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UNION OIL COMPANY OF CALIFORNIA

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Permits (see letter 28-5-62 from Ottawa)

2834-2840  
2849-2852  
2090-2105 (see memo. 30-4-63)

The Geology of the  
LIARD RIVER AREA

Northwest Territories

Yukon Territory

and

British Columbia

FOR SUMMER SEASON OF 1959

By

W. Blake Brady

Calgary, Alberta  
1960

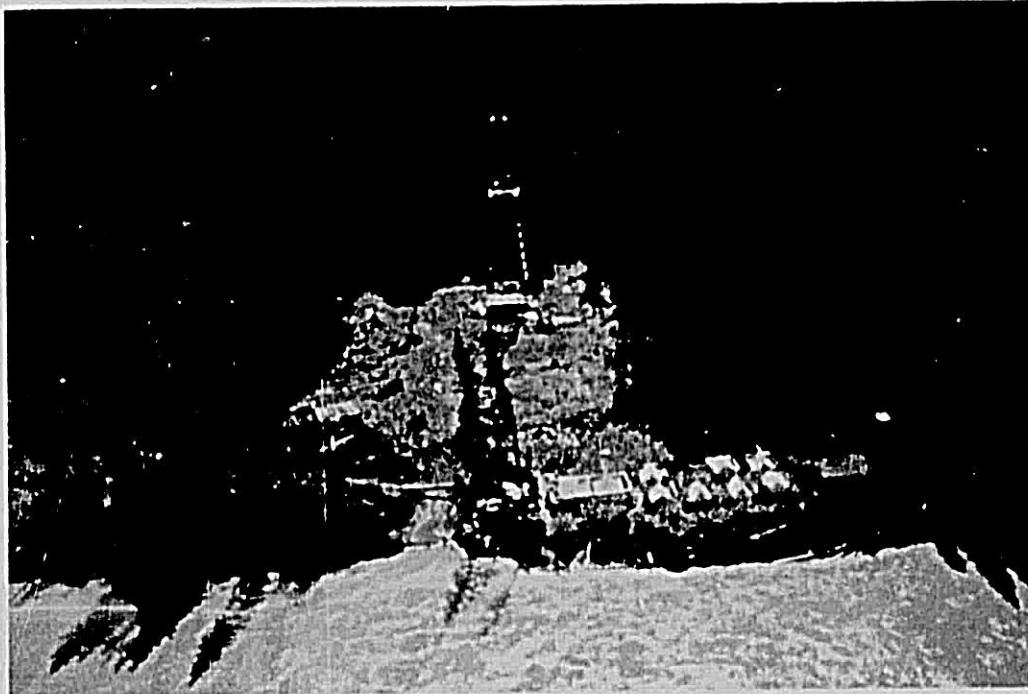
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Frontispiece - Base camp at the abandoned Central  
Leduc Toad River #1 well site on  
the Liard River.

## LIARD RIVER AREA

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### INTRODUCTION

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The area here mapped as the Liard River area is situated northwest of the town of Fort Nelson, British Columbia (Figure 1, Index Map). It includes part of Northeastern British Columbia\*, southeastern Yukon Territory and the southwestern part of the Mackenzie District, Northwest Territories. Of Bostock's (1949) physiographic subdivisions, it embraces part of the Interior Plains, the northern extension of the Rocky Mountain Foothills, and, in part, the Liard Plateau (Figure 2).

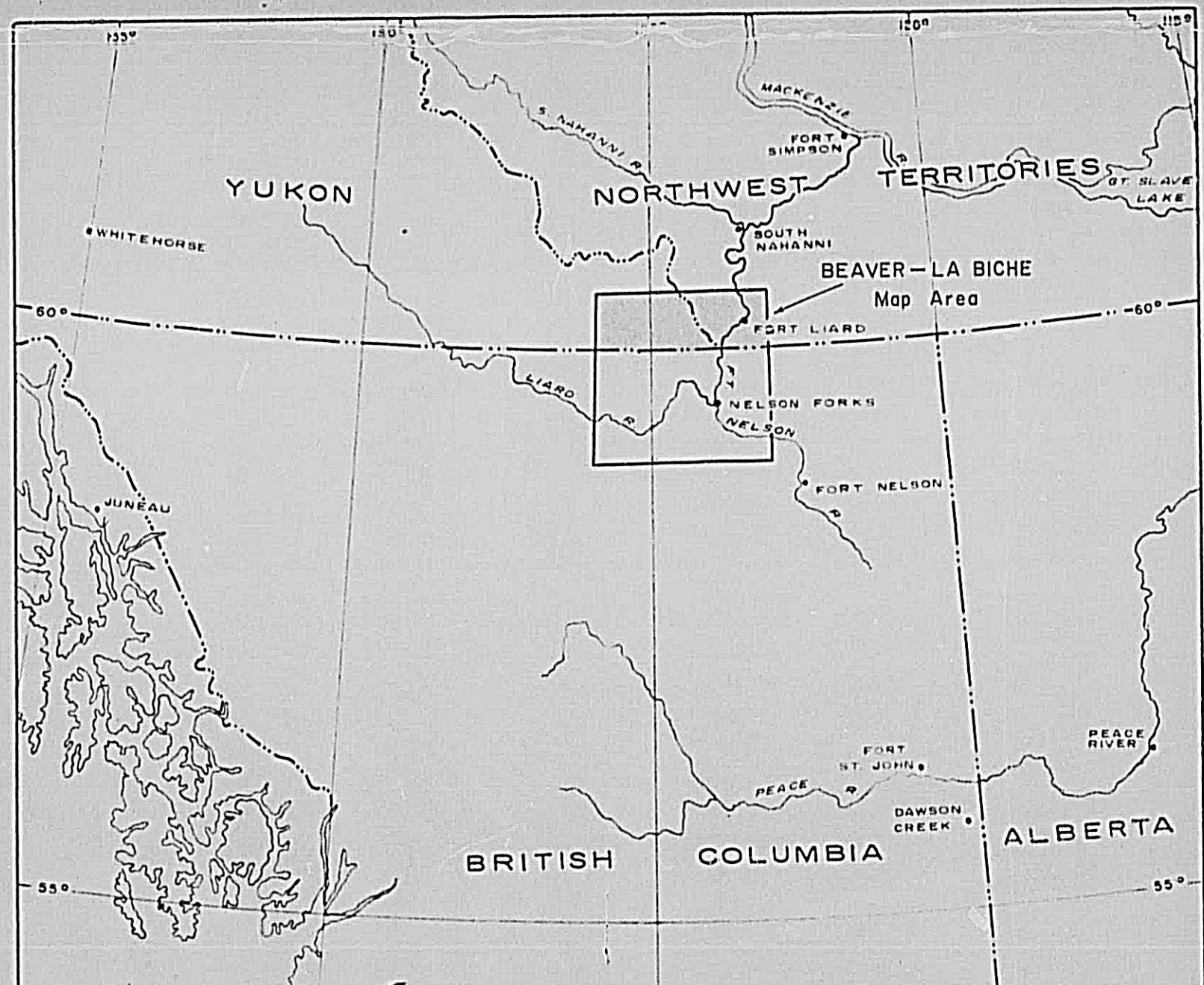
It was proposed to investigate and compare the structural relations of the folded Foothills Belt with those of the Liard Plateau. The structure of the area was therefore mapped in detail with particular references to those structures favourable for the accumulation of hydrocarbons.

Stratigraphic information regarding prospective oil-bearing horizons was also obtained by measuring and describing several sections, including some type sections occurring within the area.

This combination of structural and stratigraphic investigation is essential for a clear understanding of the area.

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\*The northeastern British Columbia portion of the field map is not included in this report, however much of the stratigraphy as discussed applies to this southern portion.



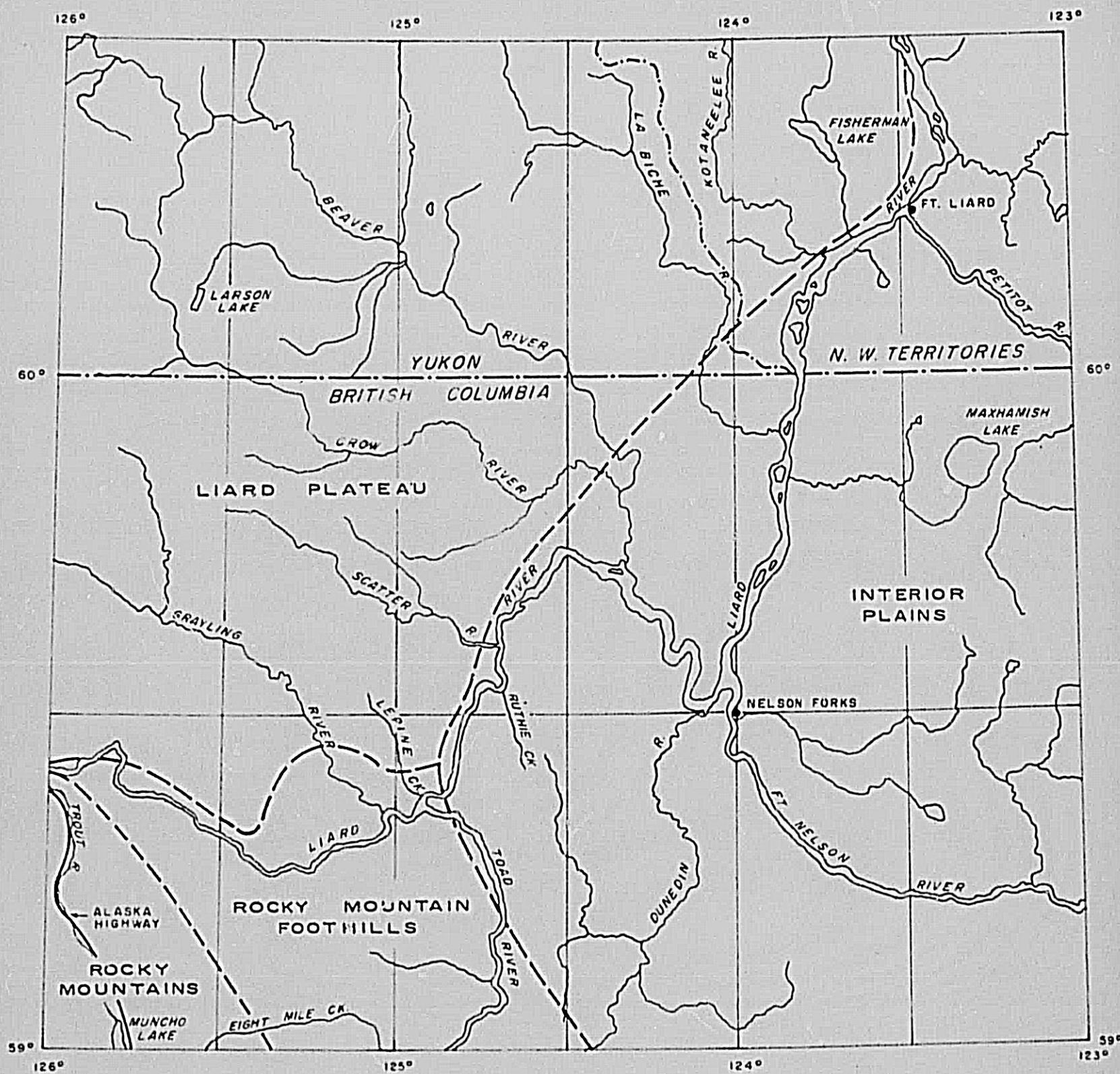
INDEX MAP

Western Canada showing  
location of the Liard  
River map - area.

Scale: 1" = 100 mi.

FIGURE 1





### INDEX MAP

Liard River map - area showing the  
physiographic subdivision after Bostock

## ACCESSIBILITY AND FIELD WORK

---

At the townsite of Fort Nelson, British Columbia, begins an eight hundred and fifty mile route to the north by way of the Fort Nelson, Liard, and Mackenzie Rivers along which supplies and equipment can be moved by barge during the summer months. It is also possible to navigate up the Liard River by barge to Hell Gate, above which rapids and turbulent water make further travel dangerous or impossible.

Equipment can be moved by land only during the winter months when the many tractor trails and seismic roads are sufficiently frozen to support heavy weights.

Field work was commenced during the early part of June, 1959. The first base camp was established at Nelson Forks where supplies had previously been cached by barge. Subsequent base camps were established on the Liard River at the abandoned Toad River #1 well site (see Frontispiece), and lastly at Fantesque Lake in the Yukon. These three base camps were 70, 90, and 120 air miles from Fort Nelson, respectively. Numerous two-man "fly" camps were set out from base camp in order to obtain stratigraphic information. Gasoline caches were made by barge at Nelson Forks, at Fort Liard, and at Nahanni Butte.

A Beaver De Havilland float-equipped aircraft was chartered from Gateway Aviation, Edmonton, Alberta. This plane was used for geological reconnaissance flights over the area, camp moves, gasoline caching, and weekly supply service from Fort Nelson.

A Bell Model G-2 helicopter was chartered from Foothills Aviation, Calgary, Alberta. This craft was used in daily set-outs of two geologists, movement of fly-camps, and for detailed structural mapping including numerous stops for examination of the outcrops and their altitudes.

A 35-foot boat powered by a 35 H.P. outboard motor was used for traverses on the Liard and Toad Rivers. The Beaver River was traversed by canoe downstream from approximately Latitude 126°. Except for a short portage south of Fantasque Lake, this river is navigable for over sixty miles, although low water conditions in July made the trip hazardous.

Operations ceased in the area near the middle of August when the entire party moved north to Little Doctor Lake on the Nahanni Range, N.W.T., for further work in that area.

A goodly portion of the area north and northeast of Fantasque Lake is after Douglas (1959), as time did not permit a detailed examination of this area. This portion of the map area was checked in the office from air photographs, however.

#### ACKNOWLEDGEMENTS

The author wishes to express his sincere thanks to all members of the field party, which included as geologists, Pim Linckens, Ulrich Wissner, Jack Fotheringham, and Reg Griffiths; to Harry Lawrence, cook, and to Al Davis, cook's helper; to Doug Rae and Bill McKinnon, pilot and engineer of the Beaver; and to Frank Croomees and Roy Orcherton, pilot and engineer of the helicopter. Without the full

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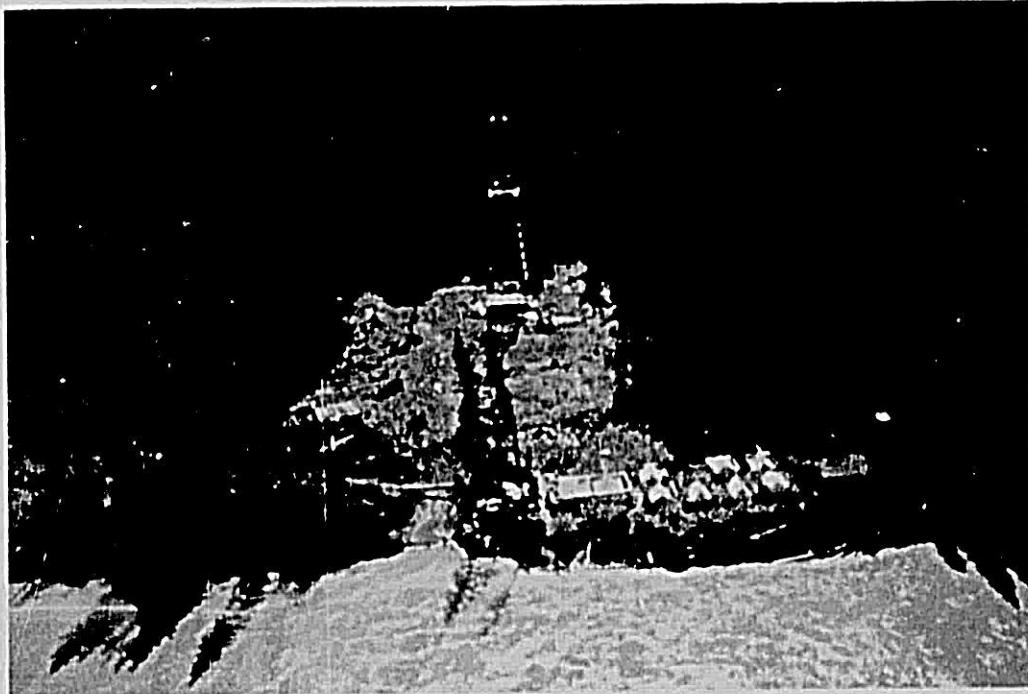
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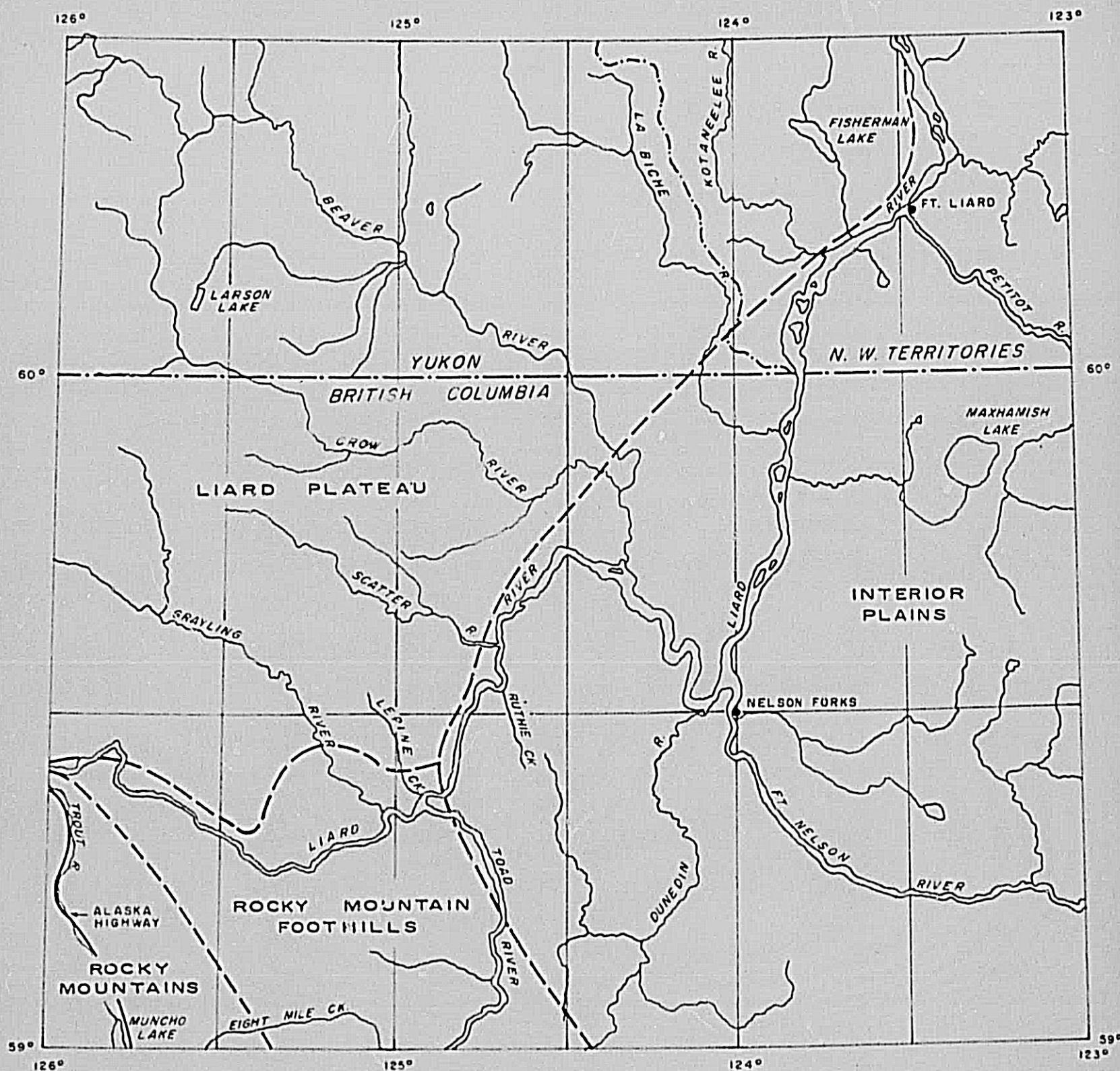
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Thanks are also extended to Mr. H. M. Johnston who supervised and planned the operation, spent several days in the field and by his constructive criticism, contributed much to the completion of this report.

Dr. C. R. Stelck and Dr. P. S. Warren of the University of Alberta made all identification of fossils submitted from the field.

#### PHYSICAL FEATURES

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The physiographic subdivisions (Figure 2), as outlined by Bostock (1943), are used in this report with only minor changes.

The Interior Plains constitutes the eastern one-third of the map area. This in turn may be subdivided into two parts as suggested by Henderson (1950). To the east, is a low-lying area, poorly drained by meandering streams. Heavy forest growth is common except locally where large muskeg areas limit the growth of trees. Outcrops are rare, as most of the area is covered by a thick mantle of glacial drift. The western part of the Interior Plains is characterized in this area by a relatively high plateau composed of gently dipping Cretaceous strata. Locally, relief is in excess of three thousand feet and steep scarp faces are common.

The Rocky Mountain Foothills consists of a northwest trending belt, twenty miles wide, of tightly folded and locally faulted, predominantly Triassic strata (Figure 3). The eastern boundary coincides with the first zone of closely folded strata

west of the Interior Plains. The western boundary is less distinct. In the Summit Lake area, it may be placed at the eastern edge of the first, faulted, mountain-forming Paleozoic carbonates. This boundary, extended north from Summit Lake, lies east of other mountain-forming Paleozoic strata brought to the surface in the cores of large anticlines. Thus, only an arbitrary division can be drawn between the Rocky Mountains and the Rocky Mountain Foothills in the Liard River area.

The Liard Plateau continues the habit of the Rocky Mountain Foothills in following the first distinct folds west of the Interior Plains. The plateau is broken by broad hills, wide valleys, and in the east, by rugged, anticlinal mountain ridges.

Bostock (1948, p. 14) states that the Liard Plateau is wholly underlain by sedimentary rocks in contrast with the Hyland Plateau which contains several intrusions. This summer, however, at least six small basic intrusions and one syenitic body were found in the vicinity of Beaver River, on the Liard Plateau.

## STRATIGRAPHY

### General Statement

The area is underlain by sedimentary rocks, locally in excess of 15,000 feet. These rocks range in age from pre-Upper Ordovician to Upper Cretaceous. The Mesozoic formations consist predominantly of clastics with only rare carbonates. The Paleozoic formations, on the other hand, are dominantly carbonates and minor shales. Sandstones are common, however, in the Carboniferous and as a thin occurrence in the Upper Ordovician.

The following Table of Formations summarizes the lithology and thickness of the stratigraphic sequence found in the Liard River area:

### .. TABLE OF FORMATIONS ..

Era	Period or Epoch	Group, formation (map-unit)	Lithology	Thickness (feet)
MESOZOIC	Upper Cretaceous	Wapiti (23)	Sandstone, coal.	±1,000
		Kotaneelee (27)	Concretionary shale, sandstone, coal.	± 500
		Fort Nelson (26)	Conglomerate, sandstone, shale.	600

...continued

Table formations cont.

Era	Period or Epoch	Group, formation (map-unit)	Lithology	Thickness (feet)
PROTEROZOIC	Lower Cretaceous	GROUP (20)	Sikanni (24)	Concretionary shale, sandstone
			Lepine (22)	Dark grey, concretionary shale.
			Scatter (21)	Fine grained, glauconitic sandstone
			Garbutt (20)	Dark grey, concretionary shale.
	Triassic	TRIASSIC UNDIVIDED (19)	Liard (18)	Medium to coarse grained sandstone, minor siltstone and limestone.
			Toad (17)	Fine grained sandstone, siltstone, mudstone and minor limestone.
			Grayling (16)	Shale, siltstone, mudstone, minor sandstone.
	Permian	Fantasque (15)	Chert and silicified shale.	0 - 150
	Carboniferous and Permian	Mattson (14 and 14a)	Sandstone, minor shale and limestone; (14a - basal resistant sandstone in the western part of map-area).	1,500-3,000
	PALEOZOIC	Map-unit 13	Grey, fossiliferous limestone.	±1,200
		Map-unit 12 (Kindle)	Dark grey, arenaceous limestone, siltstone, shale.	± 500
		"Banff" (11)	Dark grey shale and interbedded limestone (on cross-section only)	±1,000

Table formations cont.

Era	Period or Epoch	Group, formation (map-unit)	Lithology	Thickness (feet)
PALEOZOIC	Mississippian and Upper Devonian	Map-unit 10	Dark bluish-grey shale.	1,000-1,900
	Middle Devonian	Nahanni (8)	Grey, very fine grained limestone; dolomite and crinoidal limestone.	± 800
	MIDDLE DEVONIAN AND OLDER (9)	Map-Unit 7 (Bear Rock-Lone Mtn.)	Dark and light grey banded dolomite.	1,200-3,000
		Map-unit 6	Dark grey, graptolitic shale.	± 500
		Map-unit 5	Dolomitic sandstone and arenaceous dolomite.	0 - 500
		Map-unit 4 (Muncho-McConnell)	Banded dolomite.	300 - 1,700
		Map-unit 3 (Mt. Kindle)	Reefoidal dolomite.	300 - 800
	pre-Upper Ordovician	Map-units (2 and 2a)	Red argillite, sandstone, and shale (2); white sandstone (2a).	± 1,000
		Map-unit 1	Quartzite.	± 800

CRETACEOUS  
(Map-units 20-23)

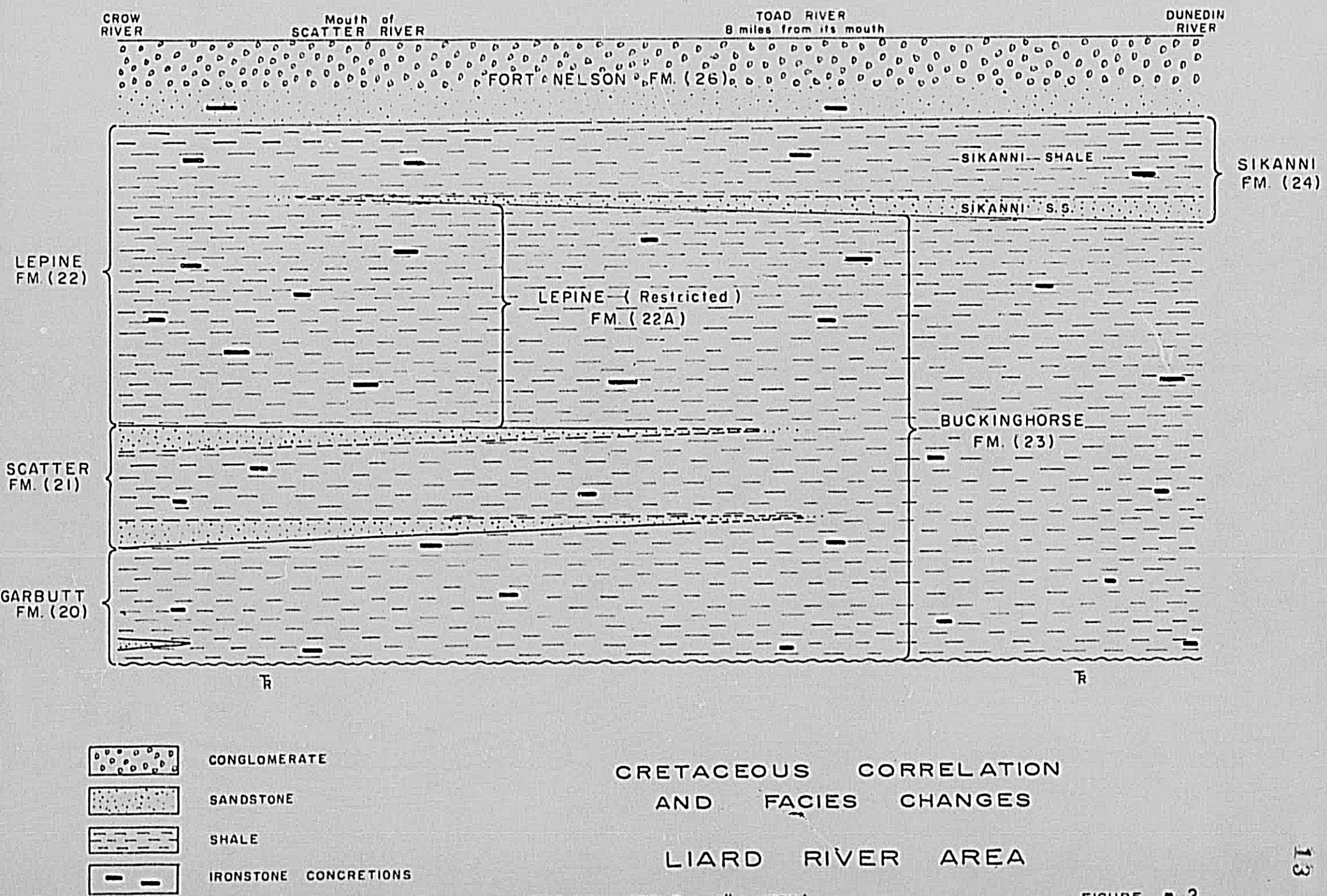
The Cretaceous formations underlie a large portion of the Liard River area. The Cretaceous nomenclature used in the Liard River area was proposed for the most part by Kindle (1944). Type sections occur on, or adjacent to, the Liard River in the vicinity of the Scatter River. The only modifications of Kindle's nomenclature in this report is the restriction of the Lepine formation in areas where the Sikanni formation can be recognized and the addition of 80 feet of strata to the Fort Nelson formation, which were formerly included within the Lepine formation. The Cretaceous correlation and facies changes within the Liard River area are illustrated in Figure 3 and the measured sections are shown on Plate (in pocket).

Wapiti Formation (Map-unit 23)

Locally on hills in the Liard River Valley, Hage (1945) described non-marine beds of sandstone and shale with interbedded, low-grade coal overlying the Kotanelee formation. The sandstones are massive to thin-bedded, banded, medium to coarse grained, buff weathering, feldspathic and calcareous.

No fossils were found in these beds but from their stratigraphic position, they are correlated with the Wapiti formation of Upper Cretaceous age (Douglas, 1959).

This unit was not examined during the present study.



# CRETACEOUS CORRELATION AND FACIES CHANGES

## LIARD RIVER AREA

VERTICAL SCALE : 1" = 1000'

FIGURE 3

### Kotaneelee Formation (Map-unit 27)

The term, Kotaneelee formation, was first used by Hage (1945, p. 21) for 500-1,000 feet of marine shale, sandstone, and locally rare conglomerate overlying the Fort Nelson formation. No type section was designated, although partial sections were examined by Hage on the Petitot and Kotaneelee Rivers.

#### Areal Extent

Within the map area, the Kotaneelee formation is confined to the trough of the Liard syncline. Outcrops, although sparse, were examined on the Dunedin River and at one locality on the Liard River.

#### Lithology

Hage (1945, p. 21) describes the Kotaneelee formation as an "assemblage of marine strata" composed of "dark grey shale, some thin sandstone beds, and a bed of conglomerate", somewhat in excess of five hundred feet.

On the Dunedin River, the writer found non-marine beds near the base of the formation. A brief description of this short section is as follows:

Top of section overlain by glacial drift	Unit Thickness in Feet
Shale, non-calcareous, silvery-grey, abundant long ironstone concretions.....	10
Conglomerate, hard, well rounded sandstone pebbles up to three inches in diameter lying with erosional contact on the underlying unit.....	0.1 - 0.2
Sandstone, light grey, fine grained, massive, porous, forms resistant unit, contains some white kaolinitic (?) grains.....	12

Sandstone, light grey, very fine grained, abundant iron staining.....	3
Shale, non-calcareous, black, breaks into small, smooth chips.....	3.5
Coal, massive, stands out as small ledge, sharp upper contact.....	4.0
<b>Note:</b> The twelve-foot sandstone unit thins to approximately four feet one mile south along the river while the four-foot coal seam remains unchanged.	
Shale or mudstone, grey.....	4.5
Coal, black, thin-bedded, breaks along bedding planes and joint faces. More resistant than adjacent shales.....	1.0
Shale or mudstone, as above.....	5.0
Interbedded medium light grey to brownish-grey, finely laminated sandstone and dark grey, silty shale.....	6.0
Interval to river level covered by shaly talus containing traces of yellow, vitreous amber. There is, however, approximately <u>sixty feet</u> of grey shale to the contact with the underlying Fort Nelson formation.	

Near the mouth of the Dunedin River, the Kotaneelee  
formation, where exposed, consists of a soft, medium grey, micaceous  
shale or mudstone, locally containing ironstone concretions.

Hage (1945) describes a five-foot pebble-conglomerate with  
a sandy shale matrix one hundred and forty feet above the base of the  
formation of the Petitot River.

Soft grey shale similar to that exposed near the mouth of  
the Dunedin River overlie this conglomerate on the Petitot River.  
Linckens observed a similar pebble-conglomerate within the Kotaneelee  
formation on a small creek northeast of Nelson Forks (Figure 6). The  
interval near the base of the formation, equivalent to the non-marine

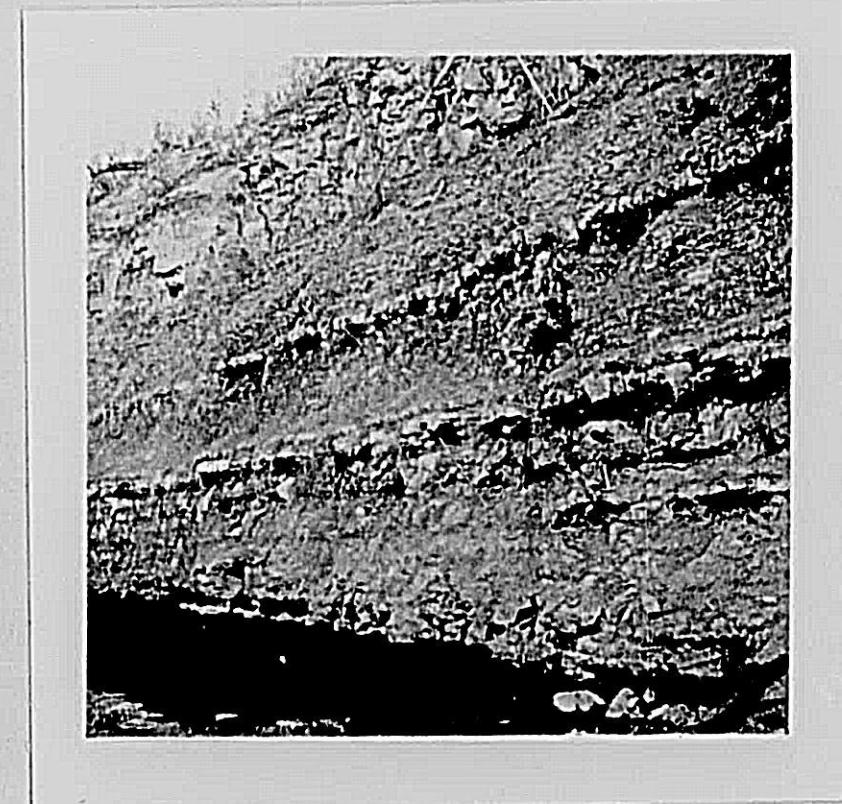


Figure 4

Pebble conglomerate and conglomeratic sandstone with a green shaly matrix occurring in the Kotaneelee formation on a small creek east of Nelson Forks. The hammer rests near the base of the conglomerate unit. This conglomerate is overlain by 20 feet of shale and approximately 10 feet of cliff-forming sandstone.

beds observed by the writer on the Dunedin River, is covered on the Petitot River.

#### Age and Correlation

No fossils were found in the lower one hundred and forty feet of the formation below the conglomerate bed described by Hage. It is suggested that these basal beds, however, may be equivalent to part of the Bighorn and Blackstone formations of the Alberta Foothills. A spore analysis of the coal found on the Dunedin River could possibly substantiate such a correlation.

A Scaphites ventricosus fauna collected by McLearn in northeastern British Columbia indicates a correlation of the Kotaneelee formation with the uppermost part of the Blackstone formation and the lower part of the Wapiabi formation of the Alberta group. An Inoceramus fauna found in the upper part of the Kotaneelee formation correlates with the upper part of the Wapiabi formation (McLearn and Kindle, 1959, p. 106).

#### Fort Nelson Formation (Map-unit 26)

##### Definition

The Fort Nelson formation was named by Kindle (1944) for a sequence of more than six hundred feet of massive to thick-bedded conglomerate, sandstone and minor interbedded shale. Kindle designated the "scarp along the east side of Liard River" as the type section (Figure 5 and 6). This scarp extends from near the mouth of the Toad River to four miles west of the Beaver River, a distance of nearly twenty-five miles. A section measured and



Figure 5

Lower part of the type Fort Nelson formation, opposite the mouth of Scatter River where it consists of alternating sandstone and shale.



Figure 6

Upper part of the Fort Nelson formation showing the massive, resistant, scarp-forming conglomerate beds.

described by Kindle (1944) along this scarp opposite the mouth of the Scatter River is here taken as the type section and was re-examined in part by Linckens and Griffiths.

#### Areal Extent

The Fort Nelson formation is exposed in massive vertical cliffs along the flanks of the Liard syncline (Figure 7). In general, heavy tree growth occurs to the edge of these cliffs, thus limiting exposure to the immediate cliff face. The upper part of the Fort Nelson formation is exposed along narrow gorges on the Dunodin River (Figure 9) for a distance of 25 miles overlain higher on the river banks by the Kotaneelee formation. The Fort Nelson formation is also exposed on the Liard, Beaver, La Biche, Kotaneelee and Fort Nelson Rivers where these rivers cut the flanks of the Liard syncline. This syncline plunges north and the outcrop pattern is lost beneath the glacial drift.

#### Lithology

The lower part of the Fort Nelson formation was examined by Linckens and Griffiths at its type section on the scarp, opposite the mouth of the Scatter River (Figure 5). The section begins sixteen hundred feet above the river where it is underlain by shales of the Lepine formation (Kindle, 1944, p. 14), or as used in this report, by the sandstones and shales of the Sikanni formation (see discussion of the Sikanni formation - this report). This section as described by Linckens and Griffiths is as follows:



Figure 7

West flank of Liard syncline from top of Fort Nelson formation escarpment looking north. Second and lower escarpment (Middle left) is the sandstone member of the Sikanni formation.

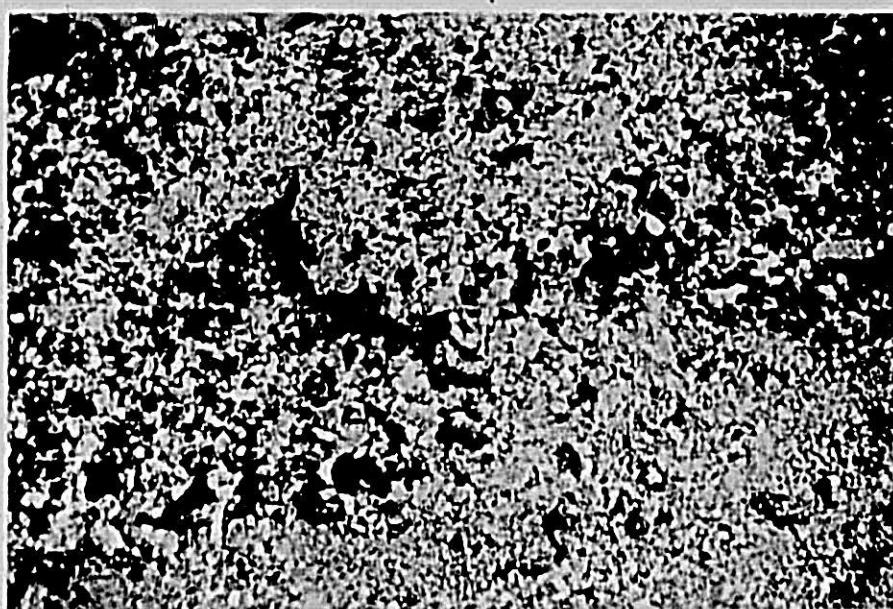


Figure 8

A bedding plane of the Fort Nelson conglomerate. Black chert and quartz pebbles predominate, averaging one inch in diameter.

21  
APR . 60



Figure 9

Resistant beds of the Fort Nelson formation forms a falls on the Dunedin River. The tree covered banks are underlain by the Kotaneelee formation.

Overlying the section described below is 300 feet of conglomerate measured by altimeter and described by Kindle as "conglomerate; clean, well washed beds".

	<u>Unit Thickness</u> <u>in Feet</u>
Shale, silty, grey, contains carbonaceous and micaceous laminae; rare plant remains.....	6
Conglomerate; pebbles mainly chert ranging in size from 1/2 inch to 2 inches; appears quite porous in part.....	19
Sandstone, quartzose, light grey, clean, porous, contains weathered feldspar grains.....	1
Sandstone, quartzose, light grey, clean, porous, contains a few thin conglomeratic beds.....	2
Shale, locally with thin-bedded sandstone especially towards the top.....	37
Sandstone, light to medium grey, medium grained, "salt and pepper", contains ironstone concretions and abundant carbonaceous and argillaceous laminae, cliff-former.....	10
Covered interval; probably consists of soft, dark grey shale.....	16
Sandstone, non-calcareous, light grey, coarse to medium grained, unsorted and locally conglomeratic, cross-bedded, carbonaceous and argillaceous streaks common.....	14
Shale, dark brownish-grey, soft.....	3.5
Sandstone, argillaceous, carbonaceous, fine grained, trace of amber.....	.75
Mostly covered, but probably soft, brownish-grey, micaceous shale.....	14
Sandstone, non-calcareous, light grey, "salt and pepper", unsorted containing pebbles and silt between the sand grains, cross-bedded, cliff-former becoming harder towards the top, worm burrows.....	5

Sandstone, non-calcareous, coarse grained, friable.....	2
Covered interval; probably black shale and friable sandstone.....	36
Coal.....	.3
Sandstone, light to medium grey, coarse to medium grained, "salt and pepper".....	5
Sandstone, "salt and pepper", coarse to medium grained, friable with several hard beds ranging from one inch to one foot in thickness, conglomeratic toward base with chert and ironstone pebbles.....	61
Poorly exposed - consists of very soft shale and friable sandstone.....	36
Sandstone, slightly calcareous, light to medium grey, fine grained, thin bedded, laminated.....	23
Shale, dark grey, soft, a few one-foot sandstone interbeds, poorly exposed.....	35
Sandstone, light grey, fine grained, possibly kaolin in matrix.....	16
This sandstone forms a cliff characterized by very large, round sandstone concretions locally with concentric bedding.	—
	649*

#### Sikanni Formation

Covered interval; probably shale.....	20
Shale, dark grey, soft, blocky with one inch siltstone beds.....	118
Shale, dark grey, fissile, soft, less frequent siltstone beds than above.....	21

\*This thickness, including the added 80 feet of strata is 118 feet  
greater than that measured by Kindle.

The Fort Nelson formation is revised in this report to include 80 feet of interbedded sandstone and shale previously assigned to the Lepine formation by Kindle (1944). Although the Fort Nelson formation is transitional with the underlying unit, the lower contact is better placed at the base of these first sandstone beds which overlie a predominantly shale unit, than it was within the interbedded sandstone and shale unit.

The upper part of the Fort Nelson formation (Figure 6) is a cliff-forming unit three hundred and twenty-five feet thick consisting of massive conglomerate interbedded with coarse grained sandstone. One of the most detailed descriptions of this conglomerate is that by Cook (1950) from the east flank of the Liard River syncline. Quartz and black chert constitutes the predominant pebbles (Figure 10<sup>8</sup>), although Jasper, chalcedony, quartzite, grey and green chert, and argillite pebbles are locally present. Granite and granodiorite pebbles have been reported as rare occurrences by Cook (1950) and by McLearn and Kindle (1950, p. 100). On the whole, the pebbles are sub-rounded to rounded, but may range from sub-angular to well rounded.

Cross-bedding is common in most of the conglomerate and conglomeratic sandstone beds. Locally, where cross-bedding predominates, it is difficult to determine the true bedding altitudes. Lenses and pockets of coarse grained sandstone occurs within, and intergrades laterally with, the coarser conglomerate.

Age and Correlation

To date, no diagnostic fossils have been reported from the Fort Nelson formation. Locally, however, fragmentary plant fossils have been found that resemble fragments from the Dunvegan formation. From its stratigraphic position the Fort Nelson formation may be considered the northern correlative of the Upper Cretaceous Dunvegan formation.

Henderson (1950, p. 36) considered the interbedded sandstone and shale underlying the massive conglomerate to be the equivalent to the Sikanni formation and thus correlates only the upper conglomerate with the Dunvegan formation. This opinion is not held by the present author who by tracing the Sikanni formation north from the Alaska Highway, found it to occur well within the Lepine formation described by Kindle (1944).

Sikanni Formation (Map-unit 24)Definition

The Sikanni formation was named by Hage (1944) from the type locality on the Sikanni Chief River, east of the Alaska Highway bridge. At this locality, the Sikanni formation can be divided into two members. The upper member is about 600 feet thick and is composed predominantly of dark grey shale. The lower unit is 330 feet thick; it is composed of four massive sandstone units, each separated by interbedded shale and siltstone.

Areal Extent

Previously the Sikanni formation was not recognized in the Liard River area (Kindle, 1944; Hage, 1945). However, by tracing

this formation northward from where it is exposed near Steamboat Mountain on the Alaska Highway, the extension of the formational name to this locality was made possible.

The formation was briefly examined in the northeast corner of the Tetsa River map-area, west of Steamboat Mountain by the writer during the summer of 1958. The formation, here, as at its type locality, can be divided into two members (Pelletier, 1959). The lower member contains four "strong" sandstone units which form an escarpment below the main Fort Nelson (Dunvegan) formation escarpment. This lower sandstone escarpment (Figure 5) can easily be traced to the north where it occurs 650 feet below the top of Kindle's Lepine formation. In following this escarpment northward, such a marked thinning of the sandstone was observed, that 3 miles north of the Scatter River, the Sikanni formation no longer served as a mappable unit. An arbitrary cut-off was made at this point, with the strata equivalent to the Sikanni formation included within map-unit 21, which corresponds to the Lepine formation as originally described by Kindle.

Douglas (1959, p. 15) indicates the Sikanni formation to be present in the La Biche and Fort Liard map-areas, which lie north of the British Columbia boundary. He divides the formation into an upper shale member 700 to 1,500 feet thick and a lower sandstone member, 185 to 350 feet thick. If these map-units are actually equivalent to the Sikanni formation to the south, it must be concluded that the sandstone member has lensed out south of

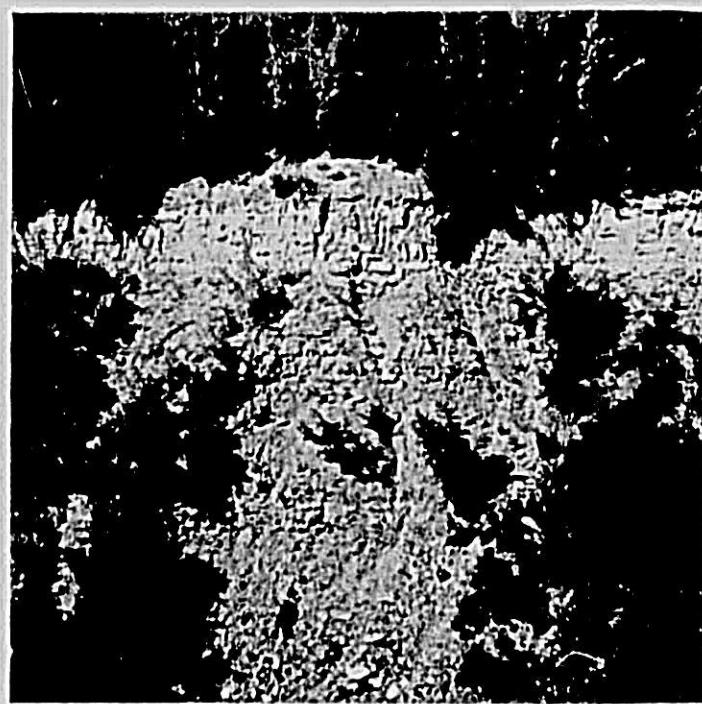


Figure 10

Lower (sandstone) member of the  
Sikanni formation on Ruthie Creek.

Liard River and has reappeared in the area to the northeast. It is the writer's belief, however, that the "glauconitic sandstone" of the Sikanni formation as mapped by Douglas is actually the Scatter formation. This is based on two observations: first, the thinning of the Sikanni sandstone to the north, and second, the absence of glauconite in the laminated, "salt and pepper" sandstone of the Sikanni formation. Until there is conclusive evidence to the contrary, therefore, the Sikanni formation is not extended into the area around Fort Liard.

#### Lithology

Scattered outcrops of the Sikanni formation were examined on the Dunedin River where the lower member is thin-bedded, with fine laminations of "salt and pepper" type, fine grained, non-calcareous sandstone.

On Ruthie Creek, 8 miles south of the Scatter River, a section of the scarp-forming lower member, measured by Linckens and Griffiths, is as follows (see Figure 10):

Overlying beds not exposed.

	<u>Unit Thickness</u> <u>in Feet</u>
Sandstone, non-calcareous, light grey, "salt and pepper", thick-bedded, cross-bedded, laminated, well sorted, weathers light brown, locally iron stained, locally conglomeratic.....	56
Covered interval.....	23
Sandstone, non-calcareous, light grey, "salt and pepper", medium bedded, soft, brownish-grey shale interbedded with the sandstone.....	19

Mainly covered, rare shale exposure.....	35
Sandstone, non-calcareous, light grey, "salt and pepper", medium to thick- bedded, micaceous partings, cliff- former.....	13
Interbedded sandstone and shale.....	4
	159

#### Sikanni Formation

Covered interval.....	170
Sandstone, non-calcareous, light grey, fine to very fine grained, "salt and pepper", thin to medium bedded at top, argilla- ceous partings, some ironstone concretions and carbonaceous material.....	11

Opposite the mouth of the Scatter River, a section examined by Linckens and Griffiths indicates that the lower member of the Sikanni formation has thinned to 43 feet. A brief description of this section is as follows:

Overlying beds - Fort Nelson formation.

	<u>Unit Thickness</u> <u>in Feet</u>
Covered interval, probably shale.....	20
Shale, dark grey, soft, blocky with one inch siltstone beds.....	118
Shale, dark grey, fissile, soft, less frequent siltstone beds than above....	21
Shale, non-calcareous, dark grey, fissile, contains bog iron and sulphur, a few ironstone concretions.....	83
Siltstone or very fine grained sandstone...	10
Shale, non-calcareous, dark grey, fissile, contains bog iron and sulphur, a few ironstone concretions.....	311

Lower Sandstone Member

Sandstone, non-calcareous light grey, fine grained, "salt and pepper" laminated with micaceous and argillaceous partings, ripple marked, carbonaceous plant fragments.....	15
Shale, non-calcareous, dark grey, fissile, contains bog iron, a few ironstone concretions.....	10
Sandstone, as above.....	18
	—
Total thickness of Sikanni formation	611

Lepine Formation

Shale, non-calcareous, dark grey, contains  
bog iron and sulphur, a few ironstone  
concretions.

The finely laminated, "salt and pepper-type" sandstone  
is apparently characteristic of the lower member of the Sikanni  
formation, in contrast to the highly glauconitic sandstone of the  
Scatter formation.

Age and Correlation

Fossils collected by Linckens and Griffiths on Ruthie  
Creek and identified by Dr. Warren and Dr. Stelck indicate an Upper  
Albian or Cenomanian (?) age. This places Map-unit 24 high within  
the Fort St. John group and thus correlative with the Sikanni  
formation at its type locality.

### Lepine Formation (Map-unit 22)

#### Definition

The Lepine formation was named by Kindle (1944, p. 12) for approximately 2,000 feet of grey to black marine shale and minor sandstone. No type section was designated. It may be assumed, however, that the type section is opposite Lepine Creek from which the formation derives its name, although a more complete section is exposed opposite the mouth of the Scatter River.

In the original definition, the Lepine formation included all the strata between the Scatter formation and the Fort Nelson formation. In areas where the Sikanni formation is recognized, the Lepine formation (Map-unit 22a) is herein restricted to include only those strata lying between the Scatter formation and the overlying Sikanni formation. In areas where the Sikanni formation does not constitute a mappable unit, the Lepine formation (Map-unit 22) includes all those strata as originally defined by Kindle.

#### Areal Extent

The Lepine formation crops out in the northeastern part of the map area, along the west limb of the Liard syncline. In the southeastern part of the map-area where the underlying Scatter formation cannot be recognized, the Lepine formation forms the upper part of the Buckinghorse formation.

#### Lithology

The Lepine formation consists predominantly of dark grey shale with only minor interbeds of sandstone and siltstone. Clay ironstone concretions, commonly containing fossils, are characteristic of the formation.

The following section is one described by Kindle (1944) for the Lepine formation opposite the mouth of the Scatter River. Adjacent to this described section are outlined the revisions as used in this report.

<u>Top of Section</u>	<u>Thickness</u> <u>(feet)</u>	<u>Revised section</u> <u>(1959)</u>
Shale, dark, with rusty concretions.....	30	
Sandstone, straw colored, with rusty concretions.....	10	
Shale, dark, with rusty concretions.....	30	
Sandstone, straw colored, with rusty concretions.....	10	Fort Nelson Formation
	-----	-----
*Shale, dark, friable, with rusty concretions.....	110	
*Shale, dark, firm, with concretions	90	
*Shale, friable, grey, breaking in thin flakes, with concretions..	330	Upper Member
	-----	-----
Sandstone and shale, with a few concretions.....	10	FORMATION
Shale, friable, with rust-stained concretions.....	15	FORMATION
Sandstone and shale in alternating beds, with concretions.....	4	Lower Member
Shale, soft, crumbly, with concretions	10	FORMATION
Sandstone in 2 to 6-inch bands; with thin shale partings.....	10	FORMATION
Shale, friable, with concretions....	18	FORMATION
Sandstone, impure, shaly, with concretions.....	2	FORMATION
	-----	-----

\*The thickness of these three units measured by Linckens was 569 feet compared to Kindle's 530 feet.

Shale, dark, with 1 to 2-inch rusty argillite beds at 10 to 20-foot intervals.....	160	
Sandstone and fine conglomerate.....	1	
Shale, dark, rust-flecked, crumbly, with scattered iron-stained concretions and a few 1 to 2-inch beds of argillite.....	820	Lepine Formation (restricted) Map-unit
**Shale, concealed beneath Liard River and drift at mouth of Scatter River, at least.....	340	
	-----	-----
Revised total thickness of the Lepine formation (Map-Unit 22).....	1,644	

#### Age and Correlation

Marine fossils collected by Kindle (1944) were identified as late Lower Cretaceous. These include Gastropites cf. kingi, Inoceramus cadottensis var., I. altifluminis, and 'Placenticeras' liardense.

It was suggested by Kindle (1944) that the Lepine formation was equivalent in part to "the Sikanni formation in the Sikanni Chief district south of Fort Nelson". This correlation was substantiated by the present field work as previously outlined.

\*\*Kindle's lower 340-foot covered interval has been increased to 660 feet by scaling the distance from an air photo assuming a constant dip of ten degrees to the east.

### Scatter Formation (Map-unit 21)

#### Definition

The Scatter formation was first used by Kindle (1944). The type section is on the Scatter River (Figure 11) one and one-half miles west of its confluence with the Liard River.

#### Areal Extent

The Scatter formation can be recognized along a belt extending from north of the Beaver River to approximately ten miles south of the mouth of the Toad River. From its type section on the Scatter River, the formation rises abruptly to the west to form steep cliffs up to 1,000 feet above the valley floor (Figure 13).

Immediately north of the Scatter River, the formation forms its widest outcrop, a distance of more than ten miles. The Scatter formation is also exposed to the northeast where it flanks the Kotaneelee anticline and the Liard syncline.

#### Lithology

Essentially the Scatter formation consists of two sandstone units separated by a middle shale unit (Figure 11 and 13). The sandstone is quartzose, fine to very fine grained, greenish-grey, finely cross-bedded and characteristically glauconitic.

Linckens and Griffiths measured and described a section originally studied by Kindle, (there are several dissimilarities in the character and thickness of units as presented in the two descriptions):

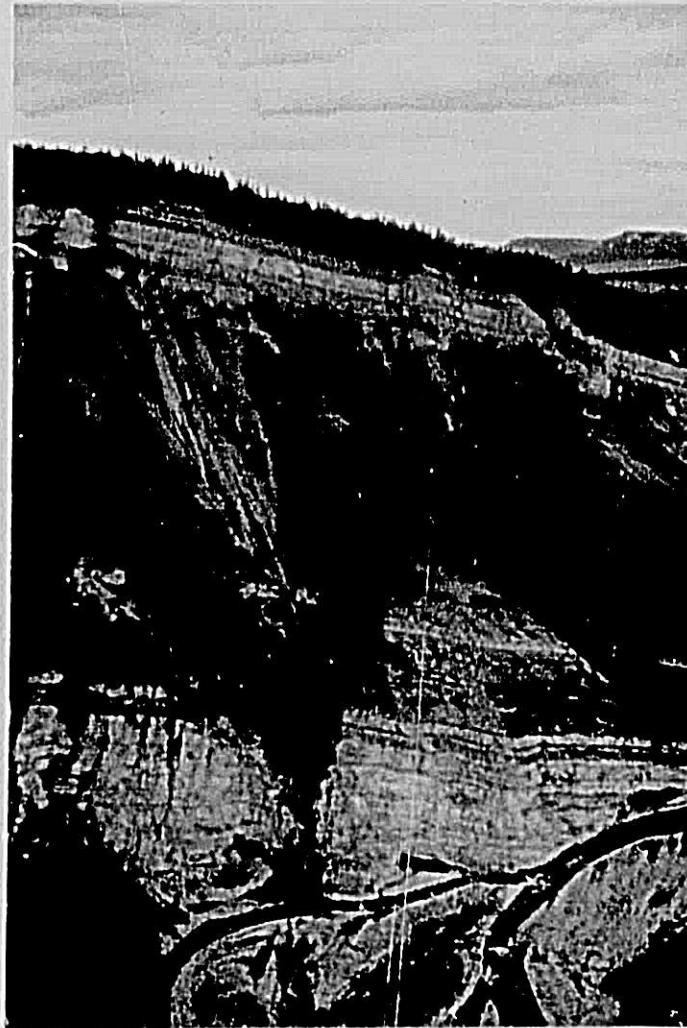


Figure 11

Type Scatter formation,  $1\frac{1}{2}$  miles west of the mouth of the Scatter River. The formation consists essentially of an upper and lower sandstone unit and a middle shale unit. The scarp-forming Fort Nelson formation can be seen on the upper right.



Figure 12

Scatter formation on the Liard River, south of the type section looking north. The beds dip to the right crossing the river to form the Scatter River monocline.



Figure 13

Scarp-forming Scatter formation along the Scatter River.

Kindle.

<u>Unit</u>	<u>Description</u>	<u>Thickness</u>
K-1	Sandstone and shale.	100
K-2	Shale, black.	200
K-3	Sandstone and shale.	250
K-4	Shale.	125
K-5	Sandstone.	<u>75</u>
		750

Linckens and Griffiths

L-1	Sandstone with minor shale.	109
L-2	Shale, dark grey to black.	482
L-3	Sandstone and shale.	159
L-4	Sandstone, thick to medium bedded.	100
L-5	Sandstone, thin to medium bedded.	<u>111</u>
		961

It is readily apparent that Unit L-1 corresponds to Unit K-1, L-2 to K-2, and a combine L-3 and L-4 to K-3. The major difference here is the increased thickness of Unit L-2 over Unit K-2. The thickness as measured by Linckens and Griffiths compares more favourably with the corresponding shale unit of the Scatter formation on the Toad River.

Below Units L-4 and K-3 much discrepancy arises, all of which cannot be accounted for by different methods of measuring. It is possible that part of the difficulty may be due to the non-recognition of large blocks slumped from adjacent cliffs and which appear to be "in situ" at river level.

Another section of the Scatter formation was measured by Wissner and Fotheringham on the Toad River, and summarized as follows:

<u>Unit</u>	<u>Description</u>	<u>Thickness (feet)</u>
1	Shale, dark grey, fissile, soft, concretions.	200
2	Shale, dark bluish-grey to grey, chunky, hard concretions.	360
<u>Scatter Formation</u>		
3	Sandstone, medium grey, very fine grained, glauconitic, resistant.	57
4	Shale, dark bluish-grey, locally silty concretions.	500
5	Sandstone, medium grey, very fine grained to fine grained, cliff-former, concretions.	50 <sup>+</sup>
Underlying beds not exposed.		

Wissner and Fotheringham would place Unit 2 within the Scatter formation, believing it to be lithologically more related to the underlying units than to the overlying shale of the Lepine formation. As a structural map unit, however, the formation contact should be drawn at the top of Unit 3, a resistant sandstone unit. This coincides with the contact at the type section, where, however, the overlying 660 feet is covered and thus possibly includes the equivalent of Unit 2.

#### Age and Correlation

Fossils collected from the Scatter formation indicate a late Lower Cretaceous age (Kindle, 1944). This fauna includes Inoceramus cadottensis, some of which were collected on the Toad River during the past summer. Other fossils include Gastropides liardensis, G. canadensis, and Bentantoceras sp.

With the thinning of both the upper and lower sandstone units, the Scatter formation no longer constitutes a mappable unit and an arbitrary cut-off was made at a point 8 miles south of the mouth of the Toad River. From this point southward, the Buckinghorse formation is used for the stratigraphic interval of the combined Garbutt, Scatter, and Lepine formations. Beds equivalent to the Scatter formation are present as a silty horizon within the Buckinghorse formation south of the Alaska Highway (H. Johnston, personal communication). This horizon also carries an Inoceramus cadottensis fauna.

#### Garbutt Formation (Map-unit 20)

##### Definition

The Garbutt formation, at its type section on Garbutt Creek, 14 miles south of the Scatter River, was first named and described by Kindle (1944). The Garbutt formation is underlain in this area by Triassic beds, or, depending on the amount of pre-Cretaceous erosion, by Paleozoic strata.

##### Areal Extent

The Garbutt formation is preserved in the troughs of many of the synclines within the highly folded Triassic belt, west of the Liard syncline. It is also exposed along much of the Scatter River gorge and to the north on the flanks of the Beaver River Basin and the Kotaneelee anticline.

##### Lithology

The Garbutt formation consists predominantly of black to dark grey, fissile shale, locally containing abundant ironstone concretions.

On the Scatter River (Figure 16), the Garbutt formation is 900 feet thick, measured from the top of the Triassic Toad formation to the base of the Scatter formation. Towards the northern part of the map-area, a quartzose, glauconitic sandstone develops about 150 feet above the base.

#### Age and Correlation

No fossils have been found in the Garbutt formation. However, on the basis of lithology and stratigraphic position, the Garbutt formation equates with the lower part of the Buckinghorse formation of Lower Cretaceous age. Thin beds of bentonite occurs in the lower part of the formation at Mile 375 on the Alaska Highway. It has been suggested that these beds correlate with similar bentonite beds in the lower part of the Buckinghorse formation at its type section.

#### Buckinghorse Formation (Map-unit 23)

- and -

#### Fort St. John Group (Map-unit 25)

The Buckinghorse formation was first named by Hage (1944) for 3,000 to 3,500 feet of dark grey marine shales on the Buckinghorse River. As previously mentioned, it is the equivalent of the Garbutt, Scatter and Lepine formations in areas where the Scatter formation is not mappable. Within the map-area, it occurs, although rarely exposed, in a belt 4 to 10 miles wide on the west flank of the Liard syncline, overlain by the Sikanni formation and underlain by sandstone and siltstone of the Triassic.

East of the Liard syncline, the Buckinghorse and Sikanni formations are mapped as undivided Fort St. John group (Map-unit 25).

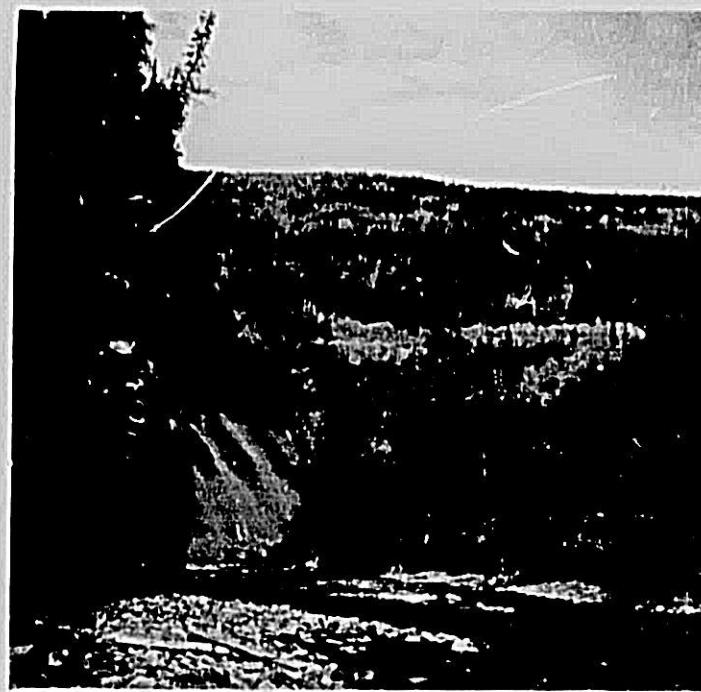


Figure 14

Siltstones of the Toad formation in the foreground on the Scatter River overlain by shales of the Garbutt formation. The hill in the background is capped by the Scatter formation.

42

### Triassic

#### General Statement

The Triassic strata form a continuous sequence of predominantly clastic sediments, divisible into three units, which are in ascending order, the Grayling, Toad and Liard formations. Transitional contacts make it difficult to recognize exact boundaries under the best of conditions. Considering the high percentage of tree cover in the area and the scarcity of outcrop, formation boundaries can only be placed arbitrarily.

A pre-Lower Cretaceous unconformity has progressively stripped the higher formations to the east and northeast. Thus on the west side of the Toad anticline, the Liard formation underlies the Cretaceous, whereas on the east flank (Figure 12), the Liard formation is absent and the Toad formation underlies the Cretaceous.

Immediately west of the Toad River anticline, a northwest trending belt of Triassic sediments is present. This belt is characterized by tightly folded, doubly plunging anticlines and synclines easily detected on a detailed topographic map by a northwest alignment of hills and valleys, (Figure 15). Locally, black Cretaceous shale crops out in the synclines. This belt extends to the Liard River where it forms the rapids of Hell and Hades Gates (Figure 16). Similarly folded strata extends twelve miles north of the river where there occurs a general change in alignment from northwest to north. Another belt of Triassic strata occurs west of this highly folded belt, i.e., between Sulphur Creek and Eight Mile Creek. Topo-



Figure 15

View of the Rocky Mountain Foothills belt looking south. The plunging anticline on the right is capped by the Liard formation. A minor east-dipping fault in the center of the picture thrusts the Triassic Toad formation over the Cretaceous Garbutt formation.

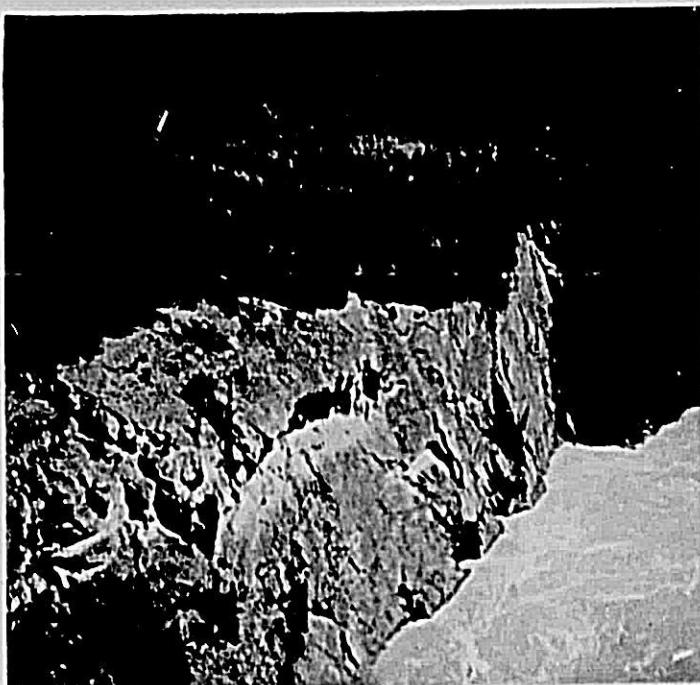


Figure 16

Steeply-dipping beds of the Liard formation on the Liard River. Covered interval on the right is underlain by the Cretaceous Garbutt formation.

graphically, this belt differs from the one to the east, in that, the elongated hills representing anticlines, so characteristic to the east, are lacking here. In contrast, the mountains are more rugged with peaks over 6,500 feet in elevation. The three-fold formational division of the Triassic is more difficult to apply in this westerly belt and as it was not studied in detail, it is indicated on the map as "Triassic undivided" or Map-unit 19. Faunal evidence indicates the presence of strata younger than the Liard formation at its type locality.

It is not the purpose of this report to subdivide stratigraphically and faunally the Triassic strata of northeastern British Columbia. Differing opinions arose during the summer as to where formation boundaries should be placed lithologically, and in many cases, the contact did not agree with faunal evidence. A more detailed study of the Triassic formations is necessary, combining a careful fauna collection and lithologic description. Two such projects along this line are now being carried out by the Geological Survey of Canada with field work by Pelletier, and a Triassic fossil monograph by McLearn.

#### Liard Formation (Map-unit 18)

##### Definition

The beds of the Liard formation were first included by Kindle (1944) in the Toad formation. Later in an appendix to a paper by McLearn (1943), he designated the higher, massive arenaceous beds as the Liard formation, restricting the Toad formation to the

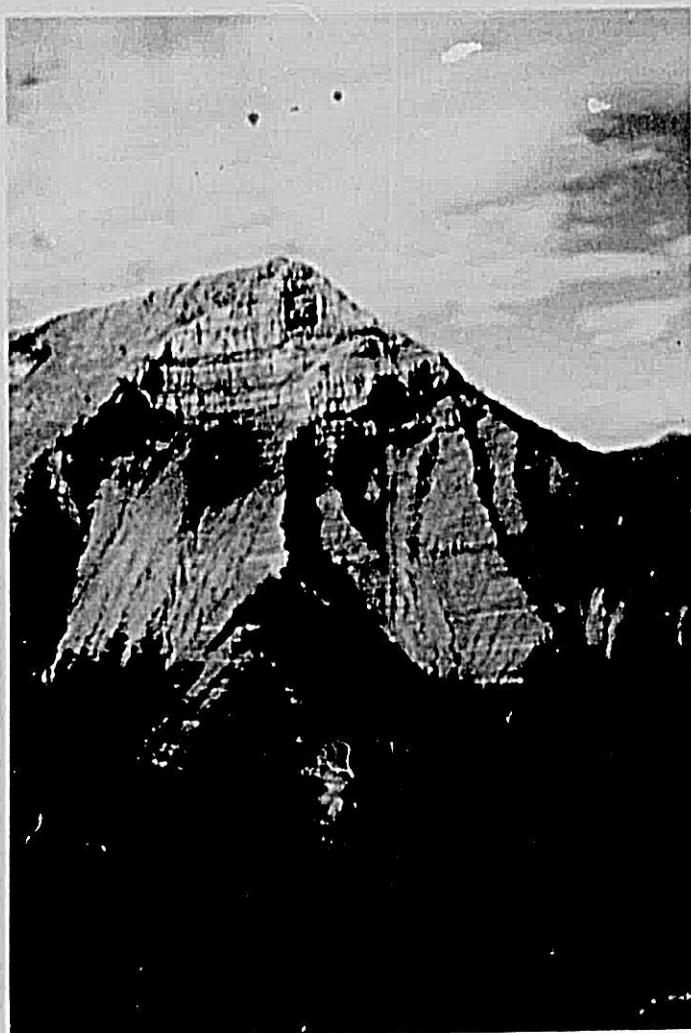


Figure 17

Massive pale brown weathering cliffs of the Liard formation underlain by dark grey weathering Toad formation.

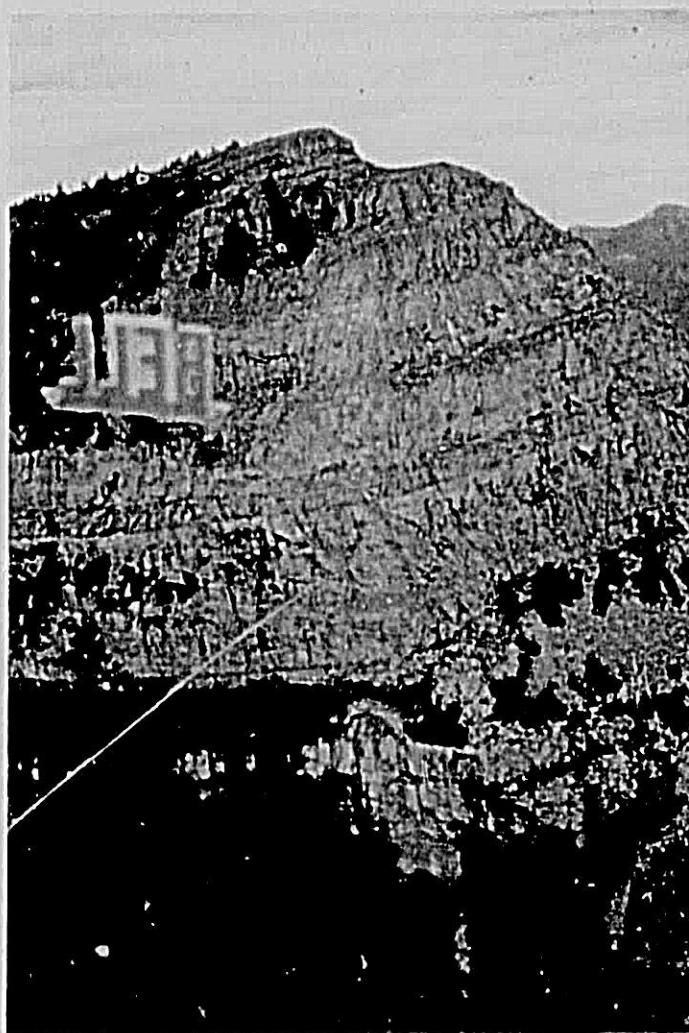


Figure 18

Close-up view of Liard formation as shown in Figure 13. Note transitional contact between the predominant sandstone of the Liard formation and the underlying dark-colored siltstone of the Toad formation.

underlying, more thin-bedded and finer grained strata. The type section is near Hell Gate on the Liard River.

#### Areal Extent

The Liard formation, being a resistant unit, caps the anticlinal hills of the highly folded Triassic belt (Figure 15 and 17). Due to post-Triassic erosion, the formation is absent on the east flank of the Toad River anticline. Because of heavy tree cover, it is generally impossible to place the exact erosional edge of the formation.

#### Lithology

The Liard formation has been described by Kindle and McLearn (1948) as 600 feet of predominantly thick-bedded to massive, grey to brown, calcareous sandstone, locally interbedded with limestone and shale. It is characteristically greyish-brown to brown weathering in contrast to the dark grey to black weathering Toad formation (Figure 17). The characteristic weathering, combined with the coarser grained, more resistant sandstones of the Liard formation as compared to the Toad formation, makes the Liard formation a suitable map-unit in the foothills of this area.

The Liard formation thickens rapidly towards the west, as the result of eastward truncation by a post-Triassic unconformity and by possible facies changes occurring between the Liard and underlying Toad formation. The thickest section occurs in the southwest part of the map area (Lat.  $59^{\circ} 05'$ , Long.  $125^{\circ} 20'$ ) where 1,300 feet was measured. This section includes beds younger than the type Liard formation, possibly equivalent to the "Gray beds", or even the Pardonet formation (T. Tozer, personal communication).

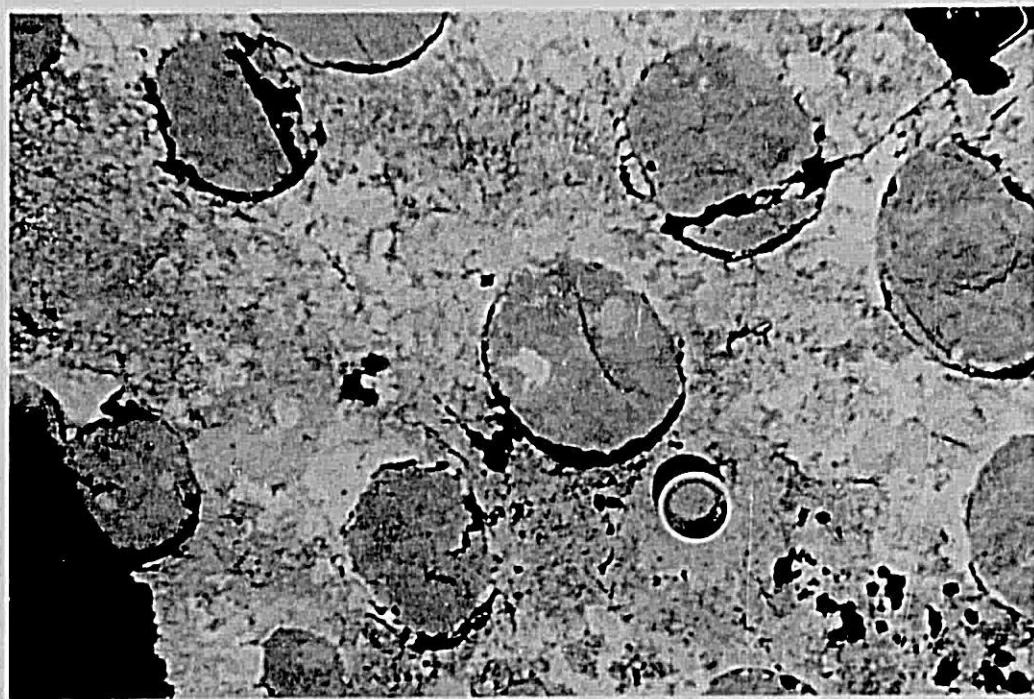


Figure 19

These rounded, calcareous concretions form a distinctive horizon within the Liard formation.

Rounded, calcareous concretions (Figure 19) occur within the Liard formation, ranging from one inch to more than six inches in diameter. Previous work by Pelletier (1959) and the writer in the Tetsa River area indicate this concretionary zone to be widespread in the Liard formation.

#### Age and Correlation

The "Nathorstites" fauna ranges throughout the Liard formation at its type locality. On this basis, Kindle tentatively places the Liard formation as late Middle Triassic.

### Toad Formation

#### Definition

The Toad formation was named by Kindle (1944) and redefined by him in 1946. The type section is on the Liard River near the mouth of the Toad River on the east flank of the Toad anticline, where it is about 800 feet thick. A more complete section is present 8 miles west, on the Liard River.

#### Areal Extent

The Toad formation is present throughout the Foothills Belt where it is overlain by the Liard formation. In the tightly folded area, the Toad formation commonly only crops out in the core of anticlines where they have been cut by antecedent streams. In areas of broad uplift and where the Liard formation has been removed by erosion, the Toad formation tends to foster tree growth resulting in little or no outcrop.

#### Lithology

The Toad formation consists predominantly of dark grey to black, calcareous siltstone, interbedded dark grey shale and

locally minor argillaceous sandstone and argillaceous limestone.

The contacts with the underlying Grayling formation and overlying Liard formation are gradational and due to facies changes may shift either stratigraphically higher or lower within the section.

At the type section, the Toad formation is only 800 feet thick, although here, the upper part has been removed below the unconformity. Eight miles to the west, Kindle reports the Toad formation to be 1,800 feet thick. The thickest observed section occurs on a high mountain south of the Liard River (Lat.  $59^{\circ} 05'$ , Long.  $125^{\circ} 20'$ ), where more than 2,200 feet was measured by Linckens and Griffiths (Figure 23). At this locality, the upper contact was arbitrarily placed where the sandstone becomes predominant over the underlying siltstone and shale.

On the Crow River, twenty feet of thin to medium bedded, grey, fine grained sandstone is present at the base of the Toad formation. Ripple marks and small scale cross-bedding are common. This sandstone is much "cleaner" than any seen in the Triassic elsewhere in the Liard River area. Had it not been for the presence of the poorly preserved ammonites "cf. Xenocerasites", this sandstone would have been included in the Grayling formation.

#### Age and Correlation

The Toad formation ranges in age from Lower Triassic represented by a Wasatchites fauna, to Middle Triassic represented by a Beyrichites-Gymnatoxeras fauna.

Fossils collected by Pelletier and the writer in 1958, and by Wisaner and Fotheringham during the past season, may represent



Figure 20

Thick Triassic section on high mountain in southwestern part of map-area. Note lack of distinctive break between Toad and Liard formations as indicated in Figures 13 and 14.



Figure 21

Predominantly siltstone and sandstone with alternating resistant and recessive units.

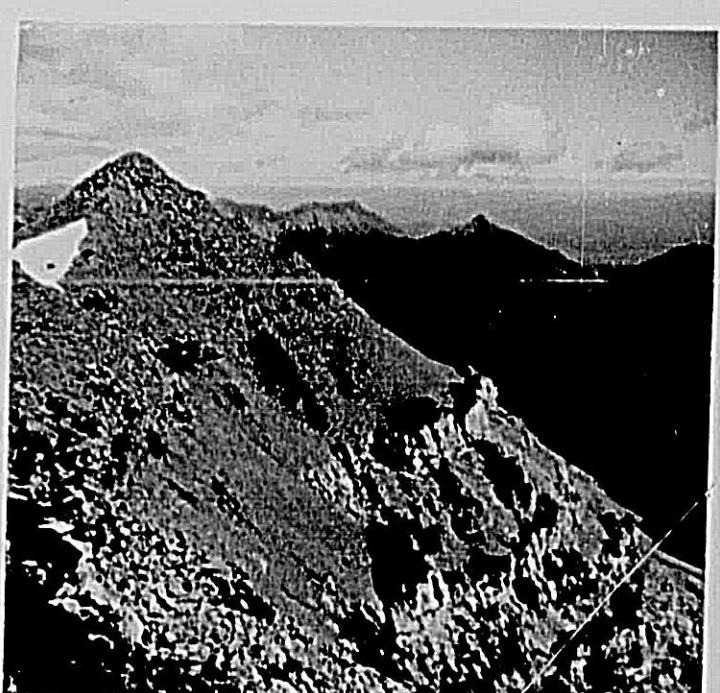


Figure 22

Top of mountain shown in Figure 20 capped by beds possibly younger than the type Liard formation.

a hitherto unknown fauna zone. Until McLearn's monograph is published, a detailed fauna correlation will not be attempted.

### Grayling Formation

#### Definition

The Grayling formation was proposed by Kindle (1944) for the Triassic shales underlying the Toad formation on the Grayling River.

#### Areal Extent

The Grayling formation is rarely exposed in the Foothills belt. North of the Liard River, however, the Grayling formation forms a wide outcrop area, due in part, to the erosion of the Liard and Toad formations, and in part, to a broad uplift in contrast to the tight folding in the south. Much of this area is highly forested, and it is possible that locally, the Toad formation may be present, although only the Grayling formation is shown on the map.

The Grayling formation thins northward due to erosion. The most northern occurrence is uncertain but it probably extends to the Beaver River.

#### Lithology

The Grayling formation consists predominantly of shale, calcareous in part, medium grey to brownish-grey in color. In general, the Grayling formation weathers a brownish-grey in contrast to the dark grey to black weathering of the Toad formation.

Thin (1 to 3 inches) interbeds of hard sandstone are common. A characteristic feature of these sandstone beds are the

abundance of "lobate rill marks" (Shrock, 1943, p. 131, Figure 92) on the undersurface of individual beds. Similar bedding structures are well illustrated by Pettijohn (1957, Plate 34). These "snailate or lingual-shaped rill marks" are essentially the down-ward protrusion of the sandstone beds into the underlying mudstone. The consistency of orientation and lineation certainly suggest current origin. Shrock ascribes these structures to the "ebbing tidal currents or retreating storm waves", whereas, Pettijohn favors as origin, the abrasive actions of turbidity currents. If the latter view is correct, a systematic mapping of these structures and associated small scale cross-bedding could ultimately lead to a paleocurrent system depicting the direction of the source area.

#### Age and Correlation

Fossils are rare in the Grayling formation, however, the presence of Clarcia stacheli collected by Kindle places the formation as Lower Triassic.

#### PALEOZOIC

The format used in describing the Mesozoic formations will not be followed for the Paleozoic strata because there is less certainty as to the age and correlation of the individual map-units compared to that of the Mesozoic map-units. Instead, each unit or formation (when named) will be discussed under a general heading.

No new formational names are proposed in this report. The proposal of such names is a matter to be handled by the Geological Survey of Canada, or by private companies only when followed by publication in a recognized journal following approval

by a stratigraphic names committee. Because of the foregoing, each individual stratigraphic unit is assigned a number to reduce confusion and uncertainty with respect to correlation with formal stratigraphic units in outside areas.

Only one complete section of Paleozoic carbonates (Figure 23) was measured in the area. Other partial sections are correlated to this section using it as a standard.

#### Carboniferous and Permian

##### General Statement

Carboniferous and Permian strata were first reported in the Liard River area by McConnell (1891). Kindle (1944) found Permian and Carboniferous fossils at Mount Merill, north of the Beaver River. To the south, Williams (1944) described Mississippian and younger Paleozoic strata on the Alaska Highway in the vicinity of Mile 332. No formational names were proposed for the strata at any of these localities.

Laudon and Chronic (1947, 1949) applied the name Kindle\* formation for all of the Mississippian and younger Paleozoic strata occurring along the Alaska Highway between Mile 330 and Mile 430. The Kindle formation was later restricted by Sutherland (1953) to exclude a chert unit averaging 150 feet in thickness at the top of the succession. This chert unit remained unnamed by Sutherland.

Patten (1953) described a section of Mississippian and younger Paleozoic rocks southwest of Nahanni Butte, at Jackfish Gap. He proposed the name Mattson formation for this thick sequence which consist predominantly of sandstone and locally, limestone and shale.

\*Not to be confused with the Mount Kindle formation (Upper Ordovician) of the Franklin Mountains.



Figure 23

View looking northwest along the east-dipping Paleozoic carbonates brought to the surface by the West Grayling fault. The grassy interval in the foreground is underlain by the black shales of Map-unit 10. These are underlain by the limestones of the Nahanni formation (8) and the dolomites of Map-unit 7. The ridge in the background is formed by Map-unit 4. The reefoidal dolomites of Map-unit 3 and the quartzites of Map-unit 1 cannot be seen in this picture.

Spores collected in a coal bed a few hundred feet from the base of the formation were identified by Chester (Upper Mississippian). The writer, during the summer of 1958, had the opportunity to examine several sections of the Mattson formation in this area. Fossils, collected from the Mattson formation during that year and identified by Harker (personal communication) of the Geological Survey, range from Upper Mississippian, through the Pennsylvanian to the Permian.

Underlying the Mattson formation at its type locality, there occurs, in descending order, an alternating limestone-shale unit, a predominantly shale unit, and a platy, argillaceous sandstone unit, which are to be named by Harker (1959, in print) the Flett, Clausen and Yohin formations, respectively. These three formations correspond to Patten's map-units 3, 2 and 1 respectively. The Yohin formation and the lower part of the Clausen formation are assigned to the late Devonian, and the Flett, together with the upper part of the Clausen formation, to the Mississippian.

Figure 24 illustrates the correlation between the section at Jackfish Gap after Patten and Harker and a composite subsurface section in the Fort St. John - Peace River area. These two sections are approximately 350 miles apart.

#### Map-Unit 15 (Fantasque Formation)

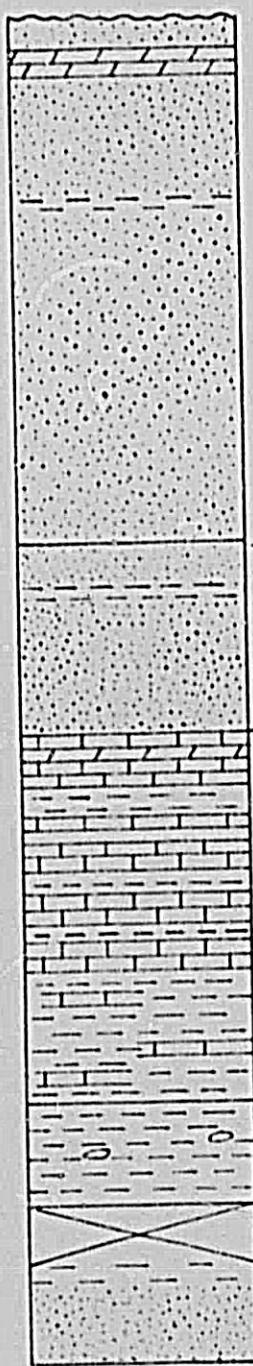
Locally, overlying the Mattson formation, is a unit consisting of medium bedded, laminated light and dark grey chert and interbedded silicified shale. On the La Biche River on the western flank of the La Biche Range, the chert is overlain by fine grained, grey, mottled sandstone and shale. These two units

JACKFISH GAP

N.W.T.

After Potton and Harker

This Mattson Formation ranges in age from  
Upper Mississippian to Permian.

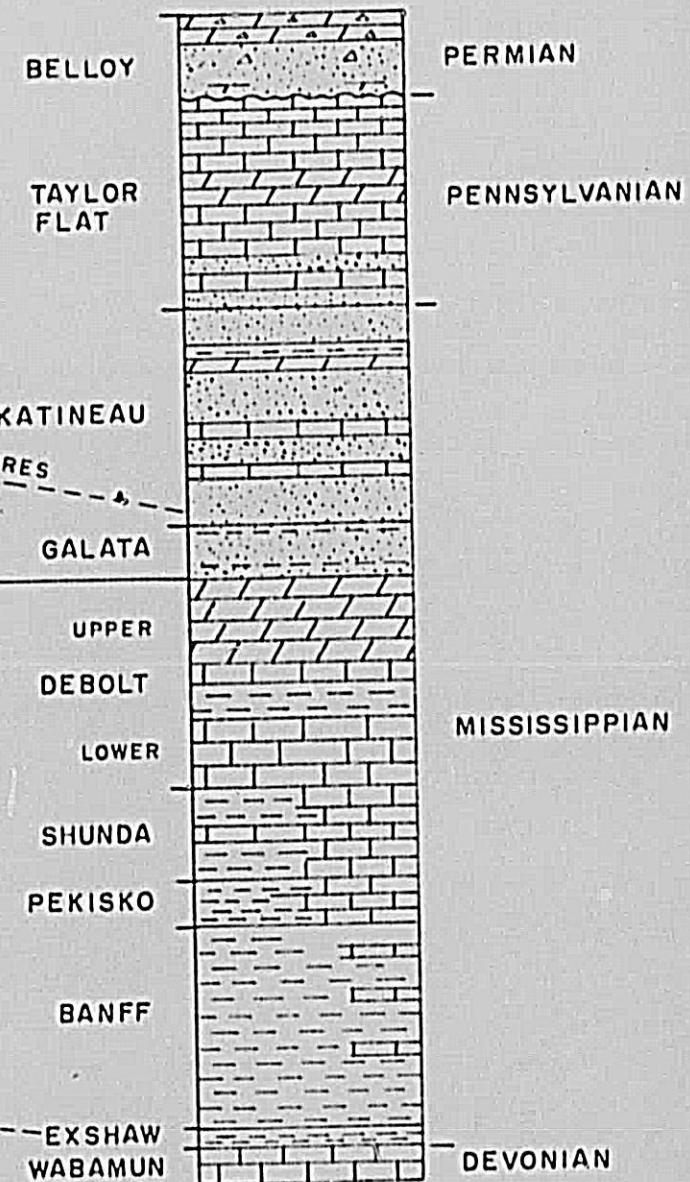


COMPOSITE SECTION

FT. ST. JOHN

PEACE RIVER AREA

After Halbertsma and Macauley



INDEX MAP  
SCALE: 1" = 300 MI. (APPROX.)

UPPER PALEOZOIC CORRELATION

Between Jackfish Gap N.W.T. and Fort  
St. John - Peace River Area.

Vertical Scale: 1" = 1000'

FIGURE 24

constitute the Fantasque formation (Harker, 1959). On the southern part of the Liard and La Biche Ranges, only the chert is present. To the west, the unit is thin, non-resistant, consisting predominantly of silicified shale and for mapping purposes is included within map-unit 14. On the northern part of the Liard and La Biche Ranges the formation is missing, and the underlying Mattson formation is overlain directly by Cretaceous shales.

Such a distribution and relationship to adjacent formations indicates that map-unit 15 overlies the Mattson formation unconformably and in turn, is truncated by a post-Paleozoic unconformity.

#### Mattson Formation (Map-units 14 and 14a)

The Mattson formation was named by Patton (1959) to include 3,734 feet of strata occurring at Jackfish Gap (Lat.  $60^{\circ} 53'$ , Long.  $124^{\circ} 10'$ ). The formation is overlain by the Permian chert unit (Map-unit 15), or where this is absent, by the Cretaceous.

In the western part of the Liard River area, the formation can be divided into two units, 14a and 14b. In areas where this division is not made, the entire formation is indicated on the map as Unit 14.

The lower map-unit (14a) directly overlies the dark grey to black shales of map-unit 10. It consists of massive to thick-bedded, fine to medium grained, light grey sandstone with minor interbedded non-calcareous shale. This unit forms a distinctive, resistant horizon and as such, can be traced over much of the western region. A detailed section of this unit was not measured, but it is estimated to be in the order of 500 feet. Douglas (1959)

assigned this unit (which in his report is Map-unit 4a) to the Devonian, but the presence of a Mississippian fauna below the sandstone in the Toad River #1 well definitely places it as Mississippian or even younger.

Map-unit 14b which overlies the basal sandstone of Map-unit 14a is less resistant than the underlying unit. The upper part consists of very fine grained sandstone and siltstone alternating with recessive shale intervals, and a lower unit, rarely exposed, consists mainly of "sooty" shale and shaly siltstone. Wissner and Fotheringham measured 713 feet in the core of the West Scatter anticline, of which the upper 20 feet, consisting of chert and silicified shale, is equivalent to Map-unit 15. Upper Mississippian fossils were collected near the top of Map-unit 14b at this locality.

The thickest section (4,592 feet) measured to date occurs at Tika Creek, 32 miles due north of Fantasque Lake. The Mattson formation thins to the west, and in the vicinity of Larsen Lake is reduced to about 1,500 feet. The Mattson formation is also rapidly bevelled to the east, where in the Trout River map-area, the Lower Cretaceous lies directly on Upper Devonian strata (Douglas, 1959).

#### Map-unit 13

Map-unit 13 was not examined during the 1959 field season. It crops out north of Fort Liard (Douglas, 1959) where it consists of medium grained, crinoidal limestone interbedded with dark grey, argillaceous limestone. These limestones apparently grade to shale to the west where they are included as part of Map-unit 10. In the subsurface to the east, map-unit 13 would be equivalent to the Mississippian limestones underlying the Stoddart group.

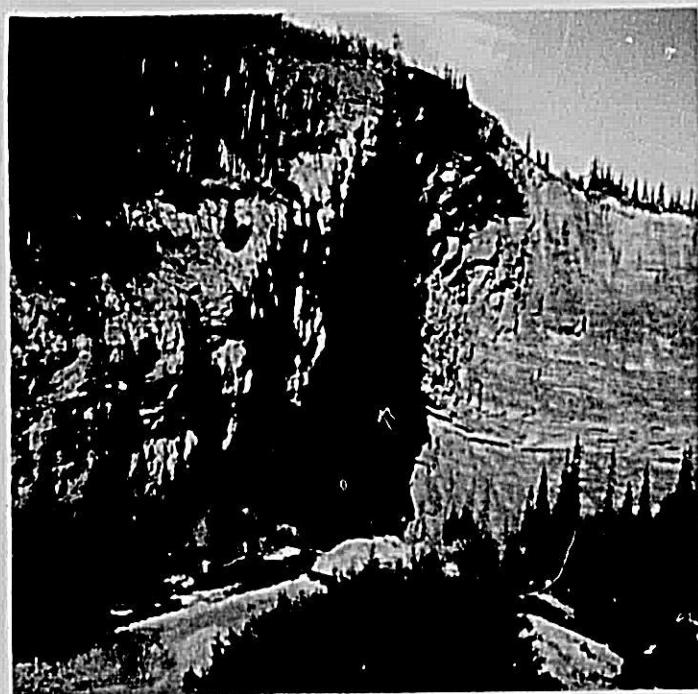


Figure 25

Calcareous siltstones and shales of Mississippian age near the mouth of Eight Mile Creek, south of the map-area.

Map-Unit 12 (Kindle formation)

By tracing the broad, structural features from the Alaska Highway at Summit Lake north to Toad River, Mississippian strata have been traced by air photo studies into the southeastern part of the map-area. Outcrops of the Mississippian belt, where it crosses the Toad River, south of the map-area were examined by Wissner and Fotheringham. The rocks consisted predominantly of silty shale and very argillaceous and arenaceous limestone, (Figure 25) and resembles much of the Triassic. These beds are equivalent to the Kindle formation on the Alaska Highway (Sutherland, 1953) and possibly represent in part, a facies change of the Mattson formation to the north.

Map-unit 11

Map-unit 11 is shown only on the cross-sections where it lies between the "Exshaw formation" and the Mississippian carbonates. In this respect, it would be equivalent to the Banff formation.

(Devonian and Mississippian) Map-unit 10

Map-unit 10 consists mainly of dark grey to black shale; the basal part, which ranges from 100 to 300 feet thick, is hard, platy to very thin bedded, locally with spotted yellow sulphurous weathering. The upper part of Map-unit 10, also a dark grey shale, is more fissile and upon weathering has a dark bluish-grey tinge. With increase of sandstone interbeds near the top, this map-unit grades transitionally into the overlying map-unit 14a, of the Mattson formation. Tentaculites are common near the base

of Map-unit 10 on One Ten Creek, south of the map-area. On the Beaver River, Tentaculites are found at least 300 feet above the base.

In the Toad River well, 815 feet above the base of Map-unit 10, a well preserved specimen of Protocanites indicates a Mississippian (Meramacian) age. Abundant anaptychi\* are present 100 feet above the base of this unit in the Toad River well. These plates were also observed in outcrop section 100-150 feet above the base at Toad River hot springs and about 400 feet above the base on the Beaver River. Stelck favors a Mississippian age for these anaptychi, although this age determination is not diagnostic.

From the foregoing, however, it is obvious that the Mississippian-Devonian boundary occurs within the shale of Map-unit 10. This unit ranged in thickness from 990 feet to 1,425 feet in outcrop section compared to an equivalent interval of 1,900 feet in the Toad River well. On the Plains to the east, this pre-Upper Mississippian/post-Middle Devonian interval is represented by more than 5,500 feet of strata of which approximately 3,500 feet is Upper Devonian, 1,200 feet is Kinderhookian shales and 800 feet Meramacian carbonates.

Such thickness relationships from east to west suggest that the Mississippian-Devonian boundary is represented by an unconformity along which much of the Upper Devonian is missing due to erosion or non-deposition. This unconformity is discussed more fully in a later section of this report.

\*Single horny plate which forms the aperture covering of ammonites.

Map-unit 9

Map-unit 9 includes all the Paleozoic formations below Map-unit 10 in the western part of the map-area where lack of outcrops did not sufficiently warrant further divisions of the map-units.

Map-unit 8

Map-unit 8 represents the first carbonate below the shale of Map-unit 10. It is exposed along the west flank of the West Grayling uplift, from the Grayling River to north of the Beaver River.

On the Grayling River and for a few miles north, the unit consists of medium bedded to massive, fine to micro-grained, medium to dark grey limestone. On the Crow River, near the top of the formation, there is 57' of coarse grained, crinoidal limestone, underlain by 21' of porous, coarse grained dolomite. Much of the remaining section on the Crow River consists of fine grained dolomite and interbedded limestone. On the Beaver River, the unit is even more highly dolomitized. Common to both the limestone section on the Grayling River and the dolomite section on the Beaver River are the local abundance of small circular crinoid stems containing a double axial canal.

Immediately east of Larson Lake, N.W.T., a coral fauna (Disphyllum, Favosites and Prismatophyllum) was collected at the top of this unit. Warren and Stelck commented that "the environmental fauna association and preservation indicated the proximity to a reef". The unbroken condition of the delicate corallines indicates that these fossils were preserved "in situ".

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Figure 26

"Pinnacle-type" weathering of the top part of the Nahanni formation (8) east of Larsen Lake. The ridge in the background is composed of Map-unit 4. The overlying Lone Mountain formation, normally resistant, underlies the covered interval between this ridge and the outcrops in the foreground.

It is noteworthy that Map-unit 8, where dolomitized, is more porous than its limestone counterpart. In general, in areas of low dip, and in particular, where the unit is dolomitized, the upper part tends to weather in "pinnacle-type" topography readily distinguishable on air photographs and illustrated in Figure 26.

Map-unit 8 is correlated with 829 feet of limestone at One-ten Creek on the Alaska Highway, there referred to as Unit D of the "Ramparts formation"\*\* by Laudon and Chronic (1949). This unit equates with the interval 5,270 to 6,070 feet in the Toad River #1 well and with the Nahanni formation on the Nahanni Range, N.W.T.

#### Map-unit 7

Map-unit 7 consists of a thick sequence of banded dolomites undifferentiated in this report, believed to be equivalent to the Bear Rock - Lone Mountain formations.

This unit is composed predominantly of light to dark grey, fine to medium grained dolomite, locally interbedded with white, micro-grained dolomite. The banded appearance of this unit is due to alternations of light and dark grey weathering, medium to thick bedded strata.

Fourteen miles north of the Grayling River on the West Grayling uplift, 2,962 feet of section was assigned to this unit by Wissner and Fotheringham.

\*\*The "Ramparts formation" as used by Laudon and Chronic includes the Nahanni, Bear Rock and Lone Mountain formations and an underlying sandstone unit.

## ORDOVICIAN

Map-unit 4

Underlying Map-unit 7 on the West Grayling uplift, a separate unit was mapped; it is believed to be equivalent to the "Muncho-McConnell" unit (Nisley, 1950, Laudon and Chronic, 1949) on the Alaska Highway.

This unit consists essentially of alternating light and dark grey, very fine to medium grained dolomite. The upper and lower parts weather to a distinct buff color, whereas the thicker middle part is notably banded light and dark grey weathering.

Although Laudon and Chronic (1949) tentatively assigned the "Muncho-McConnell" unit to the Devonian, it may possibly be Upper Ordovician representing a facies of the underlying fossiliferous dolomite of map-unit 3.

Map-unit 3

Underlying the dolomite of Map-unit 4, there occurs a porous, reefoidal unit, commonly referred to as the "Halysites-Favosites horizon". This unit on the West Grayling structure consists of 5 to 20-foot massive beds of dark grey to black weathering, biostromal, fossiliferous, porous dolomite alternating with 5-foot beds of light grey weathering, non-fossiliferous dolomite (Figure 27). The biostromal units are composed of abundant recrystallized coral, algae, and stromatoporoids.

Lithologically similar beds occur along the Alaska Highway and are there referred to as the "Ronning formation" (Laudon and Chronic, 1949). Similar beds are also present at



Figure 27

Dark grey to black weathering biostromal dolomite alternates with light grey weathering non-fossiliferous dolomite of Map-unit 3.

Redfern Lake (H. Johnston, 1953) and to the north on the Nahanni Range. North of the Nahanni Range, in the Franklin Mountains, this unit is referred to as the Mount Kindle formation.

Generally, fossils from this unit are so highly recrystallized, that it is difficult to make positive identification. This unit, although long thought to be Silurian, is now considered Upper Ordovician in age, substantiated by a Beatrix sp. collected this season on the West Grayling uplift. Upper Ordovician fossils have also been found in the aforementioned similar unit on the Nahanni Range (R. J. W. Douglas, personal communication).

#### PRE-UPPER ORDOVICIAN

##### Map-unit 1

Directly underlying Map-unit 3 is a hard, white to pinkish-grey quartzite (Figure 31). The rock is composed of fine to medium grained, rounded quartz grains completely indurated with a quartz cement. A pebble conglomerate was reported by Wissner and Fotheringham within the upper 50 feet.

This quartzite is exposed along the West Grayling uplift at two localities, each about 3 miles long, separated by a distance of 6 miles with no quartzite exposure. The non-continuity of this hard resistant unit above the West Grayling fault suggests either irregular relief on the surface of the quartzite, or an undulating fault plane.

The age of the quartzite is not known but it is believed to be one of the oldest rock units in the area, at least pre-Upper Ordovician.



Figure 28

Hard, resistant quartzite (Map-unit 1) underlies Map-unit 3 immediately above the West Grayling fault.

### Upper Beaver River Stratigraphy

A study of the stratigraphy along the upper part of the Beaver River shows different and additional units than were encountered on the West Grayling uplift, hence this area is discussed separately.

It is impossible to measure a complete and unbroken sequence from the youngest to oldest strata, as at least one, and possibly three, major faults transect the area. Other structural complications occur immediately south of Beaver River in the vicinity of a syenitic intrusion. By measuring several partial sections along the Beaver River and knowing the major structural trends to the south, it was possible to construct a composite section of the stratigraphic sequence in the area.

A brief summary of the composite section along the Beaver River is as follows:

#### Map-unit 13 (Mattson formation)

Sandstone, quartzose, light grey  
to medium brownish-grey, very  
fine to medium grained.  
(Upper part not measured)

255' +

#### Map-unit 10

Shale, dark grey to black, fissile  
becoming more platy near base  
with siltstone in lower 100 feet.

1,425'

#### Map-unit 8

Dolomite, light grey to medium and  
dark grey, fine to medium grained,  
locally coarse grained, good  
intercrystalline to vuggy porosity.

730' ±

## Map-unit 7

Dolomite, light and dark grey, fine to medium grained, banded light and dark grey weathering. 1,418' +

Base not exposed.

Remainder of section measured to the west, on a different fault slice. The contact with, and interval between, Map-unit 7 and Map-unit 6 was not observed.

## Map-Unit 6

Siltstone and shale, slightly dolomitic dark grey to black, very hard and brittle, locally cherty, very thin bedded, large calcareous concretions, Monograptus. 500' +

## Map-unit 5

Sandstone, white, very fine grained, to silty matrix with "floating" coarse quartz grains, much interbedded dolomite in lower part. 530'

## Map-unit 4

Dolomite, dark grey, fine to medium grained, medium to thick bedded. 600'

Base not exposed.

Although much of Map-unit 10 is not exposed, the overall interval has expanded by about 435 feet relative to sections to the south. Abundant Tantaculites were found up to 300 feet above the base overlain by shales containing snappychi.

Map-unit 8 (Nahanni formation) is completely dolomitized in this region. In outcrop, much of the soft, friable, granular dolomite appears to contain a high proportion of gypsum or anhydrite, however, specimens submitted to the Geological Survey of Canada for

chemical analysis indicated no sulphate. Locally small crinoid stems with a double axial canal are abundant as they are in the limestone to the south.

More than 1,400 feet of Bear Rock - Lone Mountain equivalent was measured, although the base was not reached. The lithology is similar to that in the south, characterized by the typical light and dark grey weathering dolomite alternations.

The lower part of the section was measured to the west on a different fault slice. Unfortunately, the contact and any intervening strata between map-units 6 and 7 were not examined.

Map-unit 6 consists essentially of black shale or siltstone carrying a Middle Silurian graptolite fauna. Large calcareous concretions with a "mammary-type" top are common locally (Figure 32 and 33).

Underlying the Middle Silurian shale is an alternating sandstone and arenaceous dolomite unit (5). A similar lithologic unit is present on the Alaska Highway (Unit A of the "Ramparts" formation by Laudon and Chronic, 1949, and at Redfern and Tuchodi Lakes by Johnston, 1954). Map-unit 5 is also correlated with an arenaceous unit on the Nahanni Range which contains an Upper Ordovician fauna (R. J. W. Douglas, personal communication). This sandy unit on the Nahanni Range was formerly considered to be basal Devonian.

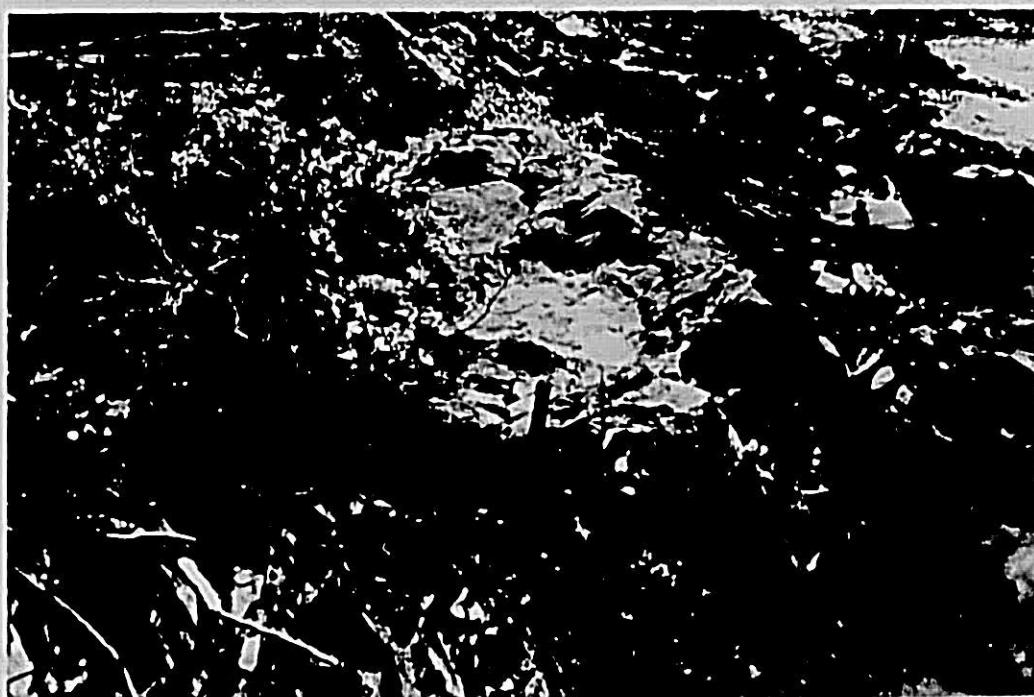
Underlying Map-unit 6 on the Beaver River, there occurs 600 feet of grey, fine grained dolomite, containing Macrurites and Actinoceras of Upper Ordovician age. The base of this unit was not exposed.



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Figure 29

"Mammillary-type" calcareous concretion in black Middle Silurian shales (Map-unit 6).



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Figure 30

Cross-section of the same concretion as above illustrating how the bedded shales are bent around the concretion.

The "Halysites-Favosites" unit does not outcrop along the Beaver River where traversed. It is believed that this coral-line unit would underlie the Upper Ordovician dolomite of Map-unit 4, if the correlation of this latter unit to the south is correct.

South of the Beaver River, along the western border of the map-area, a sequence of red shales, argillites, and sandstones crop out. These beds (Map-units 2 and 2a) are correlated with similar red beds in the vicinity of Muncho Lake, tentatively assigned to the Cambrian on the basis of their lithology and stratigraphic position (Laudon and Chronic, 1949). Lithologic similarities to strata in Waterton National Park, however, suggests a possible Beltian age (Douglas, 1959). These beds thin rapidly to the east and probably overlie the quartzite of Map-unit 1.

Much of the western and northwestern part of the map-area was not studied in sufficient detail to warrant further comments on the stratigraphy or structure. North of the Beaver River, however, much, if not all, of the Devonian carbonates grade to a shale facies. A similar facies change occurs west of the Nahanni Range. It is possible that these two areas are part of the same shale basin.

#### Thermal Hot Springs and Their Geological Significance

Thermal hot springs are common in the area extending from Tcad River north to the South Nahanni River, a distance of more than 150 miles. Geologically these hot springs are most interesting, occurring always at, or near, the contact between the Nahanni formation and the overlying shale of Map-unit 10.

Recent calcareous tufa deposits (Figure 31) up to 30 feet thick, surround many of these springs forming hot water pools more than 10 feet deep and 50 feet in diameter.

Where these hot springs were observed, the bedrock formations were east dipping. The carbonates underlying the shales of Map-unit 10 are exposed at the surface to the west. It is believed that meteoric water percolates downward within the carbonates increasing in temperature, in accordance with the temperature gradient. Upon reaching the impervious shale unit, the water tends to rise to the surface along this carbonate-shale contact.

Any prospective structures east of this line of hot springs require a synclinal area or regional downwarp sufficient to exclude such meteoric waters.



Figure 31

Recent calcareous tufa deposit formed by one of the many hot springs which occur along the contact of Map-unit 8 and Map-unit 10.

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## IGNEOUS ROCKS

### Map-unit A

Four miles south of the Beaver River in the northwestern part of the map-area, a massive, reddish weathering syenitic body is present (Figure 32). The syenite is composed predominantly of reddish, coarse grained to very coarse grained, K-feldspar with minor occurrences of chlorite after biotite. Surrounding the syenite are hard quartzites and finely banded, greenish argillites.

Small xenoliths (Figure 33) of a bedded, metamorphosed sandstone, measuring 3 to 4 inches wide and up to 4 feet long, indicate the intrusive or assimilatory nature of this body.

The age relationship of the syenite with surrounding sedimentary rocks is uncertain and would require detailed mapping in the vicinity of the igneous body, of which time did not permit during the past field season. It is believed, however, that the syenite is either Devonian or pre-Devonian.

### Map-unit B

A dark grey to dark greenish-grey volcanic rock crops out in at least six localities in the northwestern part of the map-area. The rock, volcanic in origin, has a micro-grained to aphanic matrix with phenocrysts of clear, euhedral, sanidine feldspar and locally clusters of euhedral crystals of black hornblende.



Figure 32

Reddish weathering coarse grained syenite of Map-unit A.



Figure 33

Close-up of the above syenite showing a bedded xenolith.

Two of these bodies were studied in detail. Both were roughly circular in outline, approximately one-half mile in diameter (Figure 34). A total of 350 joints were measured on these two stocks. Two sets predominate, one radial and one concentric. The concentric set forms steep, nearly vertical cliff faces (Figure 35). The radial joints less prominent than the concentric set, also dip steeply, commonly only 20 degrees from the vertical (Figure 36). On a complete traverse of these bodies, both concentric and radial joints were observed to change strike 360 degrees.

One of the bodies examined probably intrudes Triassic sediments although there are no immediate adjacent outcrops. The other body intrudes map-unit 14a of the Mattson formation. The sandstone of this unit immediately surrounding the body is metamorphosed to a highly fractured quartzite.

The lack of boulders of Map-unit B in nearby creeks suggests that these "plugs" were not feeders to an extensive flow in the area, as suggested by some authors (Douglas, 1959, a).

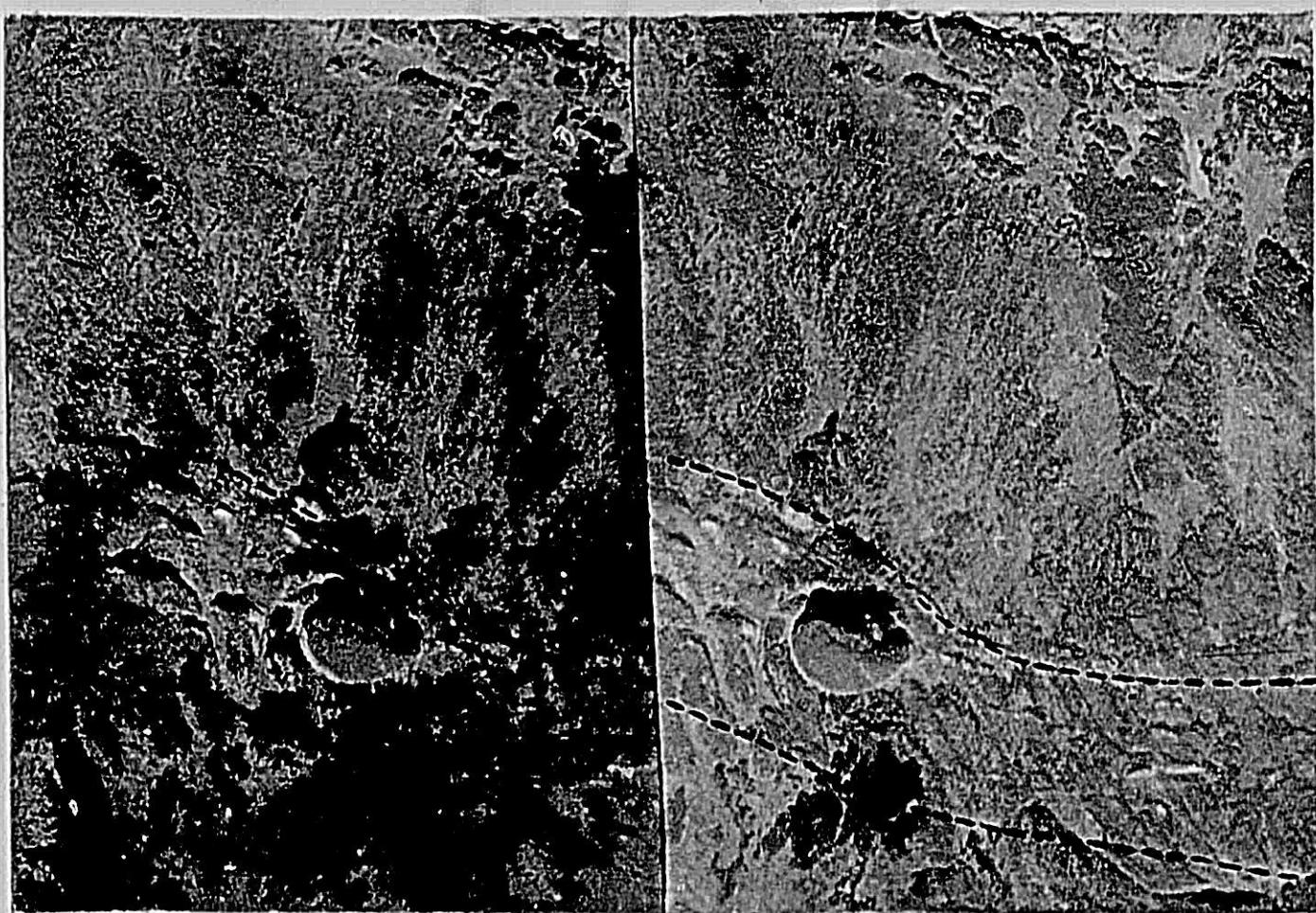


Figure 34

Stereoscopic view of one of the basic volcanic intrusives. This rounded "plug" stands approximately 200 feet above the surrounding map-unit 14a through which it intrudes.



Figure 35

Concentric joints form this steep cliff face on a volcanic stock.



Figure 36

Poorly developed radial joints dip vertically in center of picture and cut the concentric joint face which lies in the plane of the picture. Other secondary joints are developed at this locality.

### UNCONFORMITIES

Several major unconformities are present in the Liard River area and undoubtedly other minor ones are also present.

One of the most widespread of these unconformities occurs at the base of the Cretaceous. Its effects can be noted by the beveling of the Triassic strata across the map area. In the Trout River map-area (Douglas, 1959, b) the Cretaceous lies directly on the Devonian. This increased beveling may be due in part by the additional effect of pre-Triassic and pre-Permian erosion.

Another unconformity which may be more local than the pre-Cretaceous unconformity is illustrated in Figure 37. This figure shows that in the western part of the map area, the Upper Devonian - Lower Mississippian interval is extremely thin compared to the Plains section to the east. It is suggested that a structural "high" occurred in this region resulting in much of the Upper Devonian strata removed by erosion. Much of the Lower Mississippian is also missing due either to erosion or non-deposition. Figure 37 illustrates this "high" formed by geanticlinal-type positive area whereas Figure 38 suggest the "high" is due to block faulting, possibly basement controlled. The final result of erosion and missing section in the western region would be similar in either case. In the first case, possible onlap of the Mississippian may occur on the flanks of the "high". In the second case, local

CROW  
RIVER

TOAD  
RIVER I

BEAVER  
RIVER I

STANDARD PLAIN  
SECTION

W

E

MATTSON FM.

STODDART FM

MAP UNIT 10

DEBOLT FM.

NAHANNI FM.

BANFF FM.

BEAR ROCK - LONE MTN.

UPPER DEVONIAN

Positively high area  
during late Upper Devonian  
and/or Lower Mississippian due  
to a geanticline.

Erosion of Upper  
Devonian, possible  
non-deposition of  
Kinderhookian.

Erosion of Upper Devonian,  
possible on top of Kinderhookian,  
Facies change of Mermacian.

Minor unconformity on  
top of Devonian.

Vertical Scale: 1" = 2000'

Horizontal distance not drawn to scale.

FIGURE 37

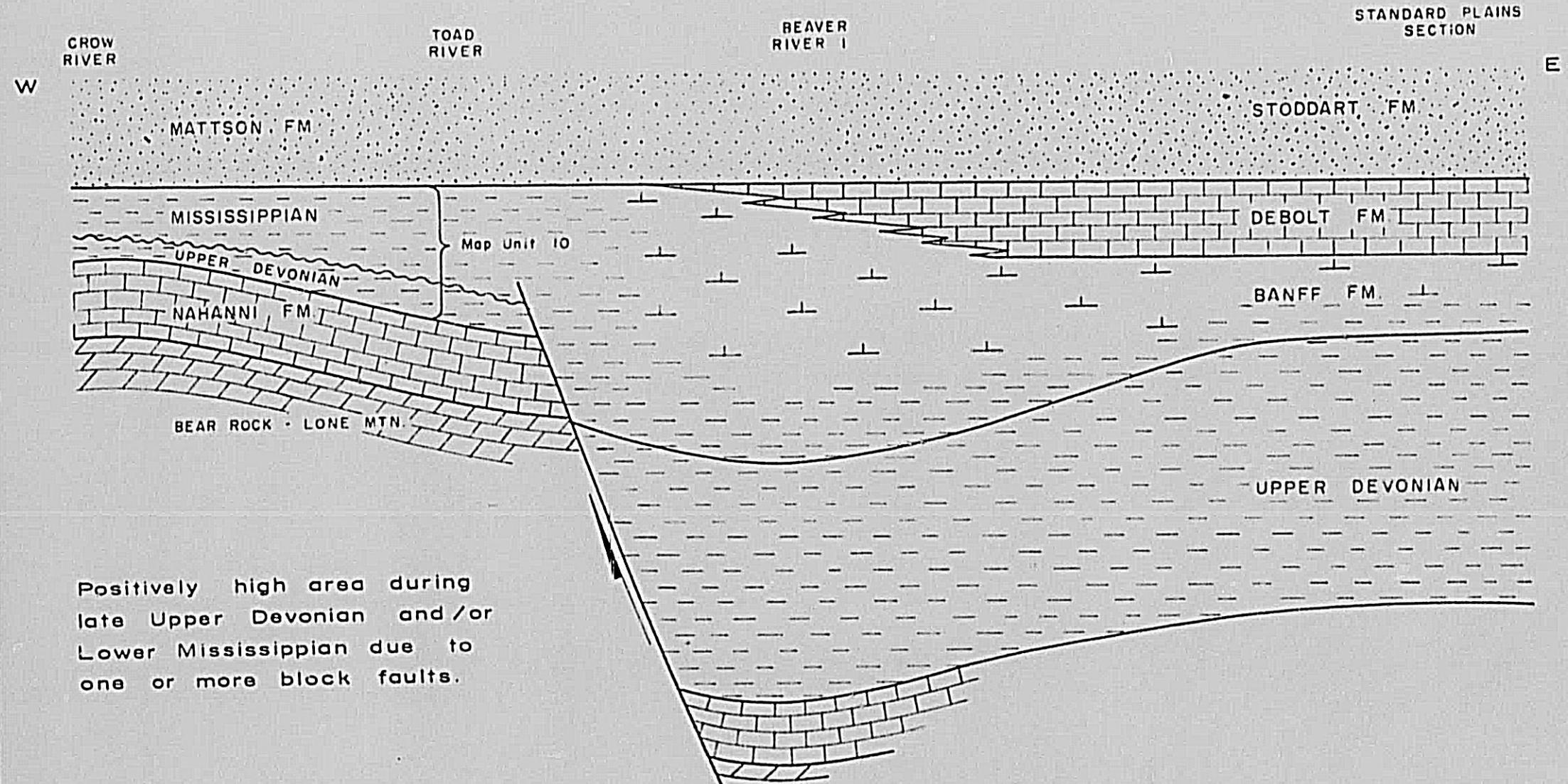


FIGURE 38

downwarp associated with the block faulting may produce a relatively thick Mississippian section immediately east of the fault. Regionally, the geanticlinal-type "high" is favored over the block faulting type.

Another widespread unconformity occurs at the base of the Devonian. This unconformity extends from the Liard River area and the mountains to the north, eastward to the border of the Precambrian Shield.

In the Upper Beaver River area, the presence of Middle Silurian shales overlying Upper Ordovician dolomites indicates another unconformity. Little is known of the pre-Upper Ordovician strata in the map-area, however, to the south, near Summit Lake, a major unconformity occurs between bedded Paleozoic strata and metamorphosed, presumably Precambrian strata.

## STRUCTURAL GEOLOGY

### General Statement

The Liard River area embraces part of the Rocky Mountain Foothills, the Liard Plateau and the western part of the Interior Plains (Figure 2). As in many other areas, the structural boundaries do not always coincide with physiographic boundaries. For example, around Fort Liard, structures of the Liard Plateau continue south beneath the Plains area (Douglas, 1959, p. 17).

The structures of the Rocky Mountain Foothills of this area are characterized by tight, northwest trending, doubly plunging symmetrical anticlines and synclines. Unlike the Foothills of Alberta, faults are rare. The Foothills have a northwest trend south of the Liard River but swing to a north to northeasterly trend a few miles north of this river.

The structures within the southern part of the Liard Plateau are, in part, a continuation of the Rocky Mountain Foothill structures. The folds, however, in contrast with those of the Foothills belt, are broader and more open. The change of structural alignment, noted in the Foothills, continues to the southern part of the Liard Plateau where many of the structural elements strike northeast. North of the Beaver River, the alignment reverses back to a generally northern direction. Associated with, and apparently related to the change from northwest to northeast, are numerous east dipping thrust faults. The east dipping nature

of these faults are apparently characteristic of this region, whereas west dipping faults prevail in the southern Foothills of Alberta and in the McConnell Mountains to the north.

The tight folding, characteristic of the Foothills Belt, does not necessarily reflect similar folding in underlying competent strata. This is well illustrated on the Liard River near Devils Portage, where a simple anticline of upper Paleozoic strata plunges into a series of highly crenulated Triassic strata. In the Liard Plateau, however, the folds which expose Carboniferous strata at the surface generally exhibit similar folding within the underlying formations, illustrated on the Grayling River where the Nahanni formation is exposed in the core of an anticline which is flanked by Carboniferous strata.

#### Bovie Lake Fault

In the northeastern part of the map-area and continuing east of the map-area, the Bovie fault brings gently west-dipping Carboniferous strata to the surface. Texaco Exploration Company drilled a well north of the British Columbia border, bottoming in the Mattson formation and are currently drilling a second well south of the British Columbia border on this structure.

Between the Bovie structure and Fort Liard lies the Petitot River syncline, Liard fault and the Liard anticline described by Douglas (1959) but not mapped in detail during the past field season.

### Liard Syncline

The Liard syncline is a major structural feature whose axis follows a sinuous course from the south boundary of the map-area to its northern termination at South Nahanni River, a distance of more than 160 miles. The trough, in much of the area, is occupied by the Upper Cretaceous Kotaneelee and Wapiti formations. Twenty to thirty degree dips have been recorded on the west limb, where a high escarpment is capped by the resistant Fort Nelson formation. The east flank is more gentle, having dips in the order of 2 to 3 degrees (Cook, 1950).

### Kotaneelee Anticline

The Kotaneelee anticline forms the north-trending Kotaneelee Range of which only part of the central and southern portions are present in the map-area (see Figure 40). Pan-American Beaver River #1 (Figure 39) was drilled on the southern segment of the anticline, where there is, apparently, a local closure. At this locality, the anticline is symmetrical in contrast to its westward asymmetry to the north.

### La Biche Syncline

The La Biche syncline lies between the Kotaneelee and La Biche Ranges and exposes mainly Cretaceous formations in its trough.

### La Biche Range

The La Biche Range, underlain mainly by the Mattson formation, is formed by a compound anticline. The southern segment

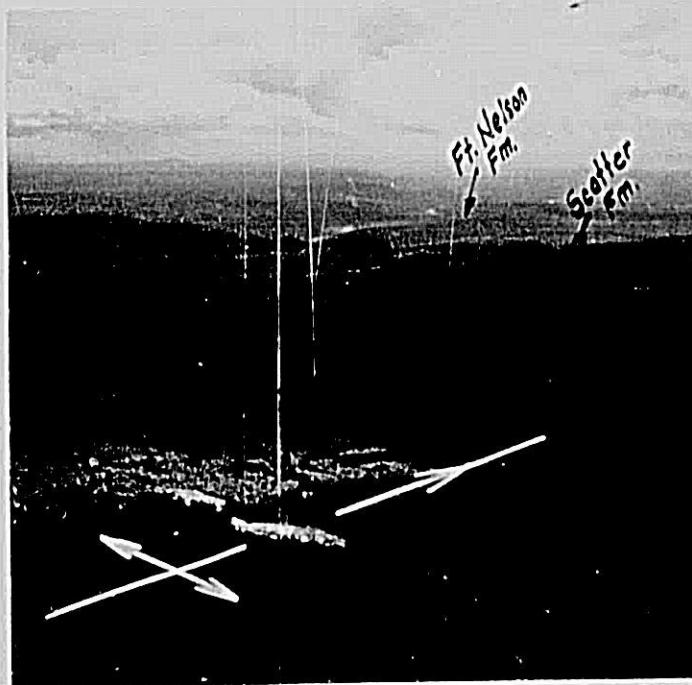


Figure 39

Pan-American Beaver River #1 on crest of Kotaneelee anticline looking southeast. The Scatter formation on the east flank forms the first ridge (right center). The second escarpment is formed by the Fort Nelson formation.

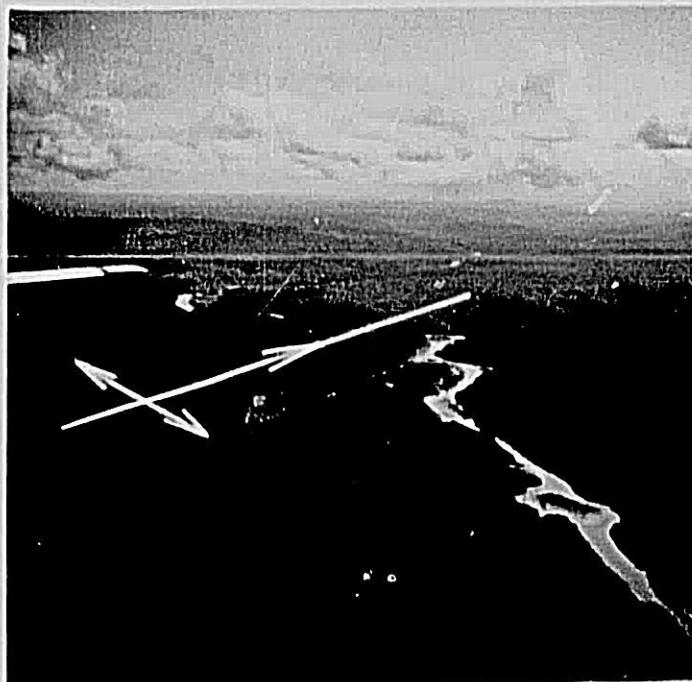


Figure 40

The Scatter formation plunging south along the Kotaneelee anticline beneath the overlying Lepine formation on the Beaver River.

APR 60



Figure 41

View looking north along the East La Biche anticline. Steeply-dipping beds of the Scatter formation in the foreground are cut-off by an east-dipping fault on the west limb. The Mattson formation is exposed in the center background (Figure 46) and the west flank of the La Biche anticline in the left background.

APR 60



Figure 42

Asymmetrical La Biche anticline showing the low-dipping beds of the Mattson formation on the east flank becoming steeply-dipping on the west flank.

consists of two anticlinal structures; the westerly one referred to as the La Biche anticline (Douglas, 1959), and an easterly previously unnamed anticline, here called the East La Biche anticline (Figure 41 and 42). This easterly anticline warrants a separate name, as it can be traced south, beneath Cretaceous cover, to the Liard River. Both anticlines have a gently dipping east flank (10 to 15°) and a steeply dipping west flank (50 to 80°), underlain on the west by an east-dipping thrust fault.

#### Beavercrow Anticline

The Beavercrow anticline is a westward asymmetrical structure, probably underlain by a northwest trending, east dipping fault of small displacement on its west flank. Dips on the east flank range from 20 to 30° in contrast to those on the west which range from 60 to 80°. Maximum east-west closure is in the order of 3,500 feet. Unlike the Kotaneelee and La Biche structures, this anticline plunges north a few miles south of Fantasque Lake. The Beavercrow anticline is one of the most favorable structures in the area, however, at present, the entire structure is held by California Standard and Shell Oil Company.

### West Grayling Fault

The West Grayling fault is a major north-trending east-dipping thrust fault which has an approximate throw of over 3,000 feet. In areas of maximum displacement, hard quartzite beds of Map-unit 1 of pre-Upper Ordovician age are in fault contact with Upper Devonian and Mississippian strata. The fault can be traced from the Grayling River north to the Beaver River, a distance of 50 miles. Along the West Grayling uplift the Paleozoic strata dip gently east and may represent the east flank of an originally broad anticline.

### Beaver River Fault

The Beaver River fault, another major east dipping thrust, parallels the West Grayling fault, 5 miles to the west. It may be traced north to the area of syenitic intrusion where it is lost, although it may possibly join a northeast trending fault in that area.

### Western Region

West of the map-area, another major fault occurs, which on the Beaver River, thrusts Upper Ordovician dolomite over shale and coal beds of possibly Carboniferous or Cretaceous age. Extended south, this fault follows the linear trend of the Toobally Lakes.

In the southwestern part of the map-area, several synclinal mountains (Figure 43, 44, and 45) stand out as "islands" in the adjacent forested area of low relief. These synclines, remnant of the high folding to the east are flanked by the resistant Liard formation (Figure 46) and commonly have the Garbutt formation preserved in their troughs.

Much of the map-area west of the West Grayling fault was not studied in detail and most structures, indicated on the map, were recorded from air photographs.

APR • 60



Figure 43

Isolated synclinal mountain capped by the Liard formation and underlain by the darker weathering Toad formation.

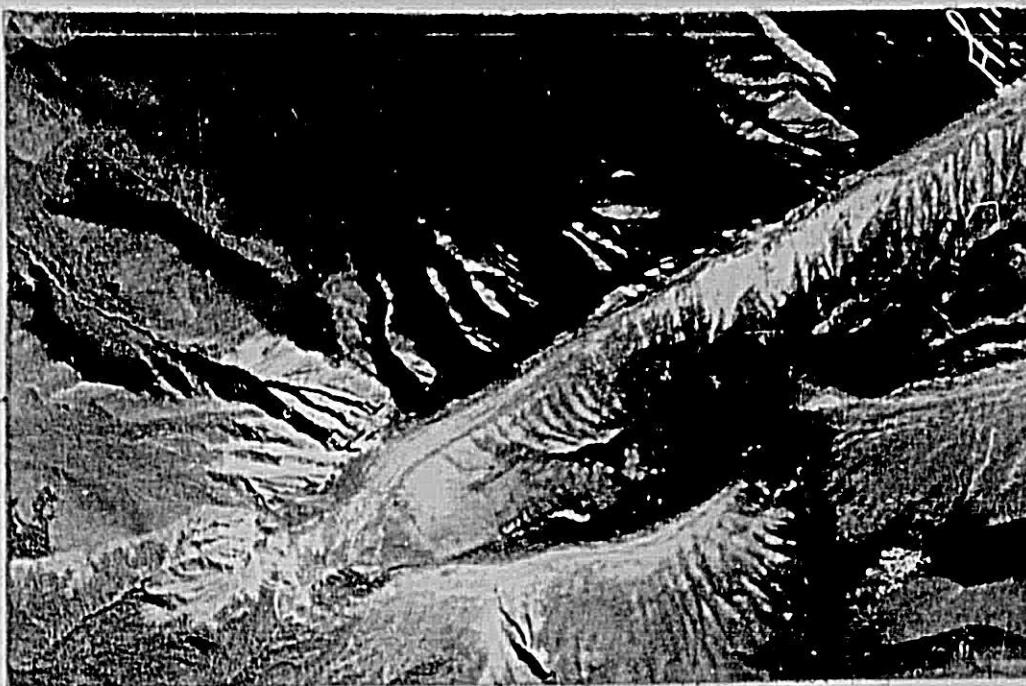


Figure 44

Air photograph of the synclinal mountain shown in Figure 45. The resistant sandstones of the Liard formation form a good geophoto unit for mapping.



Figure 45

View looking north along synclinal mountain as illustrated in Figure 44.



Figure 46

Resistant sandstones of the Liard formation flanking the syncline shown in Figure 45.

## CONCLUSIONS

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The detailed mapping and stratigraphic study in the Liard River area has led to the following conclusions:

- 1) The tight folding of the Triassic in the Rocky Mountain Foothills does not necessarily reflect similar folding in the underlying Paleozoic formations.
- 2) Simple anticlinal structures (i.e. Beavercrow anticlines) on the Liard Plateau, will, on the other hand, reflect similar folding of the underlying strata.
- 3) The change in structural alignment, the prevailing east-dipping thrust faults, and the positive area in the western part of the map-area are all probably inter-related.
- 4) Lensing within the Sikanni and Scatter sandstones may provide possible stratigraphic traps in the eastern part of the map-area.
- 5) Although the Triassic did not appear promising as a productive horizon, sandstone lenses, such as occurs near the base of the Toad formation on the Crow River, may occur in the subsurface to the east, and as such, should provide conditions for the accumulation of hydrocarbons.
- 6) The Mattson formation is essentially a well sorted, medium to fine grained quartzose sandstone unit, showing porous horizons on outcrop. This unit must be considered a potential reservoir within the Liard Basin.

7) The Mississippian carbonates underlying the Mattson formation are difficult to assess, however, unpredictable porous lenses may occur.

8) Development of porosity in the upper part of the Nahanni formation, as observed on the Crow and Beaver Rivers, may provide a stratigraphic trap in the subsurface, even in "off-structure" areas.

9) The Upper Ordovician porous biostromal dolomites of Map-unit 3 should be present beneath the structures in the western part of the area but are not present in the eastern part of the area.

## BIBLIOGRAPHY

---

BOSTOCK, H. S. (1943), "Physiography of the Canadian Cordillera, with Special Reference to the Area North of the Fifty-fifth Parallel", Geol. Surv. of Canada, Memoir 247.

BRADY, W. B. and JOHNSTON, A. H. (1960, a) "East Grayling and West Scatter Prospects", unpublished manuscript on file with Union Oil Company of California, 709 - 8th Avenue West, Calgary, Alberta.

BRADY, W. B. and JOHNSTON, A. H. (1960, b) "Toad Anticline Prospect", unpublished manuscript on file with Union Oil Company of California, Calgary, Alberta.

COOK, J. T. (1950), "Geological Report on the Fort Nelson Area, Northeastern British Columbia", unpublished manuscript in files of Union Oil Company of Calif., Calgary, Alberta.

DOUGLAS, R. J. W. (1959, a), "Fort Liard and La Biche Map-areas, Northwest Territories and Yukon", Geol. Survey of Canada, Paper 59-6.

DOUGLAS, R. J. W. (1959, b) "Great Slave and Trout River Map-areas, Northwest Territories", Geol. Survey of Canada, Paper 59-11.

HAGE, C. O. (1945), "Geological Reconnaissance along Lower Liard River, British Columbia, Yukon, and Northwest Territories", Geol. Survey of Canada, Paper 45-22.

HARKER, P. (1959-1960) "Carboniferous and Permian Stratigraphy of Southern Mackenzie Mountain Area, Northwest Territories and Yukon", Geol. Survey of Canada, Bull. (in preparation).

HENDERSON, W. R. S. (1950), "Geological Report on Northeastern British Columbia", unpublished manuscript in files of Union Oil Company of California, Calgary, Alberta.

JOHNSTON, A. H. (1954), "A Stratigraphic Reconnaissance of the Devonian System in the Rocky Mountains of Northwestern Alberta and Northeastern British Columbia", unpublished manuscript in files of Union Oil Company of California, Calgary, Alberta.

KINDLE, E. D. (1944), "Geological Reconnaissance along Fort Nelson, Liard, and Beaver Rivers, Northeastern British Columbia and Southeastern Yukon", Geol. Survey of Canada, Paper 44-15.

LAUDON, L. R. and CHRONIC, B. J. (1947), "Mississippian Rocks of Meramec Age along Alcan Highway", Bull. Amer. Assoc. Pet. Geol., Vol. 31, pp. 1608-1618.

LAUDON, L. R. and CHRONIC, B. J. (1949), "Paleozoic Stratigraphy along Alaska Highway in Northeastern British Columbia", Bull. Am. Assoc. Pet. Geol., Vol. 33, pp. 1502-1552.

McCONNELL, R. G. (1891), "Report on an Exploration in the Yukon and Mackenzie Basins, N.W.T.", Geol. Survey of Canada, Annual Report, Vol. IV, Pt. D.

MCLEARN, F. H. and KINDLE, E. D. (1950), "Geology of Northeastern British Columbia", Geol. Survey of Canada, Memoir 259.

NISLEY, D. E. (1950), "Stratigraphic Studies along the Alaska Highway", unpublished manuscript in the files of Union Oil Company of California, Calgary, Alberta.

PATTON, W. J. H. (1958), "Mississippian Succession in South Nahanni River Area, Northwest Territories", in Jurassic and Carboniferous of Western Canada, Allan Memorial Volume, Am. Assoc. Petrol. Geol., pp. 309-326.

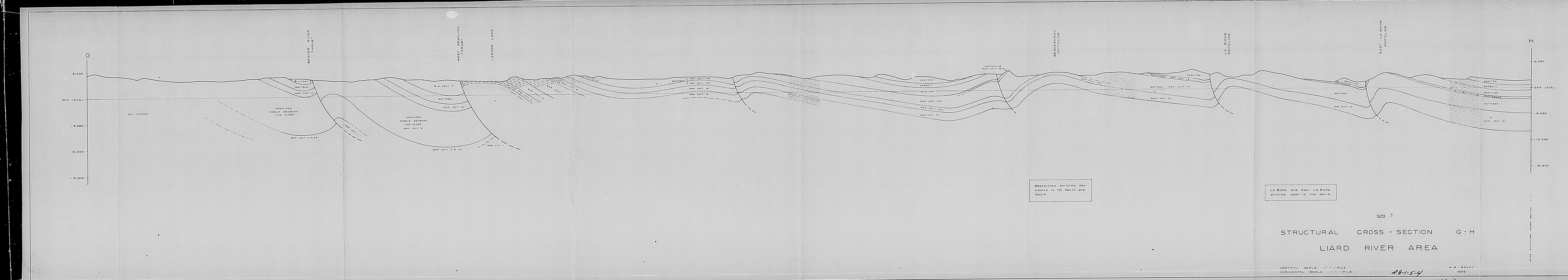
PELLETIER, B. R. (1959), "Tetsa River, British Columbia", Geol. Survey of Canada, Map 29-1959.

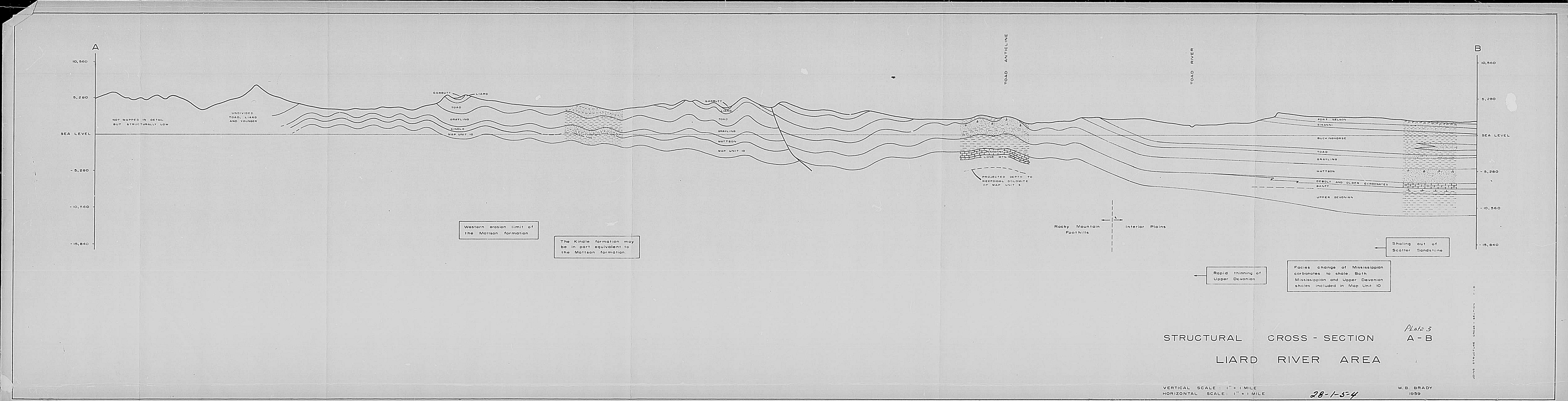
PETTIJOHN, F. J. (1957), "Sedimentary Rocks", Harper Bros. N.Y.

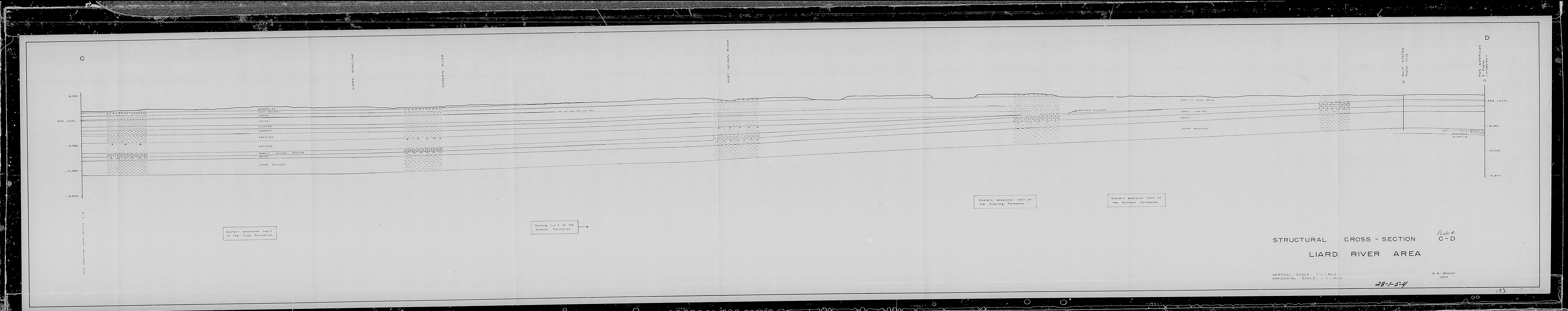
SHROCK, R. R. (1948), "Sequence in Layered Rocks", McGraw-Hill Book Company, Inc., New York, N.Y.

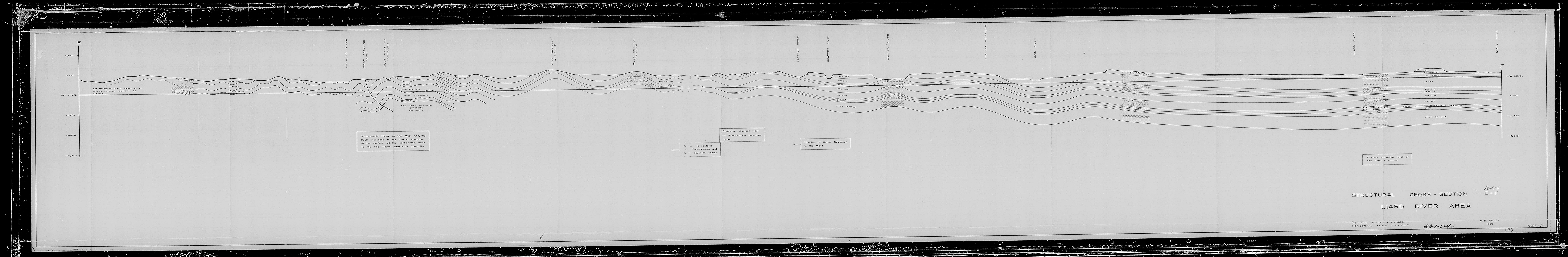
SUTHERLAND, P. K. (1958), "Carboniferous Stratigraphy and Rugose Coral Faunas of Northeastern British Columbia", Geol. Survey of Canada, Memoir 295.

WILLIAMS, M. Y. (1944), "Geological Reconnaissance Along the Alaska Highway from Fort Nelson, British Columbia, to Watson Lake, Yukon", Geol. Survey of Canada, Paper 44-23.

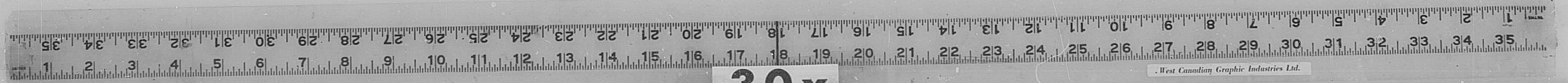



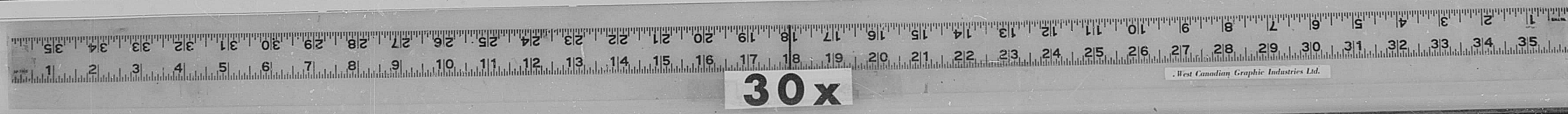











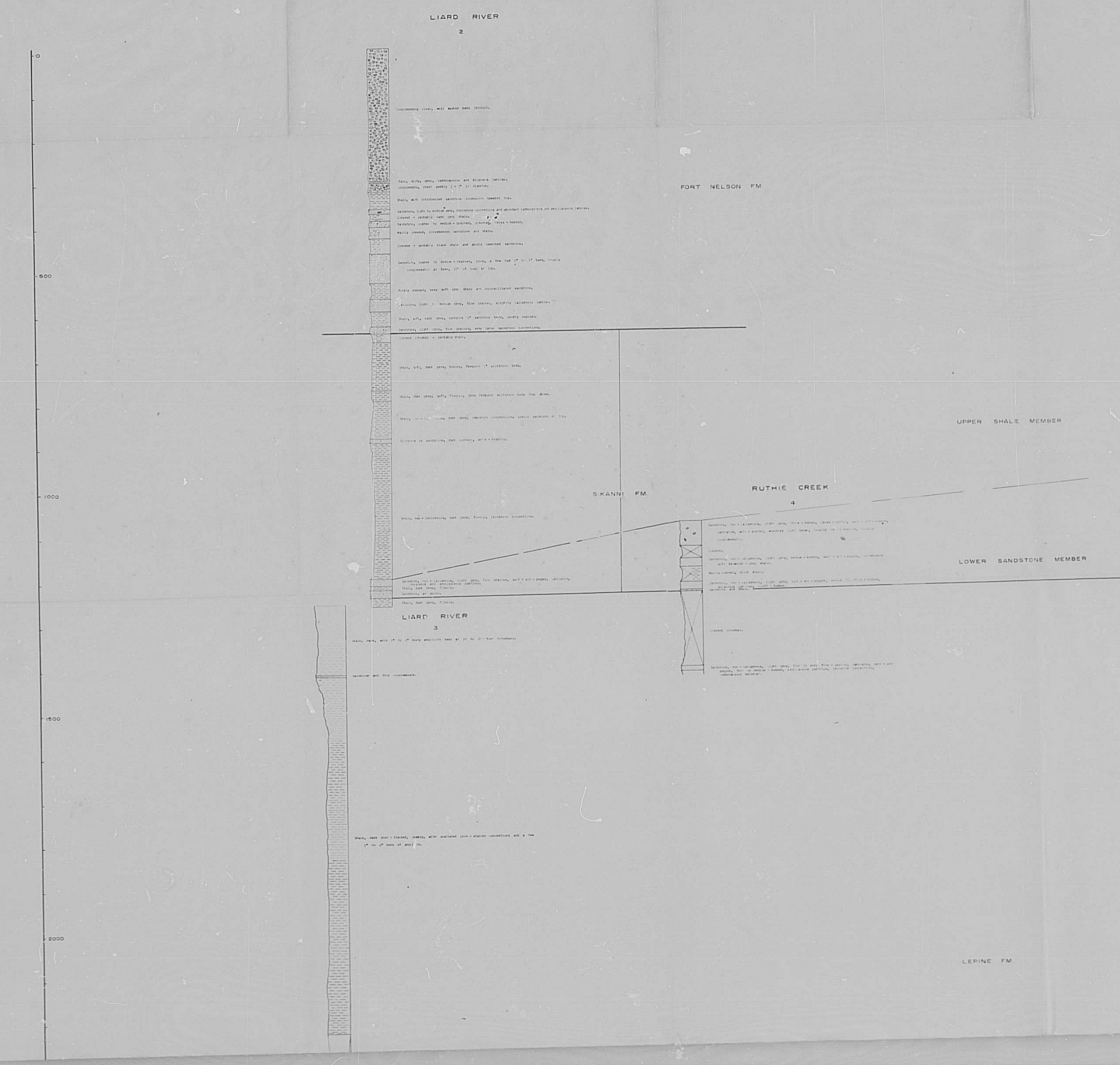


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PLATE 3  
CRETACEOUS STRATIGRAPHY

SCATTER RIVER TO TOAD RIVER

W. B. BRADY 1959



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**FALEOZOIC STRATIGRAPHY**  
GRAYLING RIVER TO BEAVER RIVER


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
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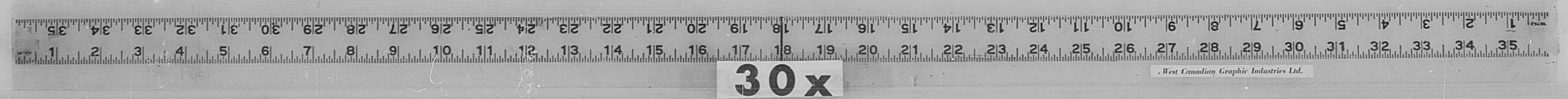
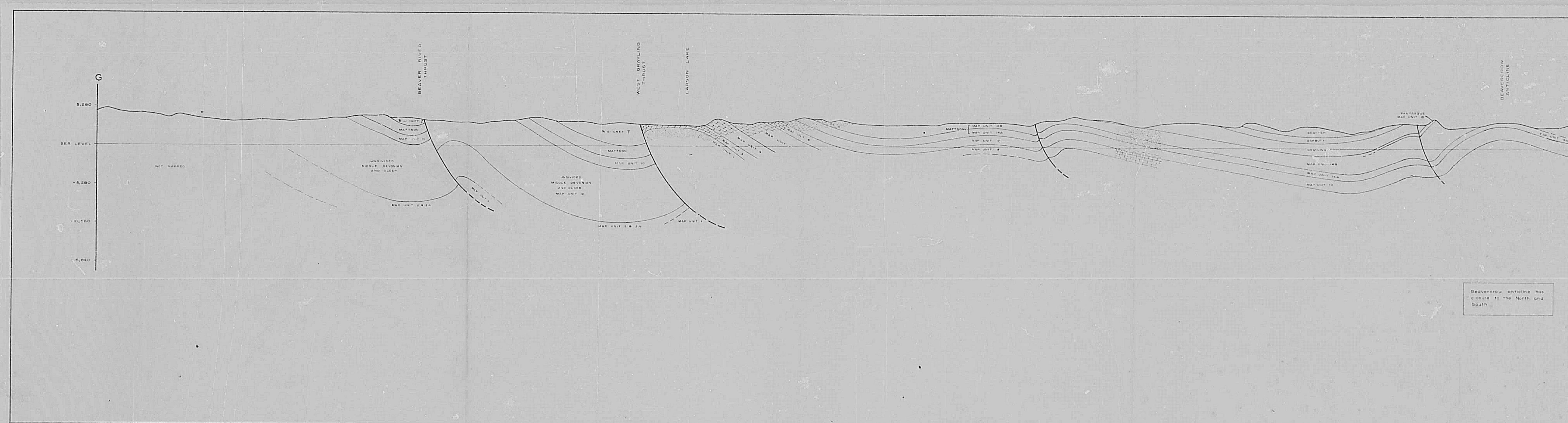
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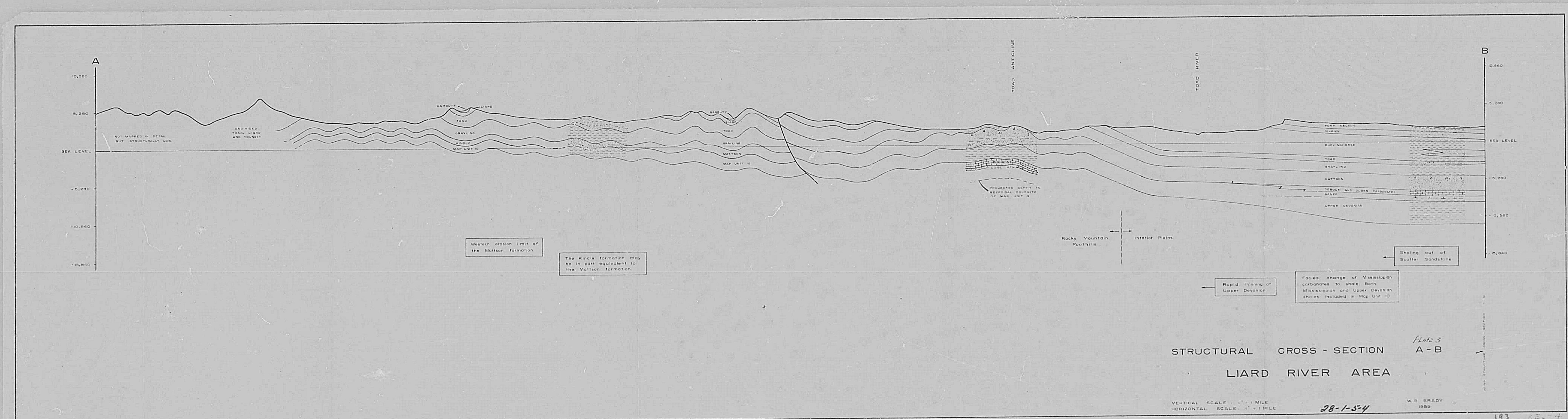


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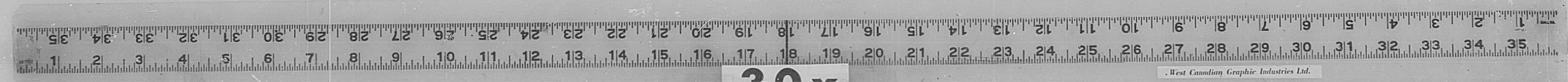
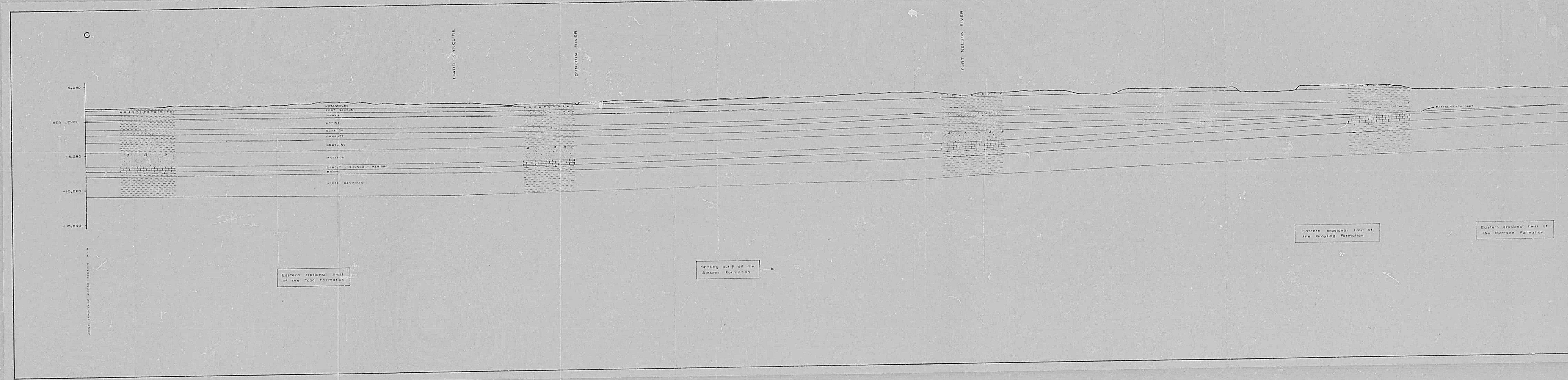
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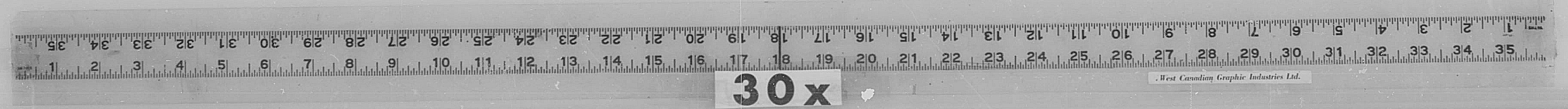
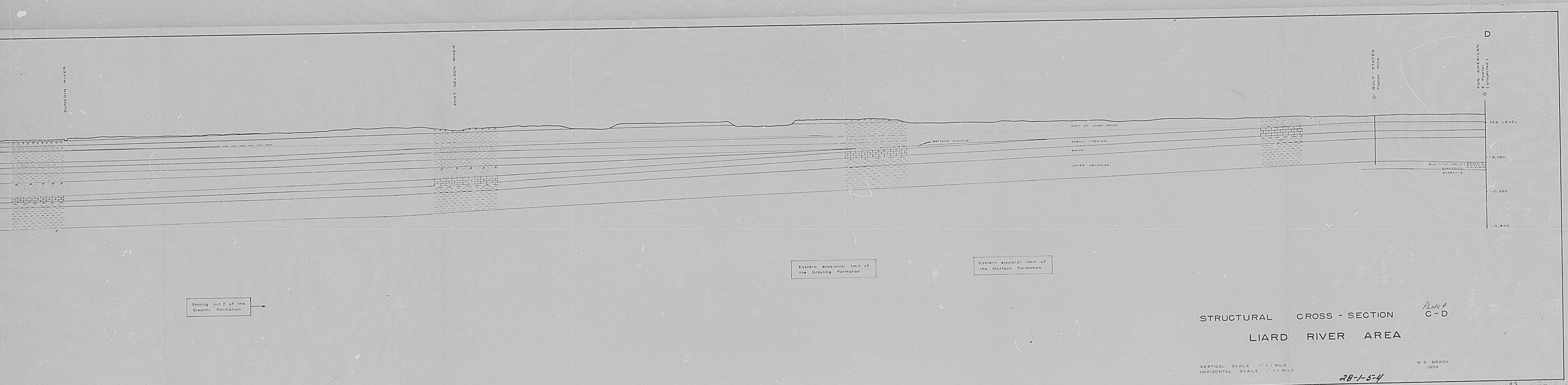


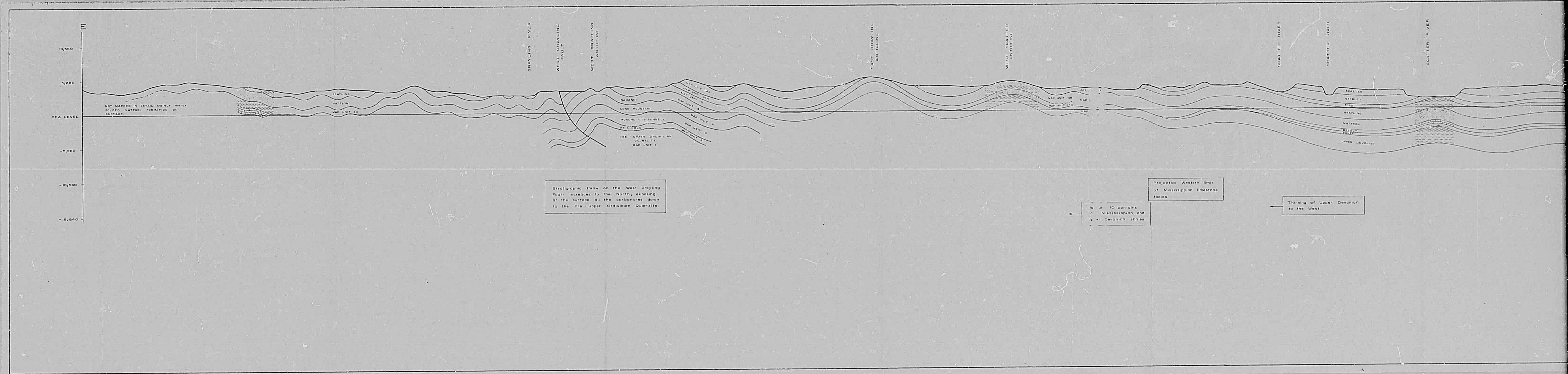
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