GEOLOGICAL REPORT ON PERMITS

1337 AND 1338

PEEL RIVER AREA

YUKON TERRITORY

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Canada.

Dear Sir:

It is my pleasure to submit herewith a report on the geology of Yukon Territories Permits 1337 and 1338 to Midland Petroleums Ltd.

The field work carried out in connection with this study was done by a field party under my direction during the 1959 field season.

I would like to express my gratitude for the active and helpful support you have given me in all phases of the study.

Respectfully submitted,

Jack L. Walper, Ph.D.

Tulsa, Oklahoma
November 20, 1959.

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PEEL RIVER AREA

YUKON TERRITORY

Prepared for

MIDLAND PETROLEUMS LTD.

by

D. BRUCE BULLOCK & ASSOCIATES LTD.

Consulting Geologists

November 20, 1959

ABSTRACT

A geological field study was carried out on Yukon Territories Permits 1337 and 1338 during the summer of 1959. The object of this survey was to obtain additional stratigraphic and structural information in order to evaluate more accurately their petroleum possibilities. Results of this survey indicate that the area occupied by the Permits is situated on the basin margin of a stable shelf, a position that would lead to accelerated reef growth as the basin margin continued to subside. The observed increasing thickness of reefal structures in the Paleozoic strata westward or toward the basin, seems to verify this postulation. The adjacent basin deposits make excellent source beds and the porous reefal structures of the stable shelf form adequate reservoirs. This, coupled with the occurrence of a satisfactory structural trap within the area, makes the Permits very attractive as a potential petroleum producing area.

CONTENTS

ILLUSTRATIONS

GEOLOGICAL REPORTS ON PERMITS

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INTRODUCTION

The object of the geological survey of permits 1337 and 1338 dur ng the summer of 1959 was to obtain more stratigraphic and structural detail of the area in order to evaluate more accurately its petroleum potentialities. This work was a continuation of the preliminary survey carried out last season under the direction of Mr. Bruce Bullock.

Inasmuch as the underlying Paleozoic strata of the Permits would be the most likely target for exploratory drilling, a major effort was made during the field season to gain a greater knowledge of these beds. In order that this could be done these strata were studied to the south of the Permits, in the Mackenzie Mountains, where they crop out.

The whole effort of the author and his party was geared to obtaining measurements of representative sections, establishing the stratigraphic sequence, working out the structural geology and interpreting the geologic history. This report, although presenting mainly the results of the stratigraphic study of the underlying rocks, attempts also to present an interpretation of the sedimentary history of these strata and an evaluation of their depositional environment as a possible habitat of oil.

LOCATION AND EXTENT

Yukon Territories Permits 1337 and 1338 are situated between the parallels of 65° 30' and 65° 40' north latitude and between the meridians of 133° 30' and 133° 52, 1/2' west longitude. The northwest corner of the nearly square block, which comprises the two permits, is located approximately 20 miles south and 9 miles east of the confluence of the Peel and Snake rivers. There is a total of 79,473 acres contained in the two permits.

TOPOGRAPHY AND DRAINAGE

Permits 1337 and 1338 are located along the southern margin of the Peel Plateau physiographic province, a great triangular terrace lying at the foot of the Mackenzie Mountains to the south and the Richardson Mountains to the west. Although the evenness of its surface is the striking feature of the Plateau, this even surface is broken in the south and west, where the Permits are located, by rounded hills and ridges standing above the main surface relief of 1500 to 2000 feet. In this portion of the Plateau the general surface configuration is controlled to a great extent by structure and resistant lithology. It appears that there has been a gently undulating surface which reflected the underlying structure. This surface has been cut by glaciers and the present dendritic drainage has become incised into it, some of the streams in the northeast part having cut fairly deep, steep-sided valleys into the less resistant shales. Surface elevations over the Permit areas vary between 1500 and 3500 feet above sea level.

Almost the entire area is drained by tributaries of the Snake River, which flows north just east of the eastern margin of Permit 1337. The extreme southwest corner of Permit 1338 is drained by a tributary of Noisy Creek and thus is part of the drainage basin of the Bonnet Plume River.

CLIMATE, VEGETATION AND WILDLIFE

The climate, vegetation and wild life of the general area has been adequately described by Bullock (1958) as follows:

> Low temperatures and light precipitation are characteristic of the region discussed in this report. The average mean temperature for Aklavik is reported to be 16° F. It is expected that the average mean temperature will be slightly higher for this area by virtue of its more southerly geographic position. Average total precipitation for Aklavik is approximately 9 inches. Snow begins to fall in early Septemberand has melted again by June 1st.
>
> Temperatures of 80° and higher are not uncommon in the summer time. During the field season of 1958 July proved to be the wettest month and August the dryest. Normally, wet unsettled weather occurs from September 1st to September 20th when freeze-up commences.

The 1959 summer field season was apparently an abnormal one for unseasonably cold and wet weather occurred throughout July and August. Considerable rain and snow hampered the field work late in July.

In regards to the general climate and wildlife Bullock states:

> As a result of low temperatures during winter months, permafrost is present throughout the entire area. During the summer months, the frost-free zone is limited to the top 10 or 12 inches of soil. This frost-free zone is composed of an upper layer of reindeer moss and lichen and a lower layer of humus soil. The moss coverseems to provide excellent insulation

thereby preventing thawing beyond this surface zone. Below this the ground is permanently frozen. Areas from which the moss has been stripped thaw to considerable depth. Areas adjacent to stream channels and lakes thaw to a greater extent than do moss covered areas.

During summer months the permafrost provides excellent refrigeration for food storage. Meat stored in pits chopped into the frozen ground with an axe can be kept for two weeks without spoilage.

Vegetal cover over the area is fairly sparse. Predominant tree type is stunted black spruce. Underbrush is comprised of alder, dwarf birch and willow. Some poplar are to be found along the dry sandstone ridges.

The trees are larger and more abundant along river valleys. Spruce trees with 12 to 15 inch butts were noted along Peel and Snake Rivers. Annular growth rings of these trees are very close together making the wood very strong. Logs from these trees make excellent building material. Similar logs have been used effectively as building materials in many of the settlements throughout the north country. It is interesting to note that logs from trees of this type are used as foundations for houses and that these logs are not subject to rot because of the permafrost conditions.

The tops of most of the ridges in the area are barren of trees. The tree line is located at about the 2000 foot level. In the areas that are free of trees typical tundra-type vegetation prevails.

Wildlife is very abundant throughout the entire area. Big game animals include moose, caribou, Dall sheep, and grizzly bear. Fur bearing animals include lynx, martin, beaver, muskrat, fox, bear and wolf. Fish common to the area include Arctic grayling, some Dolyvardin, jack fish and whitefish. Waterfowl, except for a few ducks, are not common. Ptarmagin and grouse were the only upland birds noted.

Moose are plentiful in the area. Caribou migrate into the mountains during the early spring where their young are born and the herds remain to feed all summer. Late in August the Caribou begin to migrate back into the wooded lowlands where they winter in the protection of the trees.

CULTURE AND ECONOMY

The report area itself is uninhabited but it lies in the transition zone between the territories of the Hare and Kutchin Indian tribes (Jenness 1955). These are tribes that are members of the Athapaskan linguistic group which some anthropologists suggest may be remotely connected with the Tibeto-Chinese-Siamese group of languages in eastern Asia. The present Indians are descendants of these essentially woodland peoples who made much more use of wood than of stone. The present population is localised around small trading posts, the closest one of these to the report area being Fort McPherson. The bulk of the population of this small settlement is made up of the remnants of the "Loucheax" a band of mingled Hare and Kutchin that once hunted between the Mackenzie River and the Eskimo lakes in the first half of the nineteenth century.

Their chief occupation is fur trapping but some work at numerous sawmills which are situated along the banks of the Peel and Mackenzie rivers. Others supply the labor force necessary for urban areas and find employment at odd jobs which are a part of the economy of a small village. In addition, there are a few people of European ancestry, who are engaged in the business, educational and governmental service activities of the town.

ACCESSIBILITY

The area is remote and access to the general region during the summer months must be by chartered, float-equipped aircraft. These can be arranged for in Aklavik, Northwest Territories, or Dawson City, Yukon Territory, both centers being served by regular commercial airlines. The nearest lake to the Permits, from which aircraft can operate, is Moose Lake, situated about two miles south of the southern boundary of the Permit area. Once this lake is reached, access to points within the Permit area proper must be gained by helicopter, for foot travel over any great distance of the muskeg terrain would be very arduous.

During the winter, access could be gained from Dawson City over a winter tractor road which was built to supply DEW line operations. This road cuts across both Permits 1337 and 1338 in a general east-west direction, and continues eastward to the Mackenzie River.

Supplies may be obtained from stores either in Aklavik, Dawson City, or Fort McPherson.

METHOD OF STUDY

Field study of the area was conducted during the 1959 summer field season. The general regional structure was studied by reconnaissance flights over the surrounding area in fixed-wing aircraft as well as in helicopter. The field work was done by helicopter expedited surface party working from fly-camps, which were established out from base-camp, as well as from the base-camp itself, located at Moose Lake. The base-camp was serviced from Fort McPherson by float-equipped aircraft.

Geological investigation of Permits 1337 and 1338 during the period of July 1 through July 23 consisted of a detailed study of the actual permit areas and the additional study of the underlying strata where they are exposed to the south in the Canyon Ranges of the Mackenzie Mountains. The geology was plotted directly onto aerial photos and transferred to a topographic base map with a scale of 1 : 126,720 and a countour interval of

500 feet.

The study was a continuation of the reconnaissance survey conducted by Mr. Bruce Bullock during the 1958 field season. Besides a more detailed study of the stratigraphy and structure of the areas, a systematic examination of the rocks was carried out in order to postulate the environment of deposition and to determine if possible the regional aspects of sedimentation so that the report area might be associated with the overall sedimentary basin.

The majority of outcropping strata in the Permit areas are Cretaceous in age and clastic in character. Insufficient exposures of these strata within the Permit proper prevented accurate stratigraphic measurement, but a section was measured outside the Permit boundary so that such information could be obtained. Inasmuch as strata of Cretaceous age cover almost the entire Permit areas it was necessary to carry out a study of the Paleozoic rocks, which underlie the area at depth, in the Mackenzie Mountains where these strata crop out. As many traverses as time permitted were made and the gross lithology of the stratigraphic sections encountered was noted for use in the interpretation of the geologic history and depositional environments.

PREVIOUS WORK

The history of exploration of the region in which Permits 1337 and 1338 are located has been adequately presented by Mr. Bruce Bullock in the 1958 report on this area to which the reader is referred for this information.

More recent literature pertaining to the general region has been published in a report by L. J. Martin (1959), in which he discusses the stratigraphy and depositional tectonics of the region and makes an excellent summary of the literature dealing with the geology of the area.

Interest in the area has been stimulated by the recent oil and gas discovery by Western Minerals Limited No. 1 Chance, on the 3 million acre Eagle Plains oil reservation 150 miles northeast of Dawson City. The well, a second test following the unsuccessful Eagle Plains No. 1, flowed gas at the rate of 10 million cubic feet a day and also yielded light gravity oil.

Continued surface exploration has been carried on by most major oil companies and many of the independent oil producers during the 1959 field season. Plans are being formulated for additional geologic surface studies for next year and possibly some drilling in the Peel Plateau area northeast of the Permit areas herein reported.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the help and co-operation given him by members of the party. Particular thanks is due Mr. Keith Williams, from whose base-camp at Moose Lake, the field work was conducted. His knowledge and experience, which he so kindly shared, in this type of survey, was greatly appreciated.

Sincere appreciation is due Mr. Eduard Amann, pilot of the helicopter, for his excellent handling of the craft, sometimes under very adverse weather conditions. Dr. S. J. Nelson of the University of Alberta, made the fossil identifications. I am especially grateful to Mr. Bruce Bullock under whose direction the field program was carried out, for his interest, guidance and advice so freely given in connection with all phases of the work.

And lastly, to all members of the party at base-camp, without whose help the survey would not have been possible, is thanks heartily extended.

REGIONAL GEOLOGIC SETTING

The geology of the area of Permits 1337 and 1338 can best be presented, first by acquainting the reader with its relationship to the regional tectonic framework of the vicinity, and secondly by a detailed description of its local geologic components.

The Peel Plateau is the dominant areal feature of the region. It is a great triangular terrace underlain by Mesozoic and Paleozoic strata and lying at the foot of two mountain ranges, the Richardsons on the west and the Mackenzies on the south. It overlooks the Interior Plains on the northeast. The striking evenness of its surface is broken in the south and west by hills standing above the main surface. These hills, separated from the mountain front by a broad, poorly defined valley, appear to be formed of resistant rock that have remained as erosional remnants of a great continuous area of nearly horizontal strata formerly capping this part of the Plateau. The Mackenzie Mountains, which form the southern boundary of the Plateau, are carved from a series of large east-west trending anticlines. These anticlinal structures are very flat in their central parts, the strata lying almost horizontally or dipping gently across large areas. These central portions of the anticlines have been carved into the Main or Backbone Ranges whereas the frontal or Canyon Ranges have been cut from the steeply dipping northern limbs of the anticlines. Some major faulting is associated with these ranges and the orogenic forces producing them have caused some of the anticlines to overturn to the north.

The Mackenzie Mountains trend westward along the southern margin of the Peel Plateau. In the vicinity of the Snake River the dominant east-west Structural trend of these mountains begin to take on a northerly component and although the main Mackenzie Mountains appear to join and continue westward with the Wernecke Range, this northern component is manifested in the northward trend of the Knorr Range branch, a complex structural axis which appears to have its continuation in the Richardson Mountains, which form the western boundary of the Plateau.

The junction of the Knorr-Richardson Mountain structural trend and the Mackenzie Mountain trend frames the southwest corner of the Peel Plateau and forms the margin of a structural basin. The thick series of sedimentary strata, which underlie the Peel Plateau, crop out in the Mackenzie, Knorr, and Richardson mountain ranges.

The Knorr Range, structurally a large anticline, plunges to the north along the Knorr-Richardson structural axis. This structural saddle, together with the less resistant basin facies argillites, which here dominate the section have yielded to erosion more readily than the more resistant carbonates of the southern Knorr Range and the Richardson Mountains farther north, has resulted in the formation of a low, subdued area, almost topographically continuous with the Porcupine Plateau lying to the west of the Knorr-Richardson mountain trend. Through this low area, which stands little higher than 1000 feet above sea level, has been cut the lower canyon of the Peel River.

Permits 1337 and 1338 are situated in the transition zone between the Mackenzie foothill belt and the Peel Plateau. Structural deformation has caused the thick sedimentary section to plunge northward in a series of structural noses which jut out into the relatively horizontal strata of the Plateau. In addition, an arcuate anticline accompanied by numerous faults has been formed in the foothill belt.

STRATIGRAPHY

GENERAL STATEMENT

The outcropping strata of Permits 1337 and 1338 are composed almost entirely of rocks of Cretaceous age, the exception being a narrow belt of Devonian strata cropping out along the southern margin of Permit 1337. Situated as these Permits are, in the transition zone between the Peel Plateau and the Mackenzie foothill belt, these older beds dip northward beneath the Cretaceous strata that underlie the Plateau. A resistant, lower Cretaceous sandstone caps a low east-west trending range of hills, which stand out north of the Canyon Ranges, and is usually separated from the mountain front by a broad, poorly defined valley. The regional dip is to the north and successively younger beds of Cretaceous strata crop out in east-west trending belts away from the mountains.

Well out on the Plateau the beds are nearly horizontal and the even surface of this physiographic feature is broken only by a few hills standing above the main surface. These hills are erosional remnants of a great continuous layer of resistant upper Cretaceous sandstone that formerly capped this part of the Plateau. The distribution of these erosional remnants, besides marking the former site of a continuous layer of Cretaceous rock, also reflect the minor structural warping which has effected the area.

At no place within the Permit areas were there complete sections of Cretaceous strata exposed. In order to obtain stratigraphic thicknesses and study the entire lithology of these beds, a traverse was made down the Snake River. Although high water prevented accurate measurements, a fairly detailed study was made and approximate thicknesses determined.

In order to adequately study the Paleozoic strata that underlie at depth the permit areas, a number of sections were measured and described from locations to the south of the Permits where these beds crop out in the Canyon Ranges of the Mackenzie Mountains. The following is a generalized discussion of not only the outcropping strata of the Permit area, but the rocks expected to lie at depth beneath the Permits.

CAMBRIAN

The entire Cambrian sequence was not studied in the course of the investigation. At the various places where stratigraphic sections were measured the upper contact of the Cambrian sequence was taken as the top of a thick, pink and white quartzite, which grades into a well cemented sandstone in places, was measured and found to be at least 1000 feet in thickness and directly underlying a thick sequence of Ordovician, Silurian and Devonian carbonates. Immediately east of the Snake River this thick quartzite was overlain by a sequence of red and green phyllitic shales, which in turn are overlain by about 80 feet of white and pink quartzite. Above this second quartzite is the Paleozoic carbonate sequence.

Cambrian beds composed largely of carbonates crop out within the main ranges of the Mackenzie Mountains and associated with these is a sequence of evaporites, exposures of which are present along tributary creeks of the Snake River. The lower Cambrian section is dominantly one of carbonates and this lithology appears to dominate the section farther west in the Knorr Range. However, here also are two quartzite horizons present in the upper part of the section, the thinner upper one containing a cobble quartzite conglomerate. The upper quartzite appears to be a lense from the west, formed late in Cambrian time when tectonic activity effected a positive area in the area now occupied by the Bonnet Plume basin.

A persistant sill of trap rock was noted at several localities throughout the Main Ranges. It is associated with the lower carbonate part of the section and was not studied.

The dominant carbonate sequence of Cambrian strata that is exposed in the Knorr Range west of the Permit areas, appears to become more clastic northward, for Stelck (Hume 1954) reports 6500 feet of Cambrian slates and shales at the southern end of the Richardson Mountains on the Peel River, which is only 24 miles northwest of the Permits.

Although there were no reservoir characteristics noted in the Cambrian beds and they do not appear to be a potential source for hydrocarbons, they could contribute a great deal to an understanding of the depositional pattern being established in early Paleozoic time. A more detailed study should be undertaken of these as well as underlying Precambrian strata in order to delineate the depositional basins and contributing land areas during the initial period of basin formation and to establish the location of basement structures which in all probability has influenced deposition throughout the entire Paleozoic and succeeding eras. The meager information derived from the present field study seems to indicate that the pattern of deposition, which prevailed throughout most of the Paleozoic era, was being established during this period if not earlier. More work is required on these beds to utilize them in an accurate interpretation of the geologic history.

ORDOVICIAN

The sequence of strata overlying the Cambrian quartzite consists of over 2000 feet of dark gray dolomite, dolomitic limestone and limestone. It contains abundant black chert in places, particularly in the upper part, and carries an Ordovician fauna. In many places the fossil remains are completely silicified to the extent that zones of siliceous dolomite grade to a pure quartz material or quartzite-appearing rock. Associated with these zones of silicifications are abundant silcified corals and coralline detritus.

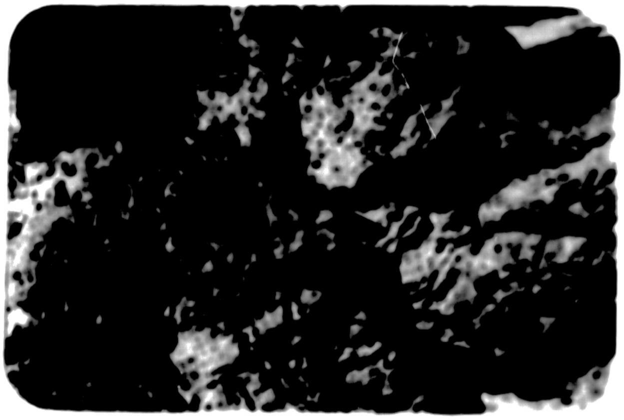
Two stratigraphic sections containing this Ordovician sequence was measured and are given in Appendix A.

In general the section consists dominantly of gray, finely crystalline, dolomite or limestone and falls within the category of "normal marine limestone" as defined by Krumbein and Sloss)1953, p. 137). Limestone of this type is commonly dolomitized, and has formed in an open marine environment where bottom conditions were anaerobic. Two factors usually responsible for this condition: either the sea bottom was below wave base and/or there was an abundance of argillaceous sediment (Illing 1959).

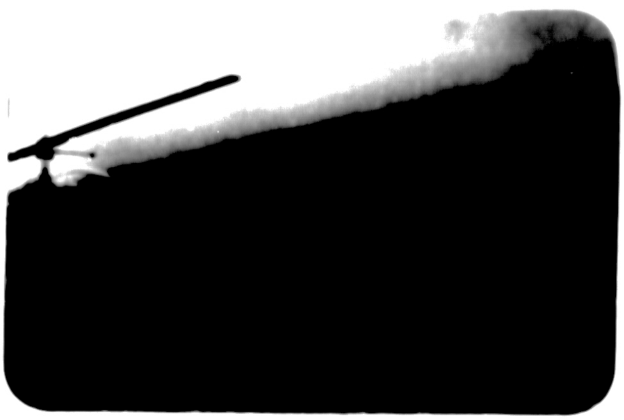
Black, nodular chert, recognized in places as secondary by replacement fossils, is widespread in the section. The clear relation between distribution and conditions of original deposition, and the preservation of the silicified fossil detritus indicate an early rather than a late diagenetic origin for the chert, undoubtedly related to pH changes during initial burial (Newell et al, 1953; Emery and Rittenberg, 1952 and Illing, 1959).

At various places the sequence contains reefal structures and a number of coarse-grained, vugular dolomite bioherms were noted (Plate 1A). The Ordovician section examined in the Knorr Range is thinner-bedded and contains more bedded chert than is the case farther east in the Canyon Ranges. The strata examined was a basin margin facies and did not exhibit the reefal structures that are present to the east.

Outcrops of Ordovician rocks were examined in Noisy Creek a few miles west of the Permits. An extensive section is exposed along the creek for a number of miles. A section was examined starting at the core of a small anticline. Approximately 1800 feet of thin bedded limestone, dolomite, and shale is present with abundant chert and argillite. The section becomes increasingly more clastic upward as more shale and argillite interbeds appear. Several Ordovician graptolites were collected from the shale and a particular zone of conglomerate is of special interest.



A. Vugular porosity of reefal structure in Ordovician strata in Canyon Ranges of the Mackenzie Mountains.



B. Resistant knob of reefal dolomite in Devonian strata east of Knorr Range.

Exposed in the south bank of Noisy Creek is a 30 foot bed of conglomerate consisting of gray, silty limestone matrix containing abundant black chert fragments randomly oriented. Besides the chert, which is the most abundant material, there are cobbles of quartzite, fragments of green siliceous shale and several large blocks of buff dolomite. Above the conglomerate bed is a 15 foot unit of black shale with thin beds of black limestone, some of which are lenticular and conglomeratic, the main fragmental material of the conglomerate being black chert.

Overlying this is 20 feet of black shale interbedded with thin limestone beds. The black shale contains graptolites. Above this is a massive limestone unit containing abundant lenticular plates of black chert. At a number of places within this bed the chert fragments are arranged in nappe-like flow folds indicating slumping during deposition of the sediments at a time when the chert had already solidified but before the enclosing lime mud had become sufficiently consolidated to yield as discrete fragments for it showed as flow lines or lineations.

A slump origin at time of deposition is indicated for these conglomeratic beds. The conglomerates are slumps that have become mobile and passed into submarine slides; the nappe-like flow folds represent an early stage which had not become mobile enough to slide.

These features of the basin sediments indicate a period of minor tectonism but more than that, the presence of the quartzite, dolomite and green shale phenoclasts, indicate a nearby tectonically active land mass. Other features and the increasing clasticity of the sedimentsto the west along the Mackenzie Mountains towards the Knorr Range imply also the presence of an active tectonic unit in the vicinity of the Knorr Range. The Ordovician strata become more characteristic basin-like northward for Decker, Warren and Stelck (1947) describe an Ordovician sequence of black shales, bedded cherts and argillites exposed in the lower canyon of the Peel River. It appears thatthis area was a rapidly subsiding basin or trough of a geosyncline and that the source area of the dominantly fine clastic material must have been from nearby to the southwest, probably just west of the Knorr Range or in the vicinity of the Bonnet Plume Tertiary basin.

This influx of argillaceous sediment may have been a contributing factor in creating anaerobic bottom conditions which led to the deposition of the abundant chert contained in the section. The influence of argillaceous pollution in the origin of penecontemporaneous cherts has been suggested by a number of investigators.

The anaerobic bottom conditions thus produced result in the decay of entombed organic remains which produces a rich organic layer in an acid environment. Amorphous silica is more soluble in alkaline water, and thus siliceous skeletal remains that were entombed in the alkaline layers beneath the highly acidic surface layer would tend to be dissolved after burial. Silica, which has an affinity for organic material, would be precipitated as the connate, alkaline, silica-rich fluids would be squeezed out of the compacted lower alkaline layers and up into the abnormally rich organic layer in the acidic environment at the surface of deposition.

The presence of this subsiding basin or geosynclinal trough is very important to the sedimentation of the area. Small reefal structures in the Ordovician beds were noted to the east, but much larger and thicker reefal development is evident as one goes west towards the basin. It is very possible that this reefal build-up was in response to the subsiding basin margin and that only under such tectonic impetus do reefal structures develop to any considerable thickness.

If this has been the case then Permits 1337 and 1338 are very favorably situated for beneath them could be some attractively thick reefal structures, thus making Ordovician strata an important objective in any well drilled in the area.

SILURIAN

Silurian strata of the Mackenzie Mountains are dominantly carbonates and contain abundant silicified corals. The rocks, which contain considerable quantities of silicified coralline debris and overlie the cherty limestones and dolomites of Ordovician age, are very similar to the underlying rocks. They are a sequence of thin bedded limestones with lenticular plates and discontinuous interbeds of black chert broken by the occasional zone of silicified coral, which weathers very dark gray with a porous vuggy texture. These coralline zones are anywhere from 2 to 15 feet thick and have a great lateral extent, assuming the appearance or aspects of biostromes rather than bioherms.

During the summer, while field work was in progress, the upper Ordovician contact was tentatively taken as a persistent zone of silicification above which numerous coral fossils occurred, themselves silicified and associated with more silicified dolomite. Subsequent fossil determinations revealed that these lower corals were Upper Ordovician (*Palaeophyllum halysitoides* (Wilson), *Favistella alveolata* (Goldfuss), *Catenipora Delicatulus* (Wilson), *Manipora amicarum* (Sinclair), *Syringopora columbiana* (Wilson), and that the unit correlates with the Beaverfoot formation of British Columbia and the Stony Mountain of Manitoba. The

Silurian corals (Favosites sp. and Halysites sp.) occurred higher in the section. What was thought to be about 1000 feet of Silurian section suddenly shrank to about 500 feet. Moreover, there now appears to be no lithologic break at the systemic boundary and it becomes exceedingly difficult if not impossible to separate the two systems for the purpose of field mapping. Consequently they are mapped as an Ordovician-Silurian unit.

The rocks which form the bulk of the stratigraphic section are, for the most part, thin-bedded limestones with lenticular plates and discontinuous interbeds of black chert broken by zones of silicified coral, which weathers very dark gray with a porous vuggy texture. Although the Upper Ordovician part of the section contains a number of these coralline zones, the part of the section containing Silurian fauna has developed extensive reef build-ups as well as several of the zones of biostromal accumulation of the coralline structures. These coralline zones are anywhere from 2 to 15 feet thick and several of those in the upper part of the Silurian section exhibit a vugular porosity and together with the reefal developments noted here, make this part of the section important from the standpoint of petroleum reservoir beds.

In the southern Richardson Mountains the Silurian is much more clastic than that found in the Canyon Ranges of the Mackenzie Mountains. Martin (1959) reports that it is composed principally of black graptolite shales and bedded black cherts. Stelck (Decker, Warren and Stelck, 1947) measured over 2600 feet of shales and argillites with a few thin crinoidal limestones, black brecciated limestones, and limestone conglomerate beds in the lower canyon of the Peel River.

The upper part of the section exposed in Noisy Creek undoubtedly includes strata of Silurian age and here increasing clasticity of the rocks was noted. It becomes apparent that the area now occupied by the southwest corner of the Peel Plateau was a site for the deposition of a thick and somewhat clastic sequence in Silurian time. The presence of this clastic basin facies in the Silurian marks a region of rapid subsidence and accumulation of sediments, an interplay of tectonism and environment began in the Ordovician.

The Permit areas are situated east of this subsiding belt in the area of the stable shelf margin and the reefal development in the Silurian may reflect a continued response to subsidence began in Ordovician time.

These rocks, as well as the overlying ones, require additional study in order to determine sedimentary strike and the configuration of this subsiding Paleozoic basin. More important than that, the geologic interpretation of an area is fundamentally the geologic history of that area. Following the collection and evaluation of field data it becomes necessary to relate the sequence of events recognized in their chronological order as well as in their spatial relations. In light of the information obtained during the past season it becomes increasingly more plain that more knowledge of the surrounding area is necessary in order to understand and secure the most interpretative value from the data collected.

This condition of insufficient data makes possible a variety of different geologic interpretations and further information may appear to support one of these in preference to another. It is the purpose of the report to set forth the one that seems most logical in light of the present evidence, but it must be stressed that additional information may tend to favor a different interpretation.

Of great importance is a knowledge of the physical sedimentation of the entire depositional basin as well as the regional tectonics which not only controlled the depositional history but later produced the major tectonic elements present in the vicinity today. Additional work is required to obtain this needed information and the presence of attractive reservoir beds in the section adjacent to a marine basin seems to warrant such work.

DEVONIAN

Only Middle and Upper Devonian strata have been identified in the vicinity of Permits 1337 and 1338 where they crop out in a narrow belt along the southern margin of the area. The Middle Devonian beds are dominantly calcareous whereas the Upper Devonian strata are clastic. Exposures within the Permit area were not adequate for study of a stratigraphic section so consequently sections were measured in the Canyon Ranges south and east of the Permits. One of these sections is located east beyond the map area (See Appendix A).

Middle Devonian

Middle Devonian strata consists of dolomite, limestone and shale and can be divided into four distinctive units. The lower unit is an unfossiliferous or sparsely fossiliferous sequence of dolomite and limestone lying above known Silurian beds. These carbonates contain considerable amounts of silt and weather a distinctive buff color which serves to identify the zone and make it recognizable as a marker on the outcrop. This buff weathering characteristic may be due in part to finely divided ferric iron associated with the silt or to the weathering of limestone and dolomite containing pyrite, which was noted in a number of places. In the latter case, however, the weathering was usually very rusty rather than just buff. More likely the similar ionic radii of Mg^{++} and Fe^{++} ions allow free substitution for each other in the Rhombohedral space lattice and the buff color may be the result of weathering of the iron-rich dolomite known as ferrodolomite. This unit has been tentatively correlated as equivalent to the Bear Rock formation of the Norman Wells area.

The overlying sequence consisting of the three remaining units has been correlated with the Ramparts formation of the Norman Wells area. The lower unit of this sequence is composed mainly of dolomite with some limestone, and although it appears to be somewhat platy in character at a number of outcrops examined, it is essentially a massive bedded unit and contains many reefal build-ups. The middle unit consists of black calcareous shales with a few interspersed beds of limestone. The upper unit is best described as a calcareous "mudstone". It is a nodular, shale limestone containing a high percent of soft, gray to buff, argillaceous material, which on weathering produces barren, clay, rain-gullied slopes. In places the beds are more calcareous and remain as distinct units of limestone scattered throughout the mudstone. In other places they retain all the characteristics of a normal limestone and form resistant caprock for some of the hills located in the area.

A number of outcrops of this member exhibited some primary structures formed by slump and interstratal flowage (Plate 2). These have the appearance of large-scale cross-bedding or small-scale angular unconformities. Although similar structures have been attributed to diastrophic movements, it is believed that the ones examined in the course of this investigation have resulted from slump of blocks of accumulating, partly consolidated sediments on the basinward slope of the shelf margin, and the discordant contacts are, in a sense, small-scale gravity thrusts.

These upper beds are very fossiliferous in places and the weathered surface is thickly strewn with a great variety of fossils. Brachiopods, gastropods, pelecypods, cephalopods, trilobites and corals were represented.

The basal unit of the Ramparts is of importance for it contains many reefal structures. Massive reefal build-ups are present all along the strike of this unitwhere it is exposed in the front ranges of the Mackenzie Mountains and in the eastern foothills of the Knorr Range. A number of these are visible on the surface as resistant knobs (Plate 1B) and others can be seen in the canyon walls

A. Discordant strata of primary structures formed by slump and interstratal flowage of internally disturbed upper Ramparts formation, Knorr Range.

B. Discordant strata formed by slump and interstratal gliding in upper Ramparts formation near Moose Lake.

cut into this unit south of Moose Lake.

Although no reefal structures were recognized in the upper unit of the Ramparts west of the Snake River, a number of small bioherma1 structures are present eastward and were recognized in the sections east of the Snake River (Appendix A and Plate 3B). The interplay of depositional environment and tectonic activity, which determines the lithologic characteristics of the accumulating sediment, was not favorable for reef build-up during this time in the vicinity of the Permits. All evidence seems to point to renewed tectonic activity in the west, which changed the stable shelf environment prevailing during early Middle Devonian to an unstable one in late Middle Devonian time, thus causing the former basin margin to become overwhelmed by clastic sediment, an environment unfavorable to reef-building organisms. Consequently there are not the reefal structure present in this member here that are found eastward.

The thickness of Middle Devonian strata in the vicinity of the permits was unobtainable because of poor and incomplete exposure of section. However, on the basis of measurements made on sections east of the Snake River, the thickness was determined to be between 3850 and 4000 feet. The higher figure is probably excessive for faulting of undetermined displacement occurred in

A. Upper Ramparts "gates section" exposed on a tributary creek east of Snake River.

B. Bioherms in upper part of lower carbonate section of Ramparts. This exposure along section MW-2.

the section and at least a part of the section was repeated.

On the basis of measurements and well controlled estimates made on this unit in the vicinity of the Knorr Range, the unit appears to thicken westward. However, the thickening takes place in the upper part and probably marks the beginning of rapid subsidence and deposition due to renewed tectonism to the west in the region of the Bonnet Plume basin.

Upper Devonian

The upper Devonian in the report area can be divided into two units: (1) a lower black shale unit overlying the Ramparts and tentatively correlated with the Fort Creek formation of the Norman Wells area, (2) an upper sandstone and shale unit tentatively correlated with the Imperial formation of the Norman Wells area.

The lower unit consists of thinly bedded, black Bituminous shale and a few thin limestone and argillite beds which are very nodular in places. The black shale is usually pyritiferous and on weathering becomes coated with yellow sulphurous and white melanteritic stains. Its lower contact with the Ramparts is very sharp but appears conformable (Plate 4A). The underlying Ramparts formation is usually a very argillaceous, nodular lime-

A. Devonian Ramparts - Fort Creek contact in Canyon Ranges of the Mackenzie Mountains.

B. Large concretions in the Fort Creek formation east of the Knorr Range.

stone or a well consolidated limy mudstone containing pyrite nodules. In either case the upper surface is nodular and the basal laminae of the Fort Creek fill in between and wrap around the upper surface of the nodules. The lithologies are distinctly different and there is no mixing. The pyrite of the upper Ramparts may be due secondary enrichment from the pyritiferous black shales of the overlying Fort Creek formation.

Normally the Fort Creek throughout the Canyon Ranges is between 250 and 400 feet thick but it measured only 160 feet along the Snake River. In the vicinity of Moose Lake it is about 250 feet thick. A measured section on the eastern flank of the Knorr Range revealed a thickness of 1375 feet. This increased thickness of the Upper Devonian sediments indicates that the renewed subsidence which began in late Middle Devonian time continued on into Upper Devonian time. The extent of this subsidence is unknown but the thinning in the vicinity of the Permits indicates more stability there than farther west. Martin (1959) and Stelck (in Hume 1954) describe an anomalous condition in the probable Fort Creek equivalent in the lower Canyon of the Peel River.

Additional study on a more regional scale is necessary to secure the final answer on the distribution and depositional history of this unit.

The Imperial formation is a distinctive clastic unit among the Paleozoic strata but is very similar to the overlying Cretaceous rocks. It is composed of light brown to greenish gray, fine grained, impure quartz sandstone with silty shale interbeds. The sandstones are well bedded to flaggy and in places cross-bedded. The surfaces of the beds exhibit various rippled markings including a miniature knob-and-tail-type marking which is characteristic of the Imperial throughout the southern Peel Plateau.

The Imperial formation exposed along the Snake River section measured 140 feet. The formation was not measured in the Knorr Range area but over 300 feet of section was estimated as being present above the Fort Creek at the locality where this formation measured 1375 feet. The Fort Creek-Imperial contact is conformable. The presence of sandstone beds, above a 30 foot unit of silty shales and a concretion zone in the upper Fort Creek, mark the base of the Imperial. The upper contact with the lower Cretaceous sandstone appears to be conformable in the Snake River section and only slightly unconformable at the few other places nearer the mountain front, where it was examined.

PENNSYLVANIAN ?

One outcrop, of an entirely different lithology from the Devonian or Cretaceous, located on Noisy Creek 10 miles west of the boundary of Permit 1338, was examined. About 60 feet of exposure, consisting of sandstone, which is cross-bedded and very carbonaceous, is present on the south bank of the creek. The carbonaceous material consists of abundant coal fragments and wood particle imprints on bedding plane surfaces. A conglomerate lense about 8 inches thick occurs near the top of the outcrop. The sandstone is well cemented but frequent layers of carbonaceous material allow it to split into thin plates and beds. Some zones are more carbonaceous than others.

This rock has a great lithologic similarity to known Pennsylvanian strata in other parts of the region but it could also be Cretaceous or Tertiary. It does not resemble the former, an outcrop of which occurs across the creek. The outcrop is completely isolated therefore its age relationship to the other identified rocks of the area is unknown. It is tentatively assigned to the Pennsylvanian but further work is necessary to confirm this age assignment.

CRETACEOUS

Cretaceous beds cover most of the Peel Plateau and they underlie nearly all of the Permit areas. The age of these strata is believed to be Lower Cretaceous to early Upper Cretaceous. The succession divided naturally into three divisions: a lower sandstone and shale unit; a middle shale unit; and an upper sandstone. Stewart)1945) named these three units the Sans Sault Group, the Slater River formation, and the Little Bear formation respectively from the Mackenzie River Valley near Norman Wells. Thicknesses applied to these units by Stewart seem rather large, however, the units thin westward according to Martin (1959) and the smaller measurements obtained in the vicinity of the Permits may be due to this thinning.

The lower, or Sans Sault sandstone and shale sequence is about 800 feet thick. The massive basal sandstone is approximately 80 feet thick and above it is a thick series of interbedded shales, thin sandstones, and argillites. Overlying this and comprising the balance of the unit is a series of interbedded sandstones and shales with the sandstones dominating so that the upper part is essentially a sandstone about 150 feet thick.

The middle shale or Slater River formation is about 1300 feet thick and is composed of dark gray, thinly bedded, soft shale with lenses and nodules of clay-ironstone interspersed throughout. There is an occasional bed of siltstone occurring in the sequence but this part of the section is dominantly shale.

The upper or Little Bear formation is essentially sandstone. It consists of fine to medium grained quartz sandstone with some carbonaceous and argillaceous material. Erosional remnants of this unit cap many of the hills on the southern Peel Plateau and northwest of the Permit areas this sandstone is the caprock of a large north-south trending ridge known as the Trevor Mountains. Although these sandstones are probably early Upper Cretaceous in age they appear to overlie the middle shale unit with apparent conformity. The total thickness of this unit is unknown as it has been eroded but thicknesses of nearly 300 feet have been estimated for erosional remnants in various places throughout the area.

TERTIARY

A small area of strata lying north of the Knorr Range has been assigned a Tertiary age on the basis of their lithologic similarity to beds which crop out along the lower Bonnet Plume and Wind rivers and which have been assigned to the Tertiary by C. R. Stelck. These beds were not studied during the 1959 field season but the dominant lithology appeared to be sandstone with minor shale, clay and coal.

QUATERNARY

Glaciation directly or indirectly influences the Quaternary deposits. Glacial drift covers most of the lowland areas and numerous glacial erratics were noted at various places well up on the sides of ridges. Stone polygons and nets abound on top of the rounded sandstone-capped hills throughout the area. The valley floors of many streams are occupied by gravel flats and the stream courses are braided throughout most of their length. Solifluction flows, landslides, earthflows, rock glaciers, and stone stripes are common throughout the area. Cirques, glacial moraines with kettles and kame terraces are to be found in the mountain valleys.

STRUCTURAL GEOLOGY

REGIONAL STRUCTURE

Permits 1337 and 1338, situated in the southwestern portion of the Peel Plateau, lie in the transitional zone between the Plateau and the foothill belt of the Mackenzie Mountains. This east-west-trending range of mountains bifurcate, the northern branch or Knorr Range trends almost due north to join with the north-south trending Richardson Mountains thus framing the southwest corner of the Peel Plateau, which is underlain by a structural basin. This convergence of structural axis has produced some rather complex structural elements in the vicinity of the Knorr Range and Permits 1337 and 1338, lying some 12 miles to the east, also come under the influence of this structural convergence.

The Canyon Ranges of the Mackenzie Mountains are carved for the most part, from the northern limbs of a series of large anticlines of which the central cores make up the Main or Backbone Ranges. These large anticlines have an east-west orientation for a considerable distance throughout their length, but towards the west, beginning at about the Snake River, their western ends tend to swing to the north causing structural reces to protrude out into the relatively horizontal strata of the Plateau. In the vicinity of Moose Lake and particularly farther west in the Knorr Range, the structural warping of these noses has yielded by faulting. The Knorr Range represents a large anticlinal fold which swings in a large arc to the north. Its eastern flank is faulted and the northern end of the anticline has been thrust to the east over the adjacent syncline. This fault is named the Solo Creek fault.

The north-south trending Richardson Mountain structural axis has all the aspects of major structural deformation but the soft basin facies sedimentary rocks which dominate the section at its southern end do not form the rugged mountain peaks that the carbonate section does to the north and south. Rather, this area has yielded to erosion more and notwithstanding its structural complexity, now forms a topographically subdued area almost continuous with the Porcupine Plateau and the Bonnet Plume basin.

These major tectonic elements as well as the lesser local ones were produced by orogenic forces acting on the area in early Tertiary or late Cretaceous time. These orogenic pulsations are a part of the Laramide orogeny that affected much of the western part of the continent at this time.

LOCAL STRUCTURE

The strong north-south directed orogenic forces which produces the Mackenzie Mountains appear to have been influenced by a stable buttress in the vicinity of the Bonnet Plume basin or by active east-west forces which produces the Knorr-Richardson mountain trend. This combination of structural deformation has produced a number of northwest-trending anticlinal noses in the Front Ranges of the Mackenzie Mountains and formed a series of arcuate anticlinal structures in the foothill belt. The Devonian strata strike east-west along the mountain front but they dip north beneath the massive, ridge-forming, basal Cretaceous sandstone and the entire sequence dips more gently north with some local structural warpings.

The main structural feature within the Permit areas is the large anticlinal fold named the Moose Lake anticline. The axial trace of the anticline is arcuate, the plunging southwest nose strikes S. 40° W. whereas the main axial crest swings northeast to eventually strike N. 80° E. The surface rocks on the anticline are Cretaceous in age but Paleozoic strata is involved in the fold for Devonian Ramparts, Fort Creek and Imperial formations are exposed on its axis where it is cut by the valley of the Snake River (Plate 5A).

A. Distant view of Moose Lake Anticline where the Snake River cuts across its axis. View is to the east.

B. Folding and faulting in Cretaceous strata exposed on a tributary of the Snake River east of the Permit Areas.

Dips on the north flank of the structure vary from 35° N. near the axis to 10° near the adjoing synclinal axis. The anticline is closed to the east beyond the Snake River and to the southwest in the vicinity of the southwest corner of Permit 1338. The plunging nose appears to pass into a fault and another fault is present on the southeast side of the nose. Apparently deformational stresses were relieved by faulting as well as folding, particularly in this area of conflicting structural trends where structural noses plunge northward off the front of the Mackenzie Mountains. This faulting, in some cases is not very deep, for farther east in another Snake River tributary some shallow faulting was confined entirely to the upper Cretaceous rocks, the faults disappearing with depth (Plate 5B).

Besides the faulting, these structural noses have the effect of producing local crests and depressions along the axis of Moose Lake anticline, which runs for a distance of over 12 miles within the Permit areas. The north flank, from crest of fold to trough of adjacent syncline, is about 7 miles wide. The south flank varies in width from 1 to 3 miles. Vertical closure, measured in relation to the syncline on the north, is nearly 2000 feet. Vertical closure is somewhat less when measured against the syncline on the south due to the northward regional dip from the mountain front.

Moose Lake anticline lies in an east-west-trending structural belt which lies out in front or north of the Canyon Ranges. Besides the series of foothills anticlines which have been formed, Moose Lake anticline being one, there is a belt of structural deformation consisting of minor folds, many of which are faulted (Plate 5B), and zones of chevron folding that extend over one half mile in width. Associated with the structural belt are some primary structures such as interstratal flowage and slumps. A number of these were noted in outcrops of Cretaceous strata exposed in tributaries of the Snake River. With the exception of minor faulting, none of these other minor structures, although plentiful to the east along the belt, appear to be present in the Permit areas.

CONCLUSIONS AND RECOMMENDATIONS

Permits 1337 and 1338 are situated along the southern margin of the Peel Plateau physiographic province in the transition zone between the plateau and the foothills of the Mackenzie Mountains. Stratigraphic studies in the adjoining mountains revealed a thick sequence of marine strata which contained not only likely source beds but excellent reservoir beds as well. These strata are believed to underlie, at depth, the Permit areas. A thick carbonate sequence, ranging in age from Ordovician to Devonian, contain numerous reefal structures in all ages of rocks. Although these are present eastward all along the Mountains, thicker deposits are encountered in areas adjacent to the Permits. This increased thickening seems to be the result of accelerated upward growth of the reef-building organisms in attempting to keep pace with the subsiding margin of a basin which was forming west of the area. The increased thickening and clasticity of the sediments to the west imply a basin environment.

The change from shelf limestones with reefal structures to typical basin sediments reflect a change in depositional environment and marks the site of a subsiding basin or part of a geosynclinal trough that was active throughout most of the Paleozoic era. The resulting basin sediments, argillaceous limestones, shales, and argillites, make excellent source beds and the hydrocarbons migrating from them would be trapped in the porous reef limestones of the shelf area. There is an excellent possibility that the Permit areas are underlain at depth by reefal limestones which would form satisfactory reservoir beds and petroleum traps.

Moose Lake anticline provides structural conditions that appear to be favorable for the accumulation of hydrocarbons in commercial quantity. Porosity in the biostromal reef zones was noted and these could serve as a reservoir for this structural trap.

More detailed lithofacies studies should be made of the strata in the general area to delineate the basin margins and the reef trends. Further regional structural studies should be undertaken to establish regional as well as local structural trends and to delineate, if possible, basement lineaments. Movement along these undoubtedly controlled the interplay of tectonism and depositional environment which determines the overall characteristics of the accumulating sediments, which is the habit of oil.

However, even at this time there seems to be an excellent possibility, from both the structural and stratigraphic conditions obtaining on the Permits, that the area has a very good potential for the production of petroleum. The area of the Permits is favorably situated on the basin margin of a stable shelf zone, a position that would lead to accelerated reef growth, and besides this a satisfactory structural trap occurs within its boundaries.

On the basis of the data at hand petroleum bearing horizons may be expected around 3500 feet or less for axial locations in the Moose Lake anticline. This would allow for more than 1000-foot penetration of the rocks underlying the Upper Devonian, which would seem adequate to test most of the Devonian. However, preparations should be made to go to greater depths in order to test the reefs of the underlying Silurian and Ordovician.

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APPENDIX A

STRATIGRAPHIC SECTION MW-1

Location: Along second prominent north-south ridge in Canyon Ranges east of longitude 132° 45' W., and across latitude 65° 30' N.
Date: July 4, 1959.
Weather: cold, windy, scattered showers.

Measurement began at top of Cambrian quartzite which is a white to buff sandstone in its upper part and grades into brownish gray sandy dolomite of basal Ordovician. Contact appears gradational but much of lower section covered by quartzite talus.

Lithic Description	Thick (feet)	Total
Bottom		
Ordovician		
Dolomite, buff to gray, mostly talus	18	18
Dolomite, gray, finely crystalline, hard, gray weathering, chert in upper part, some covered areas.	408	426
Dolomite, gray, finely cryst. to dense, thin platy bedding, recessive unit forms topog. low, many covered areas.	760	1186
Limestone, dark gray, finely cryst., gray, weathering, rough surface, sparry calcite veining.	188	1374
Dolomite, gray, finely cryst., light gray weathering, partly covered.	246	1620
Dolomite, dark gray, cryst., dark gray weathering, some organic remains coral or algae ?	13	1633

Lithic Description	Thick	Total
Quartzitic chert, some cryst. quartz, vugular siliceous zone.	13	1646
Dolomite, dark gray, cryst., abundant chert, quartz, corals, reefoid at 1790 to 1862, sparry calcite.	381	2027
Limestone, dark gray, finely cryst., dolomitic zones mod. bedded.	173	2200
Silurian ?		
Limestone, dolomitic, gray, light gray weathering, thin bedded.	349	2549
Dolomite, buff to gray, some buff weathering, mod. bedded.	71	2620
Limestone, dolomitic, dark gray, dusky gray weathering, thin bedded, gastropods at 2691.	155	2775
Devonian, buff-weathering unit.		
Dolomite, gray to cream, buff weathering rusty streaks, recessive, interbeds of brownish gray ls. which is thin bedded and not laterally continuous.	480	3255
Dolomite with dolomitic ls. beds, gray to buff, buff weathering.	406	3661
Dolomite, buff, hard, finely cryst., buff to rusty weathering, recessive, topog. low.	87	3748
Dolomite, gray with alternating dark and light gray layers, weathers gray, finely cryst. to dense.	71	3819
Limestone, finely cryst. to dense, alternating dark and light gray and weathers to zone of dark and light bands. This is "zebra unit"	437	4256

Lithic Description	Thick	Total
Devonian, Ramparts, may include "zebra unit"		
Limestone, gray cryst. spar calcite, partly covered, recessive areas.	291	4547
Limestone, gray cryst. sparry calcite, irregular bedded, reefoid, corals, covered in upper part.	485	5032
Shale, dark gray to black with interbeds of dark gray limestone, recessive unit forms topog. low and is mostly covered.	873	5905
Limestone, dark gray, nodular bedded, cryst., gray weathering, partly covered, some talus, some grass.	388	6293
Limestone, dark gray, nodular bedded, rubbly weathering, thin irregular shale breaks, beds are dipping 80°N, abundant fossils, corals, brachiopods, crinoids, gastropods. This unit forms the upper part of the Ramparts formation. In measuring this last unit it was necessary to cross a steep gorge so the measurement may be slightly in error. The gorge may represent a shale or shaly unit that was minimized in thickness in the measurement.	130	6423

Base of Fort Creek formation.

Contact on line of section not exposed but abundant black non-calcareous shale plates indicates its presence and approximate contact was well established.

STRATIGRAPHIC SECTION MW-2

Location: On a creek from a point two miles east of longitude 133° 15' W. on latitude 65° 30' N. to its confluence with a large tributary of the Snake River. Start of section was up creek along south side of north-east-trending ridge and then up a small tributary which enters from the south, until lowest exposed part of buff weathering unit was reached.

Date: July 10, 1959.

Weathers: clear, warm, cool breeze.

Lithic Description	Thick (feet)	Total
Bottom		
Devonian, buff-weathering unit.		
Limestone, gray to light gray, hard, finely cryst., med. bedded, contains some dark gray beds and some dolomitic units but entire unit weathers buff.	315	315
Limestone, buff to creamy, alternate cryst. and finely cryst. to dense, weathers buff.	105	420
Limestone, gray to brownish gray, hard, brittle, dense to sublith. in places, thick bedded to massive, rubbly buff weathering; reefoid in places along strike in upper part.	75	495
Limestone, dolomitic, gray to buff, hard, finely cryst. to dense, massive bedded with rubbly weathering - very irregular and angular break, prominent bedding planes at about 5 to 6 feet intervals.	110	605
Limestone, dolomite, gray to buff, with alternating beds of dark gray finely cryst. dolomite, thin to thick bedded, buff weathering.	105	710

Lithic Description	Thick	Total
Limestone, dolomitic, light gray to buff, massive bedded, rubbly to angular fracture. Prominent bedding planes at 2 to 4 feet intervals, the entire unit between these planes is a broken rubbly mass of angular fragments with fracture planes in all directions. Buff weathering.	80	790
Limestone, light gray to gray, finely cryst. to dense, well bedded, med. to thick 6 inches to 2 feet rubbly weathered surface buff in color. Abundant pyrite at 850 to 860 gives rusty zone or weathering.	140	930
Limestone, gray to dark gray, finely cryst. to dense, thick bedded, buff to light gray weathering.	180	1110
Limestone, gray to creamy, finely cryst., massive, rubbly angular weathering, some 6 to 12 inch beds interspersed among massive beds. Reefoid structures with minor reef breccia, algal structures on upper surface of massive beds.	19	1129
Limestone breccia - above a prominent bedding plane, local truncation of beds but breccia not continuous laterally.	1	1130
Limestone, dark gray, cryst., med. bedded brachiopods and corals at 1175 feet, sparry calcite, massive bedded in zones where bioherms occur, these weather rubbly.	190	1320
Limestone, dark gray, to black, finely cryst. to dense, sparry calcite, interbedded med. to thick and thin platy beds, platy units 4 to 6 in. thick become more abundant upward, become almost shale breaks. Linguiform braciopods and tentaculites at 1460.	270	1590

Lithic Description	Thick	Total
Fault zone - repeat of upper part of buff weathering zone. Thickness repeated is 505 feet.		
Limestone, dark gray, finely cryst., sparry calcite, thick bedded to massive, rubbly weathering, beds are vertical.	465	2055
Limestone, dolomitic, mottled gray and white, hard, coarse cryst., massive beds forms entire unit.	10	2065
Limestone, black, fine cryst. to dense, thin bedded, calcite veining, numerous platy breaks, beds vertical.	260	2325
Limestone, dark gray to black, fine cryst., disturbed zone, possible repeat of some 20 feet of section.	40	2365
Limestone, black, thin bedded to massive, highly fractured in massive beds.	34	2399
Shale, calcareous, platy, black, some thin shaly limestone beds in unit.	10	2409
Limestone, black, shaly, platy, breaks between thick beds.	31	2440
Shale, black, platy, calcareous, some very limy beds in places.	37	2477
Limestone, black shaly, thin bedded to platy.	23	2500
Shale, black, calcareous some thin limy beds, fossils, crinoids, brachiopods.	71	2571
Limestone, black, sparry calcite, shale breaks, fossils, pyrite.	29	2600
Shale, black, calcareous, minor limestone, mostly covered. (Moved line of section to large tributary creek)	135	2735

Lithic Description	Thick	Total
Shale, black, calcareous, well bedded to platy.	514	3249
Limestone, gray, cryst., med. to thick bedded, shaly interbeds, beds are vertical and form "gates", see Plate 3A. This unit is top of section.	750	3999

Fort Creek formation.

STRATIGRAPHIC SECTION MW-3

Location: Up onto highest ridge of mountain located approximately 2 miles east and 3 miles south of latitude 65° 30' N. and longitude 133° W.

Date: July 17, 1959.

Weather: clear, windy, scattered clouds.

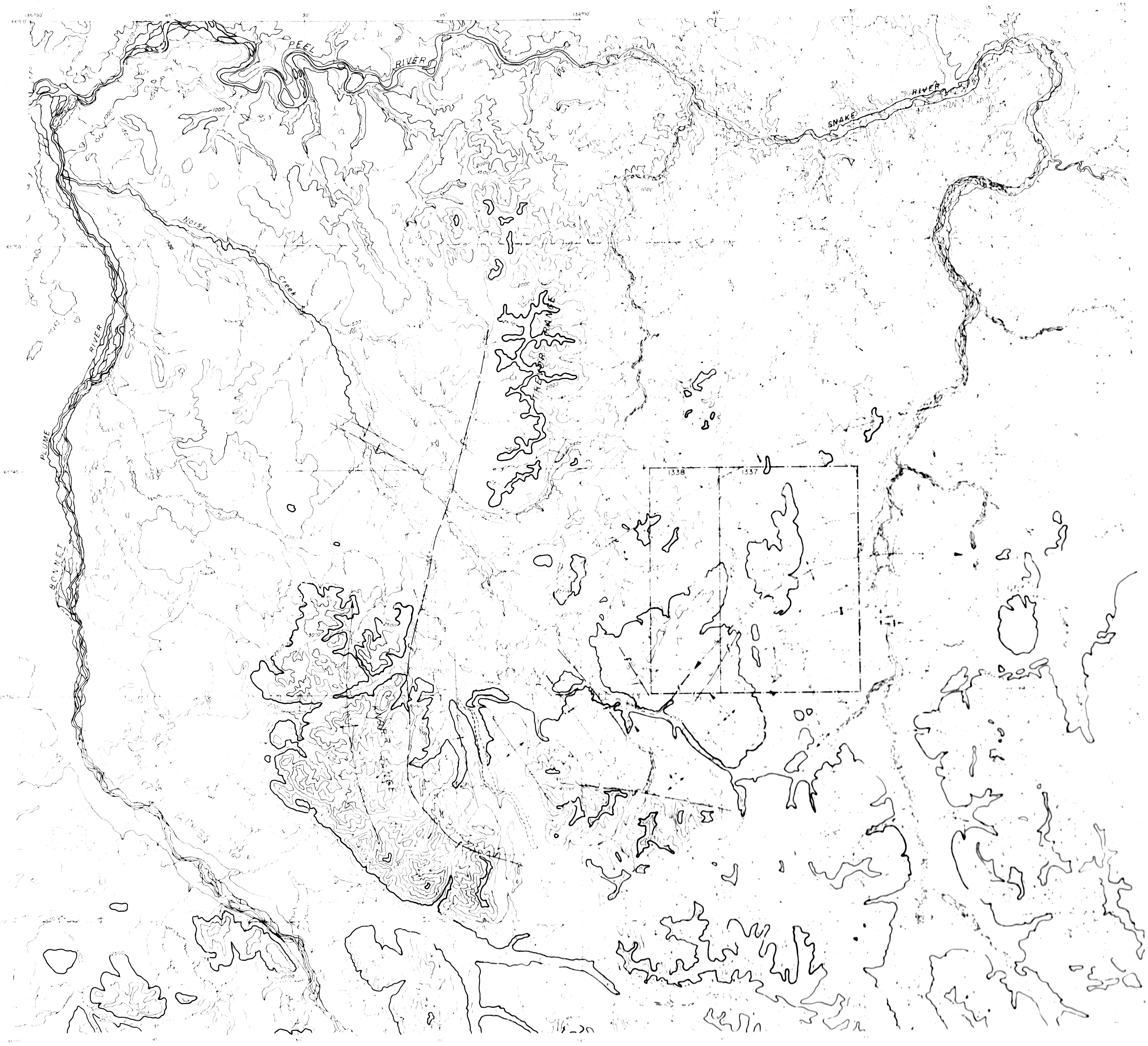
Measurement began at base of a quartzite that overlies a thick sequence of red and gray phyllitic shale which in turn overlies a lower and thicker quartzite.

Lithic Description	Thick (feet)	Total
Bottom		
Upper Cambrian quartzite.		
Quartzite, white to pink, lichen covered surface is black to green, appears dark from a distance.	78	78
Ordovician		
Dolomite, silty to sandy, buff, inter-layers of well cemented sandstone, irregular layers of silicified organic material, grades to coarse dolomite.	12	90
Dolomite, buff, coarse, cryst., silicified organic debris.	58	148
Dolomite, gray, cryst., hard, interbedded buff units, platy to nodular bedding at 280', psuedo-breccia at 320.	132	380
Dolomite, buff, silty, buff weathering, hard.	10	390
Dolomite, gray, cryst., hard, med. to thick bedded, silicified fossil layer in lower 15' this layer is quite vugular and overlying dolomite contains brachiopods.	90	480

Lithic Description	Thick	Total
Shale, calcareous, brown, platy.	5	485
Dolomite, brownish gray, cryst., med. bedded, abundant brachiopods in places, platy at 525'.	45	530
Limestone, gray, thin bedded, buff to orange cherty organic material, grades to dark gray dense ls. which contains a 2' bed of coarse cryst. ls. with fossil fragments, the upper part is dark gray and platy following the bioclastic unit.	90	620
Limestone, dark gray, weathers in bands of gray and brownish gray, fine cryst.	30	650
Limestone, dark gray, fine cryst.,platy.	5	655
Limestone, buff, laminated, bright buff weathering, platy.	25	680
Limestone, gray, dense, platy to thin bedded, weathers gray.	25	705
Covered area.	200	905
Limestone, dark gray, finely cryst. to dense, platy, calcite stringers.	215	1120
Limestone, black, dense, massive with incipient bedding, yields rubbly fractured and weathered surface. Unit becomes thin bedded to platy upwards.	260	1380
Dolomite, buff with gray mottling, cryst., thin nodular bedding, light gray weathering.	15	1395
Dolomite, gray to buff, cryst., thin to thick bedding, irregular bedding planes, silicified algae and other poorly preserved fossils, minor limonite.	72	1467

Lithic Description	Thick	Total
Dolomite, brecciated with calcite veins, dark gray, gray weathering with some weather banding.	33	1500
Dolomite, gray, cryst., light gray weathering, some calcite veining, large calcite crystals at 1535', at 1575' fragments of dolomite are cemented in sparry calcite and rock appears brecciated on weathered surface. Upper 20' massive dolomite with abundant sparry calcite throughout, reefoid.	120	1620
Dolomite, gray, cryst., light gray weathering, hard. At 1725' massive cliff-forming reefal unit begins.	220	1840
Dolomite, buff to brownish gray, coarse cryst., saccharoidal, gray weathering.	105	1945
Dolomite, dark gray, coarse cryst., abundant chert in lenses and nodules.	70	2015
Chert and dolomite zone - silicified fossil remains - Beatricea sp., Calapoecia anticostiensis (Billings) Probably Upper Ordovician.	25	2040
Dolomite, dark gray, coarse cryst., thick bedded, dark gray weathering, chert and corals.	40	2080
Dolomite, dark gray, cryst., dusky gray weathering, nodular bedding, chert and corals. Probable top of Ordovician.	95	2175
Silurian ?		
Dolomite, alternate light and dark banded zone, nodular beds with fine weathering laminae at 2255', poorly preserved fossils in a dark zone at 2305".	290	2465

Lithic Description	Thick.	Total
Dolomite, buff to gray, coarse cryst., reefoid with reef breccia.	15	2480
Dolomite, dark gray, cryst., very fossiliferous - corals, algae, Silurian ? Reefal.	60	2540
Dolomite, gray, cryst., well bedded med. light gray weathering, hard compact. Alternate dark and light banding - dark zones vugular and weathers pitted and rough, the light zones are smooth weathering. A 2' conglomerate fissure filling perpendicular to bedding at 2555'.	44	2584
Dolomite, gray, cryst. to coarse cryst. reefoid, sparry calcite, organic detritus silicified, resistant weathering.	22	2606
Dolomite, dark gray, rock is composed almost entirely of silicified corals and algae, bed is biostromal.	12	2618
Dolomite, dark gray, crystalline, with sparry calcite, light gray weathering, minor silicifications.	37	2655
Dolomite, dark gray, cryst., silicified corals and algae abundant, bed weathers dark due to chert and silicification.	5	2660
Dolomite, gray to buff, finely cryst., grades upward into buff weathering unit of Devonian. Upper part of unit has splotches of rusty and buff weathering. Contorted zone in lower part of overlying buff unit so further measurements unreliable.	10	2670



TERTIARY
T — Sandstone, shale, coal

CRETACEOUS
Ku — Upper sandstone unit
Km — Middle shale unit
Kl — Lower sandstone and shale unit
Kbs — Basal sandstone of lower unit

PENNSYLVANIAN
P — Sandstone

UPPER DEVONIAN
Di — Imperial sandstone
Dfc — Fort Creek shale

MIDDLE DEVONIAN
Dm — Middle Devonian, undivided

ORDOVICIAN - SILURIAN
O-S — Ordovician - Silurian, undivided

CAMBRIAN
€ — Cambrian, undivided

GEOLOGICAL MAP

PERMITS 1337 & 1338

PEEL PLATEAU AREA, YUKON TERRITORY

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