GEOLOGY OF THE RACING RIVER AREA, BRITISH COLUMBIA

by

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ABSTRACT

The Racing River area is situated near the northern end of the Rocky Mountains of British Columbia about sixty miles south of the Yukon border. The Alaska Highway passes through the map area from mile 370 to mile 460. The area covered is about two thousand square miles.

Rocks exposed in the map area range in age from Late Precambrian to Upper Cretaceous, and except for thin basic dykes which cut the basement rocks, are made up entirely of sedimentary sequences. Fourteen formations have been recognized, using earlier work by M.Y. Williams (1944) and Laudon and Chronic (1949) as a basis for the subdivisions. Units mapped are essentially rock units and do not always coincide with the Formations.

The area includes the physiographic provinces of the Rocky Mountain Foothills Belt, and the Rocky Mountains proper. Topography is closely related to the underlying structures, which are comprised essentially of large thrust sheets overriding each other from the west; the planes of the faults dip towards the west at varying angles. Except close to the thrust faults, the strata in general are remarkably
unfolded. Secondary tension fractures have developed, often along pre-existing dykes, and quartz and carbonate material has been introduced. The veins are in places accompanied by copper mineralization.
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**APPENDIX**

Location Map Racing River Area, British Columbia

Generalized Cross-sections

Geological Map
The lower Racing River Valley from the Alaska Highway looking south towards the Sentinel Ranges
CHAPTER I

INTRODUCTION

1. General

Location

The Racing River area lies within the Rocky Mountains of northeastern British Columbia between 124° and 126° West Longitude and 58° and 59° North Latitude. The area covered is east of the continental divide and within the Liard Mining Division, and the Peace River Land Division. Reconnaissance geological mapping covered an area of about 70 miles northwest-southeast by 50 miles northeast-southwest, or approximately three thousand square miles.

Accessibility

The Alaska Highway, an all weather gravel surfaced road, passes through the northern part of the area. Racing River Bridge is 418.5 miles from Dawson Creek, British Columbia, the start of the highway, and 216 miles east of Watson Lake, Yukon Territory.
Supplies were obtained and "trucked in" from Fort Nelson at mile 300. Limited quantities of groceries and gasoline, could be purchased at Toad River Lodge (mile 422).

Transport within the map area was by pack horse and on foot, over hunters' and game trails. Main rivers were found to provide suitable access routes into most of the area. However, several of the major streams, such as Racing River and Toad River, are swift and deep, and except at lowest water, almost impossible to cross. None of the rivers are navigable for canoes or light craft, except some of the quieter reaches of the Toad.

Due to the almost total absence of suitable lakes, the use of pontoon equipped aircraft is severely restricted within the area. However, three lakes would provide suitable landings: namely Muncho, Wokkpash and Tuchodi.

Some use has been made of light helicopters within the northern Rocky Mountains, principally by oil exploration parties, with some success but problems of fuel transportation and average summit levels in the order of 8000 feet restrict their use to the lower areas along the highway.

Object of Investigation, and methods of survey

The writer spent eight weeks from mid-June until the end of August within the area in the employ of Rio Canadian Exploration Limited. The object was to prospect the area and
to locate the source of reported copper float up the Racing River (B.C. Minister Mines Annual Report 1953). Also a rock unit geological reconnaissance map was to be compiled to outline suitable areas in which to prospect.

With this in mind traverses were made up all the major valleys with side trips across suitable sections and along mountain ridges. The rock units were usually plotted directly on unkontoured field sheets having a scale of 2 miles to 1 inch, supplemented with a 4 miles to 1 inch contour map and in certain areas by 1 mile to 1½ inch contour maps. The final map was plotted on a scale of 2 miles to 1 inch on a base taken from the Dominion Government manuscript topographical map contoured at 500 foot intervals, but using only the 1,000 foot contours.

To assist in the prospecting, use was made whenever possible of portable geochemical soil sampling kits, but due to the rugged nature of the country their usefulness was restricted to the lower and more heavily wooded areas along the lower MacDonald and Racing Rivers in the vicinity of the Alaska Highway.

To supplement ground observations, a limited number of air photographs were studied in the field and additional bedding attitudes were plotted from an outline map compiled from air photos in the head office. These are differentiated
on the accompanying map from those observed in the field since it was found in several cases that the dips were marked in the opposite direction to that observed in the field. All dips and strikes taken in the field were read to the nearest five degrees and this was found to be accurate enough for the scale of the work.

Of necessity, much of the geology of the higher and more inaccessible areas is speculative and in many cases mapping of the rougher terrain was carried out from the valley bottom or the ridges on the opposite side of the valley. This method was more reliable than is usually the case, due to the almost entire absence of vegetation on the steep mountain sides, and the distinct lithologic expression of the various rock units. For this reason air photographs are eminently suited for this part of the country and will prove very useful to any further field investigations in this area.

Since the mapping during the field work was of a reconnaissance nature and primarily intended to assist in the prospecting of the region, no stratigraphical sections were measured or closely studied. However, rock units were recognized from the published descriptions of Williams (1944) and of Laudon and Chronic (1947), (1949) and others. They can be tentatively fitted to named and correlated formations.

The Alaska Highway locality has supplied information regarding the Proterozoic and Palaeozoic in northeastern
British Columbia that has not yet been found elsewhere in the general area. On the other hand the Triassic has been studied in a number of areas, including the Tetsa Valley and much more is known of these rocks and their ages than of the older beds. The Upper Mesozoic formations have been closely studied in other parts of British Columbia and received only a very brief examination by the writer in this area.

Thus much of the following information must of necessity be taken from previous work in order to achieve a more complete and accurate picture than the scope of the field work allowed.

Previous Work

The Rocky Mountains of northern British Columbia are an area that has received very little geological investigation. It is only in recent years with the opening of the Alaska Highway, and the intense search for oil along the foothills region, that they have received any close attention.

In 1888, G.M. Dawson's scientific report of his expedition through the Yukon, Northwest Territories, and northern British Columbia was published by the Geological Survey of Canada. Although Dawson did not enter the area covered in this report, his early observations have proven to be very accurate and closely similar to geologic conditions in this part of the Rocky Mountains.
R.G. McConnell reported on the geology of the Liard River Valley in 1891. He recognized all the major time rock units exposed along the Liard and those that are now recognized further south along the Alaska Highway.

M.Y. Williams made a reconnaissance in 1922 down the Sikanni and Fort Nelson Rivers to the Liard; his observations tying in with those of Dawson and McConnell. In 1943 with the partial opening of the Alaska Highway, Williams was able to investigate the geology between Fort Nelson and Watson Lake. His report is the only publication to deal with the general geology of the map area. Later workers concentrated on more detailed observations of limited extent. Williams' 1944 report, while of a reconnaissance nature, is remarkable in the comprehension of the geology of this particular area, and it is unfortunate that time did not permit him to complete a more detailed investigation of this region. His map, prepared on the scale of 8 miles to the inch, was the only geologic map available.

In 1943 C.S. Denny presented an account of the glacial geology along the Alaska Highway and in 1944 L.O. Thomas discussed the mineral possibilities of the areas adjacent to the Highway.

In 1946 the Geological Survey of Canada published a special paper by F.H. McLearn on Middle Triassic faunas found along the Tetsa River Valley.
Limited detailed stratigraphical work was undertaken by L.R. Laudon and B.J. Chronic for the University of Kansas in the summer of 1946 and the results of their investigation were published in the American Association of Petroleum Geologists Bulletins for 1947 and 1949. They established two new formations and described several measured stratigraphical sections. However, since then not much relevant geological work has been published, but all previous work in northeastern British Columbia has been collected and summarized by McLearn and Kindle in the Canadian Geological Survey Memoir No. 259, published in 1950.

A certain amount of exploration and mapping has been carried out during recent years by various oil companies, but no detailed results have been made public. The British Columbia Minister of Mines reports refer briefly to prospecting activity within the general area since about 1950, but no specific information has been published.

In 1951 a Master of Applied Science Thesis was submitted to the University of British Columbia by M.M. Menzies, on the geology of several copper claims adjacent to the upper Tetsa River Valley. Menzies describes in some detail the stratigraphy of 3,000 feet of ancient sediments, but his investigations were of a very limited extent.
2. Physiography

The area under consideration lies entirely in the Eastern Cordillera of Western Canada, and is comprised of two distinct physiographic regions which are both closely related to the underlying rock structure. These are:

1. The eastern Rocky Mountain Foothills Belt

2. The Rocky Mountains proper, which can be divided into three sub-provinces, as follows:
   (a) the eastern Stone Ranges Sub Province
   (b) a central lower Racing River Valley Sub Province
   (c) and the western Sentinel Ranges Sub Province.

These sub-provinces are distinct and are generally oriented north-northwest by south-southeast, although parallelism is lost where the Racing River Sub-Province pinches out between the other two.

1. Rocky Mountain Foothills Belt

Immediately east of the map area the Eastern Plains stretch away to the Alberta border. This featureless terrain is one of low, rolling relief, controlled by the flat lying and almost undisturbed Upper Cretaceous sediments. Rivers such as the Muskwa have cut deep valleys in places, others have wide valley bottoms and swamps are extensive.

The plain varies in elevation from 1,800 feet on its western border, to about 1,000 feet in the east, far beyond the map area.
In the vicinity of mile 360 on the Alaska Highway, the Plains give way to the undulating, and in the east, gently folded Mesozoic sequences that go to make up the Foothills Belt.

This belt in the vicinity of the Alaska Highway is about 50 miles wide terminating abruptly against the Rocky Mountain front at mile 390 on the Highway. This front extends southwards for over one thousand miles until it passes into the United States.

On the extreme eastern margin of the map area, east of the Dunedin River, remnants of an old erosion surface are preserved on Table Mountain. This surface is at an elevation of approximately 4,800 feet. Capping Table Mountain and the other flat topped hills of the map-area to the east, such as Teepee Mountain and Steamboat, are gently dipping Upper Cretaceous sandstones and conglomerates. These are underlain by lower Cretaceous argillaceous and arenaceous strata which become progressively more disturbed towards the west until they lie in fault contact with older Mesozoic formations in the vicinity of mile 378.

These older rocks form a series of anticlines and synclines whose axes parallel the borders of the Foothills belt, and which give rise to long low hills whose relief is in the order of 2,000 feet. In this western section of the Foothills belt the drainage pattern is trellis; the major cross
cutting valleys belong to the Toad, the Tetsa, the Chischa, and the Tuchodi Rivers. Smaller streams are numerous.

This rather marked rectangular drainage pattern gives way abruptly to a dendritic pattern on passing into the Rocky Mountain Physiographic Belt, although the above mentioned four rivers flow directly across the Rocky Mountain front from the heart of the mountain ranges.

2. The Rocky Mountain Belt

The Rocky Mountain Front in this area is controlled by a major thrust fault, referred to in this report as the Rocky Mountain Front Thrust. This fault has been traced for about 45 miles and continues away to the south, perhaps eventually to join with the McConnell Thrust of the southern Alberta Rockies. It marks an abrupt physiographic change from the gently rolling rounded hills of the Foothills region to the rugged bare peaks of the Rocky Mountains themselves.

Elevations to the east of the front are seldom above 5,500 feet, but this changes abruptly to a general level of 8,000 or more feet in the Stone and Sentinel Range Sub-Provinces. Relief in the mountains attains a greater magnitude than in the Foothills Belt, reaching a maximum of 6,000 feet in the vicinity of Churchill Peak.
(a) The Stone Range Sub-ProVINce of the Rocky Mountain physiographic belt is bordered in the east by the Rocky Mountain Front Thrust and in the west by the Lower Racing River Valley Sub-ProVINce which becomes pinched out in the vicinity of the Alaska Highway at mile 400 so that the Stone Ranges abut against the Sentinel Sub-ProVINce; an arbitrary boundary being taken along the Wokkpash Valley.

Within this Sub-ProVINce the terrain is rugged and deeply dissected by the major streams. Maximum elevations are reached in five main peaks which are aligned from north to south within the belt as follows:

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<th>Minimum Elevations</th>
<th>Relief</th>
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<td>Stone Mountain 6,500</td>
<td>Toad River 2,000</td>
<td>4,500</td>
</tr>
<tr>
<td>Mt. St. Paul 6,979</td>
<td>Dunedin headwaters 3,500</td>
<td>3,479</td>
</tr>
<tr>
<td>Mt. St. George 7,419</td>
<td>Summit Lake 4,100</td>
<td>3,319</td>
</tr>
<tr>
<td>Mt. Mary Henry 8,577</td>
<td>Tetsa River 4,000</td>
<td>4,577</td>
</tr>
<tr>
<td>unnamed peak 8,586</td>
<td>Chischa River 4,000</td>
<td>4,586</td>
</tr>
<tr>
<td></td>
<td>Tuchodi Lake 2,800</td>
<td>5,786</td>
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The major valleys are U-shaped showing the results of glaciers which moved down them to the continental ice sheets of the plains. Glacial ice is absent from the Stone Ranges today but cirques are present on all the higher peaks. Glacial lakes are numerous within the valleys -- the largest and most conspicuous being the two Tuchodi Lakes, Wokkpash Lake and the
two smaller Summit Lakes which lie at the crest of Summit Pass. Summit Pass forms one of the few natural routes between the eastern and western adjoining regions.

Wokkpash River, which has been taken as the western boundary of the Eastern Sub Province in its lower reaches is seen to cut across the structure in a narrow canyon to join the Racing River about 18 miles upstream from the Alaska Highway. (See Plate I, and map in folder at end). It is evident that once the Wokkpash flowed down the broad valley of the Mooskeg branch of the MacDonald, joining the Racing in what is now MacDonald Creek. Perhaps the Wokkpash was dammed by ice which formed a large lake that overflowed to the west, and its outlet was slowly lowered until it cut down through bed rock to form the present canyon. No evidence of this lake is to be seen in the Wokkpash Valley today but there is a perceptible change of slope and the suggestion of an old rock terrace about 1,000 feet above the valley floor, above which glacial debris is absent. (See Plate II.)

(b) The central Sub-Province is that of the lower reaches of the Racing River Valley. Structurally, the physiography is controlled by the Racing River Synclinorium. This is comprised of upper Palaeozoic and some Mesozoic rocks, the latter consisting mainly of easily weathered black shales, dark limestones, and sandstone. Thus this central province forms a belt of lower more rolling country between the high bare mountains of the Stone and Sentinel Ranges.
PLATE I

View northeastwards across the Racing River Valley (foreground). Through the Wokkpash River Canyon (centre) towards snow capped Stone Ranges.

PLATE II

View south of inlet to Wokkpash Lake. Southwest dipping Windermere-type quartzites are capped by young limestones. Note change of slope above valley floor.
Because the syncline pitches to the northwest, the sub-province pinches out between the other two, at about mile 400 on the Alaska Highway. In the valley of the Toad River it reaches its maximum width of 12 miles.

Within the area elevations reach nearly 6,000 feet but average summit levels are closer to 4,500 feet while valley bottoms lie about 2,500 feet above sea level which gives a relief of 2,000 feet.

Hillside slopes are generally gentler and valley floors flatter in this region than in the other two sub-regions of the Rocky Mountains. The drainage pattern is dominated by major streams that cut across the general trend of the underlying structure, such as Four Mile Creek, Toad River, Yash Creek and part of the Racing River, and by streams which flow parallel to the structural trends, such as Nonda Creek and MacDonald Creek.

(c) To the west of the map-area lies the third sub-province of the Rocky Mountain physiographic belt, the Sentinel Ranges. This belt extends from Muncho Lake in the northwest to Tuchodi Lakes in the southeast; a distance of 75 miles, and reaches a maximum of 20 miles in width. It continues north of the map-area an additional 35 miles until it is terminated by the Liard River Plateau. It terminates in the west beyond the map-area in the Gataga River, which partially marks the western limit of the Rocky Mountain Ranges.
PLATE III

Upper valley of South Tetsa River. Gently dipping Windermere type quartzites and limestones dip southwestwards.

PLATE IV

Churchill Peak (10,500 ft.) centre background, from north. Rocks are Windermere-type sediments.
The Sentinel Ranges in part form the divide between the drainage to the east, by way of the Toad and Muskwa Rivers, and that to the west into the Gataga and Kechika Rivers.

Summit levels in this belt are, in general, higher than in the eastern belt. Several peaks rise up above the general level of the mountains to stand, as does Churchill Peak, 2,000 feet above the neighbouring crest lines.

High peaks in this area are numerous, but many are unmapped and unclimbed. Most notable are:

- Unnamed peak east of mile 450 on the Highway 7,683'
- Yedhe Mountain 8,500'
- F.D.R. Peak (unnamed) 9,381'
- Mt. Roosevelt 9,500'
- Churchill Peak 10,500'
- Mt. Stalin 9,500'
- Mt. Aida 8,500'

Valley floors are:

- Muncho Lake 2,680'
- Toad River 3,000'
- Delano Creek 4,000'
- Churchill Creek 4,000'
- Upper Racing River 4,500'
- Tuchodi Lake 2,800'

Giving a relief of about 5,500 feet.

In general the topography is one of steep, valley sides, in places vertical, rising from narrow deep valleys. In places the interfluvial areas are knife-edge ridges; elsewhere they are broad flat plateaus, usually capped with flat lying Palaeozoic limestone strata.
It is not known whether the structural control is responsible for these flat ridges or whether they belong to an earlier period of erosion and planation. Whatever the cause they are being actively modified at present by stream erosion, and by the waning action of small hanging glaciers which are the last dying remnants of what must once have been considerable mountain glacierization.

Most of the present valley bottoms seem to be about 500 feet below an older base level, for many of the valley sides show old rock benches and nearly all the side tributaries are in hanging valleys. The tributaries drop in a series of falls, or else are deeply incised and have very steep gradients as they flow into the main valley.

3. Glaciation

The evidence of Pleistocene glaciation is widespread within the map area. Features of Alpine glaciation such as U-shaped valleys, mountain cirques, aretes, matterhorns, hanging valleys and glacial sediments are present throughout the region.

As in the case of the Wokkpash, part of the present course of the Toad River flows in a narrow canyon (See Plate VIII). Where the Alaska Highway turns north at about mile 440 it follows a wide valley which is a continuation of the upper Toad River Valley, now occupied by Muncho Creek and Muncho Lake. Beyond the map-area to the north Muncho Lake is
drained by the Trout River which follows this same wide valley for 30 miles to join the Liard River. This valley is almost on strike of the Sentinel Ranges structure and represents the original valley of the Toad River. That the present Toad River canyon, as followed by the highway is preglacial in age, is evident by the amount of glacial debris that was deposited along its course.

M.Y. Williams (1944) considers that pre-glacial valleys were deeper and probably better graded than those of today. Immediately preceding glaciation uplift occurred and the streams adjusted to the new base level by rapid down-cutting—now evident in the youthful valley of the Toad, and the lower canyon of the Wokkpash. With the removal of the ice this readjustment is still continuing, possibly accentuated by isostatic readjustment, allowing incised streams to cut deep rock canyons, and the more mature streams to rapidly remove the mantle of glacial till that was deposited in their valleys.

In most of the mountainous parts of the area, cirques have formed in the higher country, often backed by aretes and in some places partially developed matterhorn peaks are recognized; Churchill Peak and Mt. Roosevelt being of this type. (See Plates IV and XV). Rock steps lead down from cirques and small glacial lakes occur near the heads of many of the valleys. In many cases the main tributary starts in a hanging valley and descends through a post glacial notch in a series of waterfalls to the main U-shaped valley. Along
the main valley truncated spurs are also evidence of glaciation. In the high areas there are still hanging glaciers and snow fields, but they are diminishing in size. (See Plate XVI). Within the map area about 40 are still present, ranging in size from a few hundred acres to 9 square miles. These glaciers are the source of most of the main streams in the area which as a consequence have very milky water in their upper reaches.

All of the lakes in the area owe their origin to glacial deposition. This is well seen by the moraines that dam up Muncho, Wokkpash and Tuchodi Lakes.

Glacial debris cloaks the sides of most valleys where it has not yet been stripped off. Pronounced terraces of glacial-till flank the sides of the valley containing Summit Lake, and are well displayed along the upper Racing River Valley above its confluence with Churchill Creek and near the Alaska Highway bridge (See Frontispiece). Erosion of these till benches has left well developed "hoodoos" which are striking for their height and thickness.

Williams (1949) has noted glacial striations on the south side of the north fork of the Tetsa within the Summit pass. They strike N. 81°E. On Mount St. Paul, to the north of the pass at an elevation of 6,000' he records striations at N. 32° E.

Glacial till occurs over most of the area, but is
commonly covered by more recent outwash and river gravels. High banks composed of glacial boulders and sand in places cemented by fine white rock flour are being undercut along the Bacing River, near the Wokkpash confluence.

Erratic boulders are composed of most rock types within the area that are resistant enough to survive transport. In some of the deposits shales occur as glacial boulders. Along the Tetsa Valley red granite and gneissic boulders are fairly plentiful, and range to a foot and a half in diameter and it is probable that they are derived from the Canadian Shield.

4. Climate

The climate of the area under consideration is sub-arctic. The area is characterized by relatively short summers and long, cold, dry winters.

In winter temperatures along the Alaska Highway drop to a mean minimum of about 55° below zero, with January the coldest month. In summer temperatures rise to a maximum of around 95° F, although the mean monthly temperature for July, the hottest month, is only 60° F.

Freeze-up starts usually in mid-October and is complete by mid-November. Break-up usually commences in late April. Thus the field season is limited to four months, and even during that time snow can be expected. Permafrost is
absent from the area but snow will lie until late August, by which time fresh winter snow has probably started. Total precipitation is from 10" to 15", with 60% falling between May and September. Winter snowfall totals only about 4 feet, and as the snow cover at any one time is somewhat less, horses can be wintered near the confluence of the Toad, Racing and MacDonald Rivers.

The following table from the United States Geological Survey Bulletin 963D may be of interest in showing climatic conditions for two stations on the east and the west of the map area. It is of note that both are on flat country, Fort Nelson lying on the Eastern Plain and Watson Lake on the Liard River Plateau.

<table>
<thead>
<tr>
<th>1940 - 1950</th>
<th>Fort Nelson B.C.</th>
<th>Watson Lake Y.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>30°F</td>
<td>31.4°F</td>
</tr>
<tr>
<td>Minimum</td>
<td>98°F</td>
<td>90°F</td>
</tr>
<tr>
<td>-54°F</td>
<td>-61°F</td>
<td></td>
</tr>
<tr>
<td>Summer Aver. Precipitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain</td>
<td>7.7&quot;</td>
<td>8.27&quot;</td>
</tr>
<tr>
<td>Snow</td>
<td>0.75&quot;</td>
<td>1.6&quot;</td>
</tr>
<tr>
<td>Winter Aver. Precipitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain</td>
<td>0.85&quot;</td>
<td>0.61&quot;</td>
</tr>
<tr>
<td>Snow</td>
<td>52.4&quot;</td>
<td>63.&quot;</td>
</tr>
<tr>
<td>Total Precipitation</td>
<td>6.11&quot;</td>
<td>6.94&quot;</td>
</tr>
<tr>
<td>Mean. Annual Precipitation</td>
<td>13.9&quot;</td>
<td>15.37&quot;</td>
</tr>
</tbody>
</table>
5. Vegetation

About three quarters of the map area is above timberline and is virtually devoid of trees. Timberline ranges from 4,500' to 5,000' in elevation. This means that trees are confined to the lower area in the east in the Foothills and to the major river valleys. The Lower Racing River physiographic sub-province being of lower elevations and more subdued topography than the Stone and Sentinel Ranges is fairly well wooded but nowhere are the trees very dense or very large.

Generally the vegetation is mixed, but with less than a dozen species dominant. These consist of:

- alpine fir
- lodgepole pine
- balsam fir
- white spruce
- larch
- black poplar
- black spruce
- trembling aspen
- white birch

Dwarf birch and willow are the main varieties of shrubs.

Usually there is a difference in tree types from the north to the south facing slopes, the south facing slopes usually having gentler gradients, and more significantly, receiving more sunshine. For example at Summit Lake the south-facing slopes are covered dominantly by pine and white spruce while the north-facing slopes are covered only with pine.

Above timberline dwarf birch and sub-alpine scrub predominate. During the summer, parts of the hills are a mass of colour from small alpine flowers. In some of the alps good grass provides grazing for both pack-horses and caribou.
6. Fauna

Northeastern British Columbia has been looked upon as a hunters' paradise, and the area under consideration is no exception.

A wide variety of game is to be found in the area. Species include:
black bear, cinnamon bear, grizzly bear, timber wolf, moose, mule deer, mountain caribou, Stone sheep, mountain goat, porcupine, wolverine, partridge, ptarmigan, duck, and Canada goose. Wapiti (elk) are to be found near Tuchodi Lakes.

A wide variety of fur-bearing animals are trapped during the winter, but the beaver is the most important at the present time.

Fish are not plentiful in the rivers due to the clouded water and steep gradients, but rainbow trout, Dolly Varden, and greyling were taken from the lakes.

7. Acknowledgments

The field season was spent in the area as part of a prospecting programme for Rio Canadian Exploration Limited, and special thanks are due to Dr. D.R. Derry for permission to publish information gathered while in the employ of the Company.

The writer was assisted in the field by R.R. Ranson of Sault Ste. Marie, Michigan, and by Duane B. Jorgensen and
Raymond L. Roe, students at the Michigan School of Mining and Technology, Houghton, Michigan.

Thanks are also due to Dr. M.Y. Williams for helpful suggestions and to Mr. W.R. Danner and Drs. W.H. Mathews and J.V. Ross for criticizing the manuscript.
CHAPTER II

STRATIGRAPHY

A. General Statement

In the Racing River area all the rocks exposed are of sedimentary origin, except for green basic dykes which intrude the oldest formations. The sequence exposed ranges in age from Late Precambrian to Upper Cretaceous, and has an estimated maximum thickness of about 21,000 feet. Several unconformities are present, the most important of which is the erosional surface upon which the Silurian-Devonian strata rest. The others are less conspicuous and often do not represent very great periods of erosion.

Basement Windermere-type rocks consist of argillites, quartzites and limestones and have an estimated thickness of about 5,000 feet. They are intruded by thin basic dykes which often extend for several miles in length. By far the greater part of the section is made up of Palaeozoic strata. These are dominantly limestones and shales, and are commonly cyclic. The lowermost Cambrian (?) formation contains quartzites and thick red conglomerates, and reaches an estimated thickness of 7,000 feet. The limestones and shales total 5,400 feet. Mesozoic rocks comprise about 4,000 feet of the column and grade from shales and limestones into sandstones and conglomerates.
## B. TABLE OF FORMATIONS

<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>System</th>
<th>Formation or Group</th>
<th>Thickness in Feet</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesozoic</td>
<td>Upper Cretaceous</td>
<td>Dunvegan</td>
<td>600</td>
<td>non-marine and marine conglomerate, sandstone and shale</td>
<td></td>
</tr>
<tr>
<td>Mesozoic</td>
<td>Lower Cretaceous</td>
<td>Fort St.John Bullhead</td>
<td>1,500, 500</td>
<td>marine shale and sandstone. Marine and non marine siltstone, sandstone and shale</td>
<td></td>
</tr>
<tr>
<td>Jurassic</td>
<td>Garbutt</td>
<td>500</td>
<td>black shale, black limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Triassic</td>
<td>Liard Toad Grayling</td>
<td>400, 800, 600</td>
<td>sandstone, limestone shale, siltstone, limestone. Shale, limestone, siltstone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## B. TABLE OF FORMATIONS - CONTINUED

<table>
<thead>
<tr>
<th>Era</th>
<th>Period - System</th>
<th>Formation or Group</th>
<th>Thickness in Feet</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palaeozoic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permian or Penn )</td>
<td></td>
<td>Racing River</td>
<td>300</td>
<td>black chert</td>
</tr>
<tr>
<td>Mississippian )</td>
<td></td>
<td></td>
<td>400</td>
<td>limestone, calcareous, sandstone, shale</td>
</tr>
<tr>
<td>Devonian</td>
<td></td>
<td>Fort Creek</td>
<td>800</td>
<td>black pyritic, shale-grey and black limestone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ramparts</td>
<td>1,500</td>
<td>grey and black limestone</td>
</tr>
<tr>
<td>Devonian</td>
<td></td>
<td>Muncho</td>
<td>600</td>
<td>grey and black limestone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>McConnell</td>
<td>680</td>
<td>grey and black limestone</td>
</tr>
<tr>
<td>Silurian</td>
<td></td>
<td>Ronning</td>
<td>1,200</td>
<td>grey and black limestone-shale and dolomite</td>
</tr>
<tr>
<td>Ordovician</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cambrian</td>
<td></td>
<td>Macdougal</td>
<td>7,000</td>
<td>Quartzite</td>
</tr>
<tr>
<td>Proterozoic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Cambrian or Older</td>
<td></td>
<td>Windermere</td>
<td>5,000+</td>
<td>White quartzite, argillite, dolomitic limestone, basic igneous dykes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>type</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C. Description of the Rock Units

1. Proterozoic or Younger (?) Basement Rocks

The oldest rocks in the map area have been divided for mapping purposes into four main divisions. These are:

(a) Predominantly quartzitic sequences
(b) Predominantly argillaceous sequences
(c) Predominantly calcareous sequences
(d) Undifferentiated successions.

As a group they have as yet received no name, but since no detailed sections were studied in the field no formal name will be proposed here. Various opinions are held concerning their age, and they have been variously referred to as Pre-Cambrian or Lower Cambrian. Okulitch (1957) in a recent paper discusses the nomenclature of similar rocks from Alaska, western Canada and the northwestern United States. He proposes that the sequence of unfossiliferous rocks lying disconformably beneath fossiliferous (*Olenellus*, *Bonnia*, *Archaeocyathus*) Lower Cambrian Strata, and unconformably over Proterozoic (Purcell) rocks, as found in the southern British Columbia Rocky Mountains, be termed Windermere System and be considered as lowermost Palaeozoic. This proposal will probably not be universally adopted, but as it fits conditions in the Racing River section of the Rocky Mountains the oldest rocks in this area will be referred to as Windermere-type in this report.
1. Windermere Type

Siliceous limestones, limey sandstones, and feldspathic quartzites have been described by M.M. Menzies (1951) from the south fork of the Upper Tetsa River north of Mt. Mary Henry (See Plate III). Here a measured section of about 2,500 feet is as follows:

<table>
<thead>
<tr>
<th>Formation</th>
<th>Lithology</th>
<th>Thickness in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4b Limestone</td>
<td>f.g. dark yellow weathering</td>
<td>1000-1500</td>
</tr>
<tr>
<td>4a Limestone</td>
<td>dark, orange weathering, 25% detrital quartz</td>
<td>400-500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100-200</td>
</tr>
<tr>
<td>3b Sandstone</td>
<td>thin bedded, black carbonaceous</td>
<td>500-700</td>
</tr>
<tr>
<td>3a Sandstone</td>
<td>thinly bedded carbonaceous</td>
<td>100-150</td>
</tr>
<tr>
<td>2c Quartzite</td>
<td>white, massive, feldspathic</td>
<td>0-300</td>
</tr>
<tr>
<td>2b Sandstone</td>
<td>calcareous, rusty weathering</td>
<td>100-200</td>
</tr>
<tr>
<td>2a Quartzite</td>
<td>white, massive, feldspathic</td>
<td>250</td>
</tr>
<tr>
<td>1c Limestone</td>
<td>siliceous, buff weathering</td>
<td>150-300</td>
</tr>
<tr>
<td>1b Quartzite</td>
<td>beds 2 feet thick</td>
<td>50</td>
</tr>
<tr>
<td>1a Limestone</td>
<td>white, massive, feldspathic</td>
<td>400</td>
</tr>
<tr>
<td>Limestone</td>
<td>siliceous, interbedded with quartzite</td>
<td>1,000</td>
</tr>
</tbody>
</table>

The lower limestone members are characteristically rather siliceous, and contain up to 15% of detrital quartz grains. A little microcline and albite is also present as well as a few grains of accessory minerals such as zircon, tourmaline and magnetite, whilst the main constituent is calcite of coarse silt size. The measured thickness of the lower member is about 700 feet, and it overlies about 1,000 feet of similar limestone whose lower contact is not exposed. Fossils are entirely absent from the beds.
Between the Lower and Upper Limestones are 950 to 1,600 feet of arenaceous rock. These have been divided into a quartzitic assemblage about 700 feet in thickness of predominantly massive white feldspathic quartzite, in which bedding is not apparent either in outcrop or in thin section. This quartzite is an even grained rock and consists mainly of quartz and feldspar grains, particularly albite, of which the latter makes up 20 to 25 per cent of the total. Small chert pebbles make up almost 10 per cent of the section. Tourmaline, zircon and iron oxides are also present in lesser amounts. It is of note that these accessories, tourmaline and zircon do not occur in the upper limestone sequence. Within the feldspathic quartzite small intraformational conglomerate lenses were noted. They appear to be due to erosion channels formed during the deposition of the arenaceous beds.

Overlying the Quartzites are 600 to 850 feet of thinly bedded, black carbonaceous sandstone. Beds are but a few inches thick, and are also finely laminated. A characteristic of these sandstones is the presence of prominent oscillation ripple marks. The amplitude varies from about $\frac{1}{8}$ inch to nearly $1\frac{1}{2}$ inches. About 80 per cent of this carbonaceous rock is comprised of irregular quartz grains, which appear to be coated with carbonaceous material. Other minerals present are feldspar (albite), tourmaline, zircon, sericite and magnetite.
The upper limestones along the Tetsa River are characterised by their orange weathering and laminated appearance. The laminae are seen to contain variable amounts of detrital angular quartz grains, the fine grained beds containing up to about 40 per cent quartz whereas the thinner beds contain only about 10 per cent quartz. The balance of the rock is made up of fine, granular calcite.

These limestone beds form the rugged peaks of all the higher mountains along the Tetsa River with the possible exception of Mt. Mary Henry whose crest, while probably of limestone, may possibly belong to one of the above limestones or could be still younger, namely either Ronning type or Ordovician in age.

Further to the west along the valley of Wokkpash Creek a thick succession of massive, gently west dipping quartzites crop out unconformably beneath young limestones. They are approximately 4,000 feet thick where exposed and contain interbedded argillaceous members. (See Plate II).

In places in the Upper MacDonald Creek area, vertical beds of quartzite underly Ronning coraline limestone. In part the quartzite is slaty but weathers typically rusty.

The type area for these older quartzitic rocks along the Alaska Highway is near the Toad River bridge in the vicinity of mile 440. Here they are interbedded with grey
slates and porcellanous argillites, which are unconformably overlain by flat lying coral reef limestone of the Ronning Formation.

The quartzites show well marked ripples. M.Y. Williams reports unspecified ripple-marks of \( \frac{1}{2} \) inch amplitude overlain by current ripples \( \frac{1}{2} \) inches in amplitude. The thickness of the quartzite and associated argillaceous beds is in the order of several thousands of feet in this locality.

An extremely thick sequence of rocks is exposed along Tuchodi Lakes. The lower part is made up primarily of quartzites and quartzitic sandstones, and the upper portion by calcareous rocks. They weather to conspicuous reds and mauves. These rocks have been compared with the well known Cambrian sequence at Mount Robson and Lake Louise in the southern Canadian Rockies.

In the Racing River Valley opposite Delano Creek a band of limestone has been mapped. It is similar to the limestones of Tetsa River and is conspicuous as a unit by its grey color distinct from the reddish weathering argillites and quartzites above and below it. It approaches 2,000 feet in thickness. No fossils were recognized in this sequence.

Besides the predominant quartzite and limestone sequences that make up the oldest rocks in the map area, a third predominantly argillaceous succession has been recognized
as a mappable unit. It consists of shales, in places calcareous, thin sandstone and quartzite bands, limestones, and argillites. On fresh surfaces they are usually green or blue, whilst they weather to a conspicuous reddish brown.

One common rock type in thin section is made up of numerous angular fragments of quartz and feldspar set in a fine-grained matrix. This type is considered to be a greywacke.

The argillaceous sequence reach their best development in the Upper Racing River and Churchill Creek Valleys where more than 5,000 feet of predominantly argillaceous rocks dip southwestward at gentle angles. Being less competent than the quartzites they are more highly folded and sheared. Well marked fracture-cleavage is prominent, at about $30^\circ$ to the bedding. (See Plate XII). In the Toad River area M.Y. Williams reports limey argillites showing well defined mud-cracks and ripple-marks and in places containing mud balls. As far as is known no fossils have been found in these rocks.

Most of the fracture-filling base metal deposits in the map area seem to be associated with these argillaceous rocks, and more rarely with the quartzites.

Cutting the older rocks are a series of basic igneous dykes. They are generally vertical or dip at steep
PLATE V

Flat lying Windermere-type white quartzites, Upper Chischa Valley

PLATE VI

Mount Stalin (9,500 ft.) from upper Racing River valley. Ordovician (?) overlying Windermere-type quartzites and argillites
angles and cut across all the older rocks. They are seen, in the Delano Valley and elsewhere to lie unconformably beneath younger coralline limestones. Their presence is thus useful in distinguishing the intruded rocks from those of younger formations.

These igneous rocks will be described in more detail later in the section on igneous geology, page 73.

The quartzites of these basement rocks are white, relatively pure quartz sands but contain in some cases appreciable amounts of feldspar. The presence of ripple marks in both the quartzites and argillites and of mud cracks in the argillaceous sediments, together with the lithological variability of these strata, are thought by M.Y. Williams to indicate near-shore conditions; "in a seaway that was receiving sediments from a fluctuating source of supply." The local development of conglomerate possibly was the result of subaerial erosion at the time of deposition, under these shallow water conditions. The source of these ancient sediments is unknown, but the presence of greywackes suggests that it was not far distant.

As previously mentioned, there is some controversy over the age of these basement rocks. Williams (1944) presumes the metamorphic rocks exposed along the Toad River Valley adjacent to the Alaska Highway to be late Pre-Cambrian or Proterozoic in age. They are older than
the tan conglomerates and sandstones he classes as Cambrian (Middle and Lower?)

Following Williams, Menzies (1951) calls his quartzites and limestones late Pre-Cambrian and states that this opinion was also expressed by a group of oil geologists working in the vicinity of Summit Lake.

Laudon and Chronic (1947) refer to Pre-Cambrian schists, slates, marble and quartzite unconformably overlain by Palaeozoic sandstones and limestone beds. In the Muncho Lake area they found Pre-Cambrian schists and phyllite to be overlain by tan sandstone and quartzite beds which resemble the Macdougal Group of Cambrian (?) age in the Mackenzie Mountains. In their 1949 publication they refer to deformed Pre-Cambrian schists and quartzite overlain unconformably by relatively flat lying tan sandstone beds of probable Cambrian age. However, in the Mt. Roosevelt area lithologically similar tan quartzite and conglomerates overly white quartzite and argillite, apparently without marked unconformity.

In the opinion of members of the Imperial Oil geological staff (personal communication) the sequences along the Tuchodi Valley and the Chischa River quartzites, both of which are cut by basic dykes, strongly resemble the Cambrian sections of the Mt. Robson and Lake Louise areas of Alberta; and thus are considered by them to be of Lower Cambrian age.
The present writer considers these rocks to be in general of the Windermere type, and so could possibly be considered to be Eocambrian in age, that is, equivalent to Okulitch's (1957) Windermere System-Period. W.H. Mathews (personal communication) however, points out that the marked unconformity above these basement rocks and below the "Macdonald" and Ronning beds is not typically Eocambrian, or Windermere, but more like the Purcell or Belt Series of the South.

Palaeozoic

2. Macdougal Formation

Overlying the older metamorphosed rocks unconformably in the northwest, and apparently conformably in the southwest is a thick sequence of arenaceous and rudaceous sediments.

In the type area west of Muncho Lake, Williams (1944) described a sequence of beds lying beneath Silurian coral reef limestones:

<table>
<thead>
<tr>
<th>Silurian coral-reef Limestone</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Limey shale with worm burrows</td>
<td>50 ft.</td>
</tr>
<tr>
<td>Grey Sandstone beds 8 ft. to 10 ft. thick</td>
<td>2,000 ft.</td>
</tr>
<tr>
<td>Red conglomerate massive, coarse, pink quartzite</td>
<td>5,000 ft.?</td>
</tr>
<tr>
<td>boulders 10&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Near the top of the sequence Williams (1944) has described a conglomerate which is massive and is made up of boulders of pink quartzite up to 10" in diameter; but it alters rapidly to pebbles less than 6" in diameter set in a
fine red shale matrix. Since the formation has not been studied very closely its true thickness is unknown, but judging by its extent beyond the map area it must be in the order of several thousands of feet.

Above the conglomerate, but not seen in contact with it, Williams (1944) described a thick sequence of grey sandstone beds, usually 8 to 10 feet in thickness.

North of the map area in the Trout River Valley, Laudon and Chronic (1949) mention that relatively flat yellow to tan, coarse grained quartz-sandstone beds unconformably overly older quartzites. They contain no fossils but near the top are filled with casts of long curving worm tubes. On the basis of lithology and stratigraphic position the conglomerates are tentatively assigned to the Cambrian system since they resemble Macdougal conglomerates in the Mackenzie River area. Laudon and Chronic (1949) consider a possible Cambrian age for relatively flat lying limestone beds 400 ft. thick which are exposed in the MacDonald Creek area beneath Ronning fossiliferous limestones.

Mt. Roosevelt (Plate XV) 37 miles south of Muncho Lake, is made up of similar tan conglomerates, some 3,000 feet of these ill sorted, red, green or purple conglomerates, apparently conformably overly the older white quartzites. The pebbles are in general up to 6" in diameter and consist mainly of white quartzite and shale fragments. Under the microscope the grains are seen to be coated with red material.
Capping the northwest peak of Mt. Roosevelt from about 9,000 ft., elevation, are approximately 500 feet of grey flat lying beds. Since they were not visited it is not known whether they are calcareous or arenaceous rocks but they possibly represent either the upper sandstones, such as are present at Muncho Lake, or they are younger sediments similar to those capping Mt. Stalin.

The environment under which red beds formed has been the subject of much discussion in the literature. In general it is held that they owe their color to finely disseminated ferric oxide in the form of hematite. A warm humid climate is generally envisaged in the source area of such beds, but it is not necessarily a prerequisite to this type of deposit. The association of coarse poorly sorted conglomerates might suggest for this area conditions of shallow water under an oxidizing environment with changes to reducing conditions to account for the green coloration of some of these rocks.

Again the age of these rocks is not known but they are strikingly similar to those exposed at Muncho Lake, which have been tentatively correlated with the Macdougal Formation of the Mackenzie River area, which is considered to be of Middle or Upper Cambrian age.

Since correlation is to a group of rocks many hundreds of miles to the north it might be well to consider these beds as a separate formation and name it as such. However, the name Macdougal will be retained for these rocks in this report.
3. Ordovician

Rocks of the Ordovician system were not recognized in the field during the course of the work. However, geologists of Imperial Oil Limited report (personal communication) that the rocks capping Mt. Stalin have been found on fossil evidence to be of Ordovician age. A marked contrast is noted here in the dull grey-weathering of the Ordovician (and younger rocks) to the brown and red weathering of the underlying Windermere-type quartzites.

Another possible location of Ordovician rocks might be the peak of Mt. Roosevelt, while still another could possibly include the limestones capping Mt. Mary Henry. Only fossil evidence could confirm this.

4. Silurian-Devonian

Following Williams' (1944) original grouping the thick sequence of predominantly grey weathering limestones was mapped as a single rock unit. It was recognized that within this were included beds of sandstone, shale, and chert as well as limestone that could by more detailed study be subdivided into formations or even series. This Laudon and Chronic have done by a detailed study of stratigraphic sections, and by resorting to fossils have been able to differentiate four formations. Since time-rock sub-divisions do not necessarily correspond to rock units the Upper Devonian Fort Creek Group is placed with the younger Mississippian Racing
River Formation (i.e. Laudon and Chronic's (1949) "Kindle Formation") since they have similar lithology.

Laudon and Chronic's (1949) subdivision of the grey limestone sequence is as follows:

<table>
<thead>
<tr>
<th>Series</th>
<th>Formation</th>
<th>Lithology</th>
<th>Thickness in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fort Creek</td>
<td>Black Shale</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>d. Ramparts</td>
<td>Upper dark, lower grey fossiliferous Limestone Siltstone and sandy Limestone</td>
<td>1,000 500</td>
</tr>
<tr>
<td>Devonian</td>
<td></td>
<td>Unconformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Muncho</td>
<td>Grey and black cyclic non-fossiliferous limestone thin basal conglomerate</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>b. McConnell</td>
<td>Grey and black cyclic non-fossiliferous limestone and some shale</td>
<td>680</td>
</tr>
<tr>
<td></td>
<td>Unconformable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silurian</td>
<td>a. Ronning</td>
<td>Dolomitic limestone and chert, thin bedded black shaley limestone alternate with massive grey non-fossiliferous dolomitic limestone Limey shale with worm burrows</td>
<td>1,200 60</td>
</tr>
</tbody>
</table>

(a) Ronning Formation

The type locality for this formation is in the Mackenzie Mountains. Since it was not recognized as a separate rock-unit during the course of the reconnaissance mapping of the area its extent within the map area cannot be stated with
certainty. However, since it forms the base of the grey limestone sequence over a considerable area of the Northern Rockies it would be expected to lie directly on the Pre-Silurian surface.

Laudon and Chronic describe a detailed section from the Sentinel Ranges north of the map area to the east of the Trout River Valley about 10 miles north of Muncho Lake, which can be considered close enough to the map area to be lithologically similar to the equivalent grey limestone beds that occur here. In the described section the basal 100 feet are made up of black, very shaley limestones, which contain fossils and are overlain by a thin band of dolomitic limestones. Above the basal assemblage Laudon and Chronic recognize a markedly cyclic sequence of dolomitic limestone which consists of a darker unit characterized by thin-bedded, black, shaley, fossiliferous limestone, alternating with a higher unit of more massive, grey, relatively pure, dolomitic limestone, which is usually unfossiliferous. In the described section 38 such cycles were recognized over a thickness of 1,190 feet.

The following is a list of fossils reported from the Ronning by Laudon and Chronic (1949) and said to be highly silicified and often intermingled with siliceous algae.
Pentamerus sp.
Favosites niagarensis Hall
Favosites favosus (Goldfuss)
Halysites catenulatus (Linnaeus)
Heliolites megastoma McCoy
Amplexus shumardi (Edwards and Haime)
Stombodes sp.
Zaphrentis sp.
Cyathophyllum sp.

This fauna is characteristic of the Middle Silurian Niagaran.

Another section of Ronning Formation was described by Laudon and Chronic from the southwest side of Mt. St. Paul. Here the lighter unit of the two-unit cycle contains intercalated black shale. Thirty two cycles are recognized over 490 feet as compared with 38 cycles over 1,190 feet in the Sentinels. This suggests to Laudon and Chronic less rapid deposition in the Stone Ranges. The marked unconformity at the top of the sequence suggests removal of part of the Formation by Pre-McConnell erosion.

Across the MacDonald valley to the west the Ronning is again exposed and here the cycles are hard to distinguish due to the similarities between the black shaly limestone and the grey limestone. Algal chert is sometimes conspicuous,
and Niagaran fossils are present, most abundant of which are:

- **Favosites favosus** (Goldfuss)
- **Favosites niagarensis** Hall
- **Halysites catenulatus** (Linnaeus)
- **Heliolites megastoma** McCoy
- **Cyathophyllum** sp.

On the west bank of the Racing River two miles above the Wokkpash Creek confluence similar cherty fossiliferous limestones were examined. Here they overly the older quartzites, and dip gently southwest at 15°. They weather irregularly with the chert and silicified fossils standing out quite prominently on the weathered surface.

The cyclic nature of this and the following sequences has been emphasized by Laudon and Chronic (1947), (1949). The sequence in the western Sentinel Ranges is more markedly cyclic than that in the Stone Ranges. This appears to hold true for all the Palaeozoic successions which show cyclic sedimentation. Thus Laudon and Chronic (1949) conclude that cyclic deposition is better developed in the deeper parts of the sedimentary basins, which in this area would have been mainly to the west of the map area.

A marked increase in the amount of clastic material and a general thinning of the section in the Stone Range in the part of the column where the cycles were most poorly developed suggests this interpretation.

(p. 219 (1949))
This is contrary to general belief which holds that shallow sea shelf conditions probably exist.

Unlike the well developed type cycles of the Pennsylvanian sediments in the Mississippi Valley area, none of the cycles of the Palaeozoic strata show any indications of change in environment from non-marine, to marine near-shore conditions. It is generally held that fine shales and muds accumulate in stagnant, deep water, whereas the pure limestones are thought to indicate shallower, perhaps near shore or shelf sea environment, or areas with no terrigenous material. However, as pointed out by Laudon and Chronic (p. 220, 1949) in the Racing River area the Stone Ranges are thought to represent deposition closer to the shore line than the Sentinels because they contain much more clastic material. Here black shales are developed relatively close to the shore while limestones could have been deposited further away in a shallow depositional basin. In this manner the dark argillaceous units of the cycles could have been deposited under shallow water conditions. It was noted that the sandstone beds were usually more closely associated with the black shales than with the limestone beds.

The occurrence of benthonic fossils in the Ronning Formation, more abundantly in the black shaly beds rather than the purer limestones, would suggest that the black shales were not the product of stagnant, deep-water conditions. The development of cycles is thought to be due to oscillating sea levels.
Laudon and Chronic state (p. 221, 1949):

In general, unconformable surfaces can sometimes be predicted from considerable distances below the contact due to the fact that cyclic sedimentation seems to not be developed in these very shallow, near-shore strand-line sediments. ... Unconformable surfaces can be predicted from above the contact only by the increase in clastic sediment such as seen at the base of the Ramparts Formation or in the base of the Ronning Formation in the Summit Lake area.

They also consider the absence of non-cyclic material at the top of a Formation to indicate extensive erosion because the normal non-cyclic upper sequence usually follows on the lower cyclic strata. This is well exemplified by the Ronning Formation which indicates considerable erosion prior to the deposition of the Devonian strata.

(b) McConnell Formation

Unconformably overlying the Ronning Formation are 680 feet of unfossiliferous black and grey limestone which according to Laudon and Chronic show marked cyclic deposition. In the measured section near mile 472 on the Alaska Highway they have recognized 52 cycles of alternating massive grey fine grained limestone and dark grey to black shaley limestone.

The change to the overlying Muncho Formation appears to be marked by a short break in cycles and deposition.

In the Summit Lake area on Mount St. Paul, the McConnell Formation, like the underlying Ronning has thinned appreciably and consists of only 185 feet of sediments in
PLATE VII

Alaska Highway west of Summit Pass. Flat dipping Silurian-Devonian grey limestone crops out along MacDonald Creek forming Stone Ranges

PLATE VIII

Toad River canyon near mile 437 Alaska Highway. Contorted grey Devonian limestones of the Sentinel Ranges
which 18 cycles have been recognized. Again erosion has
removed part of the upper section and Laudon and Chronic con-
sider that possible overlap across the Silurian has taken
place.

Across the valley of MacDonald Creek approximately
240 feet of poorly exposed sediments represent the formation
and here cyclic deposition is not entirely evident, illus-
trating the local variability of the cycles. Near the top
of the sequence are reported thin, slightly nodular, semi-
lithographic, dark grey limestones.

Lithologically the McConnell Formation of the Stone
Ranges bears little resemblance to the McConnell Formation
developed in the Sentinel Ranges where the sequence is more
clearly cyclic, and much thicker. Correlation is by strati-
graphic position since fossils are entirely absent.

Elsewhere in the area the McConnell, and overlying
Muncho Formation, were not recognized but undoubtedly are
present, probably along the west bank of the Racing River
between Yash and Delano Creeks.

On the south side of Mount St. Paul and north side
of Mount St. George a darker band of limestone was mapped and
this might represent the McConnell or Muncho Formations. A
similar dark band is conspicuous on the east side of Wokkpash
Valley about 5 miles northwest of the Lake.
(c) Muncho Formation

The Muncho formation is best developed in the Trout River Valley area near mile 472. It overlies unconformably the McConnell limestone cyclic sequence, which it closely resembles lithologically. Locally at its base is a thin, sandy, weathered conglomerate. This is followed by cyclic alternating black shaly limestone and grey, relatively massive limestone. As opposed to the underlying McConnell, the soft units are relatively thin near the base thickening upwards while the lighter units are thicker lower down thinning upwards. In 600 feet of strata 49 cycles were distinguished by Laudon and Chronic.

On Mount St. Paul seven cycles in 85 feet were recognized, whereas across the MacDonald in 95 feet of sediments 23 cycles were distinguished. The higher beds are quite sandy here but the topmost layer is the same as on Mount St. Paul.

(d) Ramparts Formation

The Ramparts Formation rests in sharp erosional unconformity above the Muncho limestones but the surface shows no evidence of relief.

One of the best exposures of this Formation has been studied in some detail by Laudon and Chronic, (1949). This
almost complete section is seen north of the Toad River at Mile 433 (Plates VIII and XIII). Silty, tan colored Ramparts sandstones unconformably overlie grey and black Muncho limestones. The basal member in contrast to the generally grey limestone section weather to a conspicuous yellow and tan zone. It consists of soft brown calcareous sandstone alternating with harder, more massive brown silty limestones; 40 cycles are present over 360 feet, becoming more calceous upwards till finally it is entirely limestone. A total of 1,760 feet were recognized by Laudon and Chronic. In general they represent alternating black shaley limestone beds with dark grey massive layers, which are differentiated by virtue of their color and hardness. The more shaley beds generally weather out more readily than the harder more massive beds. In the upper parts of the Ramparts Formation the massive limestone is relatively dark compared with lighter colored equivalents in the middle sections thus allowing a field distinctive between a middle "White Ramparts" and an upper "Dark Ramparts".

About 3 miles east of the above locality and also on the north side of the Toad River the upper contact of the Ramparts Formation with the Fort Creek Formation black shales is well seen in the thrust block of mountains on the west of Nonda Creek Valley. (Plate XIII). In this section 168 cycles closely resembling the succession to the west were recognized in 1,120 feet. Several cycles could be correlated without hesitation, whereas others showed marked facies changes.
Since four full cycles seem to be missing at the top of this section, Laudon and Chronic conclude that the erosional surface on which the Fort Creek Formation is lying must have been eroded down quite considerably.

In the Stone Ranges on the slopes of Mount St. Paul the Ramparts is again recognized. Here the basal sandy beds are more arenaceous than in the Sentinels. A lower cross-bedded sandstone 90 feet in thickness grades upwards into cyclic grey and black limestones. Exposures are not very good in this part but enough to show that the Formation is similar to that described from the Toad River area. Here it has a measured thickness of just over 1,100 feet.

A good exposure of Upper Ramparts below the Fort Creek contact is described by Laudon and Chronic (1949). It was originally located by M.Y. Williams (1944). It is north of the Highway at Mile 398 along One Ten Creek Valley. Approximately 735 feet of the Upper Dark Ramparts is exposed here and Laudon and Chronic have recognized 106 complete cycles, the lowest group of which resembles the strata capping Mount St. Paul. The sequence is similar to that of the Sentinel Ranges but contains more clastic material.

Fossils are abundant in the upper parts of the section, the following types being reported:

- *Hexagonaria percarinata* Sloss
- *Favosites* sp.
- *Cladopora* sp.
PLATE IX

East side of Muncho Lake, mile 460 Alaska Highway. Grey Silurian-Devonian limestones forming the Sentinel Ranges dip steeply westwards beneath the lake.
The first named is abundant in the Ramparts Formation of the lower Mackenzie River area, and also in similar beds in the central and mid-western United States.

M.Y. Williams (1944) reports the following faunal assemblage from the One Ten Creek locality, many of which are highly silicified and poorly preserved:

- *Favosites basaltica* (Goldfuss) (?)
- *Conocardiun* (?)
- *Fenestella* (?)
- *Bactrites* (?)
- *Atrypa cf. spinosa* Hall
- *Schuchertella* (?)
- *Proetus* sp.
- *Conolichas* (?)

Williams states that the fauna has Middle Devonian characteristics and in a general way suggests the Middle Devonian faunas of the Mackenzie River area.

5. Upper Devonian-Mississippian

A rock unit conformably overlying the grey limestone sequence was mapped. It was not broken down on fossil evidence into smaller formational units such as Laudon and Chronic have done.

Essentially it consists of dark blue or black shales, shaly limestones, and minor amounts of sandstones. It is
distinctive from the lighter grey limestones of the Sentinel and Stone Ranges and is confined to the intermountain trough of the lower Racing River physiographic sub-province, where it forms the Racing River synclinorium. Isolated strips of dark shale whose areal extent were not fully appreciated in the field, occur beneath thrust planes in the Sentinel Ranges flanking the Toad River Canyon in the vicinity of Mile 430 on the Highway. (Figure 4). It is thought that these softer black shales acted as lubricating plates along which thrusting could take place more readily than in the more competent grey limestone beneath.

Laudon and Chronic have studied these dark sediments and have subdivided them as follows:

<table>
<thead>
<tr>
<th>Series</th>
<th>Formation</th>
<th>Lithology</th>
<th>Thickness in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triassic</td>
<td></td>
<td>Dark calcareous shale</td>
<td></td>
</tr>
<tr>
<td>Mississippian</td>
<td>&quot;Kindle&quot;</td>
<td>Slight unconformity</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper cyclic cherty limestone, Lower cyclic calc. siltstone</td>
<td></td>
</tr>
<tr>
<td>Upper Devonian</td>
<td>Fort Creek</td>
<td>Unconformity Black pyritic shale</td>
<td>800</td>
</tr>
<tr>
<td>Devonian</td>
<td>Ramparts</td>
<td>Partly conformable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey limestones</td>
<td></td>
</tr>
</tbody>
</table>

(a) Fort Creek Formation

Since the Fort Creek was not mapped in the field as a distinct rock unit its extent within the map area is not
known. However, since it directly overlies the Ramparts limestones it can be stated that it occupies the eastern edge of the Racing River synclinorium, crops out around the Ramparts anticline that is exposed at Mile 424, and comprises the black shales that are exposed in thrust slices in the eastern portion of the Sentinel Ranges. In these thrust slices the Fort Creek consists of thin bedded, hard, fissile pyritic black shale, which often weathers to bright yellow, orange or brown colors. Elsewhere pyritic nodules or concretions up to 6 inches across are common, and cherty or hard grey limestone concretions are occasionally found.

The maximum thickness for these beds is about 800 feet. The Mississippian so-called Kindle Formation lies unconformably over the Fort Creek.

M.Y. Williams (1944) reports that a few feet above the lower contact the Fort Creek black shales contain several hard limey beds, which are thought to be conformable upon the Ramparts limestone. At the old Racing River bridge M.Y. Williams collected fossils from a horizon in dark grey limestone. These are considered by him to be Middle Devonian:

Reticularia modesta (Hall)
Schuchertella sp.
Meristella sp.
Odontocephalus sp.
Undetermined corals
In the exposures in One Ten Creek north of the Highway at Mile 401, Williams collected from thin shale beds the following:

*Tentaculites spiculus* Hall

*Meristella* (?)

This fauna resembles closely that of the Chemung shales of New York and Pennsylvania. Williams suggests that the general character of the shales correlates with the Minnewanka (Upper Devonian) and Banff (Mississippian) Formations of the Southern Canadian Rockies.

(b) Racing River Formation

This formation was described by Laudon and Chronic in 1947, and in 1949 was formally named by them the Kindle Formation. However, this formational name had been pre-empted by M.Y. Williams in 1921 when he named a sequence of Silurian limestones in the Franklin Mountains the Mount Kindle Formation.

Concerning the type locality for the "Kindle" Laudon and Chronic state (1949 p. 193)

The name Kindle is here proposed for the entire section of Mississippian rocks in the area. This formation lies unconformably on the Devonian, Fort Creek Formation, and is unconformably overlain by Triassic beds. The type section is on the east side of a small tributary of the Toad River, approximately one half mile south of the Alaska Highway in Mile 428, on a small ridge approximately one half mile west of Mt. Kindle. The new name Mt. Kindle is proposed here for the conspicuous mountain peak south of mile 427 on the Alaska Highway.
With regard to the new geographic name Mount Kindle which Laudon and Chronic have put forward it is suggested that this name be dropped because of the Mount Kindle that has already been named in the Northwest Territories.

In place of Kindle Formation the name Racing River Formation is submitted in this report. This name was proposed for these and similar beds by M.Y. Williams in 1944 after he had completed reconnaissance investigations along the Alaska Highway. The new formational name was not published in his report (1944) as the Geological Survey of Canada felt that more detailed work was required before the sequences were formally named. Work of this nature has since been done and it is now felt that Williams' original proposal is appropriate.

In the field these dark shaly rocks were grouped as Permian, which was in line with Williams' (1944) preliminary investigations. Subsequent work by Laudon and Chronic has shown that the sediments are in fact Mississippian in age and thus are included as part of the Racing River Formation.

Although fairly distinctive as a rock-unit these rocks were not distinguished in the field from the underlying black shales of the Fort Creek Formation, the two together being mapped as one unit.

The thickness in the type section is 291 feet but
PLATE X

Type area for "Kindle Formation" as defined by Laudon and Chronic (1949). Mississippian Racing River Formation dark shales and limestones near Mile 427 Alaska Highway.
the formation reaches a maximum of 400 feet. The sequence of sediments exhibits marked cycles of deposition. A lower group of calcareous siltstones is overlain by an upper group of thin-bedded cherty limestones.

Laudon and Chronic have recognized 206 cycles in 290 feet of strata at the type locality, and they see a suggestion of a larger rhythm which they like to think is comparable with the megacycles of the Pennsylvanian System in the United States.

In the lower group one unit of the cycle is made of thin, black, silty shale, while the other unit is relatively thicker, grey, fossiliferous calcareous siltstone.

In the upper succession the thicker massive grey unit becomes more important and the dark unit diminishes until it is represented only by a bedding break. Here the sediments have the appearance of non-cyclic pre-Pennsylvanian formations in the Mississippi Valley.

Another good exposure of these beds is along the west bank of the Racing River in the triangle formed by the Toad River, the Racing River, and the Alaska Highway. Here the central part of the formation is exposed in a high cliff face and the cyclic nature of the beds is well displayed. Massive rusty sandy limestones alternate with dark sandy shale beds for several hundreds of feet across the cliff face, the beds all dipping south-westwards at about 20°.
Fossils were recognized in these rocks at various places but no collections were made. They are abundant in the lower parts, but become less so upwards. The upper cherty beds being devoid of fossils.

In considering the faunal assemblages of these rocks the outcrops of similar beds east of Summit Lake must also be taken into account.

At Mile 381.5 in the North Tetsa River Valley a fault block of these rocks crops out. It is about 2 miles in width, but it has not been followed along the strike any distance. In the east the beds are vertical and in fault contact with Triassic beds.

M.Y. Williams reports the following fossils from this locality: (p. 20, 1944):

- **Productus crawfordsvillensis** Weller (?) both from near the base
- **Spirifer floydensis** Weller

From the upper portion of the sequence are:

- **Productus inflatus** McChesney (?)  
- **Productus burlingtonensis** Hall  
- **Productus crawfordsvillensis** Weller (?)  
- **Productus magnus** Meek and Worthen  
- **Productus jasperensis** Warren  
- **Spirifer floydensis** Weller  
- **Syringothyris subcuspidata** (Hall) (?)
Near the fault contact to the east in vertical limestones Williams collected:

crinoid columnals
byrozoa

**Productus burlingtonensis** Hall
**Productus crawfordsvillensis** Weller
**Productus magnus** Meek and Worthen (?)
**Productus inflatus** McChesney
**Chonotes chesterensis** Weller (?)
**Dielasma** sp.
**Euomphalus utahensis** Hall (?)

Another collection from near the center of the fault block taken from a loose limestone block and the adjoining hillside yielded:

**Spirifer** - close to **S. rutherfordi** Warren
**Martiniopsis** Sp. (superficially resembling **Brachythryris suborbicularis** (Hall)
**Deltopenste**n sp.
**Phillipsia** sp.
**Euconispira taggarti** (Meek)

Williams correlates these faunas with sections in Illinois, of Osage age. Chester affinities are suggested.

Laudon and Chronic who have also studied the fossil locality at Mile 381.5, list the following forms, (p. 1616, 1947):
Productina sp.
Productella sp.
Productella moorefieldana
Avonia oklahomaensis
Dictyoclostus inflatus var. coloradoensis
Linoproductus pileiformis
Linoproductus altonensis
Marginifera adairensis
Buxtonia sp.
Leiorhynchus carboniferum
Spirifer arkansanus
Brachythyris gurleyi
Ambocoelia sp.
Deltopecten batesvillensis

This assemblage Laudon and Chronic compare with the fossils in the Calico Bluff Formation on the Yukon River at Eagle, Alaska. The formation is considered to be of early Meramec age, and it lies beneath a limestone formation that carries middle Meramec fossils which resemble the St. Louis Limestone of the Mississippi Valley area. They also note the similarity to the Moorefield Formation of the Arkansas Ozark region and have also collected numerous specimens of Martinopsis from the center of the formation.

Laudon and others have shown that the Moorefield Formation of the central United States unconformably overlies
Osage beds. In Alaska the Calico Bluff Formation represents the first sedimentation following the Osage epoch of erosion, thus they conclude that Osage strata are absent from the Alaska Highway area, and that the rocks assigned to Kinderhook age by Williams (off the map area to the north) and Osage rocks are actually of Meramec age.

The upper chert beds that Williams considered to be Permian are classed as "Kindle Formation" and thus Mississippian as well.

Mesozoic

6. Triassic

Without the aid of fossils the age of the Mesozoic beds cannot be determined. Thus in the field these strata were recognized only as a lithological unit east of the Rocky Mountain Front in the Foothills Province. However, ammonite-bearing Triassic rocks are reported (Laudon and Chronic) from the Racing River synclinorium (Mile 428) to overlie Fort Creek and Racing River black shales, and since they are comprised essentially of black calcareous shales they have not been differentiated from the underlying formations.

However, they reach their maximum development in the valley of the Tetsa River and here they have been studied at some length by F.H. McLearn from the Geological Survey of Canada.
The topography in the Foothills belt is one of relatively low rolling tree covered hills and drift filled valleys. Outcrops are relatively scarce compared with the Mountainous country to the west and where exposed the incompetent shaley beds are seen to be highly folded into anticlines and synclines whose axes trend northwest-southeast, more or less parallel to the Rocky Mountain Front Thrust fault.

The sediments are predominantly dark grey or black, thin-bedded, calcareous shales, shaley siltstones, grey limestones, with some sandstone bands. They outcrop in two belts in the Foothills, separated by a fault block of Mississippian Racing River Formation limestones and shales. The western belt is about 8 miles wide and extends from Mile 382 on the Alaska Highway to the front of the Rocky Mountains at Mile 391.

The eastern belt is a strip two miles wide which is in fault contact with the Racing River Formation in the west and Cretaceous beds in the east near Mile 377.5. Williams (1944) reports the following fauna from the upper beds in the eastern strip. From these fossils McLearn tentatively dated the beds as later Middle Triassic, (p. 21, 1944):
Nathorstites mcconnelli Whiteaves
Nathorstites mcconnelli var. lenticularis Whiteaves
Dielasma liardense Whiteaves

North of the Highway at about Mile 388 the following collection was made by Williams, (p. 22, 1944):

Daonella nitanae
Coenothyris cf. liadensis
Myochoncha cf. cauriniensis
Spiriferina cf.onestae
Ostrea sp.
Eumorphotis (?)
Trigonodus
Spiriferina

The age of the last three species McLearn regards as being possibly of Triassic age, whereas the others he tentatively (1944) dated as late Middle Triassic.

McLearn has recognized the dark shales and siltstones between Miles 382.5 and 389 on the Highway, as belonging to the Liard Formation of the Triassic. This formation was recognized by Kindle in the type locality near Hells Gate on the Liard River about 50 miles from the map area to the north northwest, and contains the typical Nathorstites fauna.

More detailed work by McLearn in 1946 along the Highway between Mile 375 and 378 revealed Triassic beds exposed
in anticlines, and younger Triassic or Cretaceous dark shales in small synclines. The lower part of the sequence was correlated to the Toad Formation, and the upper part to the Liard Formation.

<table>
<thead>
<tr>
<th>Series</th>
<th>Formation</th>
<th>Lithology</th>
<th>Thickness in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cretaceous-Jurassic</td>
<td>Garbutt (?)</td>
<td>Dark shales and limestones</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>Liard</td>
<td>Sandstone and limestone</td>
<td>400</td>
</tr>
<tr>
<td>Triassic</td>
<td>Toad</td>
<td>Siltstone, shales, limestones</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>Grayling</td>
<td>Shale, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(not exposed)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Not exposed here but probably at no great depths are Grayling Formation shales, limestones and sandstones.

At this locality the Liard consists of massive thick bedded, slightly calcareous, fine to medium-grained sandstone and grey limestone. McLearn (1946) reports the formation to thin rapidly to the east until it is not more than 200 feet thick.

It is overlain by dark friable shales of Jurassic or Cretaceous age similar to the Garbutt Formation of the Liard River.

McLearn (1946) (G.S.C. Paper 46-1 p. 4 and 5,) lists the following fossil assemblage from the Triassic rocks:
Parapopanoceras tetsa n. sp.
P. tetsa n. sp. var. praematurum n. var.
Longobardites canadensis n. sp.
L. intornatus n. sp.
Gymnotocaras columbianum n. sp.
Gymnites hagi n. sp.
Trigonodus sp.
Tropigastrites (?) sp.
Ussurites arthaberi var. cameroni n. var.
U. muskwa n. sp.
Anagymnites involutus var. via-alaska n. var.
Beyrichites deleeni n. sp.
B. aff. tenuis Smith
B. cf. falsiformis Smith
Orthoceras sp.
'Ceratites' hayesi var. angulatus n. var.
'C' hayesi var. pinguis n. var.
Sphaera cf. whitneyi Meek
Acrochordiceras (Paracrochordiceras) americanum n. sp.
'Rhynchonella' sp.

This assemblage is of Anisian stage, and is similar to the Nevadan fauna in the west Humboldt Range.

In 1945 McLearn reported on the Lower Triassic from the Liard River and recognized a sequence as follows:
<table>
<thead>
<tr>
<th>Epoch - Series</th>
<th>Stage - Age</th>
<th>Fauna</th>
<th>Formation</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Triassic (Meso-Triassic)</td>
<td>Ladinian Anisian</td>
<td>Nathorstites Beyrichites</td>
<td>Liard</td>
<td>(400)</td>
</tr>
<tr>
<td>Lower Triassic (Eo-Triassic)</td>
<td>Upper Lower</td>
<td>Wasatchites Claraia cf. stachei</td>
<td>Toad</td>
<td>800-2,400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Toad</td>
<td>600-1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grayling</td>
<td></td>
</tr>
</tbody>
</table>

7. Jurassic

In northeastern British Columbia, marine shales containing some sandstone beds of Jurassic age have been given the name Fernie Group. In the map area under consideration these beds have not been recognized. However, overlying the Liard Formation are black shales and dark limestones similar to the Garbutt Formation of the Liard River which have been mentioned by McLearn. The age is not certain as they are placed as Jurassic or Cretaceous, so for the present the Jurassic will be considered as being absent from this area.

8. Cretaceous

The youngest rocks exposed in the Racing River map area crop out adjacent to the Alaska Highway in the eastern portion of the map area. They are more fully developed further east but are very flat lying and exposures of the older beds in the sequence are scarce.
M.Y. Williams, (1944), recognized three units which he correlated as follows:

<table>
<thead>
<tr>
<th>Series</th>
<th>Formation</th>
<th>Lithology</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Cretaceous</td>
<td>Ft. Nelson</td>
<td>sandstone and congl.</td>
<td>600'</td>
</tr>
<tr>
<td>Lower Cretaceous</td>
<td>Ft. St.John</td>
<td>soft sandy dark brown shale</td>
<td>1,500'?</td>
</tr>
<tr>
<td></td>
<td>Bullhead (?)</td>
<td>siltstone, sandstone, shale</td>
<td>500'?</td>
</tr>
</tbody>
</table>

Williams considered the Fort Nelson Formation to be identical with the Dunvegan Formation to the south. Kindle in 1949 mapped the Fort Nelson Formation on the Nelson River and considered it to be chronologically the same as the Dunvegan. So the name Dunvegan Formation will be used here in place of Fort Nelson Formation.

(a) Bullhead Group

The oldest Cretaceous rocks outcrop along the Alaska Highway between Mile 370 and 374. They consist of beds of black shales, sandstones, and hard slate. To the west they are in fault contact with Triassic strata but are also seen to overly Liard sediments without marked unconformity.

Marine fossils have not been found in any number from these beds, Williams bases his correlation on a poorly preserved *Cardium* sp. and lithology and stratigraphical position in assuming the age to be Lower Cretaceous.
(b) Fort St. John Group

Marine sandstones with lesser shales dip eastward at 20° from Mile 370 beyond the limits of the map to the east. It is beyond the map area that this Group has been best studied so that it is sufficient here to state that lower shales and sandstones (500') are overlain by more resistant sandstones (600') with interbedded shale carrying Inocerami and Posidonoma nahwisi var. goodrichensis, Posidonoma nahwisi var. moberliensis, and poorly preserved plant remains. Above this are 250' of shale upon which rest the Upper Cretaceous conglomerates and sandstones.

The rocks are correlated to the Fort St. John Group of the Pine River and tentatively can be divided as follows:

<table>
<thead>
<tr>
<th>Racing River Map Area</th>
<th>Pine River Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Shale</td>
<td>Cruiser Formation 800-900'</td>
</tr>
<tr>
<td>Middle sandstone</td>
<td>Goodrich Formation 500-600'</td>
</tr>
<tr>
<td>Lower shale</td>
<td>Hasler Formation 1,100'+</td>
</tr>
</tbody>
</table>

(c) Dunvegan Formation

Appearing only at the extreme eastern margin of the map area are several hundred feet of resistant massive sandstones and conglomerates, which cap the hills to the east of the Dunedin River. The pebbles in the conglomerates are up to 2 inches in diameter and consist of black chert, yellow chert, white quartzite, and sugary quartzite. Similar sediments
cap other hills in the vicinity and from fossil evidence, especially the guide fossils:

\textbf{Unio (Pleurobema) dowlingi}

\textbf{Unio (Elliptio) sulfuriensis}

\textbf{Melania}

have been correlated to the Dunvegan Formation of Upper Cretaceous (Cenomanian) age.
Figure 1.

Rose diagram showing the trends of forty-two dykes from the Racing River area.
D. Igneous Rocks

Some 42 basic igneous dykes are shown on the geological map. Some of these may be continuations of the same dyke, in other cases two or more small dykes have been shown as one. They vary in thickness from about 15 feet to a maximum of 150 feet and have been traced for over 3 miles in length. Menzies (1951), reports one dyke in the Tetsa River Valley as being continuous for 4 miles.

In general they are vertical or have steep dips and in all cases appear to show discordant relations to the country rocks which are without exception the Pre-Macdougal quartzites and argillites. The dykes are usually found to strike in two main directions so that on occasion intersection of dykes is observed; the trends of the dykes are dominantly northwest and northeast, as is shown in Figure 1.

As mentioned above they cut only the Windermere-type rocks so are only to be found where these rocks occur. In the Toad River canyon adjacent to the Highway in the vicinity of Mile 440 at least six dykes are well exposed in the walls of the canyon. They are seen to stop abruptly beneath the overlying Ronning limestones which cap the mountain tops on the north side of the valley. These dykes have been described in some detail by M.Y. Williams (1944).

Southwards between Yedhe Mountain and Delano Creek numerous small dykes were seen. They form prominent ridges
of more resistant dark rock which run diagonally up the steep hill slopes in sharp contrast to the soft shaley argillites, which weather to smooth sloping surfaces completely barren of any vegetation.

Similar conditions prevail in one of the eastern tributaries flowing into Churchill Creek.

On the west side of Churchill Creek four dykes, which possibly really represent two parallel intrusives crop out high up near the crest of the western arete. They apparently dip to the west at about $45^\circ$. The dip of the argillites is about $10^\circ$ to the west here. These two dykes stand out as prominent dark bands and weather to more resistant jagged ridges.

The contact with the country rocks is generally sharp and there is little evidence of contact metamorphism. The pure quartzites appear little altered, and even the more calcareous members of the argillaceous rocks show no marked effects as a result of the intrusions. Very often the contacts are sheared and quartz-carbonate vein matter is found. Menzies (1951), p. 52, in discussing the faults associated with the Strangward copper claims on the south Tetsa River, states:

In general, faults provide access for basic intrusions and also for later mineralizing solutions.
Later movements have in places affected the dyke rocks and have sheared and in part altered them to epidote. Many of the dykes are fractured and are cut by quartz stringers and quartz-carbonate veins, which sometimes carry chalcopyrite. The association of the basic dykes with the copper deposits within the area is noted and of 12 copper showings 8 were closely associated with or in the neighbourhood of basic dykes. All these deposits were associated with quartz-carbonate veins and as Menzies points out they were emplaced along zones of weakness and along fault planes. These provided channelways, which in many cases had already been occupied by these basic intrusive rocks.

Under the microscope the dyke rocks are seen to be made up of 30%-50% plagioclase (An_{55-60}), but which usually is highly altered to carbonate. Hornblende comprises up to 30% in the centre of the dyke, but near the margins appears to give way to augite. Both pyroxenes and amphiboles are highly altered to chlorite. Quartz is usually present up to 3%, and is sometimes intergrown with the feldspar as micropegmatite. Accessory minerals include a little biotite, actinolite, and epidote. Magnetite makes up nearly 15% of the rock in many cases and gives rise to weathering to a red coloration which is often distinctive. Sub-ophitic textures are usually recognizable but are not always present in the rocks, and due to the high degree of alteration is sometimes masked. Thus the dyke rocks can be considered as diabases or micro gabbros.
The age of these intrusives is post-Windermere-type sediments and Pre-Ronning (Silurian). They were not seen to intrude Macdougal quartzites and conglomerates (Cambrian in age?) but could conceivably have been overlooked since they weather to the same red and brown colors of the tan sediments of this sequence.
CHAPTER III

STRUCTURE

The physiography of the area under discussion is directly related to the underlying structure. As was noted there are two main physiographic regions, the Foothills Belt and the Rocky Mountains Belt.

Perhaps the most striking feature of the whole map area is the sharp, well-defined change across the Rocky Mountain Front from the soft Mesozoic shales in the east, to the more resistant Palaeozoic limestones and clastic sediments to the west. This line structurally is underlain by the Rocky Mountain Front Thrust Fault. Although rarely observed it has been traced for over 45 miles from Stone Mountain in the north, across the east side of Mount St. Paul, across the Highway at approximately mile 390.5, east of Mount Mary Henry, and as far south as the Tuchodi River, about 5 miles downstream from the East Tuchodi Lake. North of the south fork of the Tetsa in the vicinity of the Alaska Highway, it strikes N. 20° W., while to the south near the Chischa River Valley it has a strike of about N. 30° W. M.Y. Williams has examined the fault on the Highway and observed a strike of W. 25° N. (N. 65° W.) and a dip of 75° to the S.W.
In the vicinity of the thrust plate the soft shales are highly contorted, crushed and sheared and appear to underlie the older grey limestones of the thrust block. The limestones in the vicinity of the thrust are overturned in an anticlinal fold but flatten out rapidly to the west away from the Mountain front. In the valley of the Chischa River dark quartzites of the lower Cambrian formation are overturned in a large fold, to the east of which black Triassic shales dip away from the thrust at 45°. The quartzites flatten out away from the thrust until about two miles upstream in the Chischa Valley they dip gently to the west at angles of about 10°. (Plate XI Figure 2). It is probable that the older rocks rest in fault contact with the younger sediments, and the sequence is not merely an overturned fold, for huge thicknesses of intervening sediments are absent between the two successions.

To the west across the entire region of the Rocky Mountains the structure is controlled by similar more or less parallel thrust faults which cause repetition and bring older quartzitic rocks into contact with younger argillaceous and limey beds. Many of the thrust blocks appear to slide along incompetent argillaceous beds, that have acted as lubricating soles for the large thrust sheets. The thrust masses are remarkable, for they are relatively undisturbed and have mostly flat dips. Locally, and especially near the thrust faults, the beds are highly contorted and
Plate XI

Overturned Windermere-type sediments. South side of Chischa River Valley.

Scale approximately
2000 Ft. : 1 Mile

Figure 2.
generally overfolded, but usually the dips flatten rapidly away from the fault planes.

The Stone Ranges physiographic sub-province, except for the east bounding Rocky Mountain Thrust Fault, is relatively free of these flat fault planes. With the possible exception of one fault on the east side of Wokkpash Creek, which was traced for about 10 miles, and disappeared beneath fluvio-glacial drift at both ends, no thrusts were recognized within the Range.

Within the area of older rocks several well developed faults were recognized. These are usually vertical and of unknown displacement. Generally they occupy shear zones several feet wide along which the quartzites and limestones are highly sheared, with the development of graphitic gouge. Usually the faults are filled with quartz-ankerite-calcite veins. These faults and their associated vein fillings are of interest because they sometimes contain copper minerals. In the southern portion of the Stone Ranges the Strangward "A" and "B" properties and the Callison claims are situated on such filled faults. Generally within a few hundred feet of the fault the normally gently dipping beds are abruptly folded and sheared, often into a number of parallel shear zones 50' to 100' apart. (Figure 3).

On the Strangward Properties the fault system was studied in some detail by Menzies since they formed an
Plate XIII

South face Chischa valley at Callison Copper Claims. Gently southwest dipping Windermere-type argillites. Note steep fracture cleavage.

Figure 3.
important ore control: He recognized three different sets as follows:

1. The main thrust fault of the Rocky Mountain Front.

2. Vertical, west-striking normal faults with slight displacement, and a few north-striking vertical faults with small displacements. These were followed, according to Menzies, by a third type which formed with the release of pressure from the west, (which initiated the major thrusting) by tensional forces.

3. Relatively long (in the order of a mile or two), steep northwest-dipping normal faults, with a displacement in some cases of 200 feet. Apparently on two such faults a reversal in the displacement at either end produced rotational faulting.

Regional thrust faulting is best displayed in the map area in the Sentinel Ranges. Here at least four major thrusts have been recognized, and detailed mapping will possibly reveal the presence of more.

The western border of the Racing River Synclinorium is delineated by a major thrust which crosses the Alaska Highway in the vicinity of Mile 430. It is nowhere seen due to the drift-filled nature of the river valleys by which it is marked. About half way between Tentsi Creek and Wokkpash Creek on the east bank of the Racing River, the contact of black shale and grey limestone was observed at a distance.
The peak of the hill is above timberline but the lower slopes are tree covered and outcrop is relatively sparse. It appears that younger Fort Creek black shales dip beneath grey Ramparts limestone at 45°. It is not known whether the beds here are overturned or not. A possible extension of this thrust cuts Silurian Ronning grey limestones on the east side of Wokkpash Creek.

Directly north of the Highway on the contorted mountain on the west slopes of Nonda Creek a wedge of dark Fort Creek shales is seen to lie between contorted grey Ramparts limestone. This represents a thrust plate from the west that is thought to have been pushed over older formations, and has ridden on the incompetent shaly beds of the Fort Creek. (Plate XIII, Figure 4).

A few miles to the west another such overthrusted mass is seen resting on the dark shales. Lack of critical outcrop and insufficiently detailed mapping obscure the exact nature and extent of these thrusts, but Laudon and Chronic (1947, 1949) are satisfied that they represent true overthrusted masses and are not the normal sequence folded over, since they were able to trace recognizable cycles of sedimentation and distinctive lithological beds that showed the sequence to have been repeated by faulting. The fault contact here dips at about 45° to the west but elsewhere it varies from about 50° to almost vertical. The contact itself is abrupt.
Plate XIII

Contorted grey limestone, north of Toad River valley near mile 430 Alaska highway.

Scale 1 Mile : 2 Inches

Figure 4.
The beds immediately overlying the thrust plane are sharply distorted, whereas the black shales are sheared and deformed. Their incompetent nature absorbs and masks much of the effects. A certain amount of brecciation is common but mylonites appear to be absent.

These fault zones adjacent to the Highway in the northwest portion of the map strike in general N 25° W. The fault east of Muncho Lake and the suspected thrust through Muncho Lake and Upper Toad River Valley strike N. 15° W. They all dip to the west and represent displacement of a western mass riding up and over the eastern. (Figure 8). The amount of movement is unknown, but could be in the order of several miles.

Between Wokkpash Creek and Mt. Roosevelt three faults have been recognized. The most easterly thrust plane cuts Silurian-Devonian grey limestones less than 2 miles upstream from Wokkpash Creek on either side of the Racing River Valley. The plane dips west at about 45°, and strikes N 40° W. The overlying limestones are highly contorted and locally overfolded.

About two miles up Racing River another fault is intersected by the valley, and is clearly exposed on the northwest side. High on the valley side the well-bedded limestones are seen to be dragged and crumpled into small folds near the fault plane.
The best exposed of all the major thrusts within the Rocky Mountain Region was traced from the vicinity of Yedhe Mountain, west of Mt. Roosevelt, across Churchill Creek as far as the headwaters of Upper Racing River, a distance of about 27 miles. The fault itself is not clearly seen but is clearly marked by an abrupt change in dip of the beds, and intense folding. Often the rock types change abruptly on either side of the fault. It follows a general strike of about N 40° W and appears to dip to the southwest.

On the hill slopes on the south side of the west fork of Upper Racing River intricately folded rocks are well displayed. Argillites in the east abut against quartzites, which are in turn structurally overlain by argillaceous rocks that are intensely folded. (See Plate XIV, Figure 5).

In the vicinity of Delano Creek the thrust becomes obscured because it cuts rocks which are mostly grey argillaceous shales and shaley limestones that weather to smooth shale-covered slopes. Where outcrops were seen the beds were highly folded and contorted. One hillside showed numerous drag folds that must have been about 1,000 feet between crests. It was found in the field that the presence of contorted and highly folded beds usually indicated the presence of large scale faults and on this basis the northern extension of this thrust was predicted. However, the Mount Roosevelt massif almost necessitates a fault on its east side to explain why
Plate XIV

Highly folded Windermere-type argillites and quartzites
West Fork of the Upper Racing River.

Northwest 8000 Southeast

West Fork Racing River

Scale 2 Inches : 1 Mile

Figure 5
relatively flat-lying tan conglomerates fail to crop out on the neighbouring peaks at the same elevation. (See Figure 6) The presence of a thrust plane diagonally across the valley conveniently explains this.

It is of interest to note that associated with this major structural break and up to about two miles distant from it on the upper thrust sheet for a distance of about 20 miles are seven known quartz-carbonate veins which fill secondary faults and carry copper mineralization. Thus the recognition of this major feature is of importance economically and might be regarded as a large scale regional ore control.

Within each of the sub-provinces of the Rocky Mountain Region the generally flat lying sediments have been warped into large open folds, complicated as mentioned above, by tight folding near the fault planes.

The Stone Ranges represent a large anticlinal structure, whose axis in general strikes parallel to the mountain front. Dips are generally in the order of $5^\circ$ to $10^\circ$. Between the south fork of the Tetsa River and Wokkpash Creek a second anticline is developed.

Within the Sentinel Ranges to the west, folding of the strata appears to be more intense and is accompanied by the development of thrust faults. In general the strata
Plate XV

Mount Roosevelt (9500 ft.) from Delano valley (4500 ft.)
Relatively flat lying red Macdougal-type conglomerate and quartzite

Vertical Scale 5000 Ft. : 1 Inch
Horizontal Scale 10000 Ft. : 1 Inch

Figure 6
dip to the southwest at fairly shallow angles of from 5° to 35°. Northwest of the confluence of Racing River with Delano Creek, the strata are bent down into what appears to be a monocline. Dips reach 75° to the west but on approaching Mount Roosevelt they flatten out again. (See Figure 7). Further up the Racing River, between Mt. Stalin and the Churchill Creek confluence, the valley appears to be definitely structurally controlled. No fault or thrust plane was recognized but it is felt that a dislocation is probably the cause of the long narrow valley. Near Churchill Creek the rocks on the northeast side of Racing River are overturned in a steep anticline. Further upstream near the west fork of Racing River the east face of the valley appears to represent an overturned syncline, whose axis dips to the northeast. Around the head of the valley, on the slopes of Mt. Stalin, a symmetrical syncline is seen with inward dips of about 20°. To the west in the pass through to the Tuchodi River watershed a small anticline is exposed, and southwest the beds dip uniformly away to the southwest at about 10° (See Plate VI). Structures along this part of the Racing River are quite complicated and more detailed work would be required to clarify the situation.

The structure of the highest peak in the map area is relatively unknown. Mount Churchill rises to an estimated 10,500 feet. This represents a relief difference of about 6,000 feet within two miles. The mountain consists of two peaks
Plate XVI

Upper Delano Creek valley. Note hanging glacier, U-shaped valley, and morains.

Scale 1 Mile : 2 Inches

Figure 7.
of which the western peak is the higher. Between these two are large snow fields which feed hanging glaciers high above the Churchill Creek Valley. The peaks are conical and from about 3 miles away appear to be of the matterhorn type. (Plate IV). They appear to be underlain by gently dipping dark sediments which from a distance resemble the ancient Windermere-type sequences that make up most of the country in the vicinity. Since Mount Stalin is known to be capped by Ordovician rocks, it is thought possible that Churchill Peak may be made up of younger formations but it is recognized that it lies on a different thrust sheet from that which Mount Stalin occupies.

The valley of the Trout River and Muncho Lake is bordered along its eastern side by very striking ranges of steep westerly-dipping Ronning limestones. (Plate IX). These disappear beneath the lake and apparently are overlain on the west shore by the older Macdougal red conglomerates. To explain this a thrust fault is postulated along the Muncho Valley. It is thought to continue on south along the Upper Toad River. A diagrammatic section across Muncho Lake is shown in Figure 8.

One of the striking features of the Rocky Mountain Belt is the marked angular unconformity between the older Windermere-type quartizites and argillites and the younger Ronning and Devonian limestones. This is well displayed along
Figure 8.
the valley of the Toad River in the vicinity of Mile 440 on the Alaska Highway. Here high on the mountain sides the buff weathering steeply-dipping quartzites and associated rocks, and in some instances the vertical basic dykes, are unconformably overlain by almost flat lying grey limestones. This unconformity is again briefly seen from the Highway in the valley of MacDonald Creek where it leaves the Highway just west of Summit Lake. Further up the valley the contact is well displayed. On the north side of Delano Creek grey fossiliferous limestones overlie contorted and folded green and brown argillites, and further up the Racing River nearly all the interfluvial ridges appear to be capped with younger, lighter coloured, flat-lying rocks.

In general the erosional surface appears relatively flat, changing in elevation and attitude from one thrust block to the next. Only on the east side of Wokkpash Creek does it appear to have been down-buckled by folding association with thrust faulting. It is perhaps conceivable that this unconformity represents in fact a very flat thrust plane rather than an erosional surface, but no evidence for this was recognized.

Other less obvious unconformities are present between the various Palaeozoic Formations but generally the relief on these is not great, so that they can be recognized only by detailed stratigraphical study or from palaeontological evidence.
Between the Stone Ranges and the Sentinels lies the Racing River synclinorium. This represents an area of highly folded, soft, black argillaceous rocks. Faulting on the scale recognized elsewhere in the Rocky Mountain Region is apparently absent, or else has been obscured by the more subdued surface expression of the strata. Minor faults were seen and as already mentioned in the west along the front of the Sentinel Ranges black shales of the Fort Creek formation occupy the base of several low angle thrust faults.

Laudon and Chronic (1949) in their generalized cross section along the Alaska Highway show the structure of the synclinorium (Figure 9). The section compiled from the present field work, which doubtlessly missed some of the many folds, is shown in Figure 10 page 96. For this reason the sequence appears thicker than it probably really is.

Almost in the centre of the synclinorium in the Toad River Valley grey Ramparts limestone is exposed in a sharp, slightly overturned anticline about one mile wide. It is exposed on the surface for about 5 miles, plunging beneath black shales at each end. On its east side, near the Highway the black shales are sheared and overturned. Here they weather with bright yellow, orange, and brown colors due to iron staining. Some radioactivity is reported from this area. However, it does not appear to be of any economic importance.

In general the Racing River synclinorium plunges to the northwest at an estimated $25^\circ$. Its axis strikes
Figure 9.

Vertical exaggeration six times
After Laudon and Chronic (1949)

Figure 10.

Vertical Scale 5000 Ft.: 1 Inch
Horizontal Scale 10000 Ft.: 1 Inch
approximately N \(25^\circ\) W, which is more or less parallel to the strike of the Rocky Mountain Front.

The structure of the Rocky Mountain Foothills belt was not studied very fully. This was because of the greater tree cover, poorer physiographic expression of the underlying geology, and because the area was outside of that considered favorable for prospecting. However, it is suspected that if the northern foothills are at all similar to those of the southern British Columbia and Alberta Rockies, then highly complicated structures are to be expected.

Williams in his reconnaissance investigation in 1944 recognized three main faults east of the front thrust. Two of these he thinks are steeply dipping but the westernmost one dips westward at a fairly shallow angle.

The Mesozoic rocks are in general fairly soft and have been crumpled, sheared and folded into a number of synclines and anticlines. This can be seen in cross section A-A (in folder at end).

Laudon and Chronic (1949) in their generalized section along the Alaska Highway show several west-dipping thrusts parallel to the Rocky Mountain Front Thrust. From their diagram there does not appear to be very much movement on these. However, they do not discuss the Mesozoic rocks or the structure east of the Rocky Mountain in much detail, (Figure 11). Further eastwards the sediments become less
Approximate Scale 5 Miles : 1 Inch
After Laudon and Chronic (1949)

Figure 11.
disturbed until on the east margin of the map area they dip gently at less than $15^\circ$ to the east into the broad Cretaceous basin of the Eastern Plains.
CHAPTER IV

HISTORY OF THE AREA

Any account of the historical geology of a region such as the Racing River map area made after only reconnaissance geological investigation, must be open to correction and is subject to revision as new data is accumulated. A study of the stratigraphy and structure within the area indicates a geological history as follows:

Pre Cambrian:
First of the sequence of events was deposition within an ancient geosynclinal basin. The sediments were deeply buried and metamorphosed to argillites and quartzites and then in Pre Silurian times intruded by basic igneous dykes, uplifted to form elevated terrain, and eroded to a generally uneven, in places deeply dissected, land surface.

Palaeozoic:
The Palaeozoic appears to have been a time of encroachment and withdrawal of various seas, whose extent and characteristics are largely unknown.

The Macdougal Group sands and gravels were laid down on the old eroded surface of the basement, according to McLearn and Kindle (1950), "in a sea possibly of Cambrian Age."
However, the striking color of these red beds tends to suggest a continental or near shore deltaic environment.

The Ordovician history is almost entirely unknown in northeastern British Columbia. As evident by the absence, and so possible removal, of most of the Cambrian sediments over the map area, the Ordovician was probably a period of erosion. According to McLearn and Kindle (1950) evidence from limestone beds west of Mount Wright on Halfway River (100 miles southeast of the map area) indicates a boreal sea at this time, which they think spread over a wide area on the site of the Rocky Mountains and Foothills.

Within the map area fossiliferous Ordovician rocks are reported from the summit of Mount Stalin, indicating that Ordovician Seas covered at least parts of the map area at one time, but today have been largely removed by erosion.

Prior to the Silurian there was a period of erosion followed by the encroachment of a clear sea abounding in corals. The sea was of definite Middle Silurian Age and it apparently extended northwards towards the present Arctic Ocean across the Mackenzie River Valley. The extent of the seaway to the south and east is unknown, but to the west it is thought there was a land mass, which could possibly have supplied sediments to the Silurian sea.

Material being deposited in this sea was mainly
cherty and dolomitie limestone, rich in fossils, and interbedded thin shales. The cyclic nature of the sedimentation is thought to be due to fluctuating sea levels which were associated with unstable land conditions.

The three limestone formations of the Devonian are all separated by unconformities, which possibly represent interruption of sedimentation due to the temporary withdrawal of the sea, because of unstable land conditions. During the Middle Devonian, a sea similar to that of the Silurian and rich in coral life covered the present site of the Rocky Mountains and extended possibly as far north as the Arctic Ocean. Later dark muds were deposited and are represented by the Fort Creek black shales and by the Upper Mississippian sediments of the Racing River Formation.

The earlier Devonian limestones are markedly cyclic and are perhaps the reflection of fluctuating sea levels. Black interbedded shales within these limestone sequences are not necessarily deep water facies. However, the later argillaceous sediments represent nearly 1,500 feet of black shales which are thought to have accumulated in deeper perhaps stagnant water. Pyrite nodules are common.

The upper Racing River Formation black chert is interesting. It is entirely unfossiliferous and shows no evidence of organic remains, and it is concluded to have
formed by the primary deposition of silica under possible geosynclinal conditions.

In contrast to the late Palaeozoic formations in the Fraser tectonic belt of the North American Cordillera, there is an almost complete absence of volcanism from the eastern part, referred to as the Millard Belt. No flows, tuffs, or breccias are interbedded with the sediments in this northern extension.

Mesozoic:

The contact between Palaeozoic and Mesozoic formations is not very clear in the map area. Triassic sediments are reported to overlie Racing River shales in the Racing River synclinorium and apparently with only slight unconformity, but if the Racing River Formation is Mississippian in age then the Pennsylvanian and Permian succession must be absent. McLearn and Kindle (1950) state that the contact was not marked by orogeny east of the Rocky Mountain Trench. (p. 128).

...the interruption of marine aggradation was not prolonged, there ... (north eastern British Columbia) for beds of Permian Age are preserved in places and fairly early Lower Triassic beds have been recognized. Some uplift and erosion, of course, may have taken place.

Conditions prevailing during the Mesozoic are speculative. Three faunal zones of the Triassic are thought to represent either three inundations of the continental interior, or three successions within one Triassic sea.
The extent of these seas was variable. Some or all are thought to have been connected with the Arctic Ocean. (McLearn and Kindle, 1950). The Lower Triassic Wasatchites Sea is represented by the lower Toad Formation, and may have been continuous south of the International Border, for there appears to have been a connection with the Wasatchites Sea of Utah. The Upper Toad Formation Beyridrites Sea is thought to have extended as far south as the Central Canadian Rockies and perhaps as far as Nevada and California. While the Nathorstites Sea, now represented by the Liard Formation, has not been traced south of the Peace River, (McLearn and Kindle, 1950).

During the late Triassic period this part of the continent appears to have undergone emergence. The Garbutt Formation, which is mentioned by McLearn, is of unknown exact age and is possibly Late Jurassic–Early Cretaceous, so that the Early and possibly Middle Jurassic was also a time of emergence and non-deposition.

McLearn and Kindle report that: (p. 130).

Early in Lower Jurassic time northeastern British Columbia was again flooded by the sea. Details are lacking, but the Jurassic seas, or sea, are known to have covered western and southern Alberta, large areas in British Columbia, and parts of Yukon and Alaska.

The final evidence of deposition within the map area is found only in the extreme eastern portion. Here the marine phases of the Bullhead Group record an ancient seaway
that covered the Foothills area perhaps as far south as the Athabaska River Valley and is thought by McLearn and Kindle to have even been a southward invasion of the Arctic Ocean. The age of this so-called Aucella Sea is probably very late Jurassic to early Lower Cretaceous.

These marine conditions gave way to continental deposits as is evident from plant remains and the more arenaceous nature of the beds. Apparently the Cretaceous was a time of fluctuating shore lines and the development of wide deltaic plains. The recognition of this requires a study of a far wider area than that covered by the map, whose record can only be fully appreciated by a study of a much larger region. Briefly the events that took place in the eastern Foothills and Eastern Plains according to McLearn and Kindle are as follows:

1. In the Middle-Lower Cretaceous there was possible emergence above sea level, however, there is no proof of a break in deposition between the lower Bullhead marine beds, and the upper Bullhead non-marine.
2. A boreal sea which included several faunal inundations extended from the Arctic Ocean in the north as far south as central Alberta and Saskatchewan. The marine late-Lower Cretaceous Fort St. John Group is the surviving record of this sea.
3. In Mid-Fort St. John time marine sand bottom material,
alluvial plains, and coastal swamps were formed. This age marks the appearance of abundant dicotyledons on the deltic plains.

4. The Late Fort St. John is recorded by the Goodrich Formation and equivalent sandstones, which represent a widespread sandy sea floor.

5. In the Upper Cretaceous a great marginal alluvial plain or delta occupied an area previously flooded by Fort St. John seas. It is recorded in the Dunvegan and Fort Nelson Formations. In the vicinity of the map area it shows an environment representing the Piedmont slopes of that time.

6. This was followed by a retreat of the Dunvegan marginal alluvial plain and inundation by seas of middle Upper Cretaceous age. They extended perhaps across the present Rocky Mountains, and from the Arctic Sea in the north to the Gulf of Mexico, in the south.

7. The last middle Upper Cretaceous sea was expelled by a final advance of a delta or marginal alluvial plain from the east. It is recorded by non-marine strata of the Wapiti Group off the map area.

McLearn and Kindle (1950) discuss the source of the Cretaceous sediments in some detail, but as these rocks make up a relatively unimportant part of the geological column in the map area this problem will only be considered briefly.
Armstrong (1949) believes that the sediments derived from the denudation of the Ominica and Cassiar batholiths which were uplifted into mountainous areas at the end of the Jurassic or beginning of early Cretaceous time could have been the main source of the Lower Cretaceous sediments, McLearn and Kindle think that the arenaceous sediments of the Bullhead Group could very likely have come from these old mountains west of the Rocky Mountain Trench.

The source of the Upper Cretaceous rocks presents a greater problem as large quantities of coarse sediments are represented by the Fort Nelson-Dunvegan deposits. Their source is not so easily explained as coming from the ancient mountains west of the Trench and might have been from the Hyland Plateau and Logan Mountain area of the Yukon.

The Rocky Mountain Revolution:

It was finally in the Laramide Orogeny (late Cretaceous—early Tertiary) that the thick accumulation of sediments in the "Rocky Mountain" geosyncline was folded, faulted, and elevated into the present mountain ranges.

The exact date of this orogeny is not clear in northeastern British Columbia and from evidence within the map area it can only be placed as post—Upper Cretaceous Dunvegan, pre—Pleistocene.

Quoting McLearn and Kindle (1950), p. 138) they state:
In the central and southern Foothills, where beds of Paleocene age have been accurately identified, the folding of the Paleocene with the Cretaceous strata and the lack of an angular unconformity between them indicate that the Rocky Mountain orogeny did not affect the beds on the site of the Foothills until post-Paleocene time.

Following their uplift the Rockies have undergone deep erosion, which has stripped off most of the Mesozoic cover and much of the upper Palaeozoic beds. In the Foothills much of the Cretaceous sediments have been removed exposing the Lower and Middle Mesozoic successions, but on the eastern Plains late Cretaceous and even Tertiary sediments remain.

Subsequent earth movements after the Laramide revolution are evident along the Alaska Highway and Williams (1944 p. 12) recognizes:

Post-Cretaceous uplift is recorded in minor folds in Upper Cretaceous formations of the Foothills and in uplifted and tilted plateaus underlain by Upper Cretaceous beds. This uplift was followed by the development of a peneplain that matches similar plains farther south. By analogy, the uplift may be assigned to Eocene time and the peneplanation to Miocene time.

Another uplift followed, probably early in Pliocene time, and broad lowlands and flaring valleys were developed 400 to 500 feet below the peneplained surface. Late Pliocene uplift initiated the deep dissection of plains and mountains, which increased in tempo until the ice cover grew to glacial proportions and the Ice Age had begun.
CHAPTER V

MOUNTAIN BUILDING AND CRUSTAL MOVEMENTS IN THE ROCKIES

The structure of the northern Rocky Mountains as exemplified by the Ranges of the map area is similar to the Rocky Mountains further south. In general movement from the west relative to the east was translated along westerly dipping faults and thrust planes comparable to the Rocky Mountain Front and similar thrust-faults, of which at least seven are recognized within the Racing River area.

It is not my intention to enter into a discussion of the theoretical considerations of mechanisms and processes of mountain building as this problem has already been attended to in various publications.

Reference is made to de Sitter's "Structural Geology" (1956), in which he discusses thrust faulting in the world's major orogenic belts. He draws attention to an often overlooked phenomenon which might be applied to the structures of parts, at least, of the Canadian Rockies. This is gravitational gliding.

The field work in the map area was not sufficiently detailed to throw any light on this process. de Sitter, however, points to a close association of gliding structures
with lateral compression. Usually the structures are thought to have started as thrust sheets and when a suitable slope had been formed the gliding tectonics occurred as an accompanying feature.

F.K. North and G.L. Henderson in their article on the geology of the southern Canadian Rockies (1954) have raised several interesting questions concerning these mountains. A consideration of one or two of these points might be pertinent to the Rockies of the Racing River area.

It is worth quoting them directly concerning the Rocky Mountain syncline: p. 72 (1954)-

The depositional environment of the Pre-cambrian and early Palaeozoic sediments of the Rocky Mountain province is usually regarded as having been that of a true geosyncline - not merely in the very wide sense adopted by Marshal Kay and others, but also in the original and much stricter sense used by Dana and Schuchert. If this is so, why was the geosyncline not deformed until the early Tertiary? All other known Palaeozoic geosynclines were deformed during the Hercynian and Appalachian revolutions if they had escaped earlier ones.

This problem perhaps can be explained by holding that there was no geosyncline in the strict sense in early Palaeozoic times, although to the west in the Cassiar and Ominica districts there may have been true geosynclines developed. However, the site of the Rocky Mountains received sediments over a very long period of time. The lack of metamorphism and extensive deformation of the thrust blocks,
in spite of the fact they are made up of ancient rocks, now at high elevations is striking.

Henderson and North bring out an interesting theory regarding these thrust faults. They regard the major thrusts to have originated in pre-Laramide time and crustal shortening on them to have taken place over a long period of time, since at least before the close of the Cretaceous. This viewpoint could doubtless be extended to the northern Rockies. In any event the relative ages of the different thrusts probably varies somewhat. Not enough information has been gathered from the northern system to attempt to estimate the relative ages of the thrusts or the amount of crustal shortening that has taken place. In the Rocky Mountain System in the latitude of Banff, Henderson and North (1954) have estimated a reduction of about 50%, which in that area is about 100 miles. The northern Rockies are not as high and contain possibly fewer thrusts than in the south, but because they are virtually unstudied, any estimate of crustal shortening would be purely conjecture.
CHAPTER VI

ECONOMIC GEOLOGY

As far as is known until the opening of the Alaska Highway to civilian traffic at the end of World War II, the area under consideration received no attention from prospectors and mining companies.

In 1944, L.O. Thomas published several papers on the mineral possibilities adjacent to the Highway, but no mention was made of the writer's map area as being of any economic interest. In 1949 the Strangward claims were staked and examined by Menzies the following year. His report was written in 1951 but was unpublished and so unavailable before the current field work was done. The Annual Report by the British Columbia Minister of Mines for 1953 reported the presence of copper float in the Toad River and Racing River Valleys.

During the summer of 1955 a prospector working for Rio Canadian Exploration made a brief visit to the area, and confirmed the presence of the mineralized float and reported favorably on the general area, hence it was decided by the company to send a party into the field to try and run down the source of the material and to prospect the mountainous area. Thus it was that the writer came to spend the summer of 1956 in this area.
The outcome of the summer's investigations were satisfactory in that the mineralization was traced to its source, and no less than six mineralized showings were found. Another two were visited, and four more noted. Despite the fact that no copper deposits of economic proportions were discovered, it is interesting to note that this area which in the past was considered to be absolutely barren of mineralization contains a remarkable number of mineralized showings.

1. Copper

The metalliferous lode deposits of the map area are in general all of the same type, that is quartz-carbonate fissure veins which carry scattered and pockety copper mineralization, principally in the form of chalcopyrite.

Three of the largest deposits of this type are to be found in the Stone Range sub-province of the Rocky Mountain System. The most accessible of these is the Strangward "A" property, which is situated on the north bank of the south fork of the Upper Tetsa River about 3 miles west of the Rocky Mountain Front Thrust Fault. The Strangward "B" group is located a further three miles upstream, i.e. to the southwest of the first group. These two properties formed the subject of a detailed report by M.M. Menzies, (1951).

About 12 miles due south, on the upper reaches of the Chischa River, about eight miles west of the Front Thrust,
are situated the Callison claims. This deposit was located in 1955 and of all the mineralized veins is the most promising in the district.

The balance of the remaining copper showings are aligned roughly adjacent to the thrust fault that extends from Mount Roosevelt to the headwaters of the Racing River. With the exception of a reported occurrence due south of Mount Stalin on the divide between the Racing River and Tuchodi River drainage systems, and a group of claims 15 miles from the northern-most mapped limit of the thrust, on the south and east of the Toad River, all the mineralization lies to the west; that is, within the thrust sheet of the fault. Usually the veins are located a mile or two back from the leading edge of the actual thrust, and all appear to occupy subsidiary fractures. Four are located north of Delano Creek immediately north of Mount Roosevelt. Another two are situated along the Churchill Creek Valley, one on the west side about four miles from the Racing River forks, the other on the east, a further four miles up the valley. The seventh was found near the head of the west fork of Upper Racing River (See Location Map). Without exception all the copper mineralization occurs in the ancient Windermere-type formations. Thus the favorable area for prospecting can be clearly delineated. In almost all cases, basic green dykes were seen near, or intimately related with the fissure veins.
1. The Strangward Properties

The copper deposits of the Strangward "A" claim group are situated at an average elevation of about 6,200 feet on the northern slopes of the South Tetsa River Valley. Menzies (1951) reports on four showings on these claims, of which his No. 3 showings received the most attention.

All are found to be quartz carbonate veins, striking in general north-westwards and occupying faults of small displacement. The veins in general are narrow; No. 3 attaining nearly 3 feet in width, but they make up a zone up to 275 feet wide in which a number of thin parallel veins are to be found.

The veins can be traced for varying distances along the strike, up to about 600 feet. Another vein outcropping 3,000 feet from the No. 3 set was thought to be a continuation of the same system.

The vein material is usually quartz or calcite or both, and in places contain lenses of chalcopyrite, bornite and chalcocite. Malachite staining is usually conspicuous on the vein material and on the wall rocks.

Under the microscope chalcopyrite is seen to make up about 80% of the metallic minerals. It occurs as massive ore, or as exsolution laths in bornite in Widmanstetten texture.
Bornite with exsolved chalcopyrite make up only about 15% of the ore minerals. Often paralleling the chalcopyrite laths are thin borders of chalcocite, which show irregular margins, and at times becomes quite patchy suggesting it has replaced earlier formed bornite and chalcopyrite.

Secondary deep blue covellite fills fractures cutting across all the previously formed minerals.

Menzies (1951, p. 49) considers primary chalcocite to occur as exsolution laths along crystallographic directions in the bornite. He thus recognizes two types of chalcocite: hypogene and supergene. Re-examination of Menzies' polished section No. 152 failed to reveal any chalcocite exsolution lamellae, or any chalcocite that could be considered to be of hypogene origin. It is concluded that Menzies must have been referring to chalcopyrite (CuFeS₂) and not chalcocite (Cu₂S).

The Strangward Claim Group "B" is closely associated with a basic dyke. Pockety chalcopyrite-chalcocite mineralization occurs along the west contact of the eastern of two long, parallel, vertical dykes, which lie 200 feet apart and strike N 25° W. Menzies reports the dykes to extend for at least four miles to the northwest. On their southern extremity they appear to branch out to form several smaller dykes. To the west several more small dykes were observed by him but appear to be unassociated with mineralization.
Of the larger dykes Menzies reports gossans to occur within the dykes and to be distributed over a length of about 8,000 feet, which apparently are associated with pyrite replacement. This is considered to be the source of supergene enrichment which alters the primary chalcopyrite and bornite to chalcocite and covellite. This can be readily seen in the polished sections, where chalcopyrite is strongly replaced by chalcocite, and both are veined by covellite along fractures.

Although only the "A" Claim Group was visited by the writer, it is not felt that either of these deposits is of economic interest, because of the small amount of copper mineralization and limited extent of the showings.

2. Callison Claims

The mineralization of the Upper Chischa River is similar in many respects to that on the Tetsa to the north.

Patchy copper mineralization occurs within quartz-calcite-ankerite veins that occupy fault planes cutting through older shaly limestomes, calcareous shales, and argillites. The fault strikes approximately North 40° West and occupies a vertical zone about 150 feet wide in which intense shearing has taken place. The amount of displacement is unknown. (See Figure 3).

The Copper mineral is primarily chalcopyrite which
occurs as massive pockets up to two feet wide. Under the microscope it can be seen that there are no other metallic minerals present. The chalcopyrite is accompanied by quartz, and some limonite and malachite.

The northern extent of the mineralization is unknown but copper float has been found in the talus slopes on the north side of the valley. About 3,000 feet south of the original outcrop in the creek canyon the zone is again exposed, about 500 feet above the valley floor at the first rock outcrop above the talus slopes. (See Plate XII). Here the shear zone is about 50 to 100 feet in width and carries at least two mineralized zones, each a few feet wide, containing some chalcopyrite and much quartz-carbonate material. The fault is again recognized up the south tributary valley, giving an overall length of about 10,000 feet.

This exposure appears to be the most promising of all those visited in the area, mainly because of its greater length, more abundant copper mineralization, and relative accessibility. However, whether it would represent an economic undertaking would require careful geologic investigation and considerations of the economic problems involved in an operation in this country.

3. Copper Deposits between Yedhe Mountain and Mt. Stalin:

As mentioned on page 114 most of the other copper deposits of the area are situated in the upper thrust plate
west of the Mount Roosevelt thrust fault. These are on the whole small subeconomic occurrences but three or four of those north of Delano Creek have received some attention from prospectors.

In general, they are very similar to the mineralized showings of the Strangward and Callison holdings to the east.

Inevitably they occur in the basement rocks within quartz-carbonate veins, which, in two instances at least, are on the contacts of basic dykes. Usually the veins are only a foot or two in width, and were never traced for great distances along the strike, except where dykes were associated, in which case the mineralization was traced sporadically over 1,200 feet or so.

Where there were no dykes to be seen there appeared to be several fracture veins, usually a few tens or hundreds of feet apart that carry the mineralization. When the copper was closely associated with dyke rocks the fracture zone was about 20 feet wide.

Copper mineralization appears in all cases to be chalcopyrite, which due to surface weathering usually gives rise to distinct malachite stains. These stains aid considerably in the prospecting for these deposits, as they stand out well against the dark weathering argillites and quartzites which contain them. (See Plate XVI).
Quartz-carbonate vein fifteen feet in width stained with malachite and carrying pockets of chalcopyrite cutting Windermere-type argillites.
Examination of polished sections under the microscope revealed no other minerals besides chalcopyrite and very minor amounts of secondary chalcocite and limonite.

Controlling factors in the deposition of Copper Mineralization:

In his report on the Strangward Copper properties Menzies, (1951) discusses the controls of ore deposition in some detail. Similar controls are recognized for the other deposits in the region. The following factors are considered:

(1) faults:

Without doubt the major control of the copper mineralization is the quartz-carbonate veins in which the copper minerals are found, and these veins inevitably occur as fracture fillings along shear and secondary faults. Not all faults have vein material in them, and those that do are not necessarily mineralized with copper. But in no instance was a copper deposit seen not to be in these veins. Menzies thinks the veins probably fill secondary tension cracks.

The primary compressional faults represented by the major thrust planes are not thought to be important controlling factors, except where they bring these ancient rocks to high elevation, enabling the copper deposits to be exposed by subsequent erosion. When the pressures resulting in the thrust faulting were finally released tension openings are
thought to have occurred, often, but not always, along dykes, and these openings were occupied by vein filling material.

(ii) Favorable Host Rocks:

Only the basement formations of Pre-Ronning age are known to carry copper-bearing veins. Although no replacement of any of the sediments by copper minerals was seen, Menzies consider the calcareous rocks to be the most favorable host rock for the deposition of copper within the veins. Usually the deposits were found within the argillite unit, which was often calcareous, rather than in the quartzites. Thick beds of quartzite cut by one or more sets of faults might constitute a structurally favorable host rock, due to the greater competency, and thus greater shattering of the rock.

Menzies, after studying the Tetsa River area, considers the basic dykes to be favorable rock types in which large replacement bodies are thought possible. However, no sign of any such replacement was seen in nearly 40 dykes observed in the field.

The close association of copper mineralization that is sometimes seen with the dyke rocks is thought to be due to the fact that the dykes form suitable planes of weakness along which fault movement may take place, with the subsequent deposition of vein material, and perhaps copper mineralization.
The age of the dykes, as pointed out on page 73 is Pre-Ronning (Silurian), whereas the faulting (and presumably the copper mineralization) is late Mesozoic at earliest.

It is possible, since no copper is found in the Palaeozoic limestone that the dykes, tension faults, and the copper deposition as well are related to an earlier period of movement, and that they are all Pre-Ronning in age.

W.H. Mathews (personal communication) reports that quartz veins stained by malachite are known in the Nahanni Butte area latitude 61° North, Northwest Territories (about 150 miles from the Racing River Map Area). He noted at least one such vein occurring in Ronning limestone beds immediately over the Front Range Thrust on the east front of the mountains. The age of this mineralization would be post-Silurian, and possibly late Mesozoic.

(iii) Folding:

There appears to be no connection between folding and mineral deposition. Earlier folding might have led to the development of fractures and brecciation, which might have allowed later mineralizing solutions easier access. But the folds themselves were never seen to affect the deposition or non-deposition of the copper minerals.
2. Fluorite

Williams (1944) mentioned the occurrence of purple fluorite in the grey limestone near Summit Pass, and at the south end of Muncho Lake. Only small quantities were found, although of relatively high quality.

At present it is understood that several groups of fluorite claims are held directly north of Summit Lake. Some of these are thought to be high grade deposits, but usually limited in extent. Barite is also reported from the area.

A small amount of fluorite was found in the creeks draining Mount St. George, south of the Alaska Highway, but none was seen in place.

In some instances the grey limestone was found to be brecciated and locally highly folded, and often very coarse calcite was deposited along these fractures.

About 30 miles to the north of the map area near the Liard River Hot Springs a deposit of purple fluorite and witherite in rocks similar to those in the Racing River area is known, and it is felt that similar deposits might be found in the Sentinel or Stone Ranges of the map area.

3. Mineral Springs

The hot springs of the Liard River are well known
in northeastern British Columbia. Not so accessible and consequently less visited are the mineral springs on the Toad River, not far from its confluence with the Racing River.

Rand (1944) reports that there are about fifteen springs varying in size from small pools to "... one big enough for five men to swim in at once." Although the springs are seldom visited today an Indian burial ground nearby suggests that they have been known for a long time.

No analysis of the Toad mineral water or its temperature is available but the Liard Hot Springs have a temperature of 90° to 125°F. and contain approximately the following:

<table>
<thead>
<tr>
<th>Ion</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Ca</td>
<td>30%</td>
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<tr>
<td>Mg</td>
<td>7%</td>
</tr>
<tr>
<td>Na₂O</td>
<td>3%</td>
</tr>
<tr>
<td>SiO₂</td>
<td>6%</td>
</tr>
<tr>
<td>CO₂</td>
<td>3%</td>
</tr>
<tr>
<td>SO₃</td>
<td>40%</td>
</tr>
<tr>
<td>Sr</td>
<td>2%</td>
</tr>
<tr>
<td>Cl. etc.</td>
<td>2%</td>
</tr>
</tbody>
</table>

100%

Analyst, B.C. Department of Mines.

The probable combination of the major constituents is thought by the British Columbia Department of Mines chief analyst to be approximately

<table>
<thead>
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<th>Ion</th>
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</tr>
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<tbody>
<tr>
<td>CaSO₄</td>
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</tr>
<tr>
<td>CaCO₃</td>
<td>5%</td>
</tr>
<tr>
<td>SrSO₄</td>
<td>2%</td>
</tr>
<tr>
<td>MgSO₄</td>
<td>20%</td>
</tr>
</tbody>
</table>
It is likely that the Toad River Hot Springs also carry calcium and magnesium sulphate in large amounts.

4. Other Ore Mineral Possibilities

A group of claims was staked some time ago along the Alaska Highway near Mile 423 to cover an area in the Fort Creek black shales near the lower contact with the Ramparts limestones that were thought to give evidence of radioactivity.

This location was carefully examined and specimens tested with a geiger counter. It was concluded that if the shales were radioactive the radiation must have been only just above the background count. Like the shales elsewhere they weather to bright yellow, orange, and red colors, but no uranium minerals were recognized, and the shales always failed to give any marked count on the geiger counter.

An interesting feature of the black shales of the Racing River synclinorium was revealed by testing their weathering products with a field geochemical kit. In many instances they were found to carry an above average base metal content. Careful examinations of these rocks both in the field and in the laboratory failed to reveal the presence of megascopic metallic minerals or any concentration of economic interest.

A spectrascopic analysis of the shale indicated
notable amounts of copper, zinc, and vanadium. A geochemical analysis of the rock was undertaken using the aqua-regia and concentrated HCl extraction method with dithizone. The results of this are:

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration</th>
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</thead>
<tbody>
<tr>
<td>Copper</td>
<td>950 parts per million</td>
</tr>
<tr>
<td>Zinc</td>
<td>180 ppm</td>
</tr>
<tr>
<td>Combined CuZn</td>
<td>1000 ppm</td>
</tr>
</tbody>
</table>

Analyst, S. Boyle, U.B.C. Biogeochemical Lab.

The only sulphide identified was pyrite, but the presence of small amounts of copper and zinc minerals is not entirely unexpected in black shales of this nature.
BIBLIOGRAPHY


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Figure 1.

Rose diagram showing the trends of forty-two dykes from the Racing River area.
Plate XI

Overturned Windermere-type sediments. South side of Chischa River Valley.

Figure 2.
Figure XII

South face Chischa valley at Callison Copper Claims.
Gently southwest dipping Windermere-type argillites.
Note steep fracture cleavage.

Scale: 50 Ft. : 1 Inch

Figure 3.
Plates XIII

Contorted grey limestone, north of Toad River valley near mile 430 Alaska highway.

Figure 4.
Plate XIV

Highly folded Windermere-type argillites and quartzites
West Fork of the Upper Racing River.

Northwest 8000 Southeast

West Fork Racing River

Scale 2 Inches : 1 Mile

Figure 5
Plate XV

Mount Roosevelt (9500 ft.) from Delano valley (4500 ft.)
Relatively flat lying red Macdougal-type conglomerate and quartzite

Figure 6
Plate XVI

Upper Delano Creek valley.
Note hanging glacier, U-shaped valley, and moraines.

Scale 1 Mile : 2 Inches

Figure 7
Figure 9.

Vertical exaggeration six times
After Laudon and Chronic (1949)

Figure 10.

Vertical Scale 5000 Ft. : 1 Inch
Horizontal Scale 10000 Ft. : 1 Inch
Approximate Scale 5 Miles : 1 Inch
After Laudon and Chronic (1949)

Figure 11.