

PHOTOGEOLOGICAL AND PHOTOGRAMMETRIC
STRUCTURAL STUDY
GLACIER EXPLORERS FORT GOOD HOPE PROJECT
FORT GOOD HOPE AREA, N.W.T.

Prepared For
Glacier Explorers Limited
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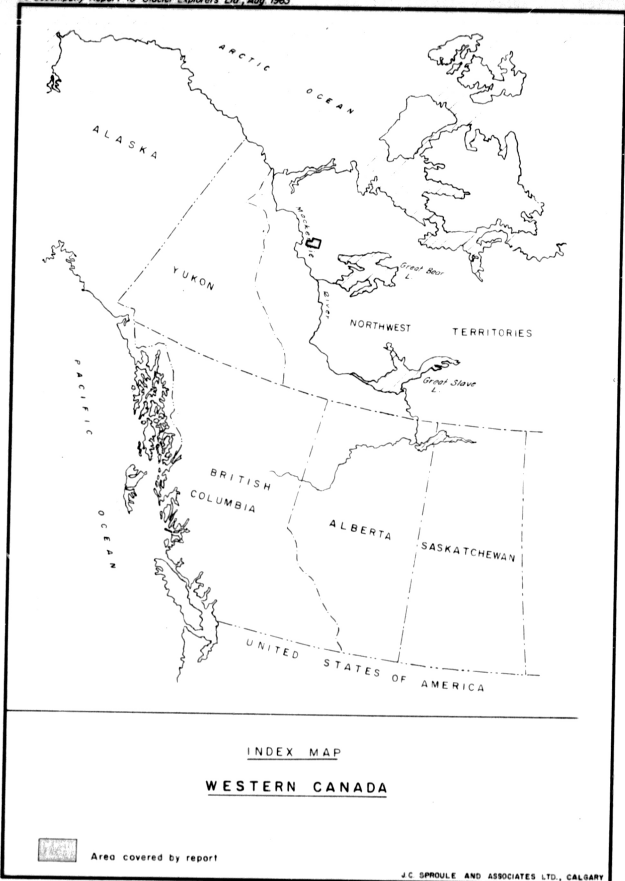
J. G. SPROULE AND ASSOCIATES LTD.
OIL AND GAS ENGINEERING AND GEOLOGICAL CONSULTANTS

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INTRODUCTION

Description of Project

This report contains the results of a structural study, utilising detailed photogeological and photogrammetric methods, of an area northeast of Fort Good Hope, N.W.T. The work has been conducted by J. C. Sproule and Associates Ltd. at the request of Mr. S. Taylor, acting for Glacier Explorers Limited, hereinafter referred to as the "Company." The project area extends northeast of the Company's P. & N. G. Permits Nos. 1533 to 1536, inclusive, and 1544, and was designed to assist in the evaluation of the Company's P. & N. G. holdings.

The principal objectives of the detailed structural study were:

- (a) to determine if northeast closure is present on the previously mapped structural high along the Hare Indian River.
- (b) to establish any other reversals or structural features which might provide traps for petroleum accumulations within the project area.
- (c) to provide data on which to base recommendations concerning the Company Permits.

The essential results of the study are presented on a geological and structure contour map. This report also includes brief discussions pertaining to sources of data, general map information, procedures for map compilation, and some of the observations and data from previous geological studies which have been conducted in the area for Glacier Explorers Limited.

Sources of Data

The map accompanying this report (Figure 1) is based on data derived from Kelsh Pletter, utilising glass diapositives of vertical air photographs (scale approximately 1" to 3,500') purchased from the Department of National Defence, Ottawa, Ontario, and from a photogeological reconnaissance map of the Company's holdings prepared by J. C. Sproule and Associates Ltd. February, 1960. The Fort Good Hope (106-1) and Lac Belot (96-L) topographic maps at a scale of 1:250,000, dated 1959 and 1957, respectively, were used to establish the horizontal and vertical control. Due to a lack of spot elevations or bench marks on the Fort Good Hope topographic sheet, it was necessary to project the river gradient from the last shown spot elevation along the Hare Indian River on the Lake Belot topographic sheet, westward to the Glacier Bayseil Climax Ramparts No. 1 well. This well has a ground elevation of 70.5' and is +15 feet above river level, establishing river level at +55 feet at Fort Good Hope.

General Map Information

The transverse Mercator projection was used in the compilation of the accompanying map. This map has been drawn using a scale of one inch to one-half mile as reduced from a Kelsh image scale of one inch to 600 feet.

Procedures for Map Compilation

For the purpose of this study, the geological and structural contour map was compiled, utilizing a key bed within the Hume Formation, approximately 140 feet stratigraphically lower than the Hare-Hare Indian Formation boundary, as the datum horizon. In addition, elevations were taken along the Bear Rock-Hume Formation boundary and other key beds, both above and below the datum horizon. These surface elevations have been projected to datum by adding or subtracting the calculated interval of that horizon noted on the map as D-170', D+40' etc. The structural contour map was then drawn, utilizing the data projected to the datum horizon. In general, throughout the area, attitudes of the bedding planes were difficult to obtain due to the gently undulating nature of the beds and to the lack of re-entrance of key beds in stream cuts, necessary to establish three-point problems. Attitudes in the southwest part of the project area are based mainly on geomorphic evidence, such as structurally controlled drainage patterns, and on lake alignments.

Faults, showing their direction of movement if possible, and alignments, which may have structural significance at depth, have been plotted.

Lake elevations have been plotted and are thought to have significance in determining the plunge of several structural features in the area. The relationships of these lakes to structure within the area may prove a valuable tool in the interpretation of structural features within the Hume Formation in otherwise mantled areas within the Company's holdings to the southwest.

PHYSIOGRAPHY AND ACCESSIBILITY

The project area is situated entirely within the Interior Plains physiographic province. To the south, lie the folded and faulted ranges of the Franklin Mountains, which curve somewhat abruptly from a westerly to a southeasterly direction. The most northerly ranges of the Franklin Mountains are Jacques Ridge and the Beavertail Anticline, which lie respectively 12 and 20 miles south of the Fort Good Hope Company holdings. These mountain ranges reach moderate heights of little more than 1,000 to 2,000 feet. In the Lower Mackenzie area the Interior Plains province ranges from the Richardson Mountains 180 miles west of Fort Good Hope up to more than 250 miles eastward to the Precambrian Shield.

The Mackenzie River flows to the north and is approximately 20 miles to the west of the current project boundary. Upstream from Fort Good Hope, the river flows between limestone cliffs which rise almost vertically to heights of 200 to 250 feet. This wide canyon is called the Ramparts.

The Company holdings lie mainly on a plateau with hills that reach a height of more than 1,100 feet in the southeast corner. Lakes and muskegs cover valleys and flat areas. The wide valley of Hare Indian River occupies a large area within the northern and central portion of the current project area. Many peculiarities of the relief are directly related to the character of the underlying rock formations. Devonian limestones, which lie near the surface in the south part of the area, have caused the development of canyons and escarpments. Shales have resulted in featureless plains with lakes, extensive muskegs and marl flats while many rounded hills are underlain by sandstone or glacial drift.

The interior of the Fort Good Hope area can be reached with heavy equipment in the winter when lakes and muskegs are frozen. In summer, only limited areas adjacent to the Mackenzie River are readily accessible. Flat-bottomed boats can possibly travel some distance on the Hare Indian River with high water in early spring, but most of the summer the river is too shallow. Tractors could move a few miles overland northeast of Fort Good Hope by taking advantage of an esker.

REGIONAL GEOLOGICAL SETTING

The lands of the present project area, which tie to the Company's holdings, lie within the central portion of the Mackenzie Basin. To the south, lie the Franklin Mountains, which consist of sub-parallel anticlinal ranges. The strata exposed in the Franklin Mountains are Cambrian to Tertiary in age and include several large stratigraphic intervals, which undoubtedly are in the subsurface of the Fort Good Hope area. Further regional geological information has been derived from outcrop sections in the Mackenzie Mountains and Richardson Mountains, and also from small exposures on the plains to the south and east of the project area. Deposition of sediments in the Mackenzie Basin began in Precambrian time and has continued with many interruptions to the present. Sand and clay sediments are still accumulating in the Mackenzie Delta, and layers of peat are forming on the upland. Periodical uplifts above sea level in parts of the basin area and, more rarely, emergence of the entire basin caused destruction

of the record of sedimentation in certain intervals of geologic time. The sedimentary succession is most complete in the western territories and in the Yukon. In the vicinity of the Company's holdings, a large hiatus exists between beds of Devonian age and Lower Cretaceous sandstones and shales. The Late Paleozoic and Early Mesozoic deposits, if they were present at any time within the area, have all been removed by erosion, but the sequence from the Late Precambrian to the Devonian is fairly complete.

The Fort Good Hope project lies within the Interior Plains, which are structurally less deformed than the adjacent mountain belts. Upon closer investigation, it has become evident that faulting and folding are much more common within the plains than it would appear from a cursory examination. The field work carried out on the Company holdings in 1957 brought out the existence of a structurally high area in the vicinity of Fort Good Hope. A detailed investigation of this feature was the principal objective of the work done during the summer of 1959. The feature concerned appears to be regionally high, with the axis trending in a northeast-southwest direction. It dips sharply to the southwest, whereas the northwest and southeast flanks are more indistinct.

STRATIGRAPHY

Parts of the stratigraphic sequence have been studied at various localities in the northern and central Mackenzie Basin. The following Table of Formations includes only those that have a bearing on the Company holdings.

A composite interpretation of the stratigraphic succession in the vicinity of Fort Good Hope follows.

Table of Formations
(Fort Good Hope Area, N.W.T.)

<u>Age</u>	<u>Formation or Group</u>	<u>Lithology</u>	<u>Thickness*</u> Feet
Cretaceous	Sans Sauk	Grey shales, siltstone and sandstone, marine; porous, friable sandstone at base. Oil saturated in places.	0-300
- UNCONFORMITY -			
Upper Devonian	Imperial	Shales, siltstones and greenish grey to brown sandstones; carbonaceous material common.	0-200
	Fort Creek	Black, bituminous hard platy shale; fossiliferous sandstone at the base in many places.	0-350

(*) Estimated thicknesses within Company Permits and vicinity.

Table of Formations - Continued

<u>Age</u>	<u>Formation or Group</u>	<u>Lithology</u>	<u>Thickness Feet</u>
Middle Devonian	Kee Scarp	Buff to grey limestones, very fossiliferous, in part reefal, bedded to massive; merges in the northern Mackenzie Basin with the Hare Indian into a Ramparts Shale Unit (undifferentiated).	600
	Hare Indian	Greenish grey shales and thin-bedded argillaceous limestones; dark shales in lower part.	750
	Hume	Grey fossiliferous nodular limestones and shales; local bioherms.	455-630
Lower Devonian	Bear Rock	Dolomite, limestone, gypsum, anhydrite; in part brecciated but well bedded at top and bottom.	500+
- UNCONFORMITY -			
Silurian and Ordovician	Ronning	Hard, light brown, dolomite; chert and vugs common.	2,000
Cambro- Ordovician		Bedded dolomites and thin shale beds, unfossiliferous.	300-1,000
Cambrian	Macdougall	Coloured shales, evaporites, limestones and dolomites.	1,500
Early Cambrian and Precambrian	Katherine- Tindir	Quartzites and argillites.	1,000+

Discussion of Formations Exposed in the Project Area

Bear Rock Formation

The Bear Rock Formation of Lower Devonian age appears at the surface in the valley and, to some extent, along the escarpments on either side of the Hare Indian River. The Bear Rock-Hume Formation boundary, with few exceptions, is concealed by hill wash, slump and talus deposits. Elevations, where taken on the generalized position of this contact, can only be approximate.

Hume Formation

Surface outcrop of the Middle Devonian Hume Formation occupies the greater portion of the project area. It forms the escarpments on either side of the Hare Indian River, the low benches where the escarpment is no longer present, and the plateaux.

The Hume Formation thins northwesterly from a thickness of 630 feet in the southeastern corner of the project area to 455 feet at Glacier-Baysel-Climax Ramparts No. 1 and to approximately 430 feet at the horseshoe bend along the Hare Indian River near Longitude 127°37' W. This thinning appears to take place mainly in the interbedded limestones and shales at the base of the Hume Formation. Variable datum intervals to the Bear Rock-Hume Formation boundary and to all key beds below D -170' have been incorporated in the structural contour data.

To the north of the Hare Indian River, near Longitude 127°42' W., there is a very rapid thinning to the northwest of all the beds below the datum horizon. For example, within a horizontal distance of one mile, the D -170' interval carried throughout the project thins to D -30'. This thinning takes place immediately to the north of a major east-trending fault, upthrown to the south, and appears to be controlled by a Pre-Hume Positive Feature, hereinafter referred to as the Pre-Hume Positive Feature, or buried ridge trending east-northeasterly and parallel to and north of the previously mentioned fault. This positive fault appears parallel to the general trend of the Hare Indian River in the immediate vicinity. Two components of 15° oppose each other where this positive feature is exposed in a stream cut near Longitude 128°32' W. Attitudes of surface beds at a higher elevation than these 15° components are from one to three degrees. The thinning in this area may, therefore, be post-ridge and pre-fault. The age and formation of this possible feature cannot be determined without field examination.

Further indication of the possible existence of this Pre-Hume Positive Feature is found in the thinning of the Hume Formation from 730 feet near the southeast corner of the project area to 455 feet at the Glacier-Baysel-Climax Ramparts No. 1 well.

The indications are that the Pre-Hume Positive Feature as followed along the trend indicated within the project area would cross under the Mackenzie River within the Company holdings near Latitude 66°20' N., Longitude 128°40' W. and appear to align with the anomalous drainage pattern on the Ramparts River near Latitude 66°11' N., Longitude 129°11' W.

Figure 2 shows the correlation of the datum horizon, formation boundaries, and main key beds used in data projection within the project area to the same horizons expressed on the Electric Log of Glacier-Baysel-Climax Ramparts No. 1. As shown on this diagram, the stratigraphic intervals between key beds and formation boundaries above the datum horizon and immediately below the datum horizon show relatively little thickness variation. The D -170' interval, as utilized throughout most of the project, may correlate to the D -140' unit of the well log, or to the D -175' unit. The correlation to the D -140' unit would indicate a thinning of approximately 30 feet westward toward the well. This thinning would have the effect of raising the projected data $\pm 15'$ in the western part

of the project area. The major easterly thickening has been limited within the project area to those beds below the D -170'. Key beds between the interval D -170' down to the top of the Bear Rock Formation have been projected utilizing a variable interval datum. The above-mentioned zone of thinning consists of interbedded limestones and shales.

Hare Indian Formation

The Hare Indian Formation is exposed at the surface near the south boundary of the project area. The contact has been placed at the top of a limestone ridge, overlain by shaly appearing beds. Field outcrop and subsurface studies have indicated that the base of the Hare Indian Formation is marked by a black shale zone. This contact is approximately 140 feet above the datum horizon. The rather abrupt appearance of this formation along an east-northeasterly trending alignment suggests a major fault upthrown to the north. This fault and the fault previously mentioned to the north of the Hare Indian River combine to form what appears to be a rather broad horst, with the general throw increasing from 0 feet east to +250 feet to the west at the southwest boundary of the project area. This horst may very well be an integral part of the Fort Good Hope high discussed in previous reports submitted to the Company.

GEOLOGICAL STRUCTURE

Introduction

Regional structure has been discussed in this report under the heading "Regional Geological Setting." Local structure within the project area is characterized by gentle folds and associated faulting.

There are three basic trends of faulting within the area. In order of importance they are (1) fault sets trending approximately N. 60° E., (2) faults trending approximately N. 30°-45° W., (3) easterly trending faults. A fourth, less definite but no less important trend, appears to parallel the Hare Indian River.

A distinction is made on the map between faults based on observed displacements of beds and those based on geomorphic evidence. The geomorphic data utilized in the interpretation of various structural features based on river and stream channels, lake alignments or trends believed to be structurally controlled and lake elevations. Lake elevations on anticlines are usually lower than those of adjoining synclines within the same stratigraphic unit and similarly lakes generally decrease in elevation in the down-plunge direction when located within the same stratigraphic unit along anticlinal or synclinal axes.

It appears probable that the regional as well as the local structure in the general Fort Good Hope area has been controlled in part by early Paleozoic facies changes. These facies changes are related to an early Paleozoic "high" in the area to the north of the project area. The marked thinning of the lower beds of the Hume Formation from south to north is evidence for this ancient Positive Feature.

Separate discussions of the main structural features of the project area follow.

Hare Indian River Trend

The Hare Indian River is itself an expression of the general structural trend within the project area. This structural trend is hereinafter referred to as the Hare Indian Structural Trend. It is comprised in general of a series of progressively bifurcating anticlines, wherein each new anticline, having its origin on the west and/or southwest flank of a previous anticline, becomes the predominant structure until it is itself replaced by a new anticlinal feature originating on or near its southwest flank. The anticline thus replaced proceeds to plunge out the the southwest. The Hare Indian Structural Trend plunges northward from the southeast corner of the project area and then southwestward into the area of the Company Permits.

Five of the anticlines associated with the Hare Indian Structural Trend have been named, as follows:

- (1) East Hare Indian Anticline
- (2) West Hare Indian Anticline
- (3) Hare Indian Anticline
- (4) South Hare Indian Anticline
- (5) Good Hope Anticline

The main local closures and fault traps along these anticlines have been indicated on the geological and structure contour map by letter and subscript references.

Fort Good Hope Horst

In the western part of the project area a horst appears to relate to the regional feature known previously as the "Fort Good Hope High." The horst is therefore named the "Fort Good Hope Horst." It embodies that part of the Hare Indian Structural Trend which includes the South Hare Indian Anticline and much of the Good Hope Anticline and the east-west trending part of the Hare Indian Anticline. A gentle southwest-trending syncline which is prominent through the central part of the map area between the South Hare Indian Anticline and the Good Hope Anticline also forms part of the Fort Good Hope Horst.

Two major faults bound the Fort Good Hope Horst. The northernmost of these two faults, which originates near Latitude $66^{\circ}29'15''$ N., Longitude $127^{\circ}44'W$, has a throw increasing southwesterly from zero to +250 feet at the western boundary of the project area. The southern fault, which originates near Latitude $66^{\circ}23'15''$ W., Longitude $127^{\circ}53' W$, has a throw increasing southwesterly from zero to 255 feet at the south boundary of the project area. A northeasterly trending hinge joining the origin of these two faults is suggested by a broad flattening along the Hare Indian Anticline and a plunge reversal along the South Hare Indian

and Good Hope anticlines. An interrupted extension of the southern fault, again upthrown to the north but with the throw increasing from ± 25 feet to 100 feet to the northeast instead of the southwest, near the northeast boundary of the project, indicates that the horst zone may be reactivated to the northeast.

East Hare Indian Anticline

The East Hare Indian Anticline is an arcuate north to northwesterly plunging, gently folded, faulted anticline. It is asymmetric, with the steep flank generally to the west and/or southwest. The anticline has its origin in the south, outside the project area. The axis is approximately 15 1/2 miles in length within the project boundaries, and continues an unknown distance to the south. Near the north boundary of the project area the axis plunges into and is offset to the north by a northeast-trending fault, upthrown from 25 to 100 feet to the northwest. From this fault the axis changes from a northerly to a westerly direction, plunging out at approximately Latitude $66^{\circ}30'$ N., Longitude $127^{\circ}34'$ W. A fault subparallel to the westerly trending portion of the anticline intersects the axis near Latitude $66^{\circ}29'30''$ N., Longitude $127^{\circ}29'$ W. It is upthrown approximately 10 feet to the south. A small feature (A₁) with a closure of ± 25 feet is indicated near the northwest terminus of the anticline. Another small feature (A₂) is closed against the northeast-trending fault. A major fault, sub-parallel to the axis of the East Hare Indian Anticline, intersects the axis from the southeast to the northwest near Latitude $66^{\circ}23'$ N., Longitude $127^{\circ}21'30''$ W. This fault is upthrown to the east about 30 feet. Other minor faults trending easterly intersect the northerly trending portion of the axis at several localities. The types of traps that such faults can create along the anticline are illustrated by the features (A₃) and (A₄).

The beds of the Devonian Bear Rock Formation are the oldest rocks exposed in the core of the anticline within the project area.

West Hare Indian Anticline

This is one of several anticlinal features plunging into the project area from the southeast. A small questionably closed feature (F₁) has been indicated on the map along with a second feature (F₂), which may be effectively closed by a fault.

Hare Indian Anticline

The Hare Indian Anticline is an arcuate, northerly to westerly trending, doubly plunging, asymmetric, faulted anticline. It originates along the steep west flank of the East Hare Indian Anticline at approximately Latitude $66^{\circ}21'$ N., Longitude $127^{\circ}24'$ W., and plunges northward to approximately Latitude $66^{\circ}25'30''$ N., Longitude $127^{\circ}28'$ W., at which location the direction of plunge is reversed to form an indicated closed linear feature (B₁) with a length of four and one-half miles and a probable closure of 25 feet or more in near-surface beds. The closed portion of the anticline is contained in the broad valley along the big bend of the Hare Indian River. From the apex of this feature the anticlinal axis curves to the southwest and appears to plunge out against a northeast-trending fault

upthrown approximately 200 feet to the southeast. This fault is the northern one of a pair of faults bounding the Fort Good Hope Horst. A small feature (C) with suggested closure lies north of the east-west portion of the Hare Indian Anticline close to the fault bounding the Horst.

The axis of the Hare Indian Anticline is +22 miles long. Northwest-trending faults intersect the axis at several localities. The throw of these faults varies from +10 feet to +50 feet. One feature along the Hare Indian Anticline (B2) has indicated closure produced by faulting. An easterly trending fault with a displacement of from +25 feet increasing westerly to +75 feet intersects the northeast flank of the anticline.

The Devonian Bear Rock Formation is the oldest exposed in the core of the Hare Indian Anticline.

South Hare Indian Anticline

The South Hare Indian Anticline is a west-southwesterly trending, doubly plunging, gently folded, faulted, symmetrical anticline. It originates along the west flank of the Hare Indian Anticline at approximately Latitude 66°27'15" N., Longitude 127°36' W., and plunges west-southwesterly. The anticline is approximately 12 miles long within the project area and is present to the west for an unknown distance. The Devonian Hume Formation is the oldest exposed in the core of the anticline.

Several closed features D₁, D₂, D₃ and others have been mapped along the axis of this anticline. One of the more interesting features is D₁, which is at the western edge of the map area immediately north of Permit No. 1535. This closed feature covers an indicated minimum area of four square miles and has an estimated closure of 50 feet. A westerly trending fault, upthrown from +25 feet to +50 feet to the south, intersects the north flank of the South Hare Indian Anticline and is parallel to the axis.

Good Hope Anticline

The Good Hope Anticline is a sinuous, southwesterly trending, doubly plunging, elongate, gently folded, symmetrical, faulted anticline. It originates along the west flank of the Hare Indian Anticline near Latitude 66°27' N., Longitude 127°34' W., and plunges southwesterly. The area is approximately 22 1/2 miles long in the project area and continues for an unknown distance beyond the current project area. The Devonian Hume is the oldest exposed formation in the core of the anticline. The total southwest plunge from Latitude 66°27' N., Longitude 127°34' W. to the south boundary of the project area is +225 feet, and an additional 895 feet of southwesterly plunge is necessary to bring the datum to its subsea elevation of -670 feet at the Glacier-Baysel-Climax Ramparts No. 1 well.

Several closed structural features have been mapped along the Good Hope Anticline. The largest (E₁) is located at the northwest corner of Permit No. 1536 and includes eight square miles or more. The closure depends in part on the strong fault which forms the south side of the Fort Good Hope Horst and the estimated closure is sixty feet or more. E₂ and E₃ are additional closed features on the Good Hope Anticline. Another feature (G) on an upthrown block to the south of the Good Hope Anticline has a vertical closure of more than 35 feet.

Pre-Hume Positive Feature

The northeast-trending Pre-Hume Positive Feature (H) is separated from the Fort Good Hope Horst to the south by a graben.

Two opposing components of 15° dip were plotted in the stream cut near Latitude 66°29' N., Longitude 127°53' W.; these components underlie beds which have a south dip of from one to three degrees. Due to mantle and vegetation cover along the banks of other streams intersecting this feature, it has not been possible to verify this feature as an anticline. The Pre-Hume Positive Feature has been mapped for a distance of nine miles and possible closure is suggested for an area four miles in length. Rapid thickening within the Hume Formation takes place to the south of the Pre-Hume Positive Feature. The Hume Formation is approximately 430 feet on the Hare Indian River at Longitude 128°57' and thickens to 630 feet at the southeast corner of the project area. A Devonian reef or buried "ridge" is a possible explanation of the rapid thinning to the northwest. Thinning is also indicated in the lower part of the Hume Formation in the Glacier-Baysel-Climax Ramparts No. 1 well. This thinning may be indicative of the continued presence of the Pre-Hume Positive Feature to the northwest of the well.

OIL AND GAS POSSIBILITIES

This subject has been covered in considerable detail in the previous reports to the Company and only a summary of the subject will be presented here.

1. Numerous oil and seepages have been observed in the Mackenzie Basin by our geologists and several others have been reported by trappers and explorers. Those seepages surrounding the project area have been indicated on the Index Map of Figure 1.
2. Oil stained and pyrobituminous rocks are commonly observed in outcropping strata of Ordovician, Silurian and Lower and Middle Devonian age.
3. The Glacier-Baysel-Climax Ramparts No. 1 well, encountered gas (shut in) in the lower interbedded shale and limestone sequence of the Hume Formation.
4. Sandstones of Cretaceous age are impregnated with oil at several known localities in Fort Good Hope area.
5. Strata of the following ages include suitable reservoir beds and are considered to provide the best prospects for the commercial accumulation of hydrocarbons within the Company holdings: Cambrian, Ordovician-Silurian, Lower and Middle Devonian (Bear Rock and Hume Formations). Cretaceous sandstones and the Middle Devonian Kee Scarp Formation show porosity and oil staining, but these beds are too close to surface to promise accumulations of commercial significance in the Company Permit area.
6. Features suitable for both structural and stratigraphic entrapment of hydrocarbons are present in the area to the northeast of the Company Permits and the Fort Good Hope Horst with its associated anticlines appears to project farther into the Company holdings.

7. A marked thinning of the Hume Formation from southeast to northwest in the project area indicates probable facies changes important to oil occurrences and accumulation. These same facies changes are probably related to the Pre-Hume Positive Feature to the northwest of the project area. This ancient "high" could, in turn, be the controlling factor for the Fort Good Hope Horst and associated structures.

CONCLUSIONS AND RECOMMENDATIONS

For the purpose of further evaluating the Company holdings in the Fort Good Hope area of the Northwest Territories this detailed photogeological and photogrammetric study of an area extending northeast from the Company Permits was undertaken.

The previously mapped Fort Good Hope structural high has been demonstrated to extend to the northeast in the general form of a regional horst which we have named the Fort Good Hope Horst. Several anticlinal structures are associated with this horst; the three main ones are the Hare Indian Anticline, the South Hare Indian Anticline and the Good Hope Anticline. Several closed features have been mapped along these anticlines, two of which, at the north edge of the Company holdings, are of particular interest. These two are Structure D₁, on the South Hare Indian Anticline and Structure E₁ on the Good Hope Anticline.

Structure D₁ extends into the project area from the west. The part mapped has an area of four square miles with an indicated closure of 50 feet.

Structure E₁ is essentially a closed feature along the Good Hope Anticline but is outlined in part by the south boundary fault of the Fort Good Hope Horst. The feature has a mapped area of approximately eight square miles with a closure of sixty feet or more.

Various other closed features have been mapped in those portions of the project area farther from the Company Permits. Some of these features depend on faults for closure.

Possibly the most significant feature in relation to oil occurrence and accumulation in the area concerned is the thinning referred to in the general vicinity of the Pre-Hume Positive Feature and the Glacier-Baysel-Climax Ramparts No. 1 which was confirmed by photogrammetric work in the area between Lac a Jacques and the area to the north of the map area. In this general area the Hume Formation shows a thinning from the Lac a Jacques area from 630 feet to 430 feet in the northern portion of the project area. This would appear to indicate the probable presence of a pre-existing high in the area immediately north of the map area. This high could easily be responsible for controlling the regional and local structure that characterizes the general map area. Thus folding could be caused by changes in competence of the folded beds, with the principal axis of such folding and faulting normal to the direction of thinning, or in other words, parallel to the face of an older, pre-existing high.

The same pre-existing high can be expected to have a significance for oil occurrence inasmuch as oil occurrence, as well as the differential sedimentary conditions conducive to oil accumulation, can be expected in an area or a zone of thinning. The fold traps with which we are concerned in this area should, as a result of the convenient relationship to an area facies change, be considerably more prospective than folds elsewhere in the area.

Prospective formations include the Hume, in which gas was discovered in Glacier-Baysel-Climax Ramparts No. 1, and an estimated section of Cambrian, Ordovician, Silurian and Devonian, Pre-Hume sedimentary beds totalling in excess of 5,000 feet. The Lower Devonian Bear Rock Formation and the Ordovician Silurian Ronning Formation are estimated to total about 2,500 feet.

On the basis of a submitted preliminary report on this study an areal extension of this study to include more of the area of the Company Permits was approved and is in process of completion.

An encouraging show of gas, estimated at 250 Mcf/day, was obtained at Glacier-Baysel-Climax Ramparts No. 1. This gas was in the Hume Formation which outcrops in the project area. The nature of this gas trap has not been determined but it may be associated with the Fort Good Hope Horst which extends beyond the present Permit holdings.

Excellent reservoirs are present in Pre-Hume Formations, as illustrated by a strong flow of water from the Glacier-Baysel-Climax Ramparts well on test of the Bear Rock Formation. Based on the results of the present study and the preliminary results of the extended study it now seems probable that large closed features on Pre-Hume horizons are unlikely to be found within the present Company holdings.

It is recommended at this time that the Company relinquish their P. & N. G. Permit holdings in the Fort Good Hope area and that consideration be given at a later date for the acquisition of P. & N. G. Permits in the area northeast of the presently held Permits.


R. H. Frantz, Photogeologist.


S. R. L. Harding, P. Geol.

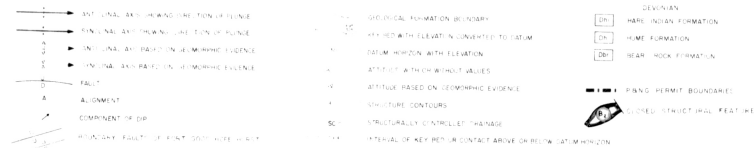
RHF, SRLH/rc

1009 Fourth Avenue S.W.,
Calgary, Alberta.
August 24, 1963.

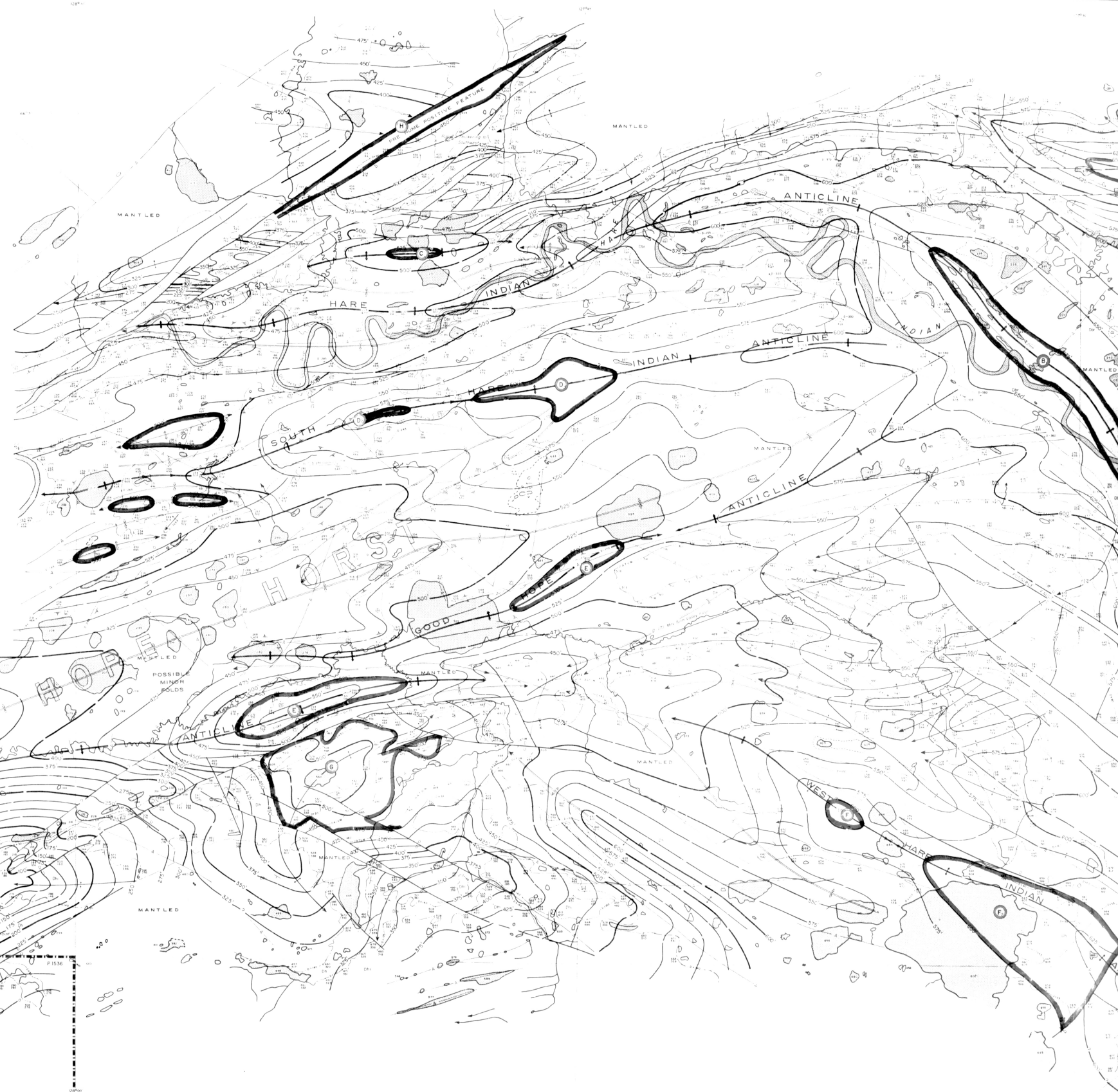
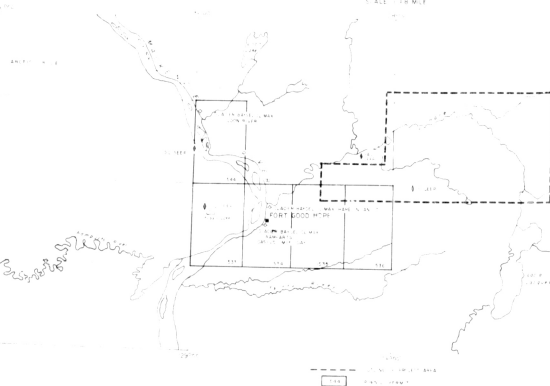
Contour interval - 25 feet

SCALE 1" = 1/4"

PREPARED FOR GLACIER EXPLORERS LTD
INTERPRETATION BY RH FRANTZ, AUGUST 1963



INDEX MAP



GLACIER EXPLORERS FORT GOOD HOPE PROJECT

PORT GOOD HOPE AREA, N.W.T.

December, 1963

$$(1) \quad \Delta F_{\text{Fe}} = \Delta F_{\text{Fe}}^0 + RT \ln \frac{F_{\text{Fe}}}{F_{\text{Fe}}^0} = RT \ln \frac{F_{\text{Fe}}}{F_{\text{Fe}}^0} \quad (1)$$

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ILLUSTRATION

Figure 1 - West Sheet, Geological and Structure Data Map
Fort Good Hope Area, Northwest Territories

In pocket

SUPPLEMENTARY PHOTOGEOLOGICAL AND PHOTOGRAMMETRIC

STRUCTURAL STUDY

GLACIER EXPLORERS FORT GOOD HOPE PROJECT

FORT GOOD HOPE AREA, N.W.T.

INTRODUCTION

Description of Project

This report presents the results of a structural study, utilizing detailed photogeological and photogrammetric methods, of an area extending to the southwest of the area dealt with in the report presented to Glacier Explorers Limited in August, 1963, entitled "Glacier Explorers Fort Good Hope Project, Fort Good Hope Area, N.W.T." The work has been conducted at the request of Mr. S. Taylor, acting for Glacier Explorers Limited, hereinafter referred to as the "Company."

The area of the present project ties to the west edge of the previous project area and continues in a southwesterly direction to a position approximately three and one-half miles west of Fort Good Hope. Portions of P. & N.G. Permits Nos. 1533, 1534 and 1536 are included in the present project. For convenience, both the present report and the report of August 1963 may be referred to as the Glacier Explorers Fort Good Hope Project and the maps accompanying these reports may be referred to as the West Sheet and East Sheet, respectively, with a total area of approximately 535 square miles.

In undertaking the photogeological and photogrammetric studies of the Fort Good Hope area, the East Sheet was dealt with first because of the better outcrop control. In extending the studies to the West Sheet, it was necessary to make use of geomorphic interpretations to a greater degree because of the increase in the amount of glacial drift, the increase in the extent of Cretaceous sands which unconformably overlie the Devonian, and the decrease in the number of reliable Devonian outcrops in the area between the East Sheet and the Mackenzie River. Because of the nature of much of the control data, it will be necessary to view the results as interpretations requiring a further check and re-evaluation utilizing stratigraphic tests in key locations.

In mapping the West Sheet some of the objectives have been:

(a) To tie the previous project (East Sheet) to existing surface data near Fort Good Hope and to subsurface data obtained from the Glacier Baysel Climax Ramparts No. 1 well and the Glacier Baysel Climax Hare Indian Structure Test No. 1.

(b) To establish, if possible, the relationship of the Hare Indian Structural Trend and the Fort Good Hope Horst to the Glacier Baysel Climax Ramparts No. 1 and Glacier Baysel Climax Hare Indian Structure Test No. 1.

(c) To look for further evidence for the Pre-Hume Positive Feature.

(d) To locate features which may potentially provide traps for petroleum accumulation within the project area.

(e) To provide data on which to base recommendations for possible future exploration or development of the area.

The essential results of the study are presented on the accompanying "Geological and Structure Data Map."

Sources of Data

The new sources of data utilized in this report are listed below:

(a) Bench marks from a 1922 triangulation net along the Mackenzie River were obtained through personal correspondence with the Department of Mines and Technical Surveys. The original elevations were not available and the elevations utilized were those obtained from a spirit level survey conducted along this triangulation net in 1953. The two bench marks, with elevations and descriptions within the area, are Bench Mark No. 91, "spike in base of blazed spruce 1,000 feet north of the Hare Indian River, elevation 140.6 feet," and disk in concrete block in yard of Hudson's Bay Company, Fort Good Hope, elevation 140.6 feet.

(b) Surface elevations and electric logs from three Glacier Baysel Climax wells, Ramparts No. 1, Hare Indian Structure Test and Loon River No. 1.

Procedures for Map Compilation

The mapping technique required for the West Sheet of the project was somewhat different from that used for the East Sheet, because surface mantle and glacial drift obscure much of the detail throughout the map area. This sparseness of data made it necessary to present portions of the structural map with form lines rather than structure contours. Although values have been assigned to these form lines they should be considered as only approximations. These form lines of interpretative nature are indicated by question marks behind the assigned values.

The areas of more reliable structural control are confined to:

- (a) That area south of the Hare Indian River, north of the herein named interpreted Jackfish Fault, and east of the herein named Depression Creek.
- (b) That area along the south side of the Mackenzie River, south of Fort Good Hope and the interpreted Jackfish Fault and northwest of the herein named interpreted North Tsintu Fault.
- (c) The area along the west side of the Mackenzie River from the axial trace of the South Hare Indian Anticline southwest to the project boundary.

Surface structural control is supplemented by subsurface data obtained from Glacier Baysel Climax Ramparts No. 1 and the Glacier Baysel Climax Hare Indian Structure Test No. 1.

Due to the mantled nature and the prevalence of faulting within much of the map area, many of the key beds could not be directly correlated with those in areas of more positive data. The datum reference to these key beds can only be approximate; however, they do retain their value in indicating the direction of strike and rate of dip. The form line values on the map are questioned where these datum references are in doubt.

Along portions of the Mackenzie and Hare Indian rivers, elevations are carried along the tops of the escarpments. Although no true key beds are visible along these particular escarpments, it is considered that the surface elevations are in part a reflection of the structure of the underlying strata. In those areas where key beds are present in the vicinity of these escarpments, elevations along these escarpments tend to conform to those of the bedding.

The lake pattern in the map area is interpreted as being indicative of the underlying structural picture. In areas of good stratigraphic control these lakes tend to conform to the bedding, and appear to be broad in areas of very low dip and narrow in areas with dips of five to six degrees or greater. Many of these lakes may also indicate lineations attributable to faulting and fracturing, although the effects of glaciation make structural interpretations more difficult. The east-west zone of lakes to the south of Jackfish Fault and the positions of those lakes immediately to the west of the herein named East Manitou Fault may reflect the low areas in front of former fault scarps.

For the above reason, the form lines on the accompanying map are positioned to conform in large part to lake patterns. The Central Manitou Fault, portions of the North and South Fort Good Hope faults, and several other unnamed faults, are also positioned along lake alignments. The wide distribution of beds of the Cretaceous Sans Sault Formation and subsequent glacial planation and mantling have made it impossible to confirm these interpreted faults by surface or photogeological studies. The location of these faults is shown by a single line on the map, but such lines should be considered as only one of a series of probable step faults.

The datum marker is that used on the previous project and lies within the Hume Formation of Devonian age, approximately 140 feet stratigraphically lower than the Hume-Hare Indian Formation boundary. Surface outcrops of the datum marker are absent throughout most of the map area with which this report deals, and are present only along the flanks of the North Tsintu Anticline to the northeast of the interpreted Jackfish Fault and within the area of the Fort Good Hope Horst near the east project boundary. Outcrops of the datum marker may also be present north of the Hare Indian River and in the vicinity of Ontadek Lake but cannot be identified on the air photographs.

The datum horizon is present in the Glacier Baysel Climax Ramparts No. 1 well at a subsea elevation of -672 feet and has been projected to the Glacier Baysel Climax Hare Indian Structure Test No. 1, at subsea elevation of 557 feet, and in the Loon River Structure Test No. 1 at a subsea elevation of 645 feet. This indicates that the datum horizon must go underground either by plunge or by faulting somewhere between the last known surface exposures with elevations of +179 feet near the east project boundary and the three above-mentioned structure tests.

The key beds within the area indicate for most structural features a general northeasterly strike accompanied by dips of low magnitude. Because of this it becomes singularly difficult to account for the approximately 850 feet of vertical difference in elevation from the east project boundary west to the Glacier Baysel Climax Ramparts No. 1 well. This necessitated assigning displacement values of relatively large magnitude to the interpreted Central and East Manitou faults and to the Jackfish Fault.

STRATIGRAPHY

The following paragraphs supplement the "Discussion of Formations Exposed in the Project Area," which was included in the report of August 1963.

Hume Formation

The area in which outcrops of the Middle Devonian Hume Formation occur is in the northeastern portion of the map area. It is probably bounded to the west by the interpreted East Manitou Fault where it is indicated to be in contact with the Hare Indian Formation, and to the south by the interpreted Jackfish Fault where it is indicated to be in contact with the Hare Indian and Kee Scarp formations. Lack of surface data prevents the exact identification of the western and southern limits of surface exposure of the Hume Formation. In some areas the Hume beds are unconformably overlain by the sandstones of the Cretaceous Sans Sault Formation.

A stratigraphic section within the Hume Formation (marked SS2 on the accompanying map to conform with the 1960 report) was measured in the field approximately one mile north of the Hare Indian River along an unnamed creek in the northeast corner of the project area. The strata north of the herein named North Fort Good Hope Fault cannot be positively identified as being of the Hume Formation. It is to a large degree either mantled by glacial drift or unconformably overlain by the Sans Sault Formation. This makes impossible further identification of the Pre-Hume Positive Feature mentioned in the previous report. The trend itself suggests a southwesterly termination against the North Fort Good Hope Fault.

An examination of the electric log of Glacier Baysel Climax Loon River Structure Test No. 1 indicates the possible presence of the Bear Rock Formation directly beneath the D-170 correlation, indicating the lower portion of the Hume Formation, mentioned in the previous report as thinning to the northwest, has wedged out somewhere between the Loon River Structure Test No. 1 and the Ramparts No. 1 well. The total thickness of the Hume Formation in Glacier Baysel Climax Ramparts No. 1 is 455 feet and in the Loon River Structure Test No. 1 is 396+ feet as shown on the graphic well log, or 350 feet if the Bear Rock Formation is present as suggested above. The presence of the Bear Rock Formation in this test would indicate a northerly thinning of the lower Hume Formation of 105 feet between the two structure tests. The approximate position of this wedge-out based on the rate of thinning and direction of strike is shown on the index map.

Hare Indian Formation

Surface exposures of the Middle Devonian Hare Indian Formation are present in the escarpments along the Mackenzie River and along the Hare Indian River as far east as the East Manitou Fault. It is overlain by the Middle Devonian Kee Scarp Formation to the south of the interpreted Jackfish Fault and along the escarpment of the Mackenzie River in the southwest corner of the project area. It is also thought to be present along the axis and flanks of the western portion of the postulated North Tintu Anticline.

The thickness of the Hare Indian Formation was calculated utilizing data from the Glacier Baysel Climax Ramparts No. 1 well and from Stratigraphic Section No. 3 measured in the field along the east bank of the Mackenzie River approximately two miles south of Fort Good Hope (SS₃ on the accompanying map). The thickness obtained from these calculations was 730[±] feet.

Kee Scarp Formation

Outcrops of the Middle Devonian Kee Scarp Formation are present in the west and southwest parts of the project area. It forms the rim of the escarpments along the Mackenzie River to the southwest of Fort Good Hope. It is also present to the south of the indicated South Fort Good Hope Fault where it is downthrown against the Hare Indian Formation and to the west of the interpreted Jackfish Fault where it is downthrown against the Hume and Hare Indian formations. A stratigraphic section measured in the field, approximately six miles southwest of Fort Good Hope, showed a partial thickness of 157 feet, where it is unconformably overlain by the Cretaceous Sans Sault Formation.

The Kee Scarp Formation consists of buff to grey, bedded to massive, limestones, very fossiliferous, in part reefal. It merges in the northern Mackenzie Basin with the Hare Indian Formation into an undifferentiated Ramparts shale unit.

Sans Sault Formation

Outcrops of the Cretaceous Sans Sault Formation are present around the outer edges of the project area, where they unconformably overlie the Hume, Hare Indian and Kee Scarp formations. They consist of marine grey shales, siltstone and sandstone and have a porous, friable sandstone at the base which is oil saturated in places; their distribution is in part fault controlled. Oil saturation probably results from migration from older beds along faults and fractures. The Cretaceous outcrops lie mainly to the west and on the downthrown side of unnamed fault in the northeast corner of the project area. The Cretaceous deposits may be more widely distributed than indicated on the accompanying map; the mantle of glacial drift makes it difficult to determine the extent of the Sans Sault beds. The Sans Sault Formation is from zero to 300 feet thick.

GEOLOGICAL STRUCTURE

The following is a continuation from the previous report (August 1963) of a discussion of the main structural features as they apply to the current project area. The structural features of this West Sheet are, however, interpreted in large part from geomorphic evidence and are not considered to have the same validity as those of the East Sheet. The principal structures are named on the accompanying map and discussed below. Closed structural features are indicated on the map by letter and subscript. In addition to those discussed in the following text, various closed, or probably closed, features indicated on the West Sheet include K, L, M, N₁, N₂, O, P₁, P₂ and Q.

Hare Indian Structural Trend

The Hare Indian Structural Trend in the southwest extension (West Sheet) of the project is composed of four interpreted major anticlines. From north to south these include the Bluefish Anticline (J), South Hare Indian Anticline (D), Fort Good Hope Anticline (E), and the North Tsintu Anticline (G). The structural trend plunges, with the exception of local reversals along the individual anticlines, from the east boundary of the current project area to the southwest boundary. The Bluefish and North Tsintu anticlines, although not contained within the Fort Good Hope Horst, trend in a similar direction to it, and are, for the purposes of this report, included in the Hare Indian Structural Trend. The main suggested possible local closures and fault traps along these anticlines have been indicated on the "Geological and Structure Data Map" by letter and subscript references.

Fort Good Hope Horst

Within the southwest extension (West Sheet) of the map area, it appears that the Fort Good Hope Horst, which was contained, in the previous project, by two major faults herein named the North and South Fort Good Hope faults, is dispersed to the southwest by a series of splinter and step faults which are upthrown to the south along the North Fort Good Hope Fault and upthrown to the north along the splinter and step faults of the South Fort Good Hope Fault. It is suggested that the North Fort Good Hope Fault probably terminates against the upthrown side of the north-trending East Manitou Fault. Splinters of this fault may continue, however, to the west outside of the project boundary.

The south Fort Good Hope Fault appears to reach its maximum throw at its juncture along the upthrown side of the east-trending Jackfish Fault. If it continues to the west of the Jackfish Fault, it probably has very little throw. The east-trending Jackfish Fault at its intersection with the South Fort Good Hope Fault becomes the dominant south-flanking fault of the Fort Good Hope Horst and continues in a westerly direction to become also the terminal fault for the north-trending East and Central Manitou faults. The Fort Good Hope Horst is bounded by the following faults:

- (a) To the north by the North Fort Good Hope Fault and its associated splinter faults.
- (b) To the southeast by the South Fort Good Hope Fault and additional splinter and step faults, including the North Tsintu Fault with a cumulative throw of ±500 feet.

- (c) To the south by the Jackfish Fault and splinter faults with a throw of $\pm 1,000$ feet.
- (d) To the west by the Central and East Manitou faults, and possibly the Manitou alignment with a cumulative throw of ± 700 feet.

Although throws in the order of 1,000 feet and 700 feet, respectively, have been indicated for the Jackfish and Manitou fault zones, it must be clearly stated that these faults have been interpreted and mapped entirely from indirect evidence.

Manitou Fault Complex

The interpreted Manitou Fault Complex comprises a series of near-vertical step faults acting as the western terminus of the Fort Good Hope Horst. These faults are represented on the map by the Manitou alignment along the Mackenzie River, the Central Manitou Fault, downthrown approximately 400 feet to the west, and the East Manitou Fault, downthrown approximately 300 to 400 feet to the west. These faults are probably associated with a combined hinge line and axis of depression which appears to provide a structural control for the location and direction of the Mackenzie River in the Fort Good Hope area.

Jackfish Fault

The Jackfish Fault is an interpreted easterly trending feature. The fault represented on the map by a single line is probably one of a series of near-vertical step or splinter faults. The surface trace of this fault is in part overlain by the Cretaceous Sans Sault Formation and is visible only as alignments on the air photographs. Presence of this fault is indicated by a relatively abrupt change from Kee Scarp and Hare Indian formations, as projected eastward from control along the Mackenzie River to Hume and Hare Indian formations and as projected westward (in part on geomorphic evidence) from known data on the east sheet of the project area.

The Jackfish Fault provides the south termination for the Manitou Fault Complex and together with the South Fort Good Hope Fault is a key fault in the south termination of the Fort Good Hope Horst.

The Jackfish Fault is interpreted to be upthrown to the north approximately 1,000 feet along the Fort Good Hope Horst and approximately 950 feet where it crosses the North Tsintu Anticline.

Because of its structural significance, further field exploration should be conducted in the vicinity of this fault, preferably in the form of structure tests near positions G₃ and G₄ along the axis of the North Tsintu Anticline.

Pre-Hume Positive Feature

A positive feature, probably related to the Pre-Hume Positive Feature described in the previous report, is suggested to the north of the project

area. The basis for this positive feature includes the northerly thinning of the lower unit of the Hume Formation, with probable absence in the Glacier Bayssel Climax Loon River Structure Test No. 1, and a geomorphically suggested regional high based on the alignment of Loon and Rorey lakes along the northwest flank and of the Hare Indian Structural Trend along the southeast flank.

Bluefish Anticline

The Bluefish Anticline is a southwesterly plunging, gently folded, faulted anticline. It has its origin to the northeast outside the project area. The axis is 15 miles long and is mapped within the current project from Latitude 66°29' N., Longitude 128°03' W. to Latitude 66°21'30" N., Longitude 128°33'30" W., where it apparently terminates against, or is offset to the north outside the project by, the East Manitou Fault. Several northwesterly trending faults intersecting the anticline have been mapped. The Middle Devonian Hume is the oldest formation exposed at the surface along the axial trace of the Bluefish Anticline.

The Bluefish Anticline is, for the greater part, based on geomorphic evidence. The form line (questioned contour) values can only be approximate due to the absence of key beds or to lack of correlation to known data of those key beds present. On the basis of the form lines (questioned contours) a fault closure is shown at position J₁ between the East Manitou Fault and a northwest-trending unnamed fault farther east. Closure within the fault block is indicated as greater than 25 feet with an area of closure of approximately three square miles.

South Hare Indian Anticline

The South Hare Indian Anticline was discussed in part in the previous report. This discussion included that portion of the anticline as far west as position D₁ near Latitude 66°21'30" N., Longitude 128°20' W. The extension to the west of this position has been interpreted as an arcuate, westerly to southwesterly trending, doubly plunging, gently folded, asymmetric, faulted anticline. From position D₁ west to the west project boundary near Latitude 66°18'30" N., Longitude 128°45' W., the axis is approximately 14 miles long. The total length of the anticline in both the previous and current project areas is approximately 36 miles and it may continue to the southwest outside the project boundary. The Middle Devonian Hume is the oldest exposed formation along the axial trace of the South Hare Indian Anticline.

Closures along the South Hare Indian Anticline within the current project are shown at positions D₁ and D₄ on the "Geological and Structure Data Map." Feature D₁ is indicated to be small with slight closure. D₄ is a doubly plunging, complexly faulted feature with possible closure indicated to be as great as 225 feet. This feature is crossed by the northerly trending Manitou Fault Complex.

Good Hope Anticline

The Good Hope Anticline was discussed, in part, in the previous report. This discussion included that portion of the anticline as far west as position E₁ near Latitude 66°18'30" N., Longitude 128°17' W. The anticline to the west of this position is a westerly trending gently arcuate, en echelon, doubly plunging, gently folded, asymmetric faulted anticline. From position E₁ to the west project boundary, the axis is approximately 20 miles long. The total length of the axis in both the current and previous project areas is 42 miles, and the axis may continue to the west outside the project boundary. In places the axis appears to be shifted in an en echelon manner. The Middle Devonian Hume is the oldest exposed formation along the axial trace of the Fort Good Hope Anticline.

Closures along the Good Hope Anticline within the current project area are shown as features numbered E₁, E₄, E₅, E₆, and E₇, on the "Geological and Structure Data Map." The E₁ feature has been discussed in the previous report. The E₄ feature is a doubly plunging, faulted anticline with an apex near Latitude 66°17'30" N. and Longitude 128°27' W. Faults may form several independent blocks within the E₄ area of closure. The anticline within the E₄ area is based for the greater part on geomorphic evidence, and the form line values can only be approximate. Possible closure within the E₄ area may be as great as 75 feet within an area of several square miles.

Feature E₅ is a suggested anticlinal nose faulted against the west side of the northerly trending interpreted East Manitou Fault, with possible vertical closure as great as 200 feet. This feature is based to a large part on geomorphic evidence and the form line values can only be approximate. The interpreted Central Manitou Fault is indicated to intersect the area of closure, which could result in a separate closure. Features E₆ and E₇ represent other possible fault traps.

North Tsintu Anticline

The North Tsintu Anticline is indicated to be a symmetrical doubly plunging, moderately folded, faulted anticline. It lies to the south of the South Fort Good Hope and North Tsintu faults. It is sub-parallel to the Good Hope, South Hare Indian and Bluefish anticlines and for purposes of this report is included in the broader Hare Indian Structural Trend. The axis is approximately 28 miles long within the project area. It extends from Latitude 66°23' N., Longitude 127°49'30" W., where the feature G₁ is located (previous report), southwestward to the current project boundary near Latitude 66°09' N., Longitude 128°33'30" W. It may continue outside the project boundary.

Features G₂, G₃ and G₄ represent the structurally high points along the axial trace of the North Tsintu Anticline. Positions G₂ and G₃ lie to the north of, and form closure against, the easterly trending interpreted Jackfish Fault. Position G₂ has an indicated vertical closure of approximately 375 feet and lies on an axial trace which has an en echelon relationship to that of G₃. The syncline separating these two axes is of a minor nature and the two anticlines are herein considered as one large faulted anticlinal closure. Position G₄ lies to the south of and on the downthrown side (indicated approximately 950 feet) of the Jackfish Fault. To the south of the Jackfish Fault,

the area is overlain in part by the unconformable Sans Sault Formation. The form lines and axial position are questioned in this area and can only be approximate. A closure in the area of at least 250 feet is indicated on the basis of the rate of dip in the exposed beds of the Hume Formation to the north of Jackfish Fault and of the Kee Scarp Formation to the northwest of the covered area. Positions G₅ and G₆ represent suggested fault trap closures along the north flank of the North Tsintu Anticline and to the northwest of the North Tsintu Fault.

The North Tsintu Anticline appears, for the following reasons, to be one of the more promising features for petroleum accumulation within the current project area.

1. The area of closure is indicated to include approximately 11 square miles.
2. A vertical closure of from 375 to 400 feet is indicated along the axis near G₃ and G₄ positions.
3. The apex of the structure is indicated to be approximately 300 feet structurally higher than that of E₄ of the Good Hope Anticline and 200 feet higher than that of D₄ of the South Hare Indian Anticline.
4. The lower part of the Hume Formation (from the D-170 unit down to the top of the Devonian Bear Rock), in which there was a gas show in the Glacier Baysel Climax Ramparts No. 1 well, has thickened southward as projected along strike from 190 feet at the well to approximately 280 feet near positions G₃ and G₄ along the axis, and should be present at depth to the south of Jackfish Fault.
5. Although the lower unit of the Hume Formation appears to have been in part breached near G₂ and G₃, the prospective portion of the Bear Rock Formation should be under adequate cover.

Relation of Glacier Baysel Climax Ramparts No. 1 to Surface Structure

The Glacier Baysel Climax Ramparts No. 1 well is indicated to lie immediately to the south and on the downthrown side of the interpreted Jackfish Fault, approximately one and one-quarter miles to the west and on the upthrown side (approximately 25 feet) of a northwesterly trending fault, and approximately one-quarter mile to the north of the southwesterly trending unnamed synclinal axis, to the south of the Good Hope Anticline. The throw of the Jackfish Fault west of its intersection with the East Manitou Fault and immediately to the north of the well could not be ascertained but it is probably less than 100 feet. The datum horizon in the well (-672) is approximately 120 feet structurally lower than the lowest closing contour on the Good Hope Anticline and holds approximately the same structural position as the fault closures indicated by position E₇ to the east. It is approximately 1,100 feet structurally lower than the apex of the Good Hope Anticline near position E₄ and 1,400 feet structurally lower than the apex at G₃ north of the Jackfish Fault and 475 feet lower than apex at G₄ south of the Jackfish Fault on the North Tsintu Anticline.

The presence of gas in the Ramparts No. 1 well may be due to a combination of fault entrapment and of the northwesterly thinning of the Lower Hume Unit from D-170 down to the top of the Devonian Bear Rock Formation. The gas encountered in this well and its structural position with relation to the apparent crests of the Fort Good Hope and North Taintu anticlines indicate a highly favourable situation for the accumulation of petroleum in these two anticlines. The South Hare Indian and Bluefish anticlines also appear favourable due to the northwesterly thinning and probable increase in sand content of the previously mentioned Lower Unit of the Hume Formation as it approaches the wedge-out.

Relation of Glacier Baysel Climax Hare Indian
Structure Test No. 1 to Surface Structure

The Glacier Baysel Climax Hare Indian Structure test penetrated only the upper limestone of the Middle Devonian Hume Formation, and for this reason it was necessary to project the datum horizon to this test utilizing thicknesses obtained from the Glacier Baysel Climax Ramparts No. 1 well and from photogrammetric measurements obtained in the previous project (East Sheet). This projected datum elevation is -557 feet. The structure test lies approximately one and one-half miles south of the axial trace of the South Hare Indian Anticline, to the south and on the upthrown side of an indicated southwesterly trending fault, approximately three-quarters of one mile to the west and on the downthrown side of the Central Manitou Fault and one-quarter of one mile to the north of the axial trace of a southwesterly plunging unnamed syncline. The well did not penetrate the gas-bearing lower unit of the Hume Formation; therefore, no data on the northward thinning of this unit is available; the indicated thickness projected along strike is, however, approximately 165 feet. This same rate of thinning projected to position D₄ along the South Hare Indian Anticline indicates a thickness at this point of 145 feet and 125 feet along the axial trace of the Bluefish Anticline. The datum horizon at the well is approximately 975 feet structurally lower than the apex of the Good Hope Anticline and from approximately 625 feet to 1,075 feet structurally lower than the crests of the South Hare Indian Anticline depending on their relations to the Central and East Manitou faults.

Relation of the Glacier Baysel Climax Loon River
Structure Test No. 1 to the Current Project Area

Although the Glacier Baysel Climax Loon River Structure Test No. 1 lies outside the current project and is approximately 16 miles to the northwest of the Glacier Baysel Climax Hare Indian Structure Test No. 1, it provides certain useful data for the evaluation of the area. From the electric log the indicated elevation of the datum marker is -645 feet and the test must therefore lie to the west of the interpreted Manitou Fault Complex. Further review of the electric log indicates the possible pinchout of the lower unit of the Hume Formation wherein the D-170 marker may rest directly on the top of the Lower Devonian Bear Rock Formation. This would indicate a minimum thinning to the northwest of the lower unit of the Hume Formation of nine feet per mile and would be further evidence for the existence of the Pre-Hume Positive Feature.

OIL AND GAS POSSIBILITIES

This subject has been dealt with in the August 1963 report and previous reports to the Company and will not be further discussed at this time.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of the report of August 1963 dealing with the East Sheet are in a large part applicable to the current project.

The southwest extension of the previous project was undertaken for the purpose of tying the geological and geomorphic data of the previous project to the existing surface and subsurface data along the Mackenzie River near Fort Good Hope, Northwest Territories, and to further evaluate the Company holdings⁽¹⁾ in the Fort Good Hope area.

The previously mapped Hare Indian Structural Trend has been extended, utilizing both geomorphic and geologic data, to at least as far west as the Mackenzie River. Two additional anticlines paralleling the Hare Indian Structural Trend, namely the Bluefish Anticline to the north and the North Tsintu Anticline to the south, have been included as structural units within this trend. The Fort Good Hope Horst has been further delineated with evidence pointing toward southwest termination against the upthrown sides of the series of step faults comprising the interpreted Manitou Fault Complex and the Jackfish Fault.

Several closed features have been mapped within the current project area. For the most part they are complex anticlines and fault-closed features. Those features of particular interest are structures G₂, G₃ and G₄ along the North Tsintu Anticline, Structure E₄ along the Good Hope Anticline, Structure D₄ on the Hare Indian Anticline and Structure J, on the Bluefish Anticline.

Brief notes on these five mapped features follow but because of their highly interpretative nature due to the use of indirect geomorphic evidence they should not be considered established features at this time. They do indicate, however, the possible size and character of features which may be proven by further exploratory work.

Features G₂ and G₃ combined have an indicated possible vertical closure of from 375 to 400 feet against the upthrown side of the interpreted Jackfish Fault and have an indicated area of closure of approximately 11 square miles.

Feature G₄ may have a vertical closure of at least 250 feet against the downthrown side of the interpreted Jackfish Fault and an indicated area of closure of at least seven square miles.

(1) These holdings were dropped August 29, 1963.

Feature E4 has an indicated vertical closure ranging from 25 feet to 75 feet or more within separate fault blocks and has an indicated area of closure of approximately seven square miles.

Feature E5 has an indicated possible vertical closure of approximately 200 feet within two interpreted fault blocks and an indicated area of closure of approximately four and one-half square miles.

Feature D4 has an indicated vertical closure of from 25 to 225 feet within separate fault blocks and a possible area of closure of approximately 19 1/2 square miles. This feature may be of particular interest with respect to its position along the strike of and approaching the wedge-out of the lower unit of the Hume Formation. This unit should become more arenaceous and therefore provide better reservoir beds as it approaches the wedge-out.

Feature J1 and the Bluefish Anticline in general has a favourable position for the accumulation of petroleum along the strike of and approaching the wedge-out of the lower unit of the Hume Formation. The lower unit of the Hume is approximately 125 feet thick along the axial trace.

The projected wedge-out is approximately nine miles to the northwest of the intersection of the axial trace with the Mackenzie River and is in line with an oil seep as shown on the index map. The lower unit of the Hume Formation should become more arenaceous and provide better reservoir beds as it approaches the wedge-out.

In the conclusions of the August 1963 report it was stated that, "Based on the results of the present study and the preliminary results of the extended study it now seems probable that large closed features on pre-Hume horizons are unlikely to be found within the present Company holdings." As a result it was recommended at that time "...that the Company relinquish their P. & N. G. holdings in the Fort Good Hope area...."

Our studies confirm the existence of the Hare Indian Structural Trend and the Fort Good Hope Horst. Abundant evidence of oil and gas occurs in association with these regional features. The present report also indicates a number of local structures which are associated with these regional features and which could be suitable traps for the accumulation of oil and gas.

These local structures are mapped in large part, however, on geomorphic evidence as a result of which the nature of the control data limits the accuracy of the quantitative interpretation. Field work and structure test drilling would be required to check these prospective features.

In the event of the re-awakening of Industry interest in the general area, such as might occur if the currently drilling Atlantic at al R-34 well, approximately 96 miles west of Fort Good Hope, yields encouraging results, it is recommended that the Company be prepared to make immediate application for the nine and one-half Permits which will include the following areas:


Area between Latitude 66°10' N. and 66°30' N. and Longitude 128°00' W. and 128°45' W.

Area between Latitude 66°20' N. and 66°30' N. and Longitude 127°15' W. and Longitude 128°00' W.

Area between Latitude 66°15' N. and Latitude 66°20' N. and Longitude 127°45' W. and Longitude 128°00' W.

It should also be further noted that, on the basis of present studies, it is considered that the area north of the Fort Good Hope project area in the vicinity of Latitude 66°30' east of the Mackenzie River is also prospective for oil and gas. This conclusion follows from the interpretation made that a Pre-Hume Positive Feature is probably located in that general area and this has been considered in making the above recommendation.

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