River is incised into the Devonian sediments and has a restricted channel in this area. The Mackenzie River Plain is southeast of the permits, and the Mackenzie River Delta is to the northwest.

Stratigraphy. Following is a list of formations occurring in the vicinity of the leaseholds.

Age	Maximum Thickness	
Cretaceous (undivided)	7000' (±)	Mackenzie Mountain front
- Regional Unconformity -		
Upper Devonian		
Imperial Formation	1900'	Imperial River
Fort Creek Formation	1600-1800'	Norman Wells
Ramparts Formation	1245'	Mountain River & Ramparts
Silurian or Devonian		
Bear Rock Formation	200'	Mountain River

The thicknesses given are maximum in the vicinity. Considerable variation is present due both to deposition and erosion. Tertiary and Quaternary deposits are absent or very minor, with the exception of the glacial deposits in the lowlands.

The Cretaceous in this area consists of a thick series of sandstone and shales, in part carbonaceous. A major truncating unconformity is present at the base of the Cretaceous. Plate II, showing the area in the vicinity of Fort Good Hope, illustrates the angular and regional nature of the unconformity. The Cretaceous onlaps the Fort Creek formation at a rate of 54' per mile.

The basal Cretaceous has been observed in contact with the following formations at the localities mentioned:

(1) Ramparts at Fort Good Hope, mouth of Mountain River, and the Mackenzie Mountain Front on Snake River;

(2) Fort Creek in Grandview Hills, in the mountain south of Fort Good Hope, and on Peel River a few miles below the mouth of Snake River;

(3) Imperial along the lower portions of the Peel and Arctic Red Rivers, along the Mackenzie Mountain Front, and north and northwest of the Glacier permits;

(4) Carboniferous along the eastern flank of the Richardson Mountains.

A simplified interpretation of the pre-Cretaceous outcrop is shown on Plate V. The Imperial formation is absent over most of the permit areas. A broad arch, trending east-northeast across the southern permit boundary, exposed Ramparts along its crest at the time of Cretaceous deposition.

The interpretation of surface outcrops shown on Plates V and VI does not differentiate the pre-Cretaceous formations, for two reasons:

(1) lack of distinguishing (photographic) characteristics between the Devonian limestones, and

(2) surface investigations were being carried on in areas of pre-Cretaceous outcrop which were not completed at the time of interpretation.

The regional interpretation on Plate V was made to confirm the suspected relation between the caribou moss and the Cretaceous sandstones. The light tones of the moss on the photography is very distinctive. Its presence is a key to determining the extent of Cretaceous outcrop, including the scattered remnants of basal Cretaceous sandstone in the northeastern portion of the permits.

Structure. The structures of the region are related to both the east-west structural trends of pre-Cretaceous time, and the Laramide orogeny of post-Cretaceous age. The surface expression of structure is further complicated by the Pleistocene glaciation.

On Plate V are shown the axes of regional structural trends, as suggested by surface outcrop patterns of Cretaceous sandstones. The solid arrows are regional dip directions and are not related to local anomalies.

The post-Cretaceous structural axes tend to parallel the Mountain front. This trend is present even in areas of Devonian outcrop, such as the Grandview Hills. Locally, these structures are a combination of both pre- and post-Cretaceous folding, with the east-west orientation dominating in older sediments. There may be several local domes in Grandview Hills with such east-west orientation, opposed to the regional southeast-northwest trend.

The portion of the structural trough, which coincides with the lowlands area of the Interior Plains, may be placed too far to the north. This would be due to the influence of glaciation on the topography. Stratigraphic studies have indicated the position of the trough to be near the mountain front, and south of the area of permits.

The pre-Cretaceous structural trends are vaguely reflected in the outcrop patterns. The two most pronounced are:

(1) the Fort Good Hope High to the east near the village of Fort Good Hope, and

(2) a syncline at the junction of the Snake and Peel Rivers.

Between these two features are several vague northeast-southwest structural trends. Though the location of these axes is not accurate, the structural trends should be kept in mind in future evaluation and study.

Local Geology

Plate VI is a compilation of the local geology prepared from stereoscopic interpretation of the photographs. This map should be considered a preliminary interpretation, subject to considerable revision.

The stratigraphic boundaries are not shown on the map, with the exception of the Cretaceous-Devonian contact near Fort Good Hope and along the western edge of the map. The area north of a line connecting these two points will approximate the northern limit of Cretaceous outcrop. North of this line, the Cretaceous occurs in scattered patches; southward the Cretaceous forms a relatively thick cover of Devonian linestones. The more prominent Devonian outcrops occur in the southeastern end of the Grandview Hills, along the Mackenzie River.

The several structural axes shown on the map reflect the two regional structural trends. Structures in Devonian trend east-west; those in the Cretaceous are southeast-northwest. The Cretaceous structures are primarily inferred from the outcrop pattern and are not the result of dip determination.

The anticlinal axes on the south edge of the map are part of a broad southeast trending arch, indicated by the drainage pattern at the southwest corner of the map.

Observations of importance in planning future field work are:

(1) Structures are reflected in the topography; anticlines are along topographic highs; and synclines are in valleys or lowlands.

(2) Very good outcrops are found along all the major stream valley and most of the tributary streams; traverses along the streams using photographs for interpolation between traverses should yield excellent results.

(3) Surface dips are low; for quantitative information, barometric leveling or shallow structural drilling should give satisfactory results.

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

Sproule, J. C., and Associates, Geological Reconnaissance Report, Glacier Explorers, Ltd., P. and N. G. Holdings - Lower Mackenzie Basin Area, N.W.T., unpublished report, March, 1958.

SUMMARY AND RECOMMENDATIONS

The Glacier Explorers, Ltd. leaseholds lie in a structural and topographic trough north of the Mackenzie Mountain salient. It is in the Interior Plains physiographic province.

Geographic factors which affect operations are:

(1) Continental glaciation has stripped 2000-5000' of sediments from the surface;

(2) Muskeg masks surface outcrops and may locally hinder operations; and

(3) Permafrost, demands special consideration in construction and drilling operations.

Surface rocks are of Cretaceous age, and lie unconformably on Devonian sediments. The Devonian is exposed on the surface near the Mackenzie River. Pre-Cretaceous structural trends in the older sediments are southwest-northeast to east-west. Post-Cretaceous structures parallel the Mountain front generally in a northwest-southeast direction.

Surface structures are found in Devonian outcrops by dip determination. In the Cretaceous sediments, structures are inferred from outcrop patterns of sandstones as reflected in the muskeg cover.

Excellent exposures are found along stream banks. Geologic structures are reflected in the topography. Future operations recommended are:

(1) Surface field traverses along the drainage channels using aerial photographs for interpolation between traverses, supplemented by barometric leveling, and/or structural core drilling.

(2) Topographic mapping from aerial photography to define surface structure and local terrain conditions.

Kenneth M. Renfro

Kenneth M. Renfro

PLATE I

Map Showing Location of Glacier Leaseholds
With Respect To Regional Geology

Scale: 1" = 120 miles
(1:7,603,200)
From GGS Map No. 1045A

LEGEND

Area covered by Plate VI

Q	Quaternary	TR	Triassic
Tv	Tertiary volcanic	M	Mesozoic (undivided)
Ts	Tertiary sediments	C	Carboniferous and Permian
Ku	Upper Cretaceous	D	Devonian
Kl	Lower Cretaceous	S	Silurian
K	Cretaceous (undivided)	O	Ordovician
JK	Jurassic and Lower Cretaceous	Є	Cambrian
J	Jurassic	P	Paleozoic (undivided)

All other symbols are Pre-Cambrian or intrusives.

PLATE II

Map Showing Location of Glacier Leaseholds
With Respect to Physiographic Provinces
Of Northern Canada

Scale: 1" = 40 miles
(1:2,534,400)
From CGS Map No. 922A

Area of Plate VI

PLATE III

Geologic Map Showing General Stratigraphic Relationships in Vicinity of Fort Good Hope

Scale: 1" = 8 miles

(1:506,880)

From CGS Map No. 1033A, Sheet 2

LEGEND

Area covered by Plate VI

9	Cretaceous
8	Devonian Imperial Formation
7	Devonian Ft. Creek Formation
5c	Devonian - Upper Ramparts limestone
5b	Devonian - Middle Ramparts shale

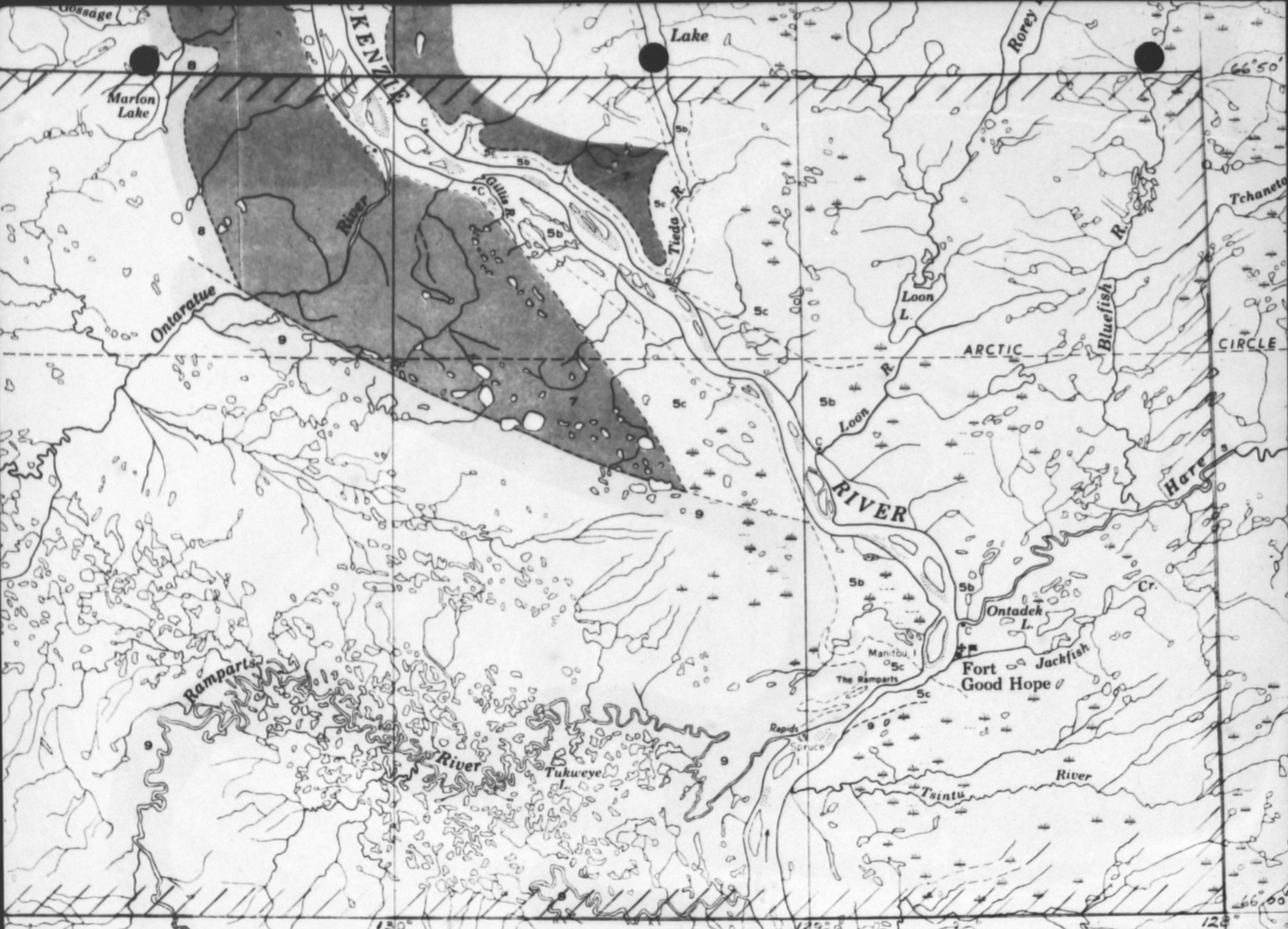

Gossage
Marion Lake
Lake
Rorey
66°50'
KENZIE
Gillis R.
River
Tieda R.
Loon L.
Loon R.
Bluefish R.
Tchaneta
Ontaratue
ARCTIC
CIRCLE
RIVER
Hare
Cr.
Ontadek L.
Manitou I.
The Ramparts
Fort Good Hope
Jackfish
Rapids
Spruce
Ramparts
River
Tukweye L.
Tsintu
River
66°00'
130°
129°
128°
5b
5c
7
8
9

PLATE III

PLATE IV

North-South Topographic Profile Along Longitude 131°W, from Latitude 65°20'N to 67°00'N

Vertical Scale: 1" = 1000'

Horizontal Scale: 1" = 11.6 miles

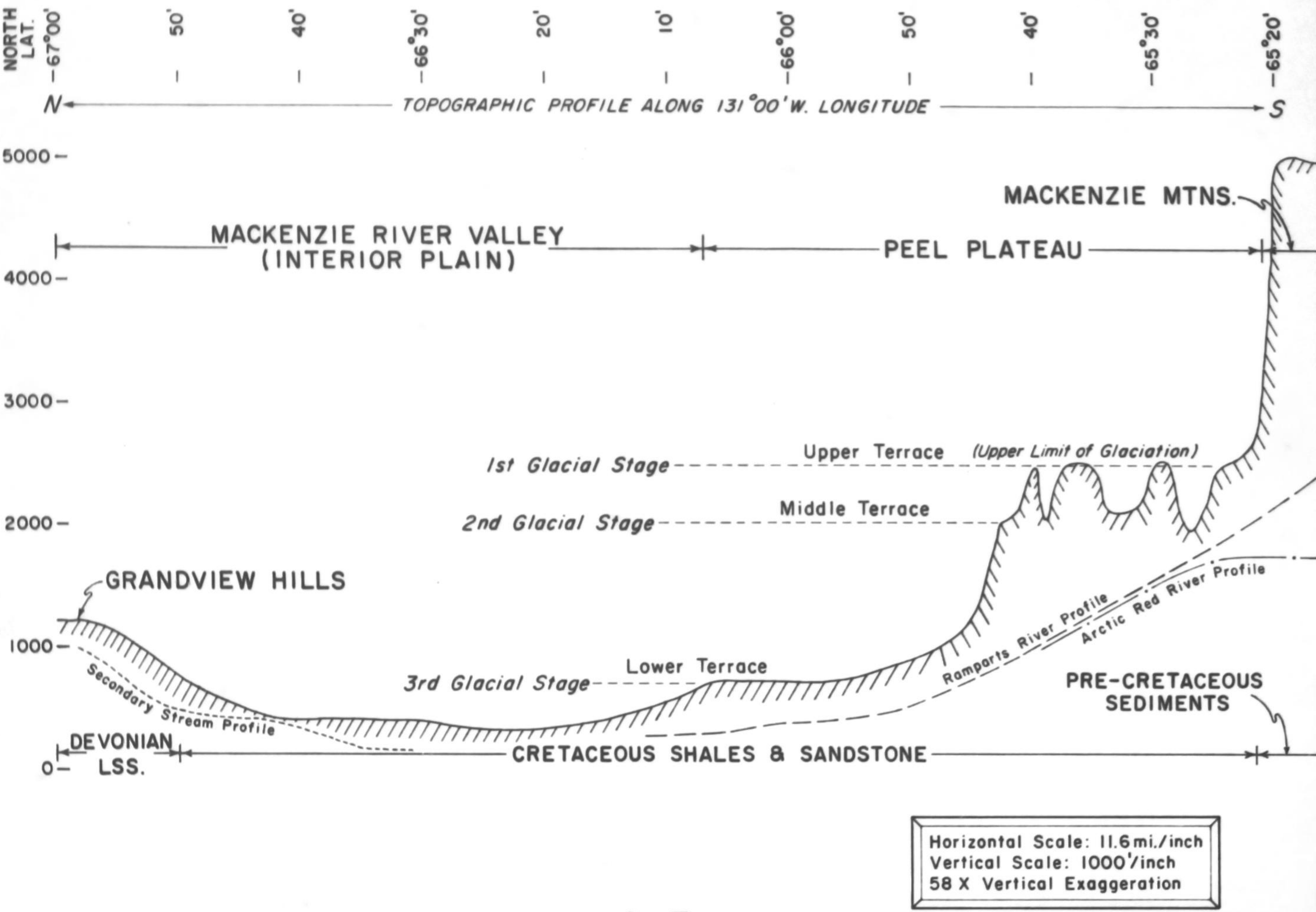
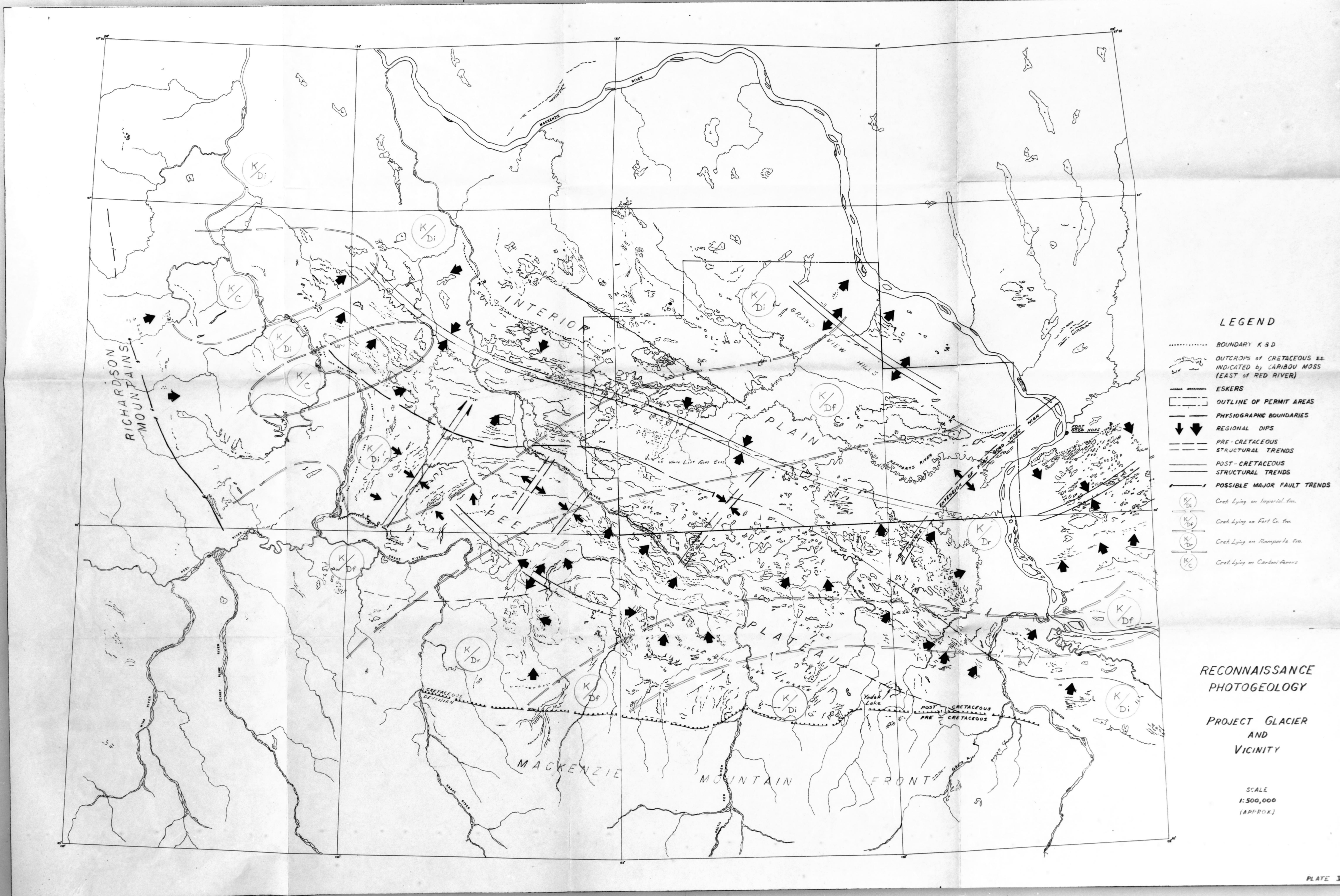

NORTH LAT.
-67°00'
50'
40'
-66°30'
20'
10'
-66°00'
50'
40'
-65°30'
-65°20'
N
TOPOGRAPHIC PROFILE ALONG 131°00'W. LONGITUDE
S
5000
4000
3000
2000
1000
0
MACKENZIE MTNS.
MACKENZIE RIVER VALLEY (INTERIOR PLAIN)
PEEL PLATEAU
Upper Terrace
(Upper Limit of Glaciation)
1st Glacial Stage
2nd Glacial Stage
Middle Terrace
GRANDVIEW HILLS
Arctic Red River Profile
Ramparts River Profile
Lower Terrace
3rd Glacial Stage
Secondary Stream Profile
PRE-CRETACEOUS SEDIMENTS
DEVONIAN LSS.
CRETACEOUS SHALES & SANDSTONE
Horizontal Scale: 11.6 mi./inch
Vertical Scale: 1000'/inch
58 X Vertical Exaggeration

Plate IV


MACKENZIE RIVER
RICHARDSON MOUNTAINS
INTERIOR
PLAIN
PEEL
PLATEAU
GRAND VIEW HILLS
MACKENZIE
MOUNTAIN
FRONT
Yadek Lake
POST - CRETACEOUS
PRE - CRETACEOUS
LEGEND
BOUNDARY K & D
OUTCROPS of CRETACEOUS s.s. INDICATED by CARIBOU MOSS (EAST of RED RIVER)
ESKERS
OUTLINE OF PERMIT AREAS
PHYSIOGRAPHIC BOUNDARIES
REGIONAL DIPS
PRE-CRETACEOUS STRUCTURAL TRENDS
POST-CRETACEOUS STRUCTURAL TRENDS
POSSIBLE MAJOR FAULT TRENDS
Cret. Lying on Imperial fm.
Cret. Lying on Fort Cr. fm.
Cret. Lying on Ramparts fm.
Cret. Lying on Carboniferous
RECONNAISSANCE PHOTOGEOLOGY
PROJECT GLACIER AND VICINITY
SCALE 1:500,000 (APPROX)
PLATE V

PROJECT GLACIER

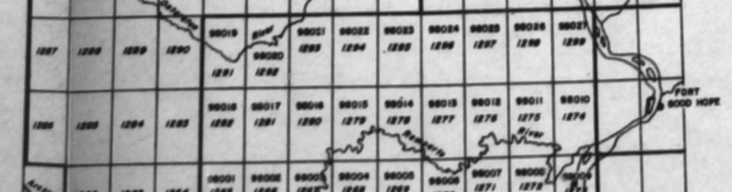
Prepared from Preliminary Topographic Sheet Numbers 106I, 106J, 106K, scale 1:126,720 Department of Mines and Technical Surveys Dated 1958; for the Atlantic Refining Company. The original manuscript meets national map accuracy standards.

Prepared for The Atlantic Refining Company by F. Feldhusen

PROJECT GLACIER N.W.T. CANADA

1 of

"GRID AREA" LOCATION MAP



Note:
98009—S.C. Number
1273—GRID AREA

"GRID AREA" SUBDIVISION

REFERENCE

- Wooded Area
- Evergreen
- Rocks
- Marsh—Muskeg
- Lakes
- Eskers
- Sand
- Aerial Photo Center Point
- Moraines

SCALE 1:126,720

Statute Miles 1 0 5 10 15 Statute Miles

Nautical Miles 1 0 5 10 15 Nautical Miles

Universal Transverse Mercator Projection

(CONTOUR INTERVAL 100 FEET)

LEGEND

CLEARLY DEFINED | UNCERTAIN | HORIZONTAL BED | CLEARLY DEFINED | UNCERTAIN | BEDDING SCARP

LOCATION MAP

PRELIMINARY

PHOTOGEOLOGIC MA

PHOTOGEOLOGY BY

K.M. Renfro

J.F. Weaver

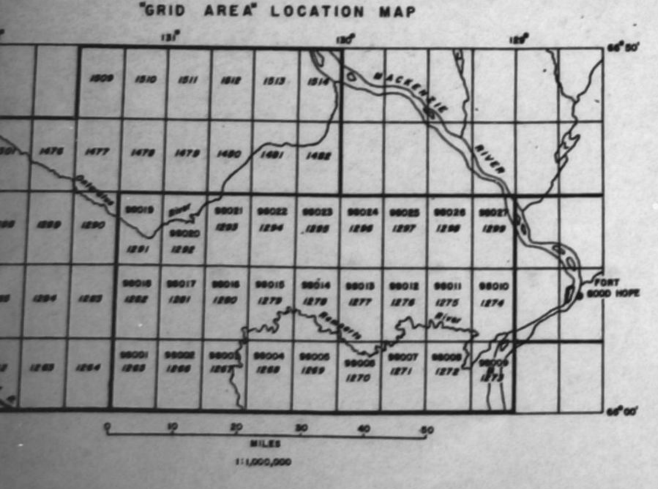
L.F. Miller


PROJECT GLACIER
Prepared for The Atlantic Refining Company by F. Feldhusen
"GRID AREA" LOCATION MAP
"GRID AREA" SUBDIVISION
REFERENCE
SCALE 1:126,720
Statute Miles
Nautical Miles
Universal Transverse Mercator Projection
(CONTOUR INTERVAL 100 FEET)
LEGEND
CLEARLY DEFINED
UNCERTAIN
HORIZONTAL BED
GENTLE DIP
LOW DIP
BEDDING SCARP
LITHOLOGIC CONTACT
FAULTS, FRACTURES, ETC.
LOCATION MAP
PROJECT GLACIER
N.W.T. CANADA
PRELIMINARY
PHOTOGEOLOGIC MAP
PHOTOGEOLOGY BY
K.M. Renfro
J.F. Weaver
L.F. Miller
2 of

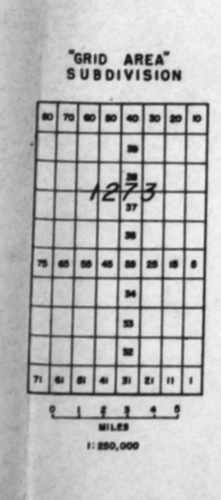
MACKENZIE RIVER
Prepared for The Atlantic Refining Company by F. Feldhusen
SCALE 1:126,720
Statute Miles
Nautical Miles
Universal Transverse Mercator Projection
(CONTOUR INTERVAL 100 FEET)
LEGEND
CLEARLY DEFINED
UNCERTAIN
HORIZONTAL BED
GENTLE DIP
LOW DIP
MODERATE DIP
BEDDING SCARP
LITHOLOGIC CONTACT
FAULTS, FRACTURES, ETC.
TREND OF GLACIAL STRIAE
ANTICLINE
SYNCLINE
"GRID AREA" LOCATION MAP
"GRID AREA" SUBDIVISION
REFERENCE
LOCATION MAP
ARCTIC RED RIVER
FORT McPHERSON
CANSO LAKE
MACKENZIE RIVER
FORT GOOD HOPE
NORMAN WELLS
NORTHWEST TERR.
YUKON TERR.
MILES
PROJECT GLAC
N.W.T. CANAD
PRELIMINARY
PHOTOGEOLOGIC
PHOTOGEOLOGY BY
K.M. Renfro
J.F. Weaver
L.F. Miller
JULY 1959
3

Prepared for The Atlantic Refining Company by F. Feldhusen

"GRID AREA" LOCATION MAP



"GRID AREA" SUBDIVISION



REFERENCE

- Wooded Area
- Evergreen
- Rocks
- Marsh — Muskeg
- Lakes
- Eskers
- Sand
- Aerial Photo Center Point
- Moraines
- Cleared Field

SCALE 1:126,720

Statute Miles 1 0 5 10 15 Statute Miles

Nautical Miles 1 0 5 10 15 Nautical Miles

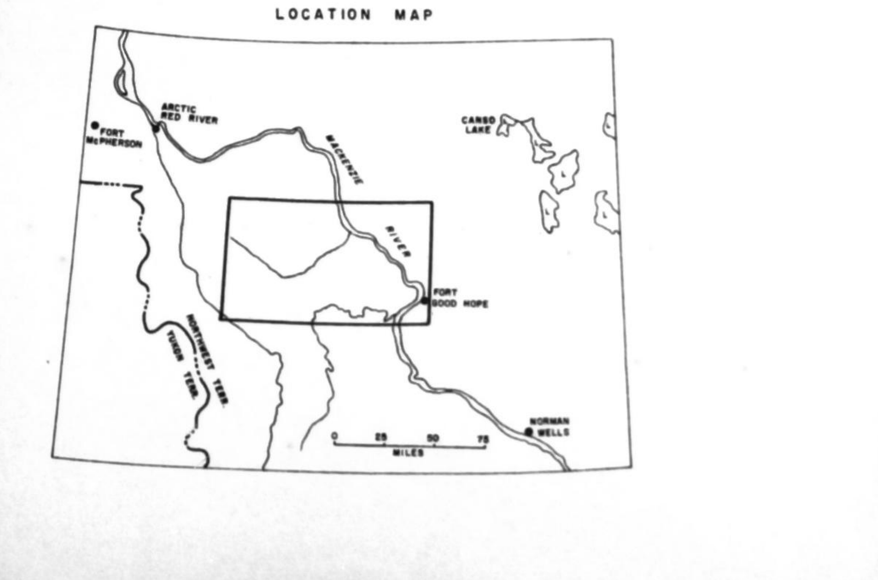
Universal Transverse Mercator Projection

(CONTOUR INTERVAL 100 FEET)

LEGEND

CLEARLY DEFINED	UNCERTAIN	
		HORIZONTAL BED
		GENTLE DIP
		LOW DIP
		MODERATE DIP
		BEDDING SCARP
		LITHOLOGIC CONTACT
		FAULTS, FRACTURES, ETC.
		TREND OF GLACIAL STRIAE
		ANTICLINE
		SYNCLINE

LOCATION MAP



PROJECT GLACIER
N.W.T. CANADA

PRELIMINARY

PHOTOGEOLOGIC MAP

PHOTOGEOLOGY BY

K.M. Renfro

J.F. Weaver

L.F. Miller

JULY 1959

4 of 4

PLATE XI

N6600/W12830 50x345