No 18

18

FINAL

GEOLOGICAL REPORT

ON

"IMPERIAL RIVER AREA"

N.W.T. (Canada)

IMPERIAL OIL LTD., Canol Project

Assignment No. 18

By: Dr. L. R. Laudon - Party Chief
D. Krulis - Assistant
C. Eggenberger - Helper.

Date submitted: August 16th, 1943.

Read and accepted by: [illegible]

Date: [illegible]

CONFIDENTIAL

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LIST OF ILLUSTRATIONS

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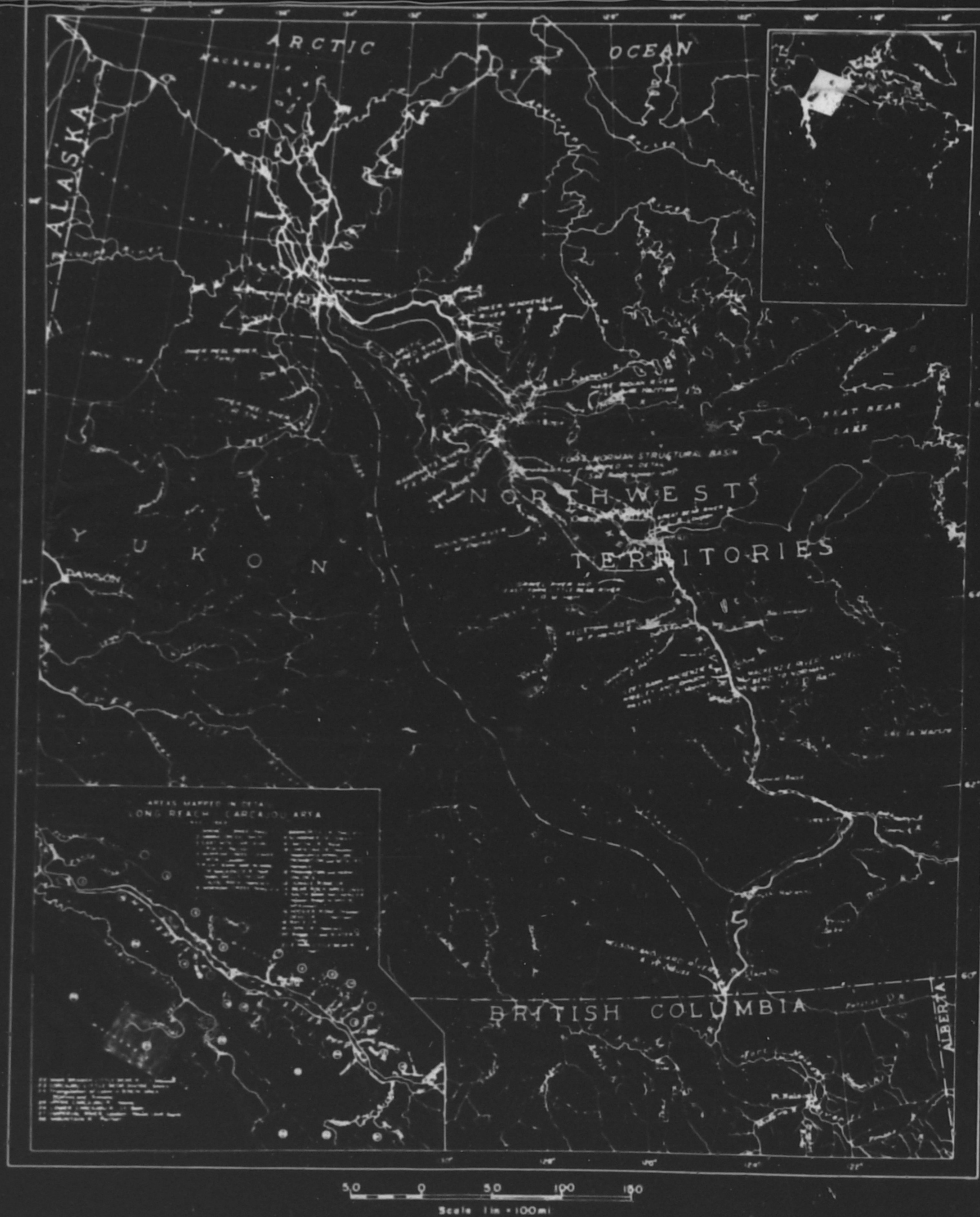

INDEX MAP OF
NORTH WESTERN CANADA SHOWING
IMPERIAL RIVER AREA

Chapter I

INTRODUCTION

The area described in this report includes the Mackenzie Mountain front between Mountain River on the west and the headwaters of the westernmost branch of the Carcajou River on the east and the Imperial River valley. The party was landed by Norseman plane in Florence Lake at the foot of the Mackenzie Mountains. The party proceeded upstream from Florence Lake to the mouth of Imperial Canyon, then down Imperial River to the Carcajou River, then down the Carcajou River to the Mackenzie River where the party was picked up.

The major portion of the area was surveyed by plane table. Occasional Brunton pace traverses were made in tributaries and more remote portions of the area. The peaks and main features along the Mackenzie Mountain front were run in by triangulation. Aerial photographs were used to supplement the data after returning to the Wells.

General Geology

The geology along the Mackenzie Mountain front is simple and easily available for study. The mountain front consists of a large regional anticline that trends almost east and west. Rivers rising in the mountains have cut deep canyons across this fold so that complete sections from the Cambrian to the Cretaceous are exposed in the area. Particularly excellent sections are exposed along the Imperial River.

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porous, permeable, sometimes glauconitic quartz sands. There is little variation throughout the section except near the top where the sands are muddy and consequently darker in color.

The shales are variable in characteristics yet the same sequence and types are rhythmically repeated throughout the section. They are predominately red in color, with light green next most common, black and slaty third, occasional chocolate browns, and a few tan and buff types. The red and green shales are commonly intricately interbedded down to fractions of inches with each color change sharp and distinct. This gives rise to the banded effect seen on all exposures. All shale zones are interbedded with sand beds.

No identifiable fossils were collected. Fucoids occur commonly in both shale and sand zones. A few calcareous algae were found in the upper shale zones. Rather excellent agates occur in the shale zones at the contact of the shales with sand beds.

The upper beds are predominately shales with minor sand and occasional impure limestone beds. Soft, flaky, black shales appear in the section. The material immediately below the contact carries considerable gypsum in both beds and in secondary veins.

The Macdougal is unconformably overlain by a series of Cambrian limestone beds. The contact shows evidence of considerable erosion in very short distances. Different beds may be seen at the contact within short distances along the Imperial canyon wall.

<u>Algal Limestone Beds</u> - Cambrian

Beds described in this series have heretofore been classed as part of the Mt. Ronning formation. They are classed as a separate unit in this report because of unconformities both above and below.

They are assigned to the Cambrian because of three reasons: 1. The basal portion is interbedded with black platy slate like beds similar to those that occur so commonly throughout the Rocky Mountain province. 2. The whole lower portion of the formation is filled with huge calcareous algae again common to the Cambrian in the south. 3. The occurrence of large numbers of limestone beach conglomerates identical with those that occur in the Cambrian over the entire Rocky Mountain province, and, so far as I know, unknown in any rocks other than Cambrian. No name is proposed at the present time pending study in other parts of the Mackenzie Mountains.

In Imperial canyon the formation consists of slightly over 300 feet of thin bedded black limestone beds interbedded particularly in the base with black slaty shales. The average limestone bed in the base does not average over six inches in thickness. The upper portion is slightly more massive.

The basal contact is sharply unconformable with the underlying red and grey gypsiferous shales of the Macdougal formation. The upper contact is also unconformable but because the overlying beds are also hard dolomitic limestone the contact does not make such a sharp topographic break.

<u>Chert Series</u> Age unknown

Beds described here have heretofore been considered as part of the Mt. Ronning formation. They have been mapped as a portion of the Mt. Ronning because of uncertainty as to their exact age. Since they are sharply different in lithology and separated from the Mt. Ronning by unconformity the writers are of the opinion that they should be separated from the Mt. Ronning formation and given a new name. They

lie in the position that would normally be occupied by Ordovician beds. Since no fossils were found no definite age can be assigned to them. In the Imperial river canyon they are approximately 530 feet in thickness.

The lower portion of this formation consists of grey, relatively massive, cavernous, distinctly non-permeable, silicious dolomite beds. The upper portion varies only with the introduction of large amounts of white, to grey chert. The chert occurs both as nodules and as persistant beds. Some parts of the upper portion are as much as 50% chert.

The basal contact is unconformable with the algal limestone beds. The basal beds are hard, quartzitic, quartz conglomerate and are overlain by black sandy shales and quartz sands. These grade into the typical cavernous, steel grey, dolomite beds.

The upper contact is unconformable, the upper beds being almost entirely chert due to solution of the limestone beds. The base of the Mt. Ronning contains reworked cherts.

<u>Mt. Ronning Formation</u>. Silurian

The Mt. Ronning formation consists of the usual very massive, hard, resistant, cliff forming, grey to brown, dolomite beds. In its restricted state it is only slightly over 450 feet in thickness. The upper beds are thin bedded and interbedded with soft calcareous shale partings.

One [illegible] the center of the formation is abundantly fossiliferous. [illegible] following fossils were identified in the rock: Favosites favosus, Favosites niagarensis, Favosites sp. Diphyphyllum, [illegible] Diphyphyllum [illegible] Halysites sp. Syringopora sp. Stratophyllum sp.

Syringopora sp. Halysites catenulatus, Halysites sp. Strombodes pentagonus, Heliolites megastoma, Alveolites sp. Paleocyclas sp. and Dawsonoceras annulatum.

The lower contact is unconformable on the chert series and contains considerable re-worked chert in the basal beds. The Mt. Ronning is unconformably overlain by the Bear Rock formation. Since almost all of the Bear Rock is conglomeratic there is little need to mention that fact. Since the basal beds contain blocks of black Cambrian slate no further evidence of erosion is necessary.

Bear Rock formation. Silurian

The Bear Rock formation is consistantly in the vicinity of 400 feet in thickness in the Imperial River area. Here it can readily be divided into three members: 1. The basal portion consists of relatively coarse fanglomerate, porous, cavernous, permeable, cemented with calcite. Boulders of underlying formations occur in the basal portion of the section. This condition was observed only in the large canyon at the east end of Lake Florence. 2. The middle portion of the section consists of dark colored well bedded, dolomite beds, usually in two series separated by fanglomerate. 3. The upper portion consists of very coarse, angular, cavernous fanglomerate, characterized by an almost total lack of bedding. It outcrops on canyon walls in sheer cliffs. It weathers to weird topographic forms. The upper portion of this member is bedded more distinctly. No gypsum or anhydrite beds were observed in connection with the Bear Rock formation in this area.

One bed carrying fossils was observed in the easternmost canyon south of Lake Florence. One dark limestone bed in the lower portion

of the middle member carried large numbers of molds of a coral closely like Diphyphyllum. These were observed near the mouth of the canyon on the right canyon wall about 250 feet up from the floor.

The Bear Rock lies unconformably on the Mt. Ronning as shown by the basal conglomerate and is unconformably overlain by the basal limestone member of the Ramparts formation. A black shale bed carrying fish teeth and phosphatic concretions occasionally marks the contact. The well bedded limestone beds of the basal Ramparts are easily separated from the Bear Rock beds.

Ramparts-Beavertail formation. Devonian

Rocks called Ramparts and Beavertail in this area belong to one formation. The dark colored coralline limestone beds of the Ramparts formation grade insensibly up into the hard, thin bedded, grey limestone designated as Beavertail.

The Ramparts-Beavertail formation falls naturally into four units all very similar in character to rocks of the same age in the Discovery Range. 1. The basal unit consists of approximately 90 feet of thin bedded, platy, dark colored limestone beds with minor black marly shale partings. This member carries a few fossils and is distinctly more evenly bedded than equivalent rocks in the Discovery Range. 2. The second unit is predominantly soft, thin, flaky shale beds with minor thin shaly limestone beds near the top. Its maximum thickness is considerably over 250 feet. It is nowhere in the area completely exposed. The upper portion is marly and carries fossils. 3. The third member of the Ramparts consists of approximately 80 feet of dark colored nodular, coralline limestone beds. It is distinctly less fossiliferous, less shaly, and harder than in the Discovery range

area. 4. The upper member or Beavertail limestone consists of normal, thin bedded, hard, grey, almost unfossiliferous limestone. It is seldom over 30 feet thick in the area.

The formation overlies the Bear Rock unconformably and its contact with the overlying Ft. Creek formation is markedly disconformable. Great care must be taken in this area in determining the Ft. Creek-Beavertail contact. Erosional valleys cut in the Beavertail surface have allowed the limestone beds in the base of the Ft. Creek to be deposited directly on various portions of the Beavertail surface. The dense, grey, slaty, calcareous siltstones of the basal Ft. Creek often make up a portion of the Beavertail-Ramparts escarpment.

Ft. Creek formation. Devonian

The Ft. Creek formation lies at the base of the long deep glacial trough that runs parallel to the base of the Mackenzie Mountains. Consequently almost no exposures other than the basal limestone beds are seen along the Mackenzie Mountain front. The upper portion of the Ft. Creek formation is excellently exposed along the walls of the Imperial River just above its junction with the Carcajou River in the core of the Imperial anticline.

The basal member consists of approximately 50 feet of dense, grey, slaty, calcareous siltstone beds between 6 and 18 inches in thickness interbedded with slaty calcareous black shales. One massive bed of dark colored nodular coralline limestone was observed at the extreme east end of the area. This bed was approximately 7 feet in thickness and was overlain by more grey siltsone material. It is unlikely that it has any relationship to Kee Scarp limestone.

Both siltstone and shale beds are remarkably fossiliferous in this area. Most common Martinia meristoides, Hypothyridina castanea, and Reticularia franklini.

The upper portion of the Ft. Creek formation as exposed in the core of Imperial anticline consists of normal, hard, platy, black pyritic shale with occasional dense, hard, grey limestone concretions or thin limestone beds. In the core of Imperial anticline these beds are oxidized to a rusty red color. Approximately 465 feet of these beds are exposed.

The Ft. Creek formation unconformably overlies the Beavertail limestone. Its contact with the overlying Bosworth may be discon formable. It is marked only a sharp change in lithology from hard, platy black shale to the soft grey muddy shales of the basal Bosworth.

Bosworth formation. Devonian

The Bosworth formation consists of three members in the Mackenzie Mountains area. The basal 360 feet consists of very soft, flaky muddy fine grained, grey to black shale with a few small inconspicuous limestone concretion zones. "Cone-in-cone" structures are common in this member. The upper portion of the member is sandy and grades insensibly up into the Bosworth sandstone beds that make up the middle portion of the section..

These shales are considered as a part of the Bosworth formation and not the Ft. Creek because of the sharp lithologic break between them and the Ft. Creek and because of the insensible gradation into the Bosworth sands.

The Bosworth sand series consists of a great thickness of shale and sand beds with a few minor impure limestone beds. The section along the Imperial River - Mackenzie Mountain front measures over 1500

feet in thickness. It is estimated that at least one-third of this is sandstone. Several very persistent thick sand bodies occur in this series.

The sand beds are thin bedded, slabby, relatively fine grained, green, shaly with minor exceptions. The porosity in these sand beds is probably fairly high but because of the shale content the permeability is likely not good. Distributed throughout the whole section are numerous thin intraformational conglomerates indicating shallow water deposition. Almost all intraformational conglomerates carry phosphatic concretions and fragmentary fish remains indicating strand line conditions.

The shale beds are green flaky and distinctly sandy near the base of the formation and become finer grained and darker colored toward the top.

The few minor limestone beds are brown, sandy, and almost without exception fossiliferous. Two distinct coral reefs occur in this series: One Prismatophyllum davidsoni reef occurs near the base of the section. Large blocks of this limestone are scattered along the base of the Norman Scarp along the Mackenzie Mountain front. A second coral reef occurs approximately 600 feet from the top of the member. This is a persistent, very porous, Cyathophylloid coral zone approximately 2 feet in thickness. It is estimated that 50% of this zone consists of fossil corals. The corals are embedded in soft marl. The zone is definitely porous enough to carry oil.

The upper Bosworth member consists of approximately 450 feet of unusually soft, flaky, muddy, black shale with occasional very thin

brown, sandstone and sandy limestone beds. Almost without exception the limestone beds are fossiliferous. Some are made almost entirely of fragmental crinoid remains.

The Bosworth formation thins rapidly toward the north and the sand content becomes less. The middle sandy member measures only slightly over 700 feet in thickness near the mouth of the Imperial River.

The Bosworth formation is unconformably overlain by Cretaceous beds. In all of the Imperial area the basal Cretaceous beds consist of a loose quartz conglomerate and quartz sandstone.

Slater River formation. Cretaceous

The Slater River formation can conveniently be divided into two units in the Imperial River area. For stratigraphic purposes in the field it is possible to recognize several other divisions.

The basal Cretaceous consists mainly of loose, yellow, porous, permeable very rounded, cross bedded, quartz sands. The basal contact is conglomeratic with pebbles mainly of chert and quartz.

This basal sand is overlain by a darker colored muddy quartz sand which grades upward into soft black, flaky pyritic shale. The basal black shale carries discontinuous lignite streaks and one fairly persistent lignite bed. This black shale is overlain by soft, yellow, rounded, cross bedded sandstone followed by black sandy shale. The top of the basal member is slightly over 125 feet in thickness and makes a series of scarps along the area of outcrop.

Closely associated with this basal sand series on the south side of the Imperial syncline but separated from it by approximately 150 feet of soft black sandy shale is another sand series. This sand

series is persistent enough to make a definite series of Scarps along the south side of the Imperial syncline. The long parallel east-west ridges in the Imperial valley about two miles below the gap are capped with these sands. They consist of about 130 feet of soft, yellow to green, fairly porous muddy, thin bedded slabby sandstone beds interbedded with soft black shales.

Large numbers of ironstone concretions are found both in the sands and shales.

The total interval occupied by sands on the south side of the Imperial syncline is slightly over 400 feet. This sand zone thins rapidly to the north and on the north side of the Imperial syncline is not over 150 feet in thickness. In this area the sequence is quite different although the lithologic character remains quite similar. Here the basal sand is about 30 feet thick, is also conglomeratic. It is overlain by about 65 feet of black sandy shale. This is followed by approximately 55 feet of alternating sand and shale beds. It is possible that these are the thinner offshore equivalents of the three zones on the south side of the Imperial syncline. If, however, these are the sands normally deposited in the base of a transgressing sea, such as most of the basal Cretaceous sands are, they may not be anywhere near the time equivalent of the basal sands on the south side of the syncline.

The upper member of the Slater River formation consists of a thick series of soft, black, flaky to muddy, pyritic shales with occasional impure muddy green sand lenses. Limestone and ironstone concretion zones are common in this section. The thickness of this shale series is somewhat over 650 feet. Because of inability to trace definite stratigraphic zones in this member and because of

local changes in dip, accurate measurement of this member is difficult in this area. Thus 650 feet may be considered as a conservative thickness. Two persistent sand zones may be seen near the top of the series.

Little Bear formation. Cretaceous

The base of the Little Bear formation is marked by a very persistent basal sandstone that reaches a maximum thickness of about 60 feet. It consists of massive, hard, tan to green, slightly shaly quartz sandstone. Because of its massive character it outcrops with bold scarps on the river valley and makes a persistent, easily traceable ridge scarp through unglaciated portions of the bush.

Overlying the basal sandstone is a variable series of sands and sandy black shales. Shales predominate in the basal portion of the sections with thin bedded slabby sand beds becoming more and more abundant toward the top. Slightly under 500 feet of these beds are exposed in the area. Since it occurs only in the truncated end of the plunging Imperial syncline the section is obviously incomplete.

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Chapter IV

OIL OCCURRENCES

Reservoir Rocks

Rocks older than the Bear Rock are not considered as possible oil reservoirs because of theabsence of source beds.

The Bear Rock fanglomerate offers possibilities for oil production in the Imperial River area. It is porous, cavernous and definitely permeable throughout the area. Several small limestone caverns were noted in the Bear Rock formation. The lower Ramparts limestone contains considerable black bituminous shale and the limestones are fossiliferous. These beds might be a possible source for oil in the Bear Rock. Whether the porosity of the Bear Rock formation is greatly reduced by calcite filling in the subsurface can be determined only by testing.

The Beavertail-Ramparts formation can be considered as a possible reservoir rock in the area. The Beavertail limestone and upper limestone portion of the Ramparts are both porous enough to hold oil. The overlying Ft. Creek limestone beds are unusually fossiliferous in this area and can be considered as possible source beds.

No Kee Scarp limestone was observed in the area.

The Bosworth Sandstones can be considered as possible oil reservoirs although due to their shaly nature their permeability is likely not high. Unusually large amounts of sand occur in the Bosworth near the Mackenzie Mountains. Fossils are abundantly scattered through a zone approximately 400 feet thick, the top of which is about 250 feet below the top of the sand. This is considered the most likely portion for oil accumulation.

Cretaceous Sands

Both basal Slater River and Little Bear sands are unusually porous and permeable. In deeply buried structures they might make excellent reservoir rocks.

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

Only one structure in the Imperial River area offers any possibilities of petroleum production. Because of closeness of Beavertail-Ramparts reservoir rock to the surface this structure is not considered as very good.

The structure consists of a closed dome on the top of the Imperial anticlinal structure. The highest point of the structure is located in the valley flat of Imperial River about a mile above its junction with the Carcajou River. Ft. Creek shales dip away from this common center at low angles. The amount of closure on the structure can be determined only with difficulty because of rough country on the west side of the river.

The Ft. Creek interval varies between 800 and 1000 feet in thickness at Norman Wells and definitely thins in the direction of the Mackenzie Mountains. Sections are not exposed at the base of the Mackenzie Mountains. Measurement of the Ft. Creek interval by plane table in this area shows that it varies between a maximum of about 600 feet in the area along Lake Florence to a minimum of only 250 feet near the mouth of Frank Canyon. Since slightly over 450 feet of Ft. Creek beds are exposed in the center of the structure, it seems logical to assume that the Beavertail limestone has a minimum cover of at least 300 feet of Ft. Creek shale. It is altogether probable that the cover is greater than this.

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APPENDIX

January 11,1944.

MEMORANDUM:

TO: Dr. T. A. Link.

RE: Fossil Identification.

Attached is a tentative identification of fossils collected by Dr. L. R. Laudon on Assignment No. 18 - Imperial River.

C.R.Stelck.

KH/cm

FOSSIL IDENTIFICATION - IMPERIAL RIVER

Dr. L.R. Laudon

Suite No.	Date	Location	Fossil	Accession No.	Age
1004	July 9	Imperial River Gap	Crinoid column	43705	Bosworth
1004	July 15	Imperial River Gap	Cyathophyllum	43706	Bosworth
1004	July 16	Imperial River Gap	Zaphrentis sp.	43707	Bosworth
1004	July 16	Imperial River Gap	Ostracods	43708	Bosworth
1004	July 16	Imperial River Gap	Cyrtospirifer	43709	Bosworth
1004	July 17	Imperial River Gap	Hypothyridina	43710	Bosworth
1004	July 17	Imperial River Gap	Athyris ?	43711	Bosworth
"	"	"	Cladopora	43712	Bosworth
1005	JJuly 10	Lake Florence	Pectin	43713	Bosworth
1005	July 10	Lake Florence	Pleurotomaria	43714	Bosworth
1005	July 10	Lake Florence	?	43715	Bosworth
1005	July 21	Lake Florence	Cyrtospirifer (flat sulcus)	43716	Bosworth
1006	July 21	Mouth Frank Canyon	Atrypa	43717	Top of Beavertail
1007	July 21	Mouth Frank Canyon	Atrypa and proetus	43718	"
1007	July 21	Mouth Frank Canyon	Schizophoria	43719	"
1007	July 21	Mouth Frank Canyon	Hypothyridina	43720	"
1007	July 21	Mouth Frank Canyon	Reticularia	43721	"
1007	July 22	Mouth Frank Canyon	Zaphrentis	43722	Basal Ft.Creek
1007	July 22	Mouth Frank Canyon	Martinia meristoides	43723	"
1007	July 22	Mouth Frank Canyon	Stropheodonta	43724	"
1007	July 23	Mouth Frank Canyon	Crinoid stem	43725	Bosworth ?
1007	July 23	Mouth Frank Canyon	Schizophoria	43726	"
1007	July 23	Mouth Frank Canyon	Schizophoria	43727	"
1007	July 23	Mouth Frank Canyon	?	43728	"
1007	July 23	Mouth Frank Canyon	Spirifer	43729	"
1007	July 23	Mouth Frank Canyon	Reticularia	43730	"
1007	July 23	Mouth Frank Canyon	Paracyclas	43731	"
1007	July 23	Mouth Frank Canyon	Pleurotomaria	43732	"
1007	July 23	Mouth Frank Canyon	?	43733	"
1007	July 23	Mouth Frank Canyon	Cup Coral	43734	"
1008	July 25		Dawsonoceras	43735	Mt. Ronning
1008	July 25	Mouth Imperial Canyon	Prismatophyllum	43736	Beavertail

PLATE II

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AREAL GEOLOGY

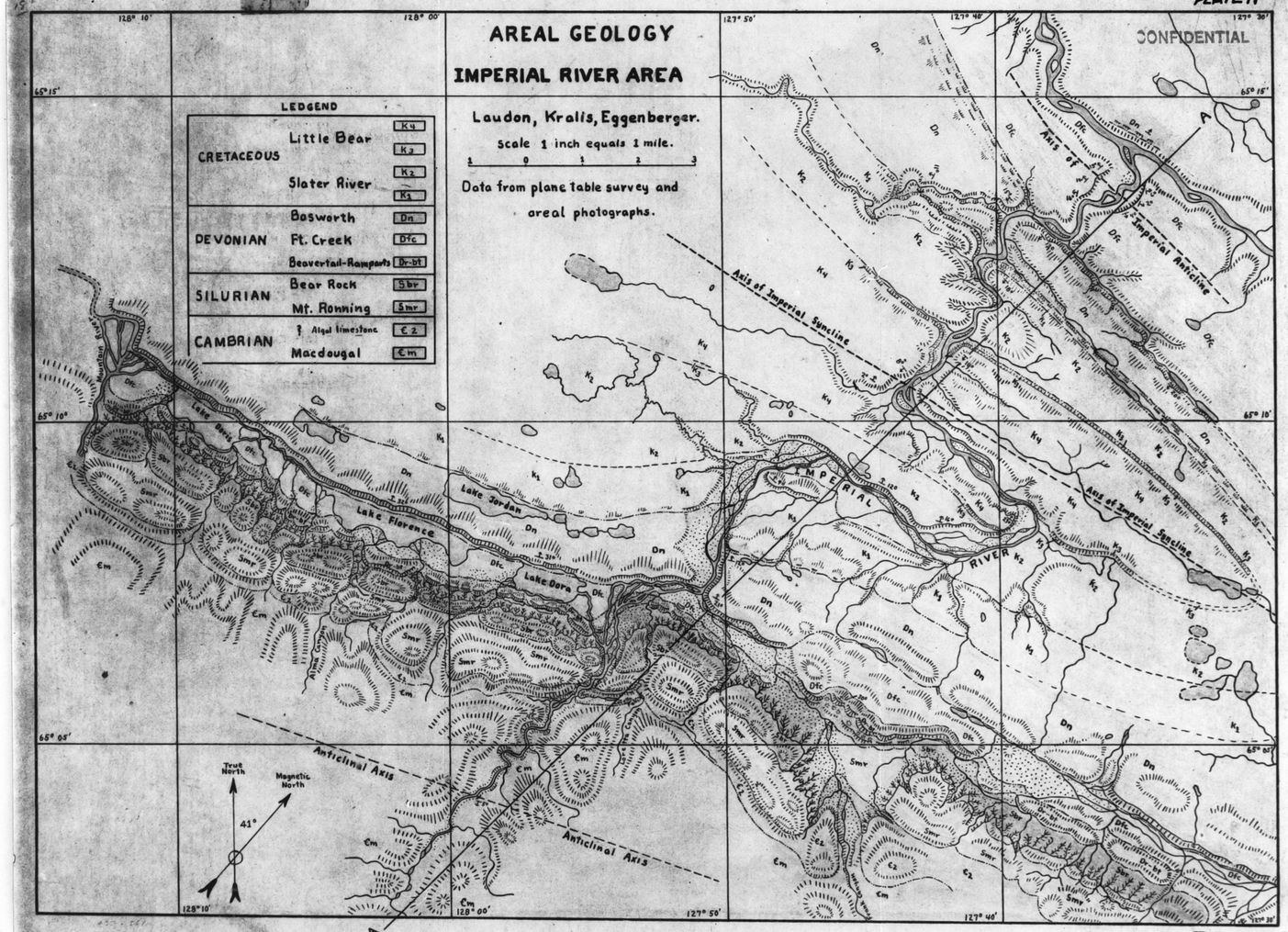
IMPERIAL RIVER AREA

Laudon, Kralis, Eggenberger.

Scale 1 inch equals 1 mile.

1 0 1 2 3

Data from plane table survey and areal photographs.



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West Canadian Graphic Industries Ltd.

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PLATE III

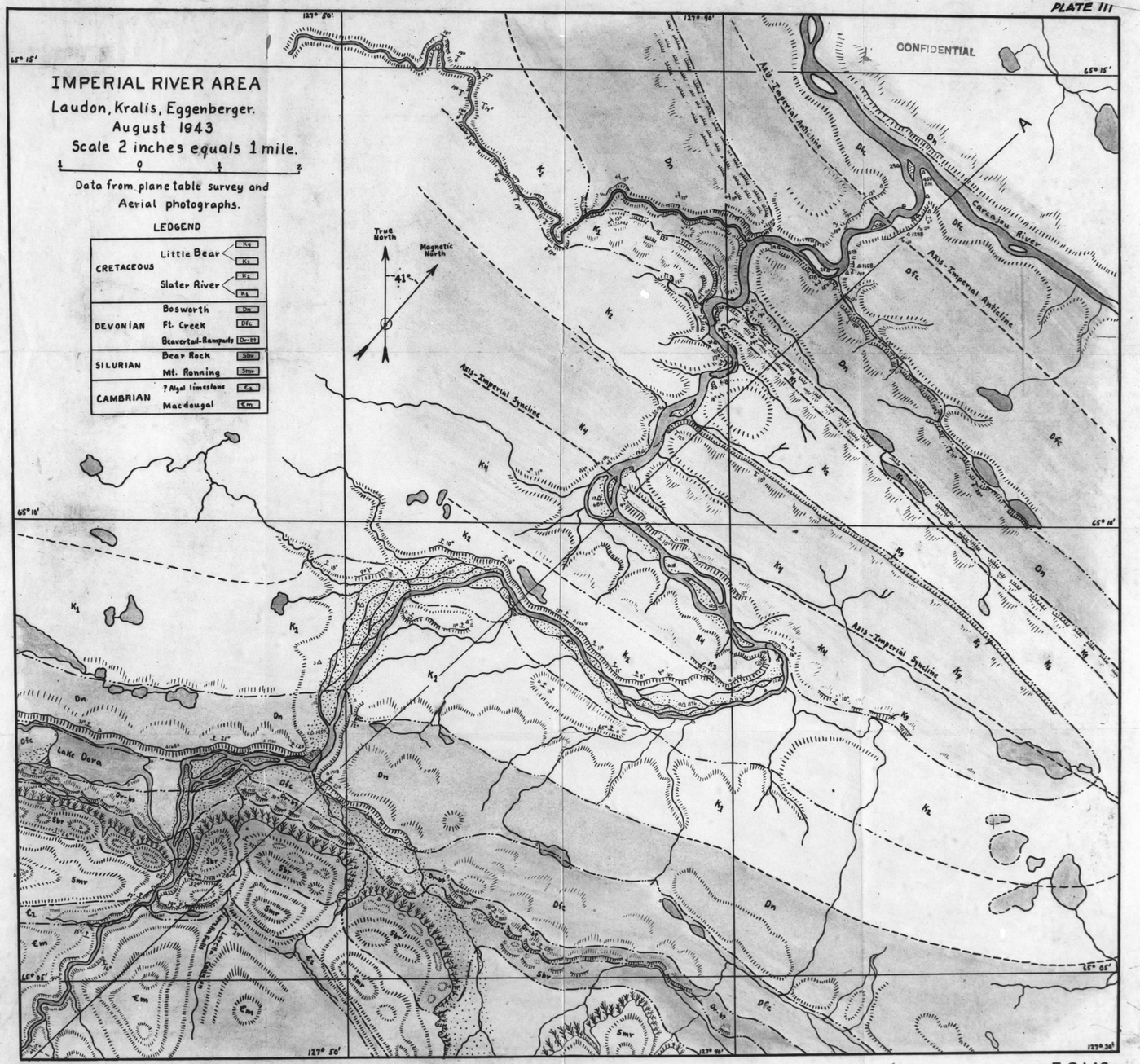

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PLATE IV

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IMPERIAL RIVER AREA.

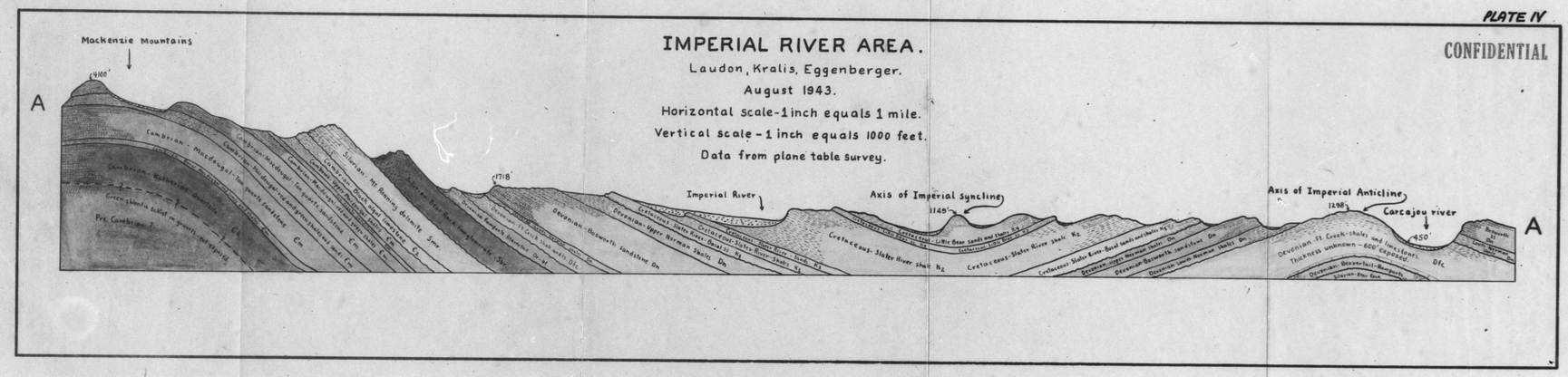
Laudon, Kralis, Eggenberger.

August 1943.

Horizontal scale-1 inch equals 1 mile.

Vertical scale - 1 inch equals 1000 feet.

Data from plane table survey.



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30x

PLATE V

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COMPOSITE COLUMNAR SECTION

IMPERIAL RIVER AREA

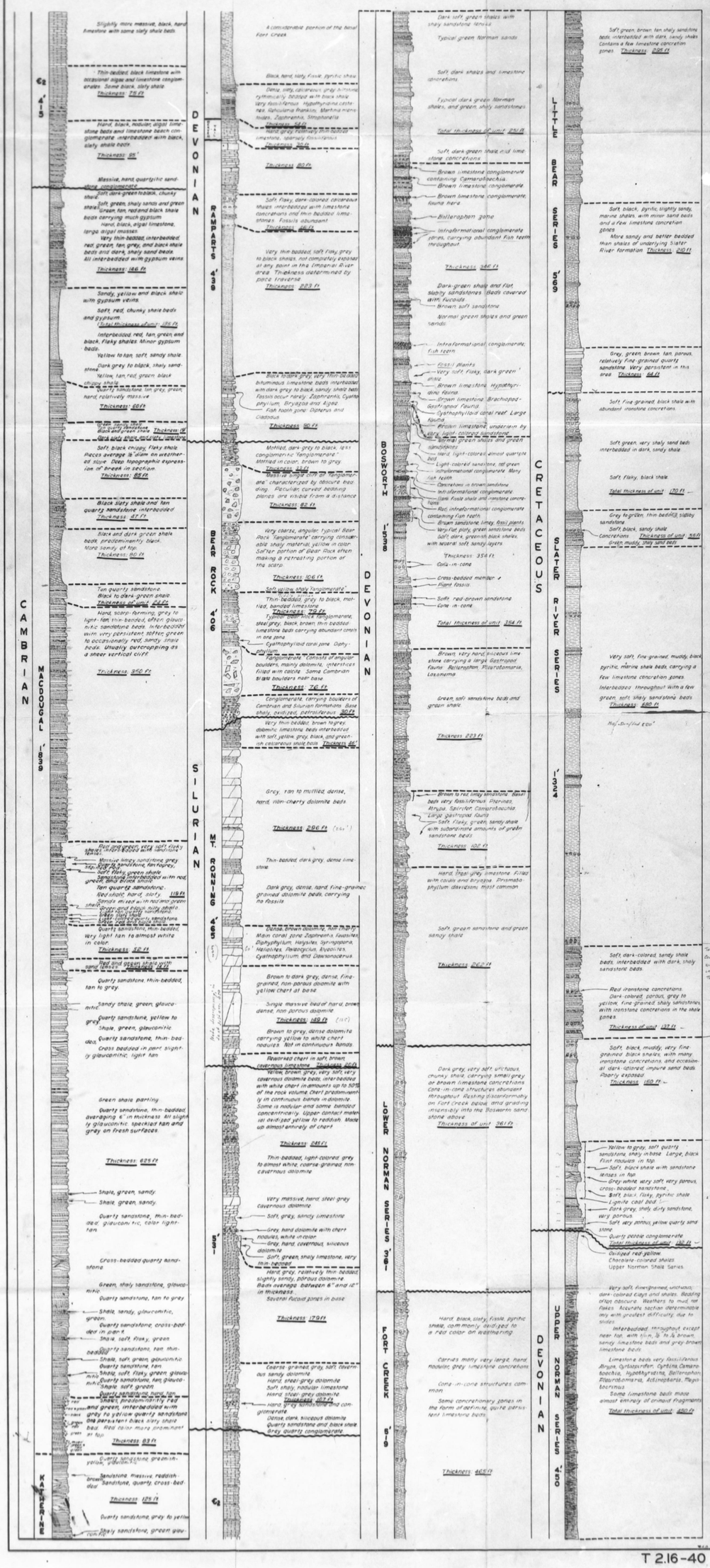
JULY, 1943

ASSIGNMENT 18

PARTY H

Laudon, Kralis, Eggenburger

SCALE: 1" = 50 feet



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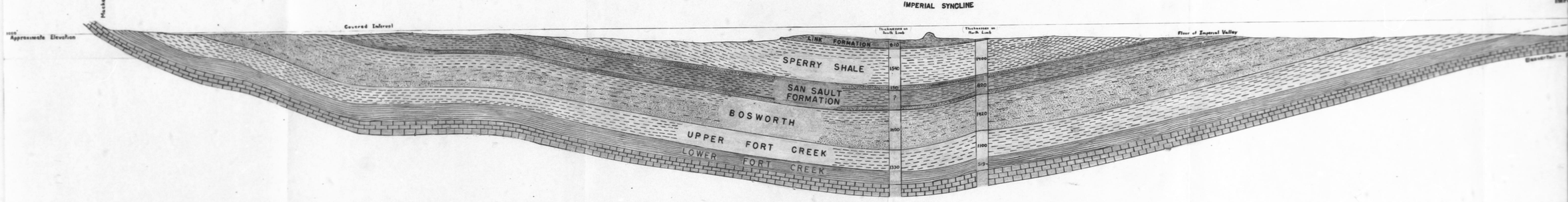
27

CROSS SECTION
of
IMPERIAL SYNCLINE AND ANTICLINE
along Imperial River

Party I Nauss, Parker, Reidford.

Vertical and Horizontal scale 4" = 1 Mile



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West Canadian Graphic Industries Ltd.

PLATE XI

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CROSS SECTION

of

IMPERIAL SYNCLINE AND ANTICLINE

along Imperial River

Party I Nauss, Parker, Reidford.

Vertical and Horizontal scale 4" = 1 Mile