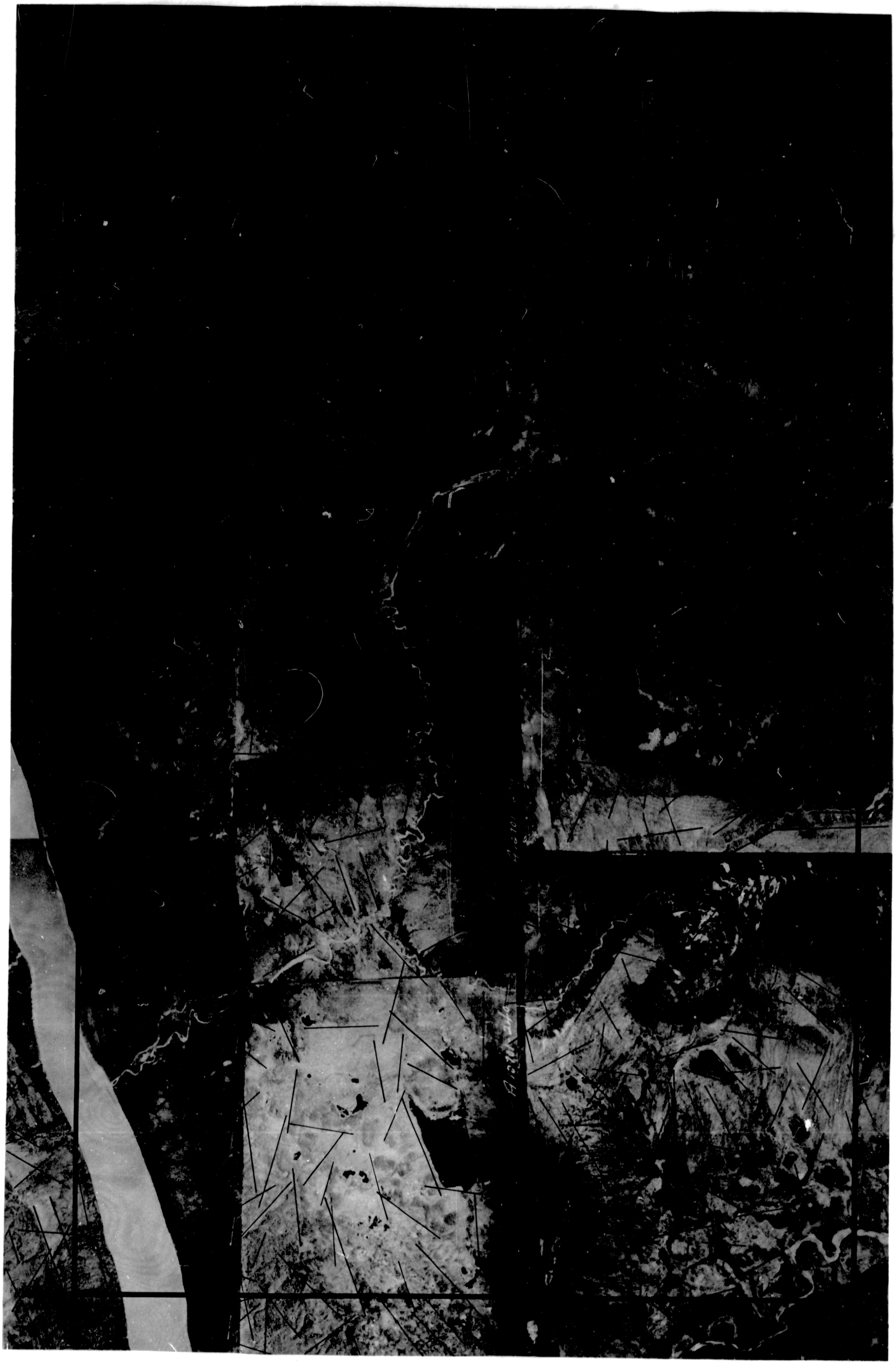

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P. & N.G. PERMIT No. 5587

NORTHWEST TERRITORIES

SCALE : 2" = 1 MI.

THIS IS A UNCONTROLLED MOSAIC AND SHOULD NOT BE TAKEN AS AN ACCURATE TOPOGRAPHIC MAP.

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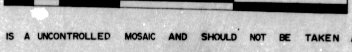
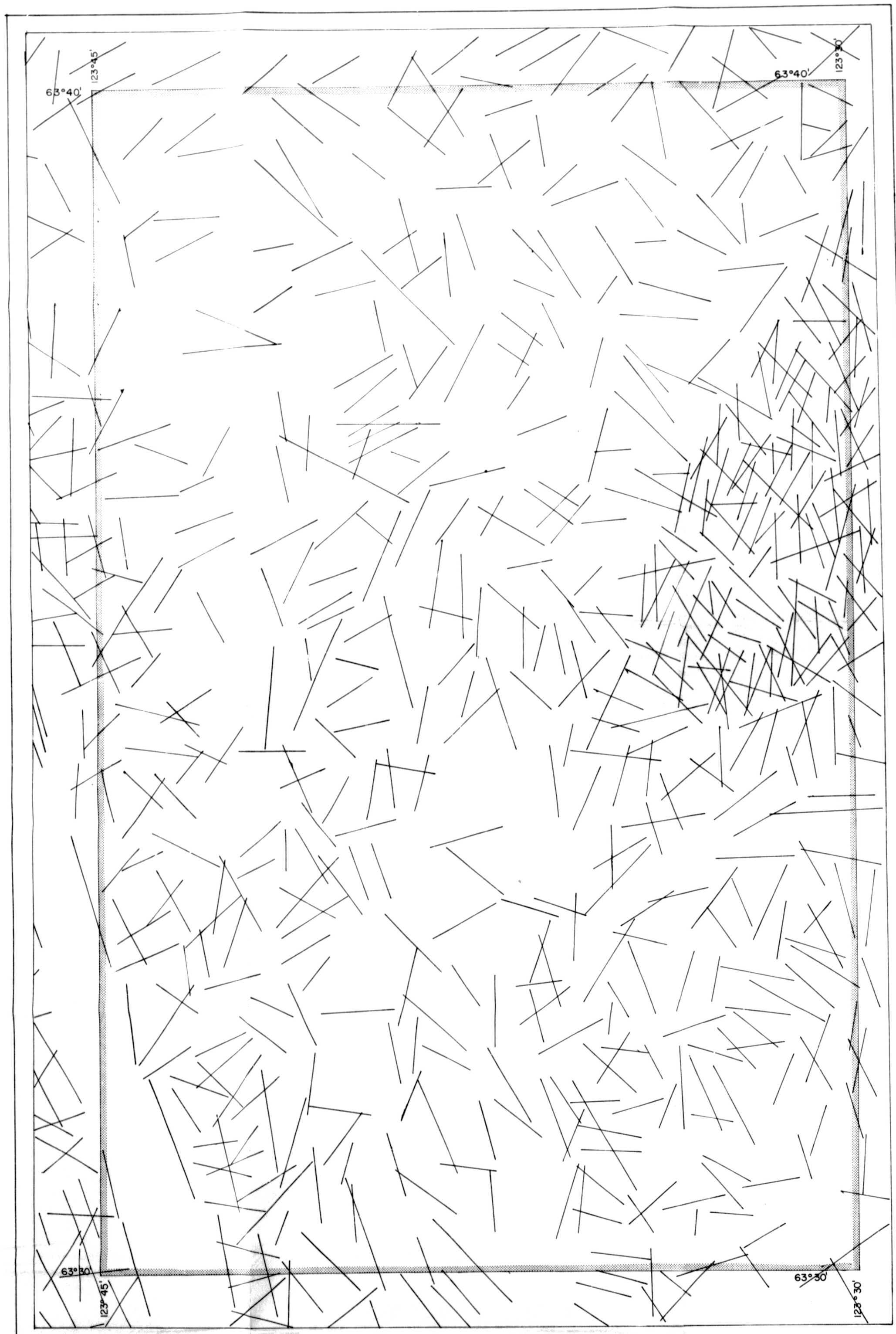
P. & N.G. PERMIT No. 5587

NORTHWEST TERRITORIES

SCALE : 2" = 1 MI.



THIS IS A UNCONTROLLED MOSAIC AND SHOULD NOT BE TAKEN AS AN ACCURATE TOPOGRAPHIC MAP



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TOTAL FRACTURE PATTERN

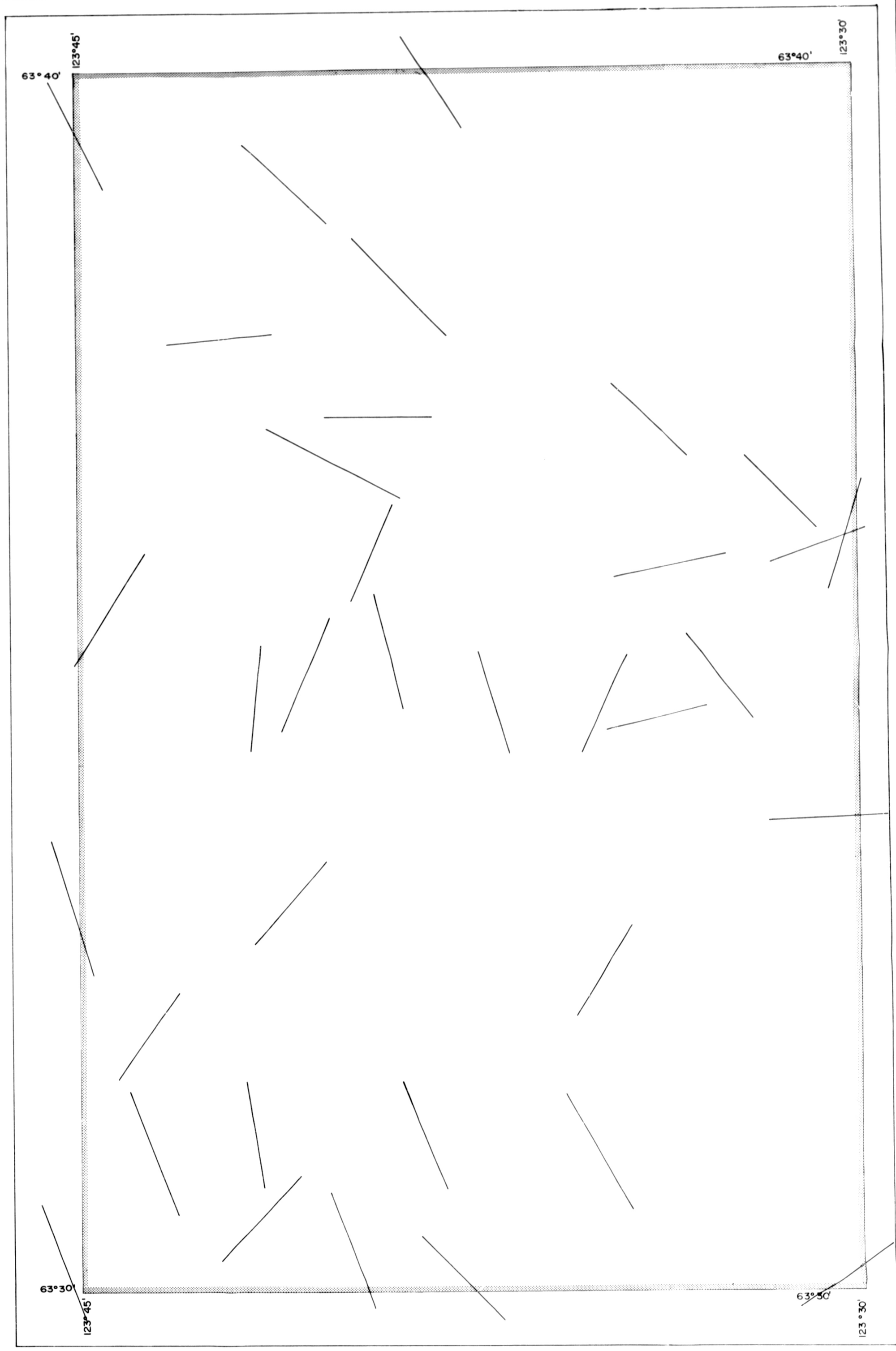
SCALE : 2" = 1 MI.

1 0 1 2

LOW DENSITY

NORMAL DENSITY

HIGH DENSITY



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MEGA FRACTURE PATTERN

SCALE : 2" = 1 MI.

1 0 1 2

No regional fractures of great length can be seen and as these are conceded to originate within the Basement, it is assumed that all fractures plotted on the mosaic originate within the sedimentary section. Furthermore, as the fractures are short for this area it is very likely that they originate in the upper two-thirds of the sedimentary section. As the surface of most of the Permit is relatively flat-lying no azimuth correction is necessary for this study. It has been demonstrated that the low incidence anomalies on a mosaic are considerably larger than the subsurface feature which causes them and thus any anomaly under Permit No. 5587 could be of reasonable size.

There are two areas on the mosaic where the fractures are less intense than the surrounding area. Some fractures are present within these areas, but they do have a lower incidence that the surrounding area. These low intensity areas are important and it is quite likely that they are due to some subsurface feature. The type of feature will be discussed in the next section of this report.

STRUCTURE

Petroleum and Natural Gas Permit No. 5587 is located in the MacKenzie Basin of the Northwest Territories, about 200 miles to the west of the edge of the Pre-Cambrian Shield. The strike of the sedimentary rocks is about north 20 degrees west and the units have been folded and faulted into typical mountain and foothill structures.

Structural features which could be present and which could cause the low incidence anomalies mentioned in this report are discussed in order of probability.

(1) TECTONIC FOLDING & FAULTING

The whole of the Permit area has been subjected to folding and faulting and the upthrust Franklin Mountains are present in the northeast corner of the area. The structural features present will control the accumulation of oil or gas and these same features control the fracture pattern.

Reference to the Total Fracture Pattern Map which accompanies this report will show that there is one area of "high" fracture intensity, and two areas of "low" fracture intensity (green). The general interpretation is that the low fracture intensity areas are underlain by topographic or structural high features. With this established, the deduction is that there are structural "highs" present under the areas colored green on the total fracture map.

(2) PRE-CAMBRIAN TOPOGRAPHY

Basement topography under Permit No. 5587 is thought to be much the same as it is today along the southwest edge of the Shield. Low rounded hills separated by gentle to abrupt valleys are seen on the Shield and these features are undoubtedly present under the subject Permit. The effect of this Basement relief on the overlying sedimentary rocks is often great. The Granite Wash sand is usually present in the topographic "lows" on the Basement, but absent on the "highs". The Granite Wash is an excellent potential reservoir.

Further effects of Basement topography on beds higher than the Granite Wash is the gentle folding present over Basement hills. These folds are anticlines in every sense and could form traps for oil or gas.

Many small faults have been reported by A.W. Norris (1955) in the Basement and immediately overlying rocks and these features could cause closure within the sedimentary units.

(3) TOPOGRAPHIC RELIEF ON AN INTRA-SEDIMENTARY UNCONFORMITY

Unconformity is a possible source of fracture intensity anomalies, but within the Permit area it is unlikely that the relief on any unconformities within the sedimentary section is great enough to affect the fracture pattern.

(4) REEFS

Reefs of any age strongly affect the fracture pattern and control the occurrence of gas and oil in the overlying beds. However, it is unlikely that any reefs are present in the area of Permit No. 5587.

These structural high features are most interesting from the oil and gas point of view. The general shape of these features is such that the causative feature must be a subsurface anticline. A fault is unlikely as the causative feature as the high areas are over 1-1/2 miles in width.. If a fault caused the fracture "low" the width of the low would be about one mile or less. These anticline areas should be investigated further and a gravity survey is recommended as the next stage in the evaluation of this Permit.

Respectfully submitted by:

RAYALTA PETROLEUMS LTD.

William J. Crook
P. Geol.

WGC/jp

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GENERAL GEOLOGY

AND

FRACTURE ANALYSIS SURVEY

OF

P. & N.G. PERMIT NO. [illegible]

FOR

GLENDALE INVESTMENT CORPORATION LTD.

BY

KAYALTA PETROLEUMS LTD.

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GENERAL GEOLOGY

and

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of

P. & N. G. PERMIT NO. 5587

for

GLENDALE INVESTMENT
CORPORATION LTD.

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RAYALTA PETROLEUMS LTD.

INTRODUCTION

This report discusses the general Stratigraphy and Fracture Pattern within, and in the immediate vicinity of, Petroleum and Natural Gas Permit No. 5587. This Permit is located in the Northwest Territories between 123° 30' and 123° 45' longitude and 63° 30' to 63° 40' latitude. This places it about 760 miles northwest of Edmonton and 320 miles north of Fort Nelson, British Columbia. The MacKenzie River flows through the southwest corner of the Permit and the settlement of Wrigley is located on the MacKenzie River, 15 miles south of the Permit.

The area can be reached by boat from Hay River via Great Slave Lake and the MacKenzie River or via aircraft. There are no roads within the area and a helicopter would be required to reach any part of the Permit other than banks of the river.

The whole of the Permit area is drained by the MacKenzie River and its tributaries. The Ochre River flows through the southeast corner of the Permit and joins the MacKenzie two miles south of the Permit. A large unnamed creek flows east through the Permit and drains most of the area. The drainage pattern is basically dendritic although in part it is controlled by the structure present in the McConnell Range of the Franklin Mountains. It is also quite possible that some major structural feature (Basement fault etc.) controls the location of the MacKenzie River.

Maximum relief within the Permit is in excess of 2,300 feet; the elevation of the MacKenzie River is below 300 feet and the highest elevation along the McConnell Range is over 2,600 feet. About two-thirds of the Permit area is more or less flat lying and is below the 900 foot contour. The remaining one-third (the northeast part of the area) is occupied by the McConnell Range of the MacKenzie Mountains and is very rugged.

The whole of the Permit is covered with evergreen trees and only a few patches of deciduous growth are present. Naturally open areas are present in a belt which trends northwest - southeast and is about two miles east of the MacKenzie River.

STRATIGRAPHY

CAMBRIAN

Rocks of Cambrian Age are not exposed in the Camsell Range or in the MacKenzie Mountains which lie a short distance west of the Camsell River. D.R. Kingston has mapped a sequence of Cambrian sediments at a location along the south Nahanni River which lies about 125 miles southwest of the Permit. The section here is brought to the surface by granite intrusives. They are also exposed at a number of locations in the general Normal Wells area. A comparison of the south Nahanni River section with the Norman Wells exposures should provide some idea of the sedimentary section to be expected under the Camsell Range.

KATHERINE GROUP

The Katherine group which represents the earliest Paleozoic sediments in the Norman Wells region are named from a section exposed in the upper Carcajou River area which lies about 45 miles west of Fort Norman. The section exposed consists of interbedded quartzites and black platey shales. The shales are green, choclate and black coloured with the black being platey and bituminous. They are contained as interbeds in the quartzites which are generally pink, buff, rusty and white coloured in outcrop. The top of the Katherine is placed at the base of a choclate coloured shale sequence. The base of the Katherine was not seen, leaving the total thickness unknown. The Katherine has not been penetrated by any wells to date.

MACDOUGAL GROUP

The type section of the Macdougal is located about 49 miles west of Fort Norman in the Dodo Canyon of Macdougal Creek. At the type section the Macdougal is divisable into a number of formations which total 997 feet in thickness. The base is placed at the bottom of a 130 foot thick chocolate brown shale while the top is placed above 50 feet of evenly bedded limestone with shale partings. Lithologically the group consists of interbedded limestones, sandstones, reddish coloured gypsum, black petroliferous shales and green, red and chocolate coloured shales. Laudon mapped the section at Imperial River which is 30 miles northwest of the type section. The Imperial River section is 1,839 feet thick, with the base not exposed. The lower part of the section consists of tan sandstones with minor amounts of maroon and green shale. About 1,380 feet above the base the section becomes conspicuously shaly. There is a five foot bed of gray nonfossiliferous limestone located 1,390 feet above the base. The upper shale unit contains a considerable quantity of gypsum and the top beds are crinkly and distorted. Laudon considers this as possibly due to solution of the gypsum resulting in collapse of the shales. Overlying the Cambrian - Macdougal is about 320 feet of tentative Cambrian limestone and shale beds. They are separated from the Macdougal by an unconformity and from the overlying Ronning by another unconformity. The limestones consist of black sandy limestones which grade upwards into a rythmically alternating series of black to dark grey slightly nodular limestones and thinly laminated shales. They contain large calcareous algae which exceed three feet in diameter in some cases. The Macdougal was noted to consist of megacyclic alternations of shallow water sandstones and deep water maroon and green shales throughout the section. The sands are cross-bedded and ripple marked in part.

SALINE RIVER FORMATION

The Saline River formation is present at Norman Wells as a 2,000 foot bed of salt within the Macdougal group. The type section of the Saline River formation lies two miles above the junction of the Saline River with the Mackenzie River which is about 76 miles up the Mackenzie River from Wrigley. The section exposed is 100 feet thick with neither the top nor the base seen. The estimated thickness is 500 feet. The section exposed consists of red and green shales interbedded in part with gypsum and salt deposits. Salt springs in this area have their source in the Saline River formation. The Saline River formation at the type section is underlain by older beds of the Macdougal group and by about 630 feet of the Katherine group. The Katherine is exposed on Clark Mountain, which is about ten miles northeast of the Saline River type section, as mainly pink and red quartzite.

The Saline River formation is a very widespread unit and is believed to extend far to the northwest of Norman Wells as well as far to the south of Norman Wells for the following reasons.

(1) The overlying Ronning carbonates are

brecciated at exposures in the northern Richardson Mountains west of Inuvik, suggesting solution collapse.

(2) Aeromagnetic coverage north of Inuvik has disclosed two features which bear a marked similarity to known salt domes in the Arctic Islands.

(3) The gypsum in three diapiric structures which intrude Cretaceous beds on the east margin at the Richardson Mountains, west of Inuvik, contains evidence of early Paleozoic origin.

(4) The Saline River type section is present about 100 miles southeast of Norman Wells.

(5) The Cambrian exposures mapped by Kingston on the south Nahanni River contains salt and gypsum bearing limestones.

The south Nahanni River section which was mapped by Kingston is similar to the Imperial River section mapped by Laudon. The age of the Cambrian was not established by fossil evidence but rather by stratigraphic position and the above noted similarity to the Norman Wells sections. The south Nahanni section is 2,160 feet thick and was measured on Dolf Mountain. The section consists of a cyclic sequence of alternating shallow water tan sandstones and siltstones, maroon shales, red to brown to black and gray limestones with some dark brown shale in the upper portion. The section differs from the Imperial River section in that it contains much more limestone indicating a deeper water deposit further removed from the source of the clastics. The limestones near the base are massive, silty and reddish brown while in the mid portion of the section they are mainly brown with fine shale laminations. Towards the top they become tan to gray and coarsely crystalline and finally the upper bed is a massive, black, medium crystalline limestone. The section was described by Kingston as consisting of a number of megacycles consisting of a basal limestone overlain by a shale and siltstone sequence and topped off by a sandstone layer. The shales and siltstones are maroon coloured and present in fine laminations in the lower half of the section while in the upper half they range from maroon to reddish yellow to yellow to brown to chocolate coloured. The sandstones are mainly tan to brown and medium to coarse grained well sorted rocks. They are generally hard and well cemented grading to sedimentary quartzites in part. Local cross bedding is present as are conglomerates both of which indicate shallow water deposition.

Basal sands, siltstone and shales with some gypsum of similar lithological characteristics to those described at Norman Wells and South Nahanni River are described by Douglas and Norris in the Horn River area which lies to the east of the Permit. They did not determine their exact age but considered them as Ordovician or older. Some of the sandstones are noted to be quite a friable, porous, loosely consolidated unit.

The section of Cambrian rocks described above indicate that Permit 5587 should be underlain by rocks of Cambrian age. Subsurface control for this interpretation is present in FPC Tenneco Root River I-60 which is about 75 miles south of the Permit. The lower 889 feet of this well was drilled primarily in red and green shales with some dark gray shale in the middle portion of this interval. There are scattered red silts throughout with some thin red sandstone stringers near the base with some hematite. Canadian Stratigraphic Service Ltd. have placed this sequence in the Pre-Cambrian. The operator of the well placed it either in the Cambrian or Pre-Cambrian. On the basis of the lithological similarity between the samples and the previously described Cambrian sections as well as geographical location it is placed by this writer with reservations in the Cambrian and the well is not considered to have reached Pre-Cambrian rocks.

The FPC Tenneco Root River I-60 well and the Permit in question are interpreted as lying on the eastern flanks of the Camsell Basin resulting in a rapid thickening of all sedimentary sequences in a westward direction. In spite of the predominately shale section in the FPC well it is felt the Cambrian in this area should contain porous shoreline sands, bar sands as well as sands on lapping Pre-Cambrian highs. Similar sands are found to be prolific producers in the Red Earth Creek and Utikuma Lake areas of northern Alberta. The delineation of prospective areas for encountering such sands is dependent on a knowledge of present Pre-Cambrian structure as well as its topographic expression during the deposition of the sands. A gravity meter and airborne magnetometer survey could be used to good advantage in locating areas requiring more detailed exploration such as a seismic program. In view of the relatively shallow depth involved plus the possibility of locating major reserves the Cambrian should be evaluated by any wells drilled in this region.

involvement of Cambrian sands in anticlinal structures could also provide a trap of major proportions.

Since the Saline River salt is so widespread there is a distinct possibility that the Permit under review is underlain by it. Solution of this salt creates the possibility of salt structures being present in the overlying carbonates of Ordovician, Silurian and Devonian age. Salt structures have been found productive at Rainbow Lake in Alberta as well as in south eastern Saskatchewan. The crinkly distorted shales mapped by Laudon at Imperial River may be a product of salt removal rather than gypsum solution as was suggested by him. As was mentioned previously the brecciation of the overlying Ronning carbonates at various outcrops may be due to removal of the Saline River salt by solution. The Middle Devonian Bear Rock formation is also widely brecciated which may be due to a later stage of Saline River salt removal.

ORDOVICIAN

SUNBLOOD FORMATION

The type section of the Sunblood formation is on Sunblood Mountain which is located on the Upper South

Nahanni River. Kingston defined the Sunblood formation as the term for the entire Ordovician section in the area. It consists of 2,500 feet of dark gray relatively massive nodular limestone beds at the type section. Douglas and Norris of the Geological Survey of Canada, modified the Sunblood formation at the type section in 1960. The thickness of Sunblood as measured by them 3,490 feet and fossil evidence places the age of the formation as Middle Ordovician. They identified and mapped as a further 2,530 feet of Middle Ordovician rocks which lie above the Sunblood and form the dip slope of Sunblood Mountain.

Rocks of Sunblood age are exposed on Whittaker and Delorme Ranges which lie southwest and west of the Permit. The basal 340 beds on Whittaker Range are composed of arenaceous dolomites, light gray, fine to medium grained interbedded with sandstones, dark gray and medium grained. Overlying this unit is a 335 foot sequence of thinnly to thickly bedded limestones which are fine grained and gray in color. This unit is in turn overlain by 680 feet of reddish orange to brownish gray interbeds of fine to medium grained, sandy to silty limestones, and fine grained dolomites and dolomitic sandstones. The uppermost 260 feet of this section consists of dark gray fine grained limestones and calcareous shales. The Delorme Range section consists of 1,600 feet of beds of silty and sandy dolomite which are medium gray, fine to cryptograined interbedded with thinnly bedded pale brown fine grained dolomitic sandstone. As was noted above the type section of the Sunblood is overlain by an additional 2,530 feet of Middle Ordovician rocks. They consist of massive to medium bedded fine to cryptograined dark gray limestone with minor interbeds of dark gray shale, siltstone and sandstone. About the middle of the formation there are several massive beds of medium to coarse grained light gray dolomite.

WHITTAKER FORMATION

The term Whittaker formation was introduced by Douglas and Norris to cover a thick sequence of limestones dolomites and shales which overly the Sunblood formation except where it is overlain by the Middle Ordovician rocks which form the dip slope of Sunblood Mountain. They make a three fold division of the Whittaker formation and state that "the lower and middle parts are approximately equivalent to map-unit number two" (which is their term for the formation forming the dip slope of Sunblood Mountain). The type section of the Whittaker formation is on the east flank of Whittaker Range or about 60 miles northwest of the Permit. The section is 4,070 feet thick with the lower unit consisting of 1,320 feet of dark gray to gray fine to medium grained limestone which is thinly bedded. The middle unit consists of 860 feet of mainly fine grained dark gray medium to thick bedded sparsely cherty dolomites. They are commonly fossiliferous, containing colonial and simple corals. The lower and middle units are dated by fossils as late Ordovician in age. The upper unit is 1,690 feet thick and is made up of dark gray to gray black fine grained, thinly bedded limestone with alternating thin beds of black to dark gray siltstone near the base. This unit was dated by O'Bertos and Jackson as late Lower through early Upper Silurian on the basis of graptolite fauna. They noted that the Whittaker formation at the type section conformably overlies the Sunblood formation is probably conformably overlain by the Delorme formation although they did not see the contact. The upper unit of the Whittaker was noted by Douglas and Norris to be a more recessive type of deposit than the lower two units which are mainly carbonates.

SILURIAN

As noted above in the discussion of the Whittaker formation the upper unit of that formation contains a graptolite fauna of Silurian age. This section is present at the Whittaker Range as well as the Delorme Range. The lithologies of both sections are essentially the same.

DELORME FORMATION

Douglas and Norris named the sequence of limestones, dolomites and shales which overlie the Whittaker formation and underlie the Camsell formation the Delorme formation. The type section is located at the headwaters of Pastel Creek on Delorme Range which is about 52 miles northwest of the Permit. The section is 3,250 feet thick with the basal 500 feet consisting of interbedded soft dark gray shales and black clayey argillaceous limestones and dolomites. They are overlain by 1,300 feet of light gray fine grained to granular massive dolomites which vary to whitish gray and brown, medium to coarse grained dolomites which are porous in part. They are in turn overlain by 700 feet of fine grained to granular and silty evenly bedded dolomites. They contain fossils from Silurian to Devonian in age. The upper 750 feet is made up of dark gray evenly and thinly bedded cryptograined limestone. The Delorme formation at the Whittaker Range section is 3,800 feet thick with the basal 2,000 feet made up of dark gray to black shale and thinly bedded dolomitic siltstones with some massive beds of medium gray dolomites and limestones. They are overlain by a 1,200 feet sequence, of dark gray cryptograined limestone which is silty and sandy. The upper 600 feet is a thin bedded fine grained light gray recessive limestone. The two sections seem to indicate the facies are becoming more basinal at the Whittaker section particularily in the basal and middle portions of the formation.

CAMSELL FORMATION

The name Camsell formation was given by Douglas and Norris to the sequence of limestones which overlie the Delorme formation and underlie the Sombre formation. The formation is 1,400 feet thick on Whittaker Range and 1,750 feet thick on Delorme Range. The section northwest of the Permit, in the Delorme Range area, consists of gray cryptograined limestone which usually is found in either massive beds or else as a large scale breccia. The fragments are found up to ten feet or more in diameter ranging from very angular to subrounded. The breccia matrix consists of coarse calcite or limonite and ochre which range from brown to yellow to orange and red in colour. Salt casts were observed on some bedding surfaces. A few miles south of this area, near the Manetoe Range area, the Camsell consists of alternating thick bedded gray fine grained limestone and shaly, fine grained, orange weathering limestone of a recessive nature. The Camsell formation thins in a southward direction. The Camsell is not easily separated from the Delorme formation at exposures lying west and southwest of those mentioned.

SOMBRE FORMATION

Douglas and Norris termed the massive gray weathering dolomites which overlie the Camsell formation and underlie the Middle Devonian Arnica formation the Sombre formation. The type section lies some 45 miles southwest of the Permit on Tundra Ridge of Nahanni Plateau. The section consists of 4,100 feet of dolomites which were divided into three units. The lower 1,160 feet of dolomite is dark gray to black, cryptocrystalline to fine grained and silty to granular and occurs in thick even beds interbedded with these dolomites are fine to medium grained, light gray, massive to thick bedded , coarsely vuggy dolomite with corals and other fossil remains. The basal unit also contains very fine grained, granular to finely vuggy, medium bedded, light to medium gray dolomite. The middle unit is 570 feet thick and contains brownish gray to black, thinly bedded, cryptograined to granular dolomites. The upper 2,370 feet of Sombre formation contains medium to thick beds of dolomite which are crypto to fine grained, very dark gray to black and coarsely vuggy with abundant fossil debris. Interbedded with these dolomites are thinly bedded light to medium brown, fine grained, silty and sandy dolomites. The Sombre thins to 650 feet in the First Canyon of the South Nahanni River which lies some 40 miles south of the type section. The Sombre is 1,600 feet thick on Delorme Range and consists of light brownish grey, thinly laminated, fine grained dolomites and light brownish gray, thin to medium bedded, silty to fine grained, granular dolomites. They also contain some dark gray, thickly bedded, silty, dolomitic limestone and cryptograined, dark brownish gray dolomite. The Sombre appears to be separated in part at least from the underlying Camsell formation by an unconformity and from the overlying Arnica formation by a definite unconformity.

Regionally the sequence of Ordovician and Silurian formations described in the preceding paragraphs can be grouped together and interpreted as part of a vas carbonate shelf. A combined isopach of Cambrian, Ordovician and Silurian age rocks is a useful map to demonstrate the depositional features and facies patterns on a regional basis. This map shows that the area covered by the Permit and the outcrop sections of Ordovician and Silurian rocks mentioned previously are part of a carbonate shelf which extends from the Arctic coast in to northeastern British Columbia. The shelf carbonates are generally clean, finely crystalline carbonates with variable porosity. Flanking this shelf along its western limits is a belt of shelf edge carbonates which are reefal in part. They are present over most of its length, generally lying on the Peel Plateau and extending through the central ranges of the MacKenzie Mountains. They lie mainly to the west of the Permit under review. The shelf edge carbonates are in turn replaced by a basinal sequence of open marine shales and argillites along their western side. East of the shelf carbonates is a sequence of shoreline sands, red and green shales, gypsum, salt, sandy dolomites and conglomerates. The eastern limit of the combined

Cambrian, Ordovician and Silurian formations is about 50 miles east of the Permit. It should be noted they extend through the Great Slave Lake area to the east but are not present over a portion of the area between Camsell Bend and Great Slave Lake.

The Permit is mapped as lying along the eastern slope of the Camsell Basin, which is a marked depositional feature extending from south of Fort Norman to the Liard Plateau area. The thickness of combined Cambrian, Ordovician and Silurian beds in this basin exceeds 10,000 feet to the west of the Permit while the Permit is expected to have between 5,000 and 7,500 feet of them. The FPC Tenneco Root River I-60 well had approximately 3,300 feet of these beds if the top of the Silurian is placed at 5,320. The section from 7,682 feet to 8,571 feet or total depth was previously mentioned as probable Cambrian age, however, it should be noted that lithologically it is also similar to map unit number six of the Horn River area as mapped by Douglas and Norris. They dated this unit as provisional Middle Ordovician age on the basis of fossil evidence. Correlation of the FPC Tenneco Root River I-60 well with the surface sections is not readily apparent. The section from 5,320 feet to 5,830 feet consists of cryptocrystalline, argillaceous, slightly evaporitic, silty to slightly sandy dolomites with no visible porosity. The section from 5,830 feet to 6,280 feet consists of a dark gray micro-crystalline, argillaceous dolomite with poor vuggy porosity and scattered quartz crystals. A drill stem test of this section recovered filtrate water cut mud. From 6,280 feet to 6,915 feet the section consists of light to dark gray, argillaceous, microcrystalline dolomite. The section contains abundant light and dark gray chert with minor amounts of clear anhydrite and pyrite. Porosity is mainly a poor vuggy type with some fracture porosity present. A test of this fracture and vuggy porosity recovered 4,400 feet of salt water. This section also contains scattered crinoid fragments and indistinct pellets. The interval from 6,915 feet to 7,510 feet is essentially composed of argillaceous, microcrystalline light gray, silty dolomite with abundant pyrite throughout and with a definite pelleted nature in the basal 260 feet. The section is non porous and contains thin interbeds of dark gray shale throughout. There are also floating coarse quartz grains throughout. From 7,510 feet to 7,682 feet the well penetrated a section of buff, microcrystalline, primary or evaporitic dolomites with interbedded red and green shale stringers.

The section is silty and contains scattered floating coarse quartz grains and clear anhydrite. Worthy of note is the fact that the FPC Tenneco Root River I-60 well is completely dolomitized throughout this section while the outcrop sections to the west contain a fair percentage of limestone and shale beds.

Trapping conditions in the combined Silurian Ordovician section may be expected to be quite varied in this region. Some of the types which may be present are outlined below:

(a) The unconformity separating the Silurian and overlying Middle Devonian formations probably produced erosional features such as scarps, monodnocks and channels which if capped by a tight facies in the overlying beds could constitute an effective trap. Leaching associated with the unconformity would enhance the reservoir properties.

(b) Marginal shoals developed adjacent to the land surface lying 35 miles east of the Permit are probably present. Shoreward lateral equivalents to these shoals would be lagoonal sediments such as evaporitic dolomites and vari colored shales which in turn would be replaced by shoreline sand bodies. The seaward equivalents would likely be tight, argillaceous, micro to crypto-grained carbonates. Traps could be present in the marginal shoal or shoreline sands or in patch reef developments within the lagoon. The Permit may contain the marginal shoal which caused the lagoonal sediments from 7,510 feet to 7,682 feet in the FPC Tenneco Root River I-60 well.

(c) Lateral facies changes from porous shelf carbonates to semi evaporitic carbonates could also provide a potential trap of considerable areal extent.

(d) Selective solution of the underlying Cambrian Saline River salt may give rise to one or two stage salt solution. structures such as are found to be productive of oil in the Hummingbird area of southeast Saskatchewan. Partial solution of the salt during the deposition of the Ordovician or Silurian would have served to provide local elevations on the sea floor where the salt was not removed. These local elevations would provide the loci for reef and or carbonate banks to grow on. Traps of the Hummingbird type would involve early local solution of the salt. This may have occurred in late Cambrian or early Ordovician time. The depressions created would have received an extra fill of sediments over that being deposited where the salt was not removed. Once sedimentation within the sink hole caught up, subsequent sediments would be deposited on a normal sea floor. The second stage in the formation of a Humming type of trap would involve the removal of the salt surrounding the original sink hole at some time subsequent to Silurian sedimentation. This would leave the Ordovician and Silurian reservoirs overlying the site of original salt solution structurally high. The Bear Rock evaporites, or equivalents, should provide an adequate reservoir seal. Some support for this theory is found regionally where lower Ronning carbonates are found to be brecciated as are the Bear Rock carbonates.

(e) Gentle to tight anticlinal folds coupled with thrust faulting are present in this area and could provide sizable accumulations of hydrocarbons.

MIDDLE DEVONIAN

ARNICA FORMATION

The Arnica is a thick sequence of dark gray dolomites which generally overlie the Sombre formation. Douglas and Norris named them from a type section at First Canyon on the South Nahanni River. The Arnica by definition may be overlain, interbedded with or grade laterally into the Funeral and Bear Rock formations as well, it may be overlain by and partly laterally equivalent to the Landry and Manetoe formations. Douglas and Norris measured a number of sections of Arnica in this region and describe it as generally dark gray and black dolomite which is fine to cryptograined, granular to finely porous and vuggy, variably fetid and in some places laminated. On Delorme Range the Arnica is 2,100 feet thick while on Iverson Range at Root River gap which is about

17 miles northeast it is 1,700 feet thick. The section on Camsell Range, north of the Permit, is 1,340 feet thick. On the east side of Whittaker Range it is 700 feet thick and is overlain by the Funeral formation. The section consists of alternating beds of dark and medium gray, fine to coarse grained, partly brecciated dolomite. There are some crinoids and corals as well as black chert bands. The Arnica thickens to the north and west as the Funeral formation thins. It thins to the south and in the Manetoe Range and northern Nahanni Plateau may be absent locally. The Arnica outcrops along the eastern side of the Permit, adjacent to the Camsell thrust.

MANETOE FORMATION

The Manetoe formation overlies the Arnica throughout the Camsell and Nahanni Ranges as well as on the northern Ram Plateau. The type section is in the First Canyon of the South Nahanni River and was mapped by Douglas and Norris. The type section consists of 375 feet of coarse, recrystallized white and black dolomite interbedded with black, medium grained dolomite with large irregular masses of white calcite and dolomite. On Camsell Range the

Manetoe is about 150 feet thick and is made up of dark gray, coarse grained, medium to thick bedded dolomite which is highly fractured and cut by while calcite and dolomite veins. The stratigraphic relationship between Manetoe and Funeral formations is well illustrated on Iverson anticline which is about 40 miles southwest of the Permit. The Manetoe on the east flank of the anticline is made up of 500 feet of medium gray, coarse grained, very porous to cavernous, massive dolomite with vugs lined by milky while quartz crystalls. The high porosity is attributed to the margin of the facies change to Funeral formation by Douglas and Norris. The Manetoe grades laterally into the upper portion of the Funeral formation in a north, south and westerly direction on the anticline. On a tributary to DeKale Creek from the east near the anticline the upper Funeral is separated from the Arnica by the Manetoe coarse, vuggy medium gray dolomites.

FUNERAL FORMATION

The type section of the Funeral formation is located on northern Nahanni Plateau. The type section is 2,550 feet thick with the lower 1,655 feet made up of dark gray to black, platey, calcareous shale and mudstone with interbedded silty to argillaceous limestone. This section is overlain by 225 feet of black, silty to argillaceous, bioclastic limestone with black shale partings. The upper 670 feet ar mainly black, platy, calcareous, shale and blacky mudstone with thin interbeds of lenses of black, bioclastic limestone and thick beds of black, hard argillaceous limestone. On Iverson Range the Funeral is 900 feet thick and is composed of dark gray, fine grained limestone that is mainly platy to thinly bedded and partly silty and argillaceous. There is some medium to coarse grained, fossiliferous limestone near the top. As noted previously, the Funeral grades into the Manetoe formation in a northeastward direction. Going north along Iverson Range the lower Funeral grades into the Arnica while the upper part grades into the Landry formation. At the Whittaker Range and Delorme Range sections the Funeral also overlies a thin Arnica and underlies the Landry formation. The Whittaker Range section consists of a basal 230 feet of interbedded fine grained limestones and calcareous shales with thin beds of black chert. They are overlain by 1,070 feet of interbedded limestones and shales. The shales are calcareous in part and dark gray to black. The shale content is great in the lower portion of the formation. The upper limestones are fine grained, dark gray weathering to light brown, to dark gray and occasionally to pink. Northwestward from here the lower Funeral grades into the Arnica while the upper part grades into the Landry formation. The Funeral formation is apparently not developed in the Camsell Range adjacent to or on the Permit.

LANDRY FORMATION

Douglas and Norris proposed the term Landry formation for the thick to massive limestones which overlie Arnica formation dolomites at sections such as the Delorme Range section. The term also applies to sections where these limestones overlie or grade laterally into the Funeral limestones such as at the Whittaker Range section. The Headless formation overlies the Landry formation. The Whittaker Range section is composed of 400 feet of medium gray to black, crypto to medium grained limestone. The limestone is partly pelletoid and fossiliferous and medium to thick bedded with the bed thickness decreasing near the base and grading into the thin bedded Funeral formation. The Landry changes facies along this range from north to south so that at the south end the Landry has gradually changed into the Funeral.

The Delorme Range section consists of 300 feet of cryptograined, dark gray to black limestone which is partly silty and argillaceous at the top while the basal portion is partially replaced by coarsely crystalline, white to brown dolomite.

BEAR ROCK FORMATION

The Bear Rock formation is exposed on the McConnell Range of the Franklin Mountains east of the MacKenzie River which is immediately east of the Permit. The section is composed of massive breccias made up of fine grained, slight silty and argillaceous brown to dark gray limestones. The type section of the Bear Rock is at Bear Rock near Fort Norman. The type section consists of two distinct facies, a basal 40 to 60 feet of white gypsiferous massive lensing dolomite or limestone and an upper 175 feet of breccia composed of brown, dolomitic, limestone boulders set in a matrix of dolomitic limestone. The two facies are separated by a 30 foot section of poorly bedded, dark gray limestone and dolomite. The Bear Rock which is a very widespread formation is the facies equivalent of the previously described Middle Devonian formations, namely the Arnica, Manetoe, Funeral and Landry formations. The anhydrite facies of the Bear Rock is equivalent to the Chinchaga of northern Alberta.

Regionally the Bear Rock formation undergoes a number of facies changes, grading from basinal shale facies to evaporitic shoreline facies. The basinal shale facies are present along the west side of the MacKenzie Mountains. They are flanked by shelf edge limestones and dolomites along their eastern side. These shelf edge carbonates are porous. Adjacent to the shelf edge carbonates are a shelf limestone and dolomite facies. This shelf facies covers most of the Peel Plateau, Interior Plains and MacKenzie Plains. They are about 2,000 feet thick in the Peel Plateau and thin markedly into the Norman Wells area and then thicken rapidly into the Camsell Basin to more than 5,000 feet. Adjacent to the shelf facies is a relatively narrow belt of shelf dolomites which appear to be the prelude to the adjacent evaporite facies. The shelf dolomites are present in the MacKenzie Mountains, as well as in the Camsell and Nahanni Ranges. The Permit is underlain by this facies. The outcrop sections present on the Permit is also in this facies. The evaporite facies begins north and west of Norman Wells and extends southwards into northern Alberta and northeastern British Columbia. The B.A. H.B. Trail Creek No. 1 well encountered the Bear Rock evaporite facies while the FPC Tenneco Root River I-60 well was in the shelf dolomite facies. The upper 635 feet in the Root River I-60 well appears to be the Manetoe equivalent of the Bear Rock and recovered salt water on tests. The Bear Rock appears to be about 1,300 feet thick in this well indicating that the well and the Permit lie on the eastern slope of the Camsell Basin. Oil shows have been obtained from the Bear Rock in the Norman Wells area from the shelf dolomite facies. The rapid facies changes within the Bear Rock and its equivalents in this region make this formation a highly prospective target for any wells drilled. The brecciated nature of the Bear Rock may be due to solution of the underlying Saline River salt.

HEADLESS FORMATION

The Headless formation is defined as a shale and limestone unit which underlies the Nahanni formation and separates it from the underlying formations. Where the Nahanni is thin or absent it is the facies equivalent of the Nahanni. The contact with the underlying beds is considered to be disconformable. On Headless Range, the Headless formation consists of 560 feet of dark gray calcareous shale. The upper 150 feet of this interval contains interbeds of dark gray to light brownish gray, cryptograined to bioclastic limestone which are ten to 50 feet thick. On the south end of this range the lime stones grade laterally into interbedded black shale and black, argillaceous, cryptograined limestone in beds six inches to two feet thick. At Cathedral Mountain, which is 40 miles northwest of the Headless Range, the Headless formation is 980 feet thick and the Nahanni is absent. On Camsell Range it is 145 feet thick on the south end and 130 feet thick on the north end. It generally consists of fossiliferous, dark gray limestone which is argillaceous, thin bedded and crypto to fine grained. It is interbedded with calcareous shale. The Headless formation is included with the Nahanni formation on McConnell Range. The B.A. H.B. Lone Mountain No. 2 well encountered 100 feet of Headless formation which consisted of argillaceous, dark brownish gray, crypto grained limestone which was slightly dolomitic near the base. The Headless is included with the Nahanni in the FPC Tenneco Root River I-60 well.

NAHANNI FORMATION

The type section of the Nahanni formation is located at Nahanni Butte which is some 150 miles south of the Permit and lies near the confluence of the South Nahanni and Liard Rivers. The Nahanni is 350 feet thick and is made up of dark gray, fine grained, medium to thick bedded partially dolomitized limestone with dark to light gray, fine to medium grained to occasionally coarse grained dolomite. It is underlain by 130 feet of Headless formation. The Nahanni thickens north westward so that on Ram Plateau, which is about 100 miles south of the Permit it is 650 feet thick while west of the Ram Plateau it is 780 feet thick on the east side of Nahanni Plateau and 830 feet thick on the west side. At these sections the Nahanni is generally a light to dark gray, thick bedded, fine grained to bioclastic limestone. The Nahanni is 830 feet thick on Delorme Range, 800 feet thick on Whittaker Range and 600 feet thick on the Root River in the northern Iverson Range. On the Camsell Range, north of the

Permit, the Nahanni has thinned to 360 feet where it is a light to dark gray, medium to coarse grained limestone. The Nahanni is about 300 feet thick on McConnell Range. In the Camsell and Root River regions the Nahanni is a fine to medium grained, dark gray, reefy limestone which generally occurs in medium to massive beds separated by thin argillaceous limestones or by argillaceous limestones of similar thickness. The thick argillaceous limestones become more common near the base as the formation grades into the Headless formation.

The F.P.C. Tenneco Root River I-60 well encountered 800 feet of combined Nahanni and Headless formation. This thickness is probably exaggerated due to crooked hole problems which this well is supposed to have encountered. The section consisted of dark brown, micro crystalline, argillaceous bioclastic limestone which was partially dolomitized in the upper 450 feet. Thin gray green shale stringers are present in the upper 600 feet. The basal 200 feet is crypto crystalline, vaguely pelleted brown, argillaceous limestone and may represent the Headless formation. No porosity was present in the Nahanni formation in this well. East of the Permit B.A.

H.B. Lone Mountain No. 2 encountered 400 feet of Nahanni composed of dark brownish gray to dark brown, crypto to fine grained limestones with chalky porosity. The B.A. H.B. Trail Creek No. 1 encountered 410 feet of combined Nahanni and Headless formations. The upper 310 feet consisted of crypto to fine grained, light to dark brown, argillaceous limestones with some calcareous, grey shale partings. The next 40 feet was a light brown, microcrystalline, slightly argillaceous dolomite, the basal 60 feet consisted of light brown, micro crystalline limestone. Regionally the Nahanni correlates with the Lonely Bay and Keg River formations. Any porosity developed in this unit could produce a significant stratigraphic trap. The Nahanni is present in outcrop on the Permit, having been brought to the surface by the Camsell thrust fault.

UPPER DEVONIAN

FORT SIMPSON FORMATION & YOUNGER DEVONIAN

The Fort Simpson formation was measured by Douglas and Norris on Deceiver Creek, which is about 75 miles south of Permit No. 5587. The section is 3,800 feet thick, however, they note it is probably faulted and a true thickness would be in the order of 2,500 feet. The base was not exposed. The lower exposures were a non calcareous, dark grey, fissile shale with nodules of concretionary limestone and some thin interbeds of siltstone. The upper part was composed of mudstone of a calcareous and silty nature and of a medium to dark gray, argillaceous, fine grained limestone with thin interbeds of calcareous siltstone and sandstone. Subsurface control is provided by F.P.C. Tenneco Root River I-60 well where more than 2,070 feet of Fort Simpson were present in much the same lithologies as described at the Deceiver Creek exposure. B.A. H. B. Lone Mountain No. 1 was bottomed at 2,905 feet in Fort Simpson without reaching the Nahanni formation. The B.A. H.B. Lone Mountain No. 2 penetrated 1,075 feet of Fort Simpson which includes 110 feet of probable Middle Devonian Horn River shale at the base. The F.P.C. Tenneco Root River well has about 80 feet of probable Horn River shale at its Fort Simpson base. B.A. H.B. Trail Creek No. 1 penetrated 420 feet of Fort Simpson which includes a basal 100 feet of Horn River black shales. The B.A. H.B. Root River No. 1 well bottomed at 2,780 in Upper Devonian beds which are younger than Fort Simpson according to the Geological Survey of Canada. The subsurface control indicates that the Upper Devonian beds are thickening into the Camsell Basin in much the same manner that the older formations followed.

Douglas and Norris mapped a number of younger Upper Devonian beds in this region. At Deceiver Creek they mapped 650 feet of interbedded olive gray, silty shale, calcareous sandstone and fine to medium grained, grey to greenish grey siltstone. Near Carlson Lake which is 75 miles to the south of Permit No. 5587 they mapped limestone reefs which are equivalent to the basal portion of this 650 foot shale, sand and silt sequence. The reefs are composed of stromatoporoids and corals forming a poorly bedded, medium gray, coarse grained, pelleted limestone. The limestone reefs apparently reach a thickness of 150 feet. The next youngest mapping unit consists of 660 feet calcareous, grey to greenish gray. Sandstone with interbedded silty, calcareous mudstone, greenish gray, fine grained siltstone and argillaceous limestone which occurs mainly at the top.

East and south of Carlson Lake the youngest Devonian beds are exposed in the axis of the Yohin Syncline. The lower 700 feet consists of gray to greenish gray, silty, slightly calcareous shale with thin, fine grained, silty, limestone bands and green, calcareous siltstone which grades to fine sandstone. Overlying them are 575 feet of calcareous siltstone, with interbedded silty, calcareous, green to reddish brown shale. The upper 50 to 100 feet is composed of argillaceous, gray brown, fine to medium, fossiliferous limestone. The B.A. H.B. Root River No. 1 well is correlated by the Geological Survey of Canada as encountering these beds below 200 feet of drift.

MISSISSIPPIAN

Overlying the youngest Devonian beds in the Yohin Syncline, Douglas and Norris mapped a 100 foot thick shale unit of which the lower half was not exposed. The shale was described as steeley gray to slightly green and mauve, fissile, with thin interbeds of iron stained sandstone. They found no fissils and concluded that it may be Post Devonian, possibly part of the thick succession of Mississippian which lies to the south of this area or part of the Pre-Fort St. John group of Cretaceous age.

CRETACEOUS

Beds of Cretaceous age are exposed in the Ebbutt Hills which lie about 30 miles east of the Permit. They consist of dark grey to black, partly bituminous, very fissile shales with abundant ironstone bands and concretions. Subsurface control indicates that the Cretaceous consists of a very thin veneer of sediments in this region.

FRACTURE ANALYSIS

This section of the report discusses the results of a Detailed Fracture Analysis Survey carried out on the area under discussion. An aerial mosaic (scale 1.5 inches equals approximately 1 mile) made from Dominion Government aerial photographs accompanies this report. These same photographs were examined stereoscopically and the fractures plotted on the individual photographs, then transferred to the mosaic for analysis.

The theory that the earth's crust is abundantly and methodically fractured is the basic premise on which is built the exploration technique known as Fracture Analysis. A Fracture is defined as "...generally abundant, natural lineation discernible on aerial photographs".

Fracturing is largely caused by external stresses on the surface. The most important are:

(a) earth tides

(b) radial acceleration of the earth along its radius vector.

(c) a gradual decrease of the earth's rate of rotation.

As stated above, the earth is systematically fractured and the fracture system would approach symmetry if the crust were homogeneous. It is considered that irregularities are caused by regional heterogeneous conditions within the earth's crust. Local departures from the norm are caused by structural or stratigraphic anomalies.

The term "photogeophysics" was introduced by Blanchet (1956) and deals with mapping, analysis and interpretation of fracture traces as recorded on aerial photographs. In a more general way "photogeophysics" can be defined as the methodical statistical analysis of linear features seen on aerial photographs and this system is applied by any method recording all observable lineations, or the totality of a certain type of linear feature, and the statistical presentation of the data on contoured intensity maps or dry plotting the fractures directly on the mosaic.

In this report a megafracture is longer than one mile and a microfracture is shorter than one mile.

GENERAL STATEMENT

ORIGIN OF FRACTURES

Fracturing is largely caused by external stresses on the earth, although internal stresses may play some minor roll. The most important of these external forces are the diurnal earth tides due to the gravitational effects of the sun and moon; the change in radial acceleration of the earth along its radius vector and the gradual decrease in the earth's rate of rotation. The endless rhythemic action of these earth tides is probably the principal cause of the systematic fracture system seen over most of the world, even though the amplitude of these tides is only 9-13 inches. The fractures are most likely generated by the process of fatigue as the end result of these stresses which are repeated regularly over millions and millions of years. Metals fatigue in the same manner when subjected to continual vibration.

In general the initiating forces which generate fractures must have continued for a very long time and the process involved are continuous and are probably active at the present time. Furthermore, Mollard (1957) states, "The mechanism required to reflect lineaments to ground surface must be reasonably simple, for simple patterns are produced on diverse topography and in diverse types and depths of surficial deposits that overlie different kinds of relatively flat-lying sedimentary rocks of varying thickness. The mechanism producing the lineament pattern must persist over extensive and widespread belts of the earth's outer shell; that is today, the engendering mechanism in fact be world wide".

External forces such as earth tides obviously fit these parameters. Some internal forces may also apply such as the action of deep seated tectonic forces, and the most probable of these is isostatic adjustment. Isostatic rebound following the melting of the glaciers may still be taking place and this will further accentuate fractures present before glaciation.

In general it can be said that fracture patterns are caused by either internal forces or external forces.

If the forces are internal the result would be different orientation of the fracture systems in areas of similar tectonic history but different position. If the forces are external the orientation of the fracture arrangement should have world wide similarity. However, stable areas such as the masses of the continents may develop fracture patterns due to external forces and tectonically active areas may develop their own pattern due to internal forces.

If joints form early in the history of a sediment then systematic joints must be successively younger upwards through the section and the joint pattern is imposed on each new layer of sediments when they have become consolidated enough to fracture. This upward propagation is caused by the fatigue caused by stress, which in turn is caused by diurnal earth tides.

EXPRESSION OF FRACTURES

Fractures have been observed in aerial photographs from every climate and on every continent in the world. They are expressed as topographic relief, vegetation differences and soil tonal differences.

TOPOGRAPHIC RELIEF LINEAMENTS

A common type are relief lineaments which can be manifested by a change (usually abrupt) of topographic elevation on either side of a relatively straight line. They may also be expressed as straight valleys or hills or by straight streams where the stream course is controlled by a fracture zone.

VEGETAL LINEAMENTS

Vegetal lineaments are the most common in the parkland and muskeg areas of western Canada and many excellent examples of fractures can be seen on almost any aerial photograph of northern Saskatchewan, Alberta or British Columbia. Straight lines of both deciduous and evergreen trees as well as scrub growth are universally visible. However, the most common vegetal lineament seen by this writer is a straight "edge" to a clump of trees or bushes. In many cases these fractures control the size and shape of cultivated fields. Excellent examples of this latter expression of fractures are present in the western part of the Peace River district.

SOIL TONAL LINEAMENTS

These reflect differentiation in soil moisture and general ground water conditions. These are common in the southern parts of Alberta and Saskatchewan, especially near large rivers.

Surface investigations have shown that fractures are associated with bedrock joints; however, in glaciated areas such as western Canada, the photoanalyst must take care to establish the direction of ice flow over an area before he begins to statistically plot and analyse the fractures. Most areas in western Canada show an abundance of grooves and flutes caused by the glacier and these must not be mistaken for fracture traces caused by subsurface structural conditions. In parts of the Lloydminster area of eastern Alberta the glacial scars are so deeply impressed on the surface that fracture analysis is at best difficult and often impossible.

INTERPRETATION OF FRACTURE DATA

The object of Fracture Analysis (Photogeophysics) is to locate shallow to deep-seated structural and stratigraphic anomalies. The actual count of fractures per unit area is made and values are contoured on a "Fracture Intensity Map". In areas of known reefs the fracture intensity is 2-3 times greater on the flanks of the reef than directly above the reef.

In any fracture pattern there are two main systems of fractures: the axial system and the shear system. In both systems the fractures are sub-parallel and in general the two systems are at approximate right angles to each other.

Because of certain inherent limiting factors, Structure Incidence Surveys have a lower order of reliability than Detailed Fracture Analysis Surveys. To some extent at least, surface conditions affect the fracture count. In areas covered by lakes, sloughs and rivers, the fracture count is zero. Cultivated areas generally yield a lower count than adjacent virgin territory. Consequently, a difference or contrast in fracture count (F/I) between two points may be in part due to structure, but, also due in part to different surface conditions. To some extent, this can be compensated for by applying appropriate weightings to the observed counts, but over or under corrections may result.

Nevertheless, in spite of these sources or error, it has been demonstrated in (plains) areas where abundant subsurface control is available, that the incidence of fracturing is considerably above normal in the surrounding area immediately out from the steepest part of the flanks of the structure. This is in contrast with a low or normal incidence over the crestal area, and also to a normal incidence off structure.

FRACTURE ANALYSIS
of
PERMIT NO. 5587

The fracture pattern as shown on the enclosed mosaic and maps shows a great variation in intensity over various areas of the Permit. The Permit is located along the MacKenzie River and is many miles from the closest settlement.

The sedimentary section is about 6,000 - 10,000 feet thick and several systems are represented. In addition a thin layer of Tertiary till covers nearly all of the area. Potential reservoir horizons are present within both the Ordovician and Devonian sections. Faulting may have increased the gross thickness of the sediments.

Fractures as plotted on the mosaic show considerable variation in intensity. There is one area where the fracture intensity is greater than normal and there are two areas where the fracture intensity is less than normal. The high intensity area is shown in red and the low intensity areas are shown in green. The average length of the fractures is about 5,000 feet and both mega and micro fractures are present. It is worthy of special note to mention the glacial problem in this area.

Reference to the mosaic will show that the area has been moderately scarred with glacial grooves and striations and that the direction of ice flow was about north 30° west. Some of these grooves are so deeply impressed on the surface that they control the shape of tree growth in the area. In any area such as this the photoanalyst is faced with the difficult problem of eliminating the glacial scars from the fracture pattern without creating false anomalies. The removal of all fractures from a 10 - 12 degree arc in any area will create fracture anomalies and it requires a delicate weighting of the whole pattern to adjust for these effects.

In any fracture pattern there are two main systems of fractures: the axial system and the shear system. In both systems the fractures are sub-parallel and in general, the two systems are at approximate right angles to each other. Within Petroleum and Natural Gas Permit No. 5587 the statistical mean direction of the axial system north 40° west and the statistical mean direction of the shear system is north 30 degrees east. A third minor system, here termed the sub-axial system, trends nearly north-south.