No. 29

29

FINAL

GEOLOGICAL REPORT

on

THE MOUNTAIN RIVER AREA

N.W.T.(Canada)

IMPERIAL OIL LIMITED - CANOL PROJECT

ASSIGNMENT No. 19.

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TABLE OF CONTENTS

Abstract

		Page
Chapter I	INTRODUCTION AND INDEX MAP	1
Chapter II	TOPOGRAPHY	4
Chapter III	STRATIGRAPHY	8
Chapter IV	STRUCTURAL GEOLOGY	18
Chapter V	HISTORICAL GEOLOGY	26
Chapter VI	OIL AND GAS MANIFESTATIONS AND MINERAL DEPOSITS	26
Chapter VII	CONCLUSIONS AND RECOMMENDATIONS.	27

BIBLIOGRAPHY

PHOTOGRAPHIC ILLUSTRATIONS

LIST OF SPECIMENS Appendix.

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LIST OF PLATES (in folder)

Plate I	-	Areal Geological Map Scale 1 inch - 1 mile.
Plate II	-	Cross Section A, B, C, D, E, North Flank of the Imperial Range to the Whirlpool Anticline. Scale 4 inches - 1 mile.
Plate III	-	Cross Section X - Y, South Flank of the Imperial Range. Scale 8 inches - 1 mile.
Plate IV	-	Cross Sections W - W' and H - H', Whirlpool Anticline. Scale 8 inches - 1 mile.
Plate V	-	Correlation Chart. Scale of Columnar Sections: 1 inch - 200'
Plate VI	-	Detail Geologic Map of the Mountain and Gayna River Gorges. Scale 1 inch - Approx. 2000'.
Plate VII	-	Columnar Section of the North Flank of the Imperial Range. Scale 1 inch - 100'.

LIST OF PHOTOGRAPHS

Photo No. 1.	Aerial view of Mountain River south of Mackenzie Mountain front.
Photo No. 2.	Aerial view of Mountain River and gorge through Mount Ronning dolomite.
Photo No. 3.	Aerial view of Mountain River gorge through the Imperial Mountain Range.
Photo No. 4.	Aerial view of the Mountain River gorge and the crest of the Imperial Mountain Range.

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A B S T R A C T

Cambrian (?), Ordovician (?), Silurian, Devonian and Cretaceous rocks are present in the Mountain River area. From south to north in this region there are six east-west trending structural units: the Mackenzie Mountains, the Imperial Syncline, the Imperial Anticlinorium, the Whirlpool Syncline, the Whirlpool Anticline and the Sans Sault Syncline.

Two different sequences of source, reservoir and cap rocks, occur in the Devonian strata. Both of these sequences occur at depth in the Whirlpool structure, which is about twenty miles southeast of the mouth of the Mountain River. The Whirlpool Anticline is believed to be a good prospect and it is recommended that a wildcat be drilled on this anticline.

Chapter I.

I N T R O D U C T I O N

The Mountain River is a swift, braided stream that rises in the Mackenzie Mountains and flows northward to join the Mackenzie River opposite East Mountain. The mouth of the Mountain River is about seventy miles down the Mackenzie from Norman Wells. The river carries a volume of water probably slightly greater than that of the Carcajou River. The area covered by this report lies between north latitudes 65° 00' and 65° 45', and west longitudes 128° 00' and 129° 20' (see Index Map, and Plate I). No previous exploration of any kind had been done on the Mountain River. Link (3) made a reconnaissance survey of the adjacent Carcajou River in 1920, and outlined the general stratigraphy and structure of that area. Adjacent areas, which were covered by Canol Project geologists during the summer of 1943, are: the Imperial River area to the east by Laudon (2), and also by Mauss and the writer (7), the Hume River area to the west by Noon (6), the lower Carcajou River area by Bath (1), and the Carcajou Ridge-East Mountain area by the writer (8).

Party 'D' of the Imperial Oil Limited, Canol Project, geological staff was assigned to the Mountain River area (Assignment No. 19) with instructions to map the geology of the area and to examine in detail a structure in the lower part of the river. This structure had been located by Dr. T. A. Link while making an aerial reconnaissance. Party 'D' consisted of Murray Hanna and the writer.

The party left Norman Wells on August 21st, 1943, in a Norseman airplane and landed on Lake Florence. (See areal map, Plate I). The men travelled in two sixteen foot canoes down "Virgin Creek" to the

Mountain River, and then down the Mountain River. They were picked up by a Norseman airplane at the mouth of the Mountain River on September the 18th and returned to Norman Wells.

The upper part of Virgin Creek is very swift, and consists of a succession of rapids. It was necessary to line the canoes down several of the worst stretches. Virgin Creek rose three feet in a few hours after one heavy rain, which prohibited travel until the water receded. After reaching the mouth of Virgin Creek, the men planned to measure and describe the excellent section exposed in the Mackenzie Mountain front on the west side of the Mountain River valley, but this was not done because a three day rain, accompanied by a ten-foot rise in the Mountain River, made it impossible to cross the river.

The Mountain River was in a high water stage throughout the time the men were travelling down it. It is an extremely fast river with a steep gradient, and canoeing is made difficult by numerous rapids, whirlpools, sharp corners and sweepers.

Field Procedure

U.S.A.A.F. Mountain River vertical aerial photographs, Roll 314, V107-146, were used in the field. Stations were located on the photographs by stereoscopic inspection in the field. A plane table traverse was made in the Imperial Range gorge to measure the section exposed there and to obtain scale control for the aerial photographs. Nine fossil suites were collected during the trip. No preliminary report has been written for this survey.

Accessibility (See Areal Map, Plate I)

The Mountain River, Gayna River, and Virgin Creek can all be descended with difficulty by canoe in the summer. In the winter,

the part of the area north of the Imperial Range could be reached by muskeg schooner. Crossing the Imperial Range with a muskeg schooner would be very difficult, if not impossible. In the area there are several lakes suitable for pontoon planes to land on, and the mouth of the Mountain River can be reached by Mackenzie River boats.

Chapter II.

TOPOGRAPHY

The land form is essentially controlled by the rock structure, and glacial erosion did not greatly modify the major features of the country. The area can be divided into four natural topographic units: (1) the Mackenzie Mountains, (2) the structural basin between the Mackenzies and the Imperial Mountain Range, (3) the Imperial Range, (4) the low relief country between the Imperial Range and the Mackenzie River. The last mentioned area consists of two structural basins separated by the "Whirlpool Anticline", which has relatively slight topographic expression.

All except the highest parts of the Mackenzie Mountains have been sculptured by glacial action, probably of both the continental and mountain types. The mountains are now in a stage of late youth with not quite complete drainage development. The tops of some of the higher peaks are flat, indicating the earlier existence of a planed surface. The elevation of the highest peak at the Mackenzie Mountain front, "Mount Dirndl", was calculated to be 4360 feet above sea level. This figure was obtained by finding the elevation of the peak above the Mountain River from parallax measurements on the photographs, and from figuring the elevation of the river about sea level by gradient calculations. The highest peak in the Imperial Range close to the Mountain River was estimated to be 1670 feet above sea level, using the method described above. The highest part of the whole Imperial range, and also the highest peak, is about ten miles east of the Mountain River Gorge. The top of the Imperial Range was not high enough to escape being trenched and planed by the glacier. In the

vicinity of the Mountain River, the Imperial Range is an anticlinorium, topographically expressed as a gently undulating area of low-relief in the axial region with one or more steep dip-slope ridges rising on both flanks. The relatively flat axial area is slightly higher, (usually not more than a hundred feet) than the flat areas on the outside of the flanks of the structure.

The structural basin areas are flat, and are covered with fluvio-glacial sands, silts and clays. Drainage development is in the stage of very early youth, except close to the Mountain River and its major tributaries where considerable stream dissection has occurred. On the west side of the river opposite photograph center 117, there are two small hillocks which are assumed to be glacial stream deposits. On the south flank of the Whirlpool Anticline there is a covering of fifty to one hundred feet of fluvio-glacial coarse sand and cobbles. In the lower ten miles of the river, similar gravel and cobble deposits are exposed in the banks.

The Mountain River is a braided stream throughout with no meander development. The larger tributaries are likewise braided, except for the lower portion of Virgin Creek, which meanders through a large Recent or Pleistocene (?) delta. The largest tributary of the Mountain River is the Gayna River, which joins the Mountain River in the Imperial Range. Both the Mountain and Gayna Rivers have cut gorges varying from seven to nine hundred feet deep through the Imperial Range. The Gayna River rises in the Mackenzie Mountains adjacent to the Hume River and probably drains a larger area in the mountains than does the Hume.

The floodplain of the Mountain River varies from one to two miles in width, except in the Imperial Mountain gorge, and the gorge at the front of the Mackenzie Mountains, where there is no floodplain.

In the Mackenzie Mountains the river has well developed terraces.

Virgin Creek flows in the bottom of a deep trench, parallel to the mountain front and the strike of the rocks. This trench extends without a break from the Katherine River to the Mountain River, and its origin is due to differential erosion on the flank of an anticline. The softer Fort Creek shales were removed from between the harder Beavertail limestones and the Norman sandstones. The trench is possibly the valley of a pre-glacial river which was diverted during the glacial period. Another interpretation is that the trench is simply a glacial groove on a grand scale.

The braided portion of Virgin Creek, extending for five miles southwest of Lake Doris, has a gradient of about fifty feet to the mile. The meandering stretch from the end of the braided part to the mouth has a gradient of about two feet to the mile. From the Mackenzie Mountain front to the gorge through the Imperial Range, the Mountain River has a gradient of about twenty-five feet to the mile, and from the gorge to the river's junction with the Mackenzie it has an average gradient of eleven feet to the mile. Because of the high velocity and steep gradient, pebbles, cobbles, and small boulders can be heard rolling on the bottom of the Mountain River when in flood. The elevation of the mouth of the Mountain River was assumed to be 230 feet above sea level. The water level of Lake Florence, calculated from barometer readings taken in the airplane, is 1165 feet above sea level.

The Mackenzie Mountains have a typical alpine flora, and timberline is about 2500 feet above sea level. The rest of the area is classified as sub-arctic, black spruce climax, forest country. Considerable parts of the area have been burned.

Near the mouth of the Gayna River, there is a seventeen foot cutbank of relatively undisturbed Fort Creek shales resting on lower Ramparts limestones. The writer believes the glacier transported this mass of Fort Creek shales to its present position from the top of the scarp which rises to the north of the Gayna River. There is a large crater-shaped depression on the top of the scarp where it is thought the transported shales had their original position. To accomplish this movement, the ice must have moved from the northwest to the southeast although in this part of the Mackenzie Basin, the main movement of the ice is thought to have been from the east to the west. Two large glacial grooves, 150 feet deep, whose trend is northwest-southeast, are located one-half mile south of this transported Fort Creek outcrop, and these grooves indicate that, in this locality, there was ice movement from the northwest to the southeast. Further discussion of this glacial phenomenon is included in the chapter on structural geology. There is a big limestone boulder dump across the Mountain River from the transported Fort Creek beds. It is believed that this boulder pile is too large to be talus from the cliff above the dump, and this deposit is also thought to have been made by the glacier. The source of the boulders was the limestone ridge northeast of the dump.

Chapter III.

S T R A T I G R A P H Y

General

Cambrian (?), Ordovician (?), Silurian, Devonian, and Cretaceous rocks are exposed in the area. Excellent sections are exposed in the Mackenzie Mountain front and in the gorges of the Mountain and Gayna Rivers through the Imperial Range. There is a notable difference between the Devonian sections in the Imperial Range and the Mackenzie Mountains as shown in the correlation chart, Plate V.

In general, the section exposed at the Mackenzie Mountain front in this area is similar to the mountain front section described by Laudon (2) in the Imperial River area. "Zed" Canyon was ascended about three miles and a trip was made to the upper end of the Mountain River gorge at the Mackenzie Mountain front, but no detailed measurements or descriptions were made of the sections exposed in those localities.

The fossils collected during the survey were identified at Norman Wells by Mr. C. R. Stelck.

The rocks exposed between the Imperial Range and the Whirlpool Anticline were studied in detail. These beds are described in the discussion of formations, and the thickness of the formations are shown in the following table:

(Table on following page)

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Section Exposed between the Imperial Range and the Whirlpool Anticline, Mountain River.
(See Plates II and VII)

Age	Formation or Member	Symbol	Thickness in feet
Quaternary	Sands, silts and clays		0 - 150
Unconformity			
	"Link" sandstone and shale	Kl	335
Cretaceous	"Sperry" shale	Ksp	2150
	"Sans Sault" sandstone and shale.	Kss	1410
Unconformity			
	Norman sandstone and shale	Dn	1200
Upper Devonian	Upper Fort Creek shale	Dfc	90
	Reef limestone	Dbt	380
	Lower Fort Creek limestone		10
	Beavertail limestone		60
	Upper Ramparts limestone	Dr	100
Middle	Middle Ramparts shale		700
Devonian	Lower Ramparts limestone		446
	Bear Rock limestone and dolomite	Dbr	200

In mapping formation boundaries and in the construction of cross-sections, it is not practicable to separate the Beavertail, Lower Fort Creek, and Reef limestone units, therefore they are all shown by one symbol, "Dbt". The three members of the Ramparts formation are easily seperable, but because of the scale of the areal map they are mapped with one symbol "Dr".

Detailed Discussion of Formations

The definitions and type localities of the stratigraphic names used in this discussion are given in the writer's report on the Carapjou Ridge - East Mountain Area (8). The origins of these beds are also discussed in the above mentioned report. The following descriptions and measurements refer only to the section between the Imperial Range and the Whirlpool Anticline, and diagrams of this section are shown on Plates II and VII. The middle and upper Devonian beds were measured by a plane-table traverse across them, and accurate strike and dip control was obtained. Fairly accurate strike and dip control was obtained in the Cretaceous section and stratigraphic intervals were computed from measurements made on the aerial photographs.

Middle Devonian (?)

Bear Rock Formation

Bear Rock beds are exposed in the tightly compressed center of the Imperial Range. In the Mountain River Gorge through the range, warm sulphur springs issue from the Bear Rock dolomites, and have built up deposits of tufa on both sides of the river. The lowest Bear Rock beds exposed have sufficient porosity and permeability to act as an oil reservoir rock. The brecciated Bear Rock beds, which occur in other localities, are believed to be the equivalent of the basal bed in this section or to lower beds which are not exposed here. Section from top to bottom: (base of formation not exposed)

Dolomite (?) -	grey-brown, well-bedded, coarse grained, banded, sugary appearance on fresh fracture, feels sandy, beds 1 - 2' thick - - - - - - - -	150 feet
Dolomite (?) -	similar to above unit, but no bedding is discernable; outcrop mostly covered with tufa from warm sulphur springs which issue from the top of this unit - - - - - - - - - -	50 feet
	TOTAL:	200 feet

Long Reach Group:

Ramparts Formation

Lower Ramparts Limestone Member

This member consists of two massive limestone units separated by rubbly, shaly and platy corraline limestones. It is considered to be a good oil source rock because of the black, petroliferous nature of the limestones.

The following fossils were collected from this member:

Suite 8551

Cyathophyllum sp.	Pugnoides sp.
Paracyclas sp.	Cladopora sp.
Gastropod	Acervularia sp.
Atrypa reticularis	Martinia sp.
Productella sp.	Euomphalus sp.
Cystiphyllum sp.	Zaphrentis sp.
Atrypa spinosa	Favosites sp.
Pugnax sp.	Paleocyclas sp.
	Prismatophyllum sp.

Total thickness of member - - - - - - - - - - - - - - - - - - - 445 feet

Middle Ramparts Shale Member

This unit is composed of grey to grey-green shales and limy shales. There are many thin (0.3' ±) limestone beds in the lower part of this unit. The shales weather grey to buff-green and buff. Many of the thin limestones in the lower 100 feet of this unit are coquinoid, and the fossils listed below were all collected in the basal fifty feet of the member.

Suite 8552

Atrypa (bizarre gigantic form)	Favosites sp.
Reticularia sp.	Crinoid stems
Productella sp.	Paleocyclas sp.
Proetus sp.	Schuchertella sp.
Zaphrentis sp.	Heliophyllum sp.
Cladopora sp.	Prismatophyllum sp.
Atrypa spinosa	Pachyphyllum sp.
Cystiphyllum sp.	Euomphalus sp.
Acervularia sp. (two types)	
Syringopora sp. (two types)	

Total thickness of member - - - - - - - - - - - - - - - 700 feet.

Upper Ramparts Limestone Member

This member is composed of dark grey limestones and black earthy shales. It contains many large Stromatoporoids and many Cladopora dentata.

Total thickness of member - - - - - - - - - - - - - - - 100 feet.

Beavertail Formation

This formation is composed of massive, buff-weathering, grey limestones that contain many Cladopora roemeri. In this area the Beavertail is classified as a fair to poor oil reservoir bed because it is not very porous.

Total thickness - 80 feet.

Carcajou Group:

Fort Creek Formation

Lower Fort Creek Limestone Member

This unit is composed of dark grey to black, slaty, fine-

grained, 0.2 foot to 2.0 foot limestone beds, separated by black shale partings. The limestones contain fragments of a brachiopod which might be Hypothyridina sp.

Total thickness of member - - - - - - - - - - - - - - - - 10 feet

Reef Limestone Member

This member consists of massive, buff-weathering, grey limestones that contain innumerable Cladopora meeneri corallites. The limestone is bituminous, especially in the upper fifty feet. Near Conglomerate Creek (see cross section X-Y) this member is about 585 feet thick. This reef unit varies in porosity and permeability, but in general, it is considered to be a fair to good oil reservoir rock.

Total thickness of member - - - - - - - - - - - - - - - - 380 feet.

Upper Fort Creek Shale Member

This member consists of black platy shales inter-bedded with dark grey, shaly limestones. It contains several bands of black limy shales that are almost coquinas of Hypothyridina. These beds are all very petroliferous, and the member is considered to be a good oil source rock. The following fossils were collected from these beds:

Suite 8550	Suite 8553
Hypothyridina sp. (3 varieties)	Hypothyridina castanea
Atrypa sp.	Leiorhynchus (?)
	Cystiphyllum (?)

Total thickness of member - - - - - - - - - - - - - - - - 90 feet.

Norman Formation

In this area, the Norman formation is divided into four members on a lithologic basis. These members are not correlative with lithologic units that have the same names in the Long Beach

area of the Whirlpool Nive-. For example, Link's (3) Lower Norman Sandstone is believed to occur at an entirely different horizon than the Lower Norman Sandstone in this area.

"Lower Norman Shale Member"

This member consists of slightly sandy, dark-grey shales that contain a few shaly sandstones and sandstones.

Total thickness of member - - - - - - - - - - - - - - - - 80 feet.

"Lower Norman Sandstone Member"

This member consists of a cyclical series of lensing sandstones, shaly sandstones and sandy shales. There is an intraformational, edgewise, limestone conglomerate at the base of this member. Two suites were collected from these beds.

Suite 8554

Atrypa reticularis

Suite 8555

Atrypa reticularis

Crinoid stems

Total thickness of member - - - - - - - - - - - - - - - - 630 feet

"Upper Norman Sandstone Member"

This member consists of massive, brown-weathering, limy sandstones that contain abundant Cyrtospirifers. Some of the sandstones in the member are shaly. Suite 8556 was collected from these beds.

Suite 8556

Cyrtospirifer sp.

Spathyridina sp.

Pelecypod

Cyrtospirifer (whitneyi type)

Productella sp.

Camarotoechia sp.

Actinopteria sp.

The upper 100 feet of this member are exposed at the Whirlpool Anticline. Suite 8557 was collected from the sandstone in that locality.

Suite 8557

Cyrtospirifer sp.

Atrypa reticularis

Phillipsastrea sp.

Total thickness of member - - - - - - - - - - - - - - - - 295 feet.

"Upper Norman Shale Member"

This member consists of black shale which grades downward into a shaly sandstone in the basal 35 feet. On the north limb of the Imperial Range this member is 195 feet thick while only fifteen feet of this member are present in the Whirlpool Anticline area where the upper part has been removed by pre-Cretaceous erosion.

Total thickness of member - - - - - - - - - - - - - - - - 195 feet.

Lower Cretaceous

"Sans Sault Formation"

The Sans Sault formation consists of a thick shale and sandy shale series with sandstone units at the base and top of the formation. The basal sandstone is about fifteen feet thick and is composed of white, very pure, medium-sized quartz grains. The unit has a few conglomerate stringers and the sandstone is sometimes streaked with yellow and grey stains. On the south side of the Imperial Range in the Conglomerate Creek area, the conglomeratic stringers in this basal sandstone are replaced by a pebble conglomerate that is one to two feet thick. The maximum diameter of the pebbles is about one-quarter inch.

The middle shale phase of the formation is 820 feet thick. The shales are dark grey to black and contain a few thin silty and sandy laminae, and some thin limestone concretionary bands.

The upper sand series consists of two fine to coarse grained and shaly sandstone units containing ironstone concretions. These two units are separated by 465' of shale and sandy shale.

No fossils were collected from this formation on the Mountain River, but collections made at the Sans Sault Rapids and on the Imperial River contain a lower Cretaceous fauna. The basal sandstone is considered to be a good oil reservoir rock.

Total thickness of formation - - - - - - - - - - - - - - 1410 feet.

Cretaceous

"Sperry Formation" (new name)

This formation consists of a thick series of dark grey to black shales that contain a few thin ironstone concretion bands and a few thin beds of siltstone and sandstone. No fossils were collected from this formation.

The type section of this formation is on the Mountain River in the area adjacent to Sperry Creek. The base of the formation is defined as the top of the Upper Sans Sault sandstones, and the top of the formation is defined as the base of the lowest sandstone in the "Link formation". This unit is a good oil cap rock.

Total thickness of the formation - - - - - - - - - - - - 2150 feet.

Cretaceous

"Link Formation"

This formation consists of fine to coarse-grained sandstones interbedded with dark grey to black shales. The type section is described in the Imperial River area report (7) by Mauss. Only 335 feet of this unit is exposed in the Mountain River area. No fossils were collected from these beds in the vicinity of the Mountain River.

Partial thickness, top not exposed - - - - - - - - - - - 335 feet.

Quaternary

Pleistocene and recent fluvio-glacial gravels, sands, silts and clays cover most of the area. The maximum thickness of these deposits was estimated to be 150 feet, but over most of the region their thickness is less than fifty feet.

Correlation with Adjacent Areas

Plate V is a correlation chart showing the relationship of the Mountain River section to sections measured in the Imperial River area and in the East Mountain-Sans Sault area.

On Plate V the section, taken from Laudon's report (2), is a composite section. His measurements of the Bear Rock, Ramparts, and Beaverteil formations were made at the Mackenzie Mountain front. The thicknesses Laudon gives for the Port Creek, Norman, Bosworth and Cretaceous beds are figures derived from measurements made on both limbs of the Imperial Syncline, in the Imperial River area.

Chapter IV.

S T R U C T U R A L G E O L O G Y

General

The regional structure of this area and a general theory outlining the possible origin of the separate structures are discussed in the Carcajou Ridge- East Mountain Report (8). It is also mentioned in that report that, although East and West Mountains are terminating mountains in a southeast-northwest Mountain chain that bends to the west at Carcajou Ridge, those two mountains are not the western terminus of the structural chain. There are anticlines of lower structural relief in a continuation of this chain to the west.

The anticlines now known to exist in this chain, beginning with East Mountain and going west are: East Mountain, West Mountain, the Whirlpool Anticline, the Hume River Arch, the Ramparts River Arch and the Arctic Red River Arch. These are separate anticlines, in an arcuate trend. The Whirlpool Anticline is at the southernmost part of this arc. East and West Mountains are northeast of the Whirlpool Anticline while the Hume River, Ramparts River and Arctic Red River Arches are northwest of the Whirlpool structure. The Hume River structure was mapped by Moon (6), and the Ramparts River and Arctic Red River structures were mapped by McKinnon (5), (4).

The oldest beds exposed close to the Mountain River in the Whirlpool Anticline are upper Norman sandstones, and the oldest beds exposed in the Hume River, Ramparts River and Arctic Red River structures are Cretaceous. As the only commercial oil-producing horizon known at present in the lower Mackenzie basin is of lower Upper Devonian age, (the Kee Scarp reef limestone), and since the equivalent beds and other promising reservoir beds occur at depth in

the above mentioned low relief anticlines, those anticlines are important as possible structural traps.

The following major structural features are present in this report area from south to north; the Mackenzie Mountains, the Imperial Syncline, the Imperial Anticlinorium, the Whirlpool Syncline, the Whirlpool Anticline, and the Sans Sault Syncline. These are discussed in detail in this chapter and their location is shown on the areal map, Plate I.

Detailed Discussion of Structures

Mackenzie Mountains (See Plate I)

The trend of the Mackenzie Mountain front from the Katherine River to a few miles west of the Mountain River is northwest-southeast. West of the Mountain River, the front has an east-west trend. Structurally, at least the northernmost fifty miles of the mountains are made of relatively gently folded symmetrical anticlines and synclines, whose axes are parallel to the mountain front. The distance between anticlinal axes is usually about ten miles.

From Mount MacDougal, in the upper Carcajou River area, to several miles beyond the Mountain River the front escarpment of the Mackenzies consists of the north flank of one continuous anticline, the MacDougal Anticline. The dip of the beds in this front escarpment from Mount MacDougal to Lake Florence is about thirty degrees.

From Lake Florence westward, the dip steepens in this north flank of the anticline and the beds are nearly vertical where the Mountain River cuts through them. A high angle reverse fault that dips to the south is present just north of Birrell Mountain on the north flank of the MacDougal Anticline. Vertical displacement along this fault is probably not more than a hundred feet.

Imperial Syncline

The Imperial Syncline extends from the Grafe River locality (See report by Nauss (7)) to the upper Gayna River area, a distance of about seventy miles. It is bounded on the south by the Mackenzie Mountains and on the north by the Imperial Range.

In the Mountain River area, the syncline is ten to twelve miles wide. Small undulations are present in the central part of the syncline where the Mountain River cuts through it. The axes of these small structures are shown on Plate I. The maximum vertical relief along the river bank of these small structures is about fifty feet, and the dips along the river bank are all very low. The extent and form of these structures is not known.

Imperial Anticlinorium

This structure forms an east-west mountain range about seventy miles long and three to ten miles wide. Fifteen miles due south of the mouth of the Mountain River the range has its maximum relief where it is approximately 2350 above sea level. Both ends of the structure consist of low ridges, some of which curve toward the Mackenzie Mountains forming the ends of the Imperial Syncline.

The anticlines which make up this anticlinorium are in general not more than a few miles long, and their axes are more or less parallel. Small faults of various kinds are common. Using aerial photographs, observations made from an airplane, and from field work done by the Canol Project geologists, the following is known concerning the whole Imperial Range:

(1) From its east end to Rainbow Arch, it consists of several folds of low relief.

(2) From the Rainbow Arch area to about ten miles west of there, the range is broader. The folds are tighter, have more relief, and the beds in the north flank of the northernmost fold are nearly vertical.

(3) To the west of this broad portion of the structure, there is a section of about seven miles where there is apparently just one anticline. All of the anticlines except the northernmost one have plunged under the surface. In this part, the north side of the range is a high north-facing scarp composed of vertical beds of limestone. Here the highest peak in the range is formed by a portion of the crest of the structure which was not planed off by the glacier.

(4) The next section has a steep dip scarp facing south, and the range again consists of several nearly parallel anticlines. This south-facing scarp dies out three miles east of the Mountain River Gorge. The range is still anticlinorial in character where the Mountain and Gayna Rivers cut through it, and it is believed that this complex structure exists almost to the western end of the Range.

Cross-section X-Y pictures the structure of the south flank of the range in the Conglomerate Creek area. This creek cuts into the part of the range that has a south-facing dip scarp. As shown in the cross-section, overlap caused by faulting was observed both at the Reef Limestone - Upper Fort Creek contact, and at the Upper Norman Shale - Cretaceous contact. Where the Mountain River cuts through the range three small anticlines are present in the central portion of the anticlinorium. The northernmost of these small anticlines is overturned to the south. Plate II is a cross-section showing the details of the anticlinorium in the Mountain River Gorge.

It has already been mentioned in the chapter on topography that near the mouth of the Gayna River, there are outcrops of Fort Creek shales resting on lower Ramparts limestones. There is a small angular discordance between the limestone and the shales. The lithology of these beds and fossil collections from both the Ramparts limestones and the Fort Creek shales established their age. This area of outcrop is shown on Plate I and Plate VI. Plate VI also shows a cross-section through the area. As a normal section is well exposed in the area

immediately surrounding this Fort Creek outcrop this anomalous condition cannot be explained by an erosional unconformity of the usual type. Because of the structure of the surrounding area, the juxtaposition of the two formations cannot be explained by faulting.

The writer believes that this mass of Fort Creek shale, one-half mile in diameter, and perhaps, originally, fifty to a hundred feet thick, was transported from the top of the scarp to the north and across the Gayna River by the glacier. The shale beds, still intact, were then left on the lower stratigraphic surface about three-quarters of a mile from their place of origin.

Whirlpool Syncline

This syncline is between the Imperial Range and the Whirlpool Anticline. The width of the trough, from the Cretaceous contact on the north side to the Cretaceous contact on the south side, is about six miles. Dips on the north side are much steeper than on the south side. The axial portion of the syncline is almost flat. Plate II shows the details of this structure.

Whirlpool Anticline

This structure was named the Whirlpool Anticline because of a whirlpool located where the axis crosses the Mountain River. The structure was first located by Dr. T. A. Link, while making an aerial reconnaissance flight. It is a broad gentle fold, and the oldest beds that were seen exposed on it are Upper Norman sandstones and shales. It is believed to be a good prospect. The possibilities of the structure with regard to oil production are discussed in the chapter on conclusions and recommendations, while the structure itself is discussed in this section. Where the axis is exposed on the south side of the Mountain River, there

is a hundred-foot cliff of Upper Norman sandstones. At the top of the cliff basal Cretaceous sandstone is exposed, and all of the other outcrops in the vicinity of the structure are Cretaceous. Only fifteen feet of Upper Norman shales are present between the top of the Upper Norman sandstone and the base of the Cretaceous. Exposures are not numerous enough in the area to delineate with accuracy the form and trend of the structure. Therefore, the cross-sections of it are interpretative in part.

As shown on the areal geologic map, the trend of the axis is east-west, with curvature to the northeast at the east end. Plate II shows a northwest-southeast cross section of the structure along the north bank of the river. On this cross section, and also on the cross section on Plate IV, the base of the Sans Sault formation is shown to be about 2500 feet below the projection on the crest of the structure of the base of the Link formation. According to the measurements made on the south limb of the Whirlpool Syncline, the stratigraphic interval between the base of the Link formation and the base of the Sans Sault formation is about 3500 feet. Therefore, there is either a big change in the thickness of the Cretaceous section between the Imperial Range and the Whirlpool Anticline, or the structure has more relief than the outcrops indicated. The latter possibility is believed more likely. The cross sections on Plate II and IV were drawn to fit the local strike and dip data as interpreted by the writer, and this picture gives a more conservative amount (about 1000 feet) of northwest-southeast structural relief.

Plate IV (cross sections W-W' and H-H') shows cross sections, at right angles to each other, through a proposed well site. Sec. W-W'

is located on the plunging portion of the axis of the fold. This section shows the axis beginning to plunge about 1000 feet east of the proposed location, and then levelling off about 1000 feet east of the east bank of the river. It is possible that the proposed location is not on the highest part of the structure and that Norman or older beds are exposed along the axis to the west of the location. This is not believed to be the case because of the following reasons: (1) The topography to the west indicates that the rocks underneath the glacial covering are soft shales, and thus Cretaceous in age. (2) Thirteen miles northwest of the proposed well location, Moon (6) mapped an anticlinal axis plunging to the southeast with Cretaceous beds exposed at the surface, and north and south of this anticline exposed along the Hume River, he mapped flat Cretaceous beds.

The following statement summarizes what is known about this structure: there is definite closure to the north, east and south, with a minimum structural relief of about 1000 feet. At right angles to the axis, and close to the west side of the Mountain River, the distance between the lowest north and south closing contours is about two miles. From the study of aerial photographs and by using topographic and drainage features as criterium, and by a study of the areal geology, the following interpretations are suggested: (1) The axis of the Whirlpool Anticline is curved, and the structure is highest and most narrow in the area of the proposed well location. (2) The plunge of the east end of the structure is towards the West Mountain Anticline. (3) It is believed the structure broadens out and plunges very gently west of the proposed location, finally dying out about ten miles from the Mountain River. (4) The Hume River Arch has an en echelon relationship to

the Whirlpool Anticline. The Hume River structure has a northwest-southeast trend, and it begins north of the area where the Whirlpool Anticline dies out.

Detailed aerial reconnaissance of the area between the Hume and Mountain Rivers might provide further information about both the Hume River Arch and the Whirlpool Anticline. It is recommended that a wildcat be drilled on this structure.

Sans Sault Syncline

Included in this structural unit is all of the Mountain River area below the Whirlpool Anticline. The Sans Sault structural basin is bounded on the south and east by West Mountain and the Whirlpool Anticline, and on the east by the structure on the west side of the Sans Sault Rapids. Several small folds are present in this Cretaceous basin. The axes of these small structures are shown on the areal map. Nothing is known of the extent and trend of these structures beyond what is shown on the areal map. The structural relief of these folds is probably fifty feet or less, judging from the strike and dip readings made along the Mountain River.

Chapter V.

HISTORICAL GEOLOGY

The geologic history of this area is summarised in the report on the Carcajou Ridge - East Mountain area (8).

Chapter VI

OIL AND GAS MANIFESTATIONS AND MINERAL DEPOSITS

Gas (?) bubbles were observed in the water in the northwest corner of Lake Doris. The stratigraphic position of this gas (?) seep is approximately at the Upper Fort Creek - Lower Norman Shale contact.

The Lower Ramparts Limestone, the Lower Fort Creek Limestone, the upper part of the Reef Limestone, and the basal part of the Upper Fort Creek Shales are all bituminous in the Mountain River area. None of the Norman or Cretaceous beds examined along the Mountain River were petroliferous, although some of the Norman sandstones and some of the basal Cretaceous sandstones are decidedly petroliferous in the Imperial River area.

Chapter VII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Two parts of the sedimentary column in this area are well suited for the generation and storing of oil.

The Lower Ramparts limestones are very bituminous and constitute a source bed. Underlying these beds are porous, coarse-grained Bear Rock limestones and dolomites that are believed to be suitable reservoir beds. Overlying the Lower Ramparts beds are the Middle Ramparts shales which are good cap rocks.

Both the Lower and Upper Port Creek members are bituminous, and are classified as source beds. Between these beds is a thick section of reef limestone which is considered to be a reservoir bed. The Lower Norman Shale member, a cap rock, overlies the Upper Port Creek shales.

Recommendations

A large structure, the Whirlpool Anticline, is present in this area, and both of the above-mentioned rock sequences occur at depth in this structure. It is recommended that a test well be drilled on this structure, which is classified as a good prospect. If a well is drilled and the Reef Limestone is barren, drilling should be continued through the Bear Rock formation, as both the Reef beds and the Bear Rock are considered to be possible producing horizons. At the proposed location (See Plate I) the estimated depth to the top of the Reef Limestone is 1420 feet. The depth to the top of the Bear Rock formation is estimated to be 3135 feet.

As previously mentioned in Chapter IV, it is possible that Upper Norman sandstones or older beds are exposed between the well location and

the flat Cretaceous beds exposed about ten miles to the west along the Hume River. Even if the Reef Limestone was exposed to the west of the location the structure would still be a good site for a Bear Rock test.

If a fairly good road location can be made, and if a seismograph survey is made in the Sans Sault area as recommended in the report on the Cercajou Ridge - East Mountain area (8), it is suggested that a seismograph survey also be made on the Whirlpool structure to outline the form of the western part of the anticline.

The well location is not readily accessible. A tentative road location to the site is shown on the areal map, Plate I. The distance from the Mackenzie River to the structure along this road location is twenty-six miles. The road location is made on the west side of the Mountain River because of the impracticability of a river crossing. An attempt was made to place the road location on fairly well-drained glacial deposits, but since aerial photograph coverage of much of the area is poor a great deal of the location is probably in muskeg country. Aerial reconnaissance would be of great value in determining a final road location.

CONFIDENTIAL

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2. Laudon, L. R. — Final Geological Report on the Imperial River Area, N.W.T., Canada, 1943, Imperial Oil Limited, Canol Project, Assignment No. 18; privately distributed.

3. Link, T.A. — Geological Report on the Fort Norman Area, N.W.T., Canada, 1921; privately distributed.

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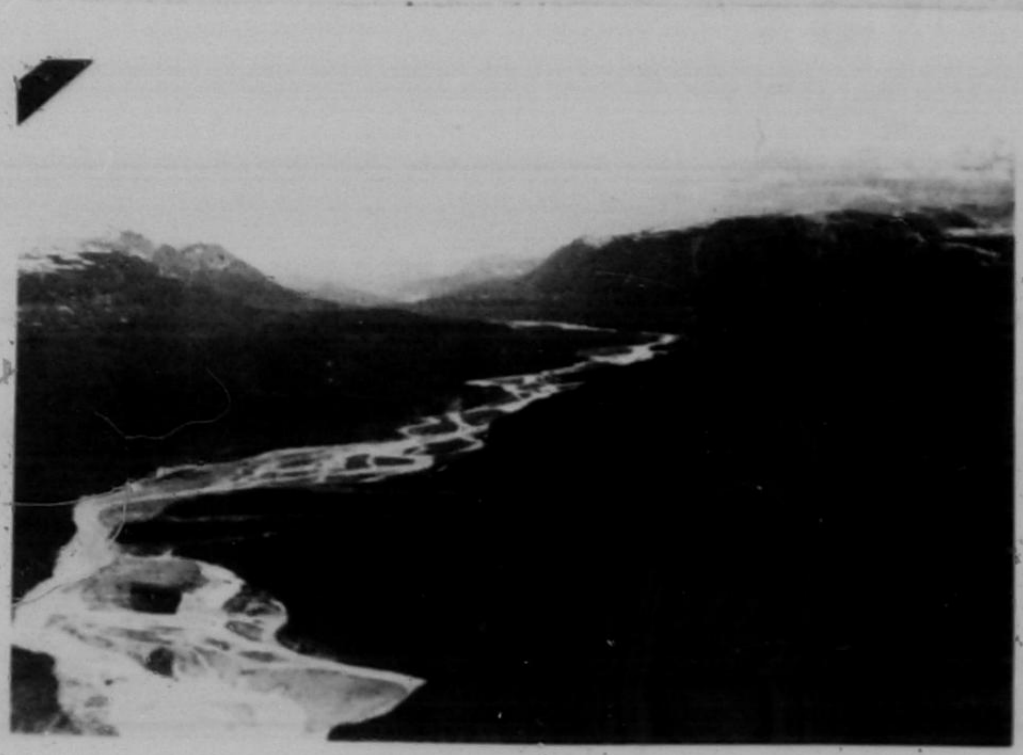
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7. Nauss, A. W. — Final Geological Report on the Upper Carcajou-Imperial River Area, N.W.T., Canada, 1944, Imperial Oil Limited, Canol Project, Assignment No 10 and 18A; privately distributed.

8. Parker, J. M. — Final Geological Report on the Carcajou Ridge-East Mountain Area, N.W.T., Canada, 1944, Imperial Oil Limited, Canol Project, Assignment No. 6; privately distributed.

PHOTOGRAPHIC ILLUSTRATIONS

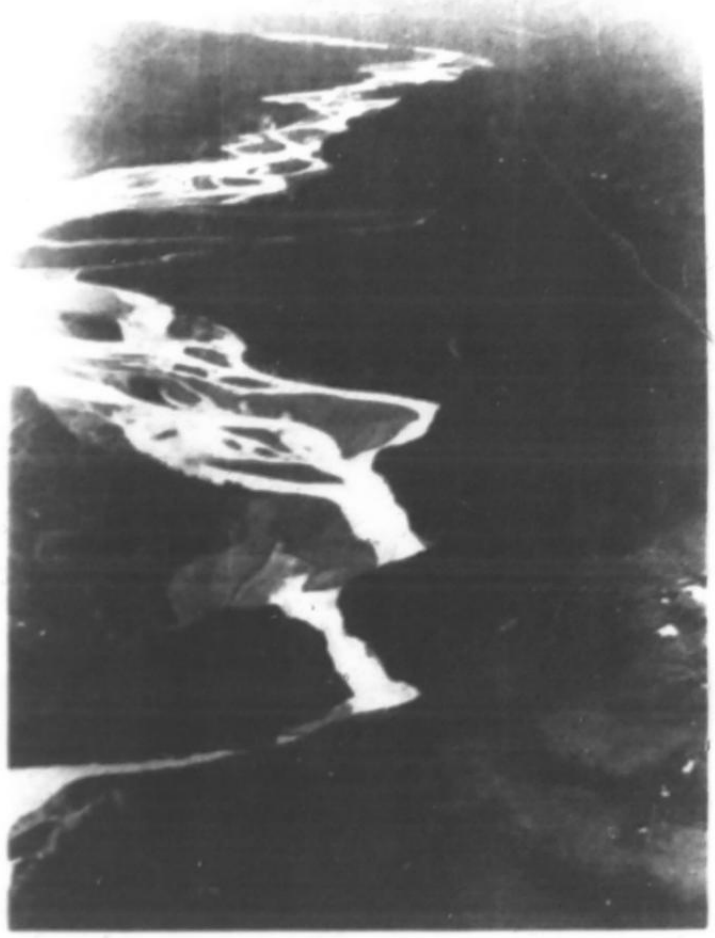
Photograph No. 1
Taken by Dr. T. A. Link, 1943.



SOUTHEAST NORTHWEST

Aerial view of the Mountain River taken at the Mackenzie Mountain front and looking southwest. Terraces rising about 500 feet above the present valley floor can be seen on both sides of the river. The tributary entering the river in the right foreground is Cambrian Creek.

Photograph No. 2
Taken by Dr. T. A. Link, 1943.



SOUTHEAST NORTHWEST

Aerial view of the Mountain River taken from the Mackenzie Mountain front and looking upstream (southwest). The delta of Cambrian Creek can be seen in the upper central part of the picture. The narrow gorge in the foreground is formed by the river cutting through the hard, massive Mount Ronning dolomites.

Photograph No. 3
Taken by Dr. T. A. Link, 1943.



NORTHWEST SOUTHEAST

Aerial view looking northeast at the Mountain River gorge through the Imperial Range. The picture was taken just inside the upstream entrance to the gorge.

Photograph No. 4
Taken by Dr. T. A. Link, 1943.



SOUTH NORTH

Aerial view looking east along the axis of the Imperial Anticlinorium. The Mountain River gorge is in the foreground. A reverse fault with 165 feet of vertical displacement is visible in the cliff on the side of the gorge away from the camera.

APPENDIX

January 17,1944

MEMORANDUM:

TO: Dr. T. A. Link.

RE: Fossil Identification.

Attached is a tentative identification of fossils collected by Mr. J. M. Parker on Assignment No. 19 - Mountain River.

C.R.Stelck

KH/cm

y1.

FOSSIL IDENTIFICATION - MOUNTAIN RIVER

J. M. Parker

Suite No	Date	Location	Fossil	Accession No.	Age
8550	Sept. 9	Conglomerate Creek Area	Hypothyridina	43837	Fort Creek
"	"	"	Atrypa	43838	"
8551	Sept. 7.	Imperial Mtn.Range Gorge of Mtn. River	Cyathophyllum	43839	Remparts.
"	"	"	Paracyclas	43840	"
"	"	"	Gastropod	43841	"
"	"	"	Atrypa reticularis	43842	"
"	"	"	Productella	43843	"
"	"	"	Cystiphyllum	43844	"
"	"	"	Atrypa spinosa	43845	"
"	"	"	Pugnax	43846	"
8552	Sept. 8	Imperial Mtn. Range. Gorge of Mtn. River	Atrypa reticularis	43847	Ramparts
"	"	"	Productella	43848	"
"	"	"	Cystiphyllum	43849	"
"	"	"	Zaphrentis	43850	"
"	"	"	Atrypa spinosa	43851	"
"	"	"	Atrypa spinosa	43852	"
"	"	"	Crinoid stem	43853	"
"	"	"	Proetus	43854	"
"	"	"	Cladopora	43855	"
"	"	"	Gastropod	43856	"
"	"	"	?	43857	"
"	"	"	Heliophyllum	43858	"
"	"	"	Paleocyclas	43859	"
"	"	"	Spirifer	43860	"
"	"	"	Prismatophyllum	43861	"
"	"	"	Acervularia	43862	"
"	"	"	Schuchertella	43863	"
"	"	"	Syringopora	43864	"
"	"	"	Favosites	43865	"
"	"	"	Pachyphyllum	43866	"
8553	Sept.8	Imperial Rvr.Gorge Imperial Mtns.	Hypothyridina	43867	Fort Creek
"	"	"	Cup Coral	43868	"
8554	Sept.10	Imperial Rvr. Gorge	Atrypa reticularis	43869	Bosworth
8555	Sept.10	Imperial Rvr. Gorge	Atrypa reticularis	43870	Bosworth
8556	Sept.10	Imperial River Gorge	Productella	43871	Bosworth
"	"	"	Cyrtospirifer	43872	"
"	"	"	Camarotoechia	43873	"
8557	Sept.12	Whirlpool Anticline	Phillipsastrea	43874	Bosworth
"	"	"	Cyrtospirifer	43875	"
"	"	"	Atrypa	43876	"
8558	Sept.12	Sans Sault Rapids East side of River	Pinna	43877	Cretaceous
"	"	"	Hoplites	43878	"
"	"	"	Inoceramus	43879	"



LEGEND

FORMATION BOUNDARIES

- Reasonably Certain
- Reasonably Certain (from photographs)
- Doubtful or Concealed

ANTICLINES

Known | Inferred | Not Certain | Overturned

SYNCLINES

Known | Inferred | Not Certain | Overturned

FAULTS

Known | Inferred | Not Certain | Horizontal

End arrows show Plunge (closure). Major or Minor by heavy and light lines respectively

- Strike and Dip
- Strike and Dip overturned
- Strike of Vertical Beds
- Horizontal Beds
- ⑦ 126 — Fossil or Sample Locality (Locality No.)
- A ——— A' — Line of Cross Section
- Scarp Faces
- x — Outcrops

KEY

CRETACEOUS	Kl	Link sandstone and shale	K — Cretaceous undifferentiated
	Ksp	Sperry shale	
	Kss	Sans Sault sandstone and shale	
DEVONIAN	Dn	Norman sandstone and shale	
	Dfc	Fort Creek shale	
	Dbl	Reef limestone, Lower Fort Creek limestone, and Beavertail limestone	
	Dr	Ramparts limestone and shale	
	Dbr	Bear Rock limestone and dolomite	
SILURIAN	Smr	Mount Ronning dolomite	
CAMBRIAN & ORDOVICIAN	€-O	Limestones, sandstones, and shales.	

GEOLOGIC MAP
OF THE
MOUNTAIN RIVER AREA

SCALE: 1" = 1 MILE

0 1 2 3 4 5 MILES

Map base compiled from U.S.A.A.F. aerial photographs, roll 314 VIO7-146.
Scale control from J. Gordon Turnbull, and Party D stadia traverses.

GEOLOGY BY
PARTY D

IMPERIAL OIL LIMITED - CANOL PROJECT
1944

T-232-69


MOUNTAIN
EAST MOUNTAIN
WEST MOUNTAIN
MOUNTAIN
RANGE
RANGE
Mackenzie River
Caribou River
Proposed road to wildcat location
Proposed "Wildcat" location
J.S. Turnbull tower No. 1
J.S. Turnbull tower No. 2
Whirlpool Anticline
Axis of Anticlinorium
Gayna River
Hayden Creek
Camsell Creek
Sammons Creek
Dahadinni River
Relatively undisturbed beds of Fort Creek shale resting on lower Ramparts limestones. The shales are thought to have been moved here by the glacier from across Gayna River.
P.M.64
P.M.63N.
P.M.65N.
P.M.66N.
P.M.64N.
P.M.67N.
P.M.C1
P.M.D-2
P.M.D-3
Dahadinni Flag
Dahadinni Flag 1140' above River
Dahadinni Flag 1145' above River
Dahadinni Flag 1140' above River
Dahadinni Flag 1140' above River
Dahadinni Flag 1140

29

PLATE II

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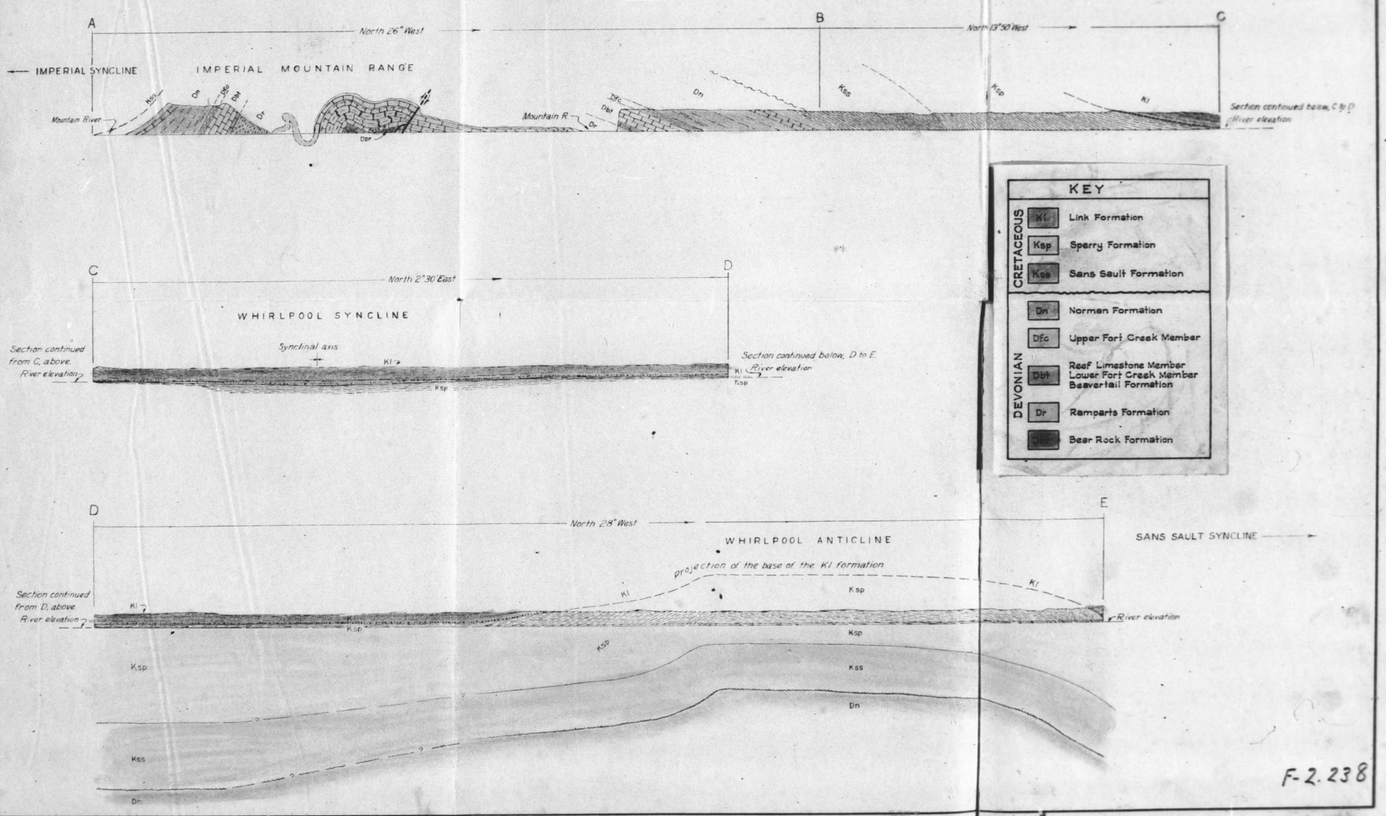
CROSS SECTIONS A,B,C,D,E.

SECTION ALONG THE MOUNTAIN RIVER, N.W.T., FROM THE IMPERIAL MOUNTAIN RANGE TO THE WHIRLPOOL ANTICLINE

VERT. & HORIZ. SCALE: 4" = 1 MI.

thousands of feet .5 0 1/4 1/2 3/4 1 miles

OCTOBER, 1943.
ASSIGNMENT No.19, PARTY D.



KEY

CRETACEOUS
- Kl — Link Formation
- Ksp — Sperry Formation
- Kss — Sans Sault Formation

DEVONIAN
- Dn — Norman Formation
- Dfc — Upper Fort Creek Member
- Dbt — Reef Limestone Member, Lower Fort Creek Member, Beavertail Formation
- Dr — Ramparts Formation
- Bear Rock Formation

F-2.238

F-2.238



29

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PLATE IV

WHIRLPOOL ANTICLINE, MOUNTAIN RIVER, N.W.T.

CROSS SECTIONS W-W' & H-H'

VERT. & HORIZ. SCALES: 8" = 1 MI.

(GROUND ELEVATIONS OBTAINED FROM PARALLAX MEASUREMENTS MADE ON U.S.A.A.C. PHOTO 3-314V-119)

DECEMBER, 1943.

ASSIGNMENT NO. 19, PARTY D.

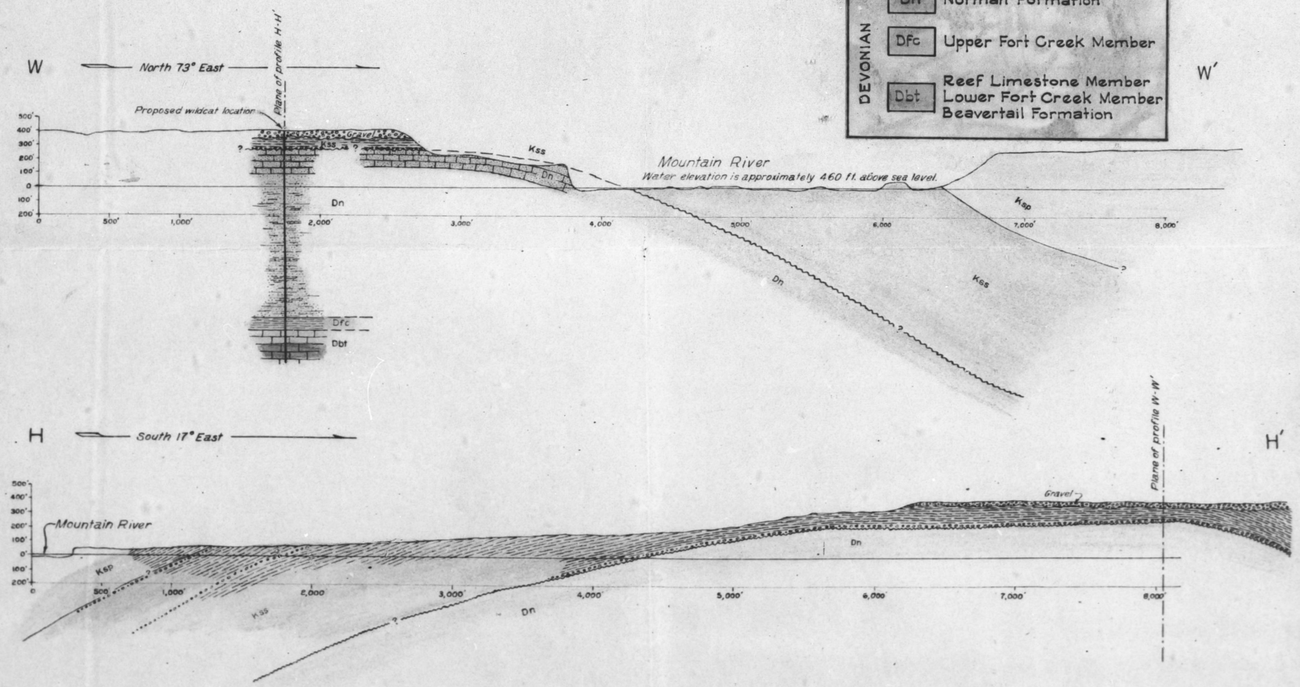
KEY

CRETACEOUS

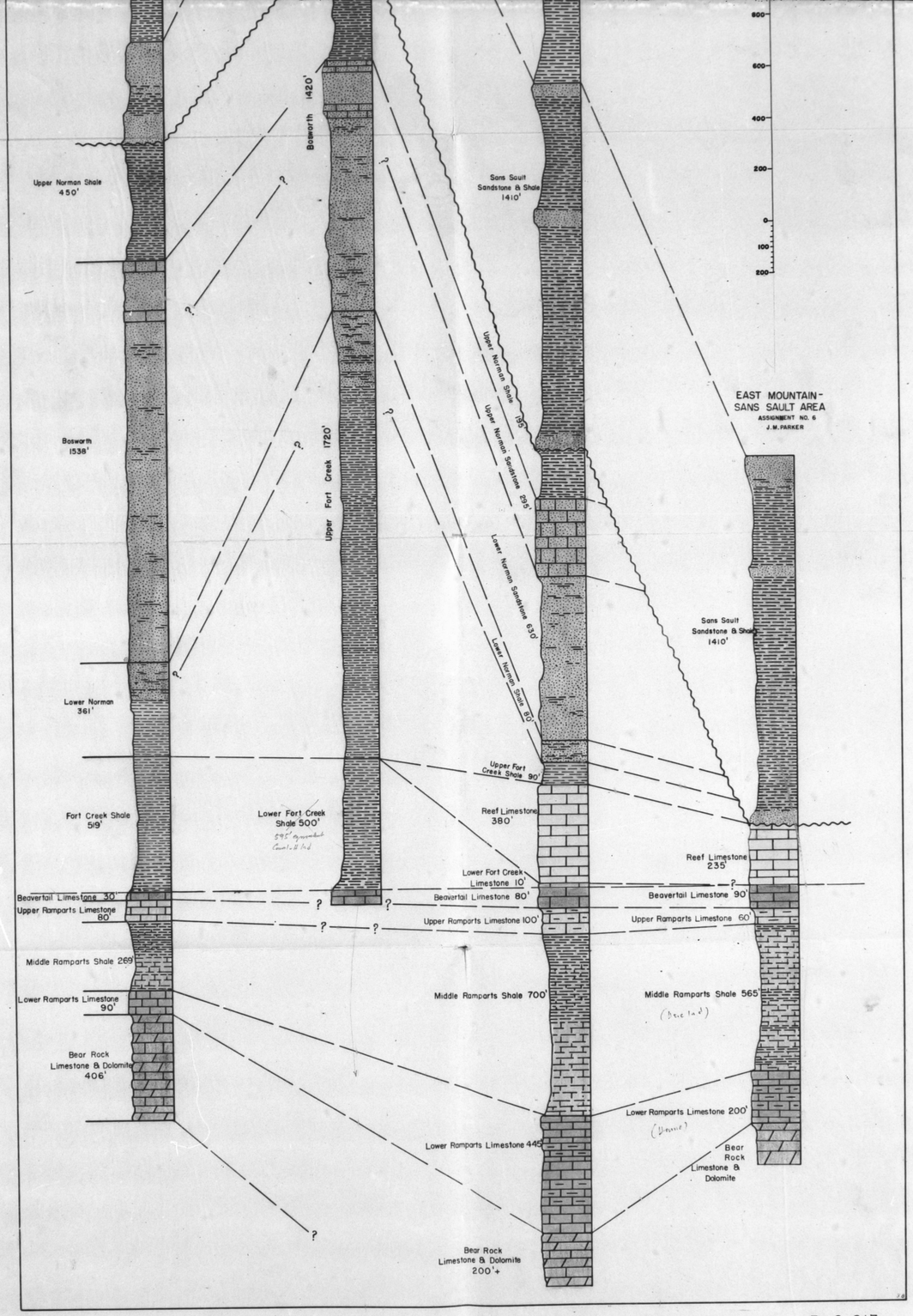
- Ksp — Sperry Formation
- Kss — Sans Sault Formation

DEVONIAN

- Dn — Norman Formation
- Dfc — Upper Fort Creek Member
- Dbt — Reef Limestone Member, Lower Fort Creek Member, Beavertail Formation



F-2-240



F- 2.217

24x
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PLATE 5

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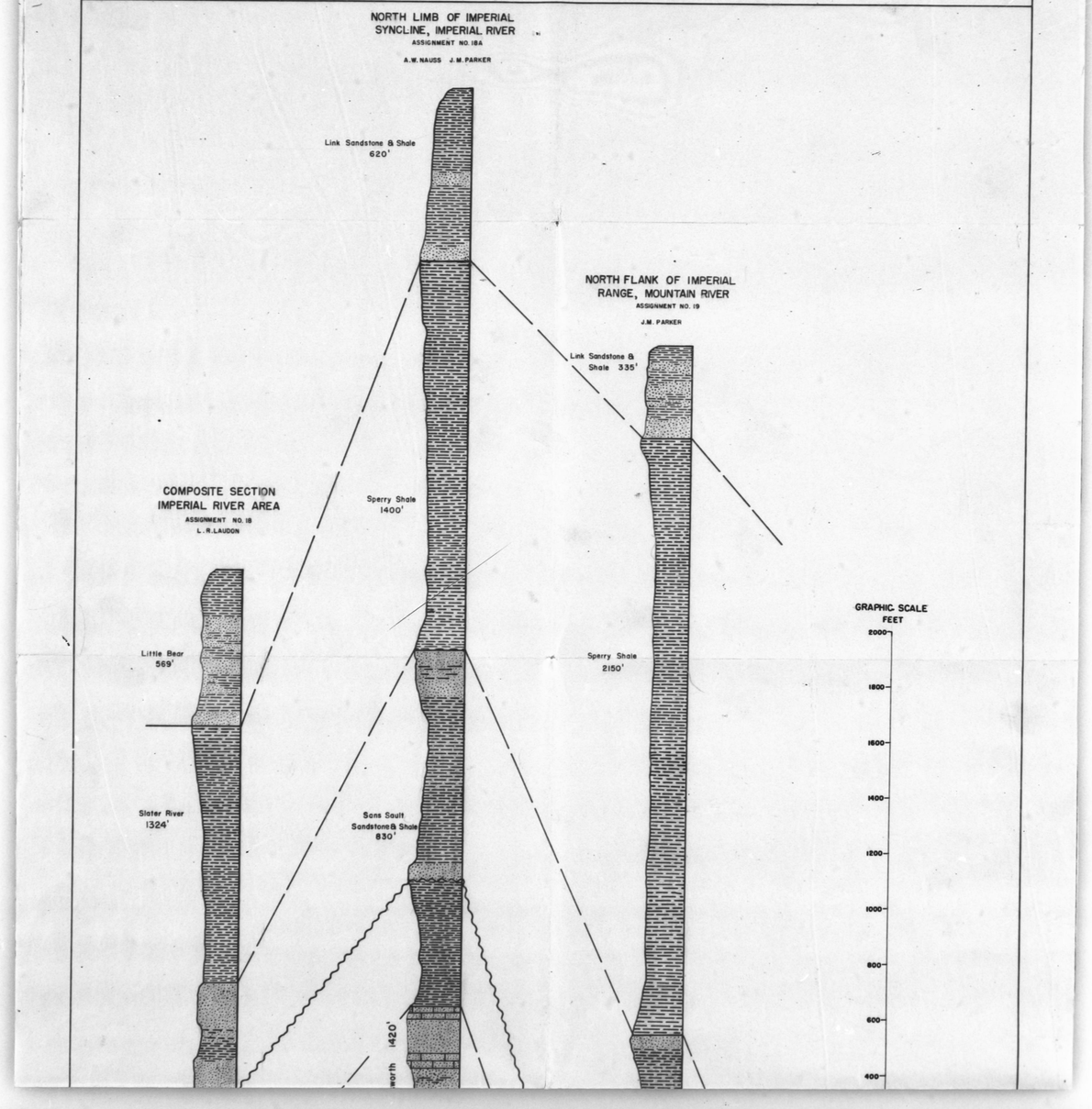
106-9

CORRELATION CHART
TO ACCOMPANY
MOUNTAIN RIVER AREA REPORT

SCALE: 1" = 200'

ASSIGNMENT No. 19 PARTY D

JANUARY, 1944.



24x

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PLATE VI

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DETAIL GEOLOGICAL MAP OF THE MOUNTAIN AND GAYNA RIVER GORGES THROUGH THE IMPERIAL MOUNTAIN RANGE

Map Traced From U.S.A.A.F. Photgraphs Roll 314V123-124

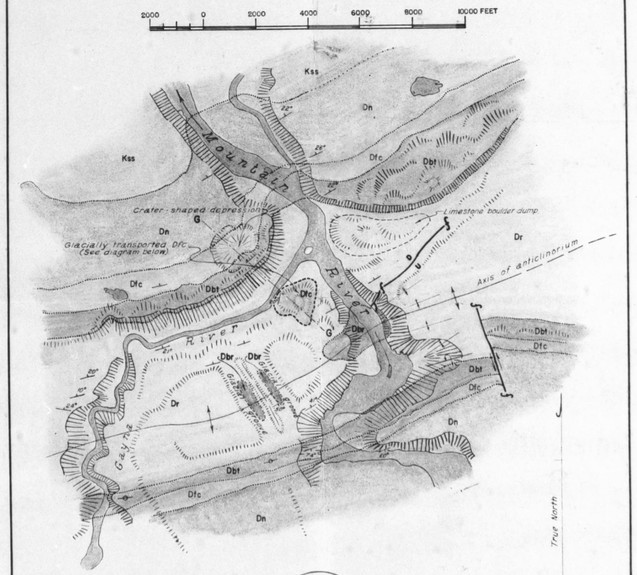
SCALE: 1"=APPROX. 2339'

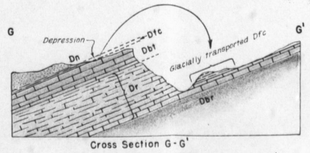
ASSIGNMENT No. 19, PARTY D.

JANUARY, 1944.

NOTE: For legend and key see Plate I.

2000 0 2000 4000 6000 8000 10000 FEET





Cross Section G-G'
(Diagrammatic, no scale)

F-2.224

24x
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PALEOZOIC — EVONIAN — DEVONIAN — MIDDLE — LONG REACH GROUP

FORT CR.			
BEAVER-TAIL LS.		10'	Limestone, dark grey to black, fine-grained. Slaty black shale partings between beds. Beds 0.2' to 2' thick. Contains some unrecognizable brachopods.
		80'	Limestone, grey, buff-weathering, massive. Many small Cladopora.
U. Ramparts Ls.		17'	Limestone, dark grey, beds 0.6' thick and separated by black shale partings. Limestone weathers grey, contains many large Cladopora.
		10'	Limestone, dark grey, massive.
		9'	Shale, black, earthy and limy, contains many large Stromatoporoids and Cladopora.
		6'	Limestone, black, massive, petroliferous.
		58'	Limy shale, black to grey-brown, petroliferous. Contains many large Cladopora.
Middle Ramparts Shale (Hare Indian Shale) - 700'		700'	Shale: Gray to green shales and limy shales. Many thin limestone beds (0.3' thick). In the lower 100' of this unit these thin limestone beds are frequently coquinoid. The shales weather grey to buff-green and buff.
RAMPARTS LIMESTONE AND SHALE - 1245'	Lower Ramparts Limestone - 445'	100'	Limestone, dark grey to black, massive, medium to fine-grained, petroliferous, beds 1.0' to 5.0' thick. Irregular and nodular black shale partings between some of the beds. Fossiliferous.
		135'	Limestone and shale. Dark grey to black, limestone is platy, limestone beds 0.6'± thick. Shale beds 0.3'± thick. Very fossiliferous. The limestone beds commonly split into ¼" slabs.
		6'	Limestone, dark grey to black, massive at top and bottom, and rubbly in the central 2.5'. Very fossiliferous.
		129'	Limestone, dark grey, rubbly to platy and shaly.
		75'	Limestone, black, hard, brittle, very petroliferous, generally fine-grained, many calcite veinlets, beds 0.6' to 8.0' thick, black shale partings between some of the beds.
BEAR ROCK DOLOMITE		150'	Dolomite (?), grey-brown, coarse-grained, banded, sugary appearance on fresh fracture, feels sandy, beds 1' to 2' thick.
		50'	Dolomite (?), no bedding discernable, outcrop mostly covered with tufa from warm sulphur springs issuing from the top of this unit.

	Cladopora dentata
	Cladopora dentata
	Cladopora dentata
	Atrypa(?), Raticularia, Productella, Proetus, Zaphrentis, Cladopora, Atrypa spinosa, Cystiphyllum, Euomphalus, Crinoid stem, Paleocyclas, Favosites, Syringopora, Schuchertella, Heliophyllum, Acervularia, Prismatophyllum, Pachyphyllum.
	Atrypa spinosa, Atrypa reticularis, Martinia, Euomphalus, Productella.
	Zaphrentis, Favosites, Paleocyclas, Prismatophyllum, Cladopora, Gastropods, Cyathophyllum.
	Acervularia, Cladopora, Paracyclas, Pugnoides.
	Cystiphyllum.

MESOZOIC — RETACIOUS — CRETACEOUS

LOWER — SANS SAULT SANDSTONE AND SHALE - 1410'

600	
700	
800	
900	
1000	
60'	Sandstone, same description as sandstone unit below
465'	Shale, same description as shale unit below, unit partly covered.
50'	Sandstone, dark grey to brown, weathers grey to brown, dirty and mottled on fresh fracture. Contains 1.0'± ironstone concretion bands that have some septarian development.
820'	Shale, dark grey to black, blocky, slightly micaceous, contains a few thin silty, and very fine sandy beds, and also a few 0.2'± limestone concretion bands.
1'	Sandstone, white, very pure quartz sand.
8'	Sandstone, mottled white to grey quartz sand, with yellow streaks.

T-2.42-84

24x
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PLATE VII

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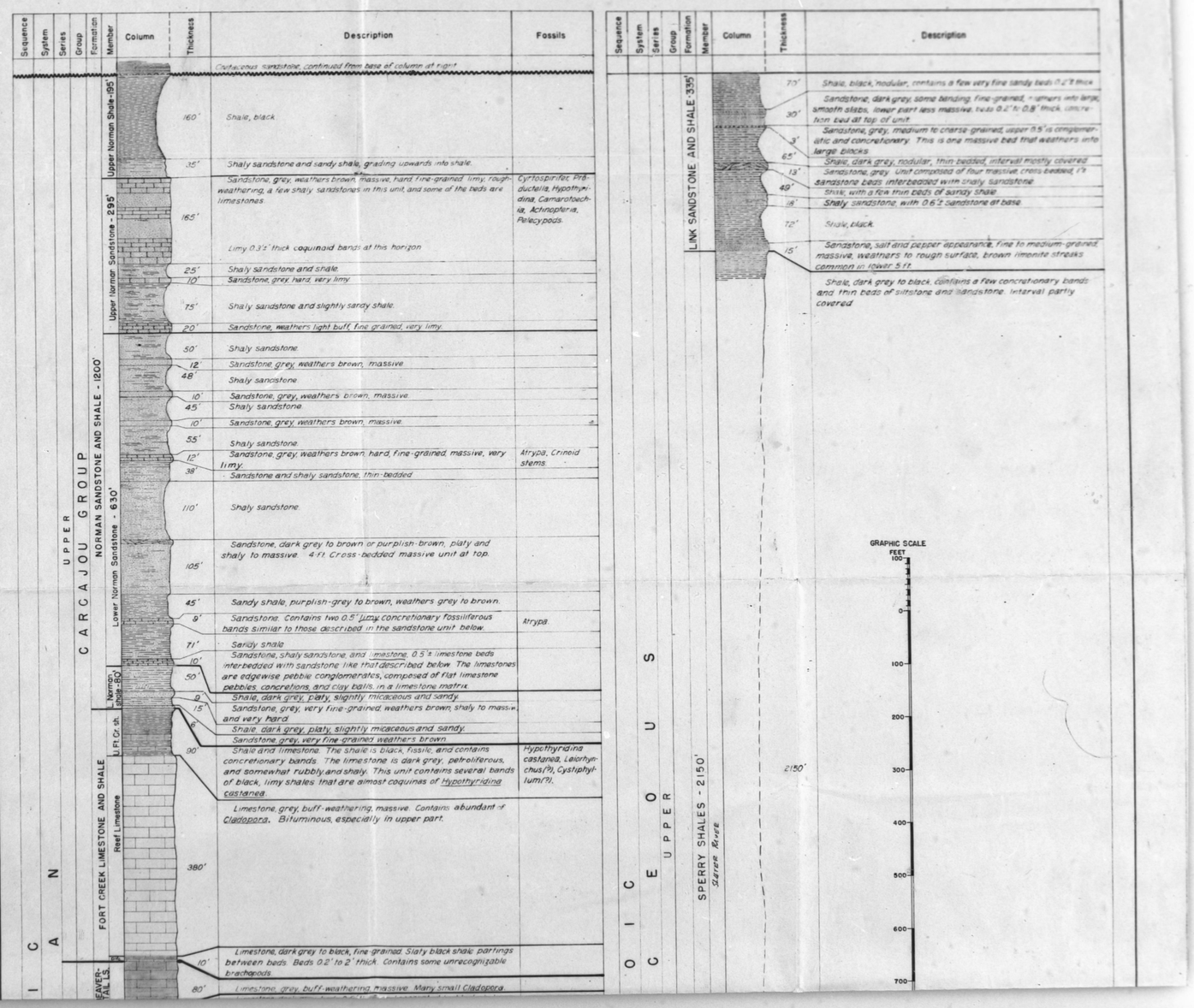
COLUMNAR SECTION
NORTH FLANK OF THE IMPERIAL MOUNTAIN RANGE
AS EXPOSED ON THE MOUNTAIN RIVER, N. W. T., CANADA

SCALE: 1" = 100 FEET

ASSIGNMENT 19

PARTY D

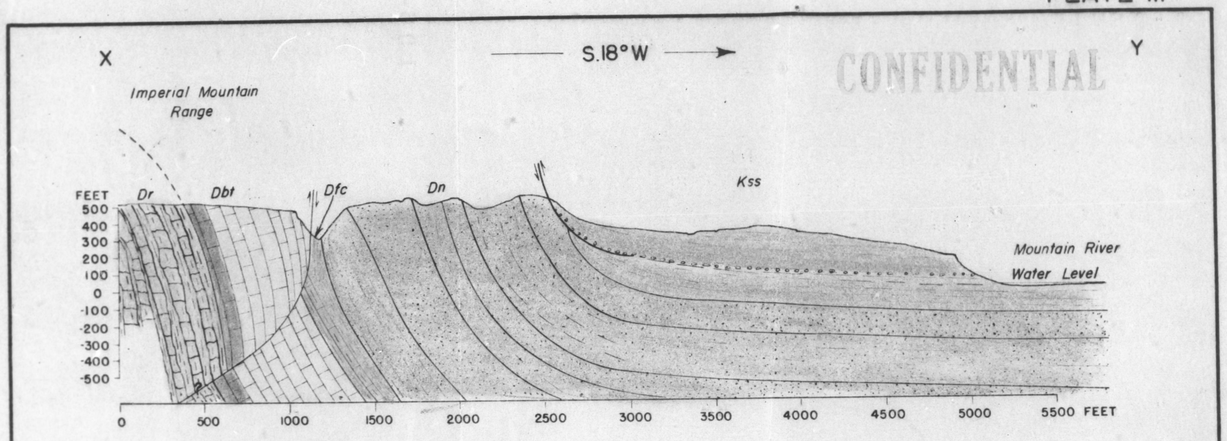
November, 1943



24x
West Canadian Graphic Industries Ltd.

29

PLATE III



CROSS SECTION X-Y

Showing

SOUTH FLANK of the IMPERIAL MOUNTAIN RANGE

VERTICAL & HORIZONTAL SCALE: 8 IN. TO 1 MI.

Elevations obtained from parallax measurements made on U.S.A.A.C photo 314V-129.

PARTY D

ASSIGNMENT NO. 19

OCTOBER 1943

LEGEND

Cretaceous

Kss — Sans Sault Formation.

Dn — Norman Formation.

Dfc — Upper Fort Creek Member Reef Limestone Member.

Devonian

Dbt — Lower Fort Creek Limestone Member. Beavertail Formation.

Dr — Ramparts Formation.

F 2.254

29