GEOLOGICAL SURVEY OF CANADA · 1842 ·

MEMOIR 334

# GEOLOGY OF THE ROCKY MOUNTAIN FOOTHILLS, ALBERTA

(between latitudes 53°15′ and 54°15′)

E. J. W. Irish

1965

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PLATE I. *Looking west through the Persimmon Range toward Eagles Nest Pass. The Rocky Pass fault separates the overthrust Palaeozoic formations of the mountains from the Upper Cretaceous formations within the Lancaster syncline in the foreground.*

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By
E. J. W. Irish

DEPARTMENT OF
MINES AND TECHNICAL SURVEYS
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# PREFACE

The foothills belt of the Canadian Rocky Mountains is a region of considerable geological complexity where folds and great thrust faults involve Palaeozoic, Mesozoic and Tertiary strata. For many years detailed systematic mapping in the region has provided a means of interpreting the structures in this disturbed belt between the Great Plains and the Rocky Mountains. The mapping has also been of direct economic application as the region has long been recognized as a source of coal, petroleum and natural gas.

In this report, the author brings together in a single volume a description of the geology of 14 adjoining map sheets. The report has chapters on stratigraphy, economic geology, and an appendix of measured surface sections and logs of several wells drilled in the region. It includes a map showing the geology of the whole area and has many figures illustrating the stratigraphy and structure.

J. M. HARRISON,
*Director, Geological Survey of Canada*

OTTAWA, December 3, 1963

Memoir 334—Geologie der Foothills der Rocky Mountains in Alberta (zwischen den Breitegraden 53° 15′ und 54° 15′).

Von E. J. W. Irish

Der Foothills-Gürtel liegt zwischen den Great Plains und den Rocky Mountains und ist ein Gebiet von beträchtlich komplizierter Struktur mit vielen Falten und Überschiebungen. Stratigraphisch umfasst er die Schichtfolgen vom Kambrium ? bis zum Paleocän.

Мемуар 334 — Геология предгорий Скалистых гор в провинции Альберте (между широтами 53° 15' и 54° 15').

Автор: Э. Дж. В. Айриш

Полоса предгорий расположена между Великими равнинами и Скалистыми горами, и представляет собой район значительной структурной сложности с большим количеством складок и взбросов. Район сложен горными породами возраст которых простирается от кембрия до (?) палеоцена.

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# GEOLOGY OF THE ROCKY MOUNTAIN FOOTHILLS, ALBERTA


## *Abstract*

This report describes the geology of a vast area of the northern part of the Rocky Mountain Foothills, Alberta.

The stratigraphic succession ranges from Cambrian? to Paleocene. The author has described in some detail the relationships and lithological content of all the formations (comprising some 25,000 feet of strata) and has attempted to clarify the nomenclature of Cretaceous stratigraphy by using the Athabasca River as an arbitrary cut-off for the northern nomenclature.

Compressive stresses have deformed the region from the southwest; thrust faulting is perhaps the dominant and initial type of deformation. Folding may post-date the initial thrusts but continued on the faults and persisted after thrusting ceased. Most of the thrusts are west dipping but there are some east-dipping faults. The formation of drag anticlines and the mechanism of steeply-dipping and folded back-limb thrusts is analysed in some detail.

Coal is perhaps the most important economic material and is treated according to locality and age. The report includes a discussion of the oil and gas potentialities of the region.

Appendices contain detailed measured sections of most formations of the larger exposed coal seams, and of the logs of wells drilled for oil. Fossils are listed according to their age, enclosing formations and geographic location.



## *Résumé*

Le présent rapport décrit la géologie d'une vaste étendue de la partie nord des contreforts des Rocheuses, en Alberta.

La succession stratigraphique va du Cambrien (?) au Paléocène. L'auteur décrit avec assez de détails les relations qui existent entre toutes les formations (quelque 25,000 pieds de strates) et les quantités de roches qu'elles contiennent; il a également tenté de clarifier la nomenclature de la stratigraphie du Crétacé en utilisant la rivière Athabasca comme limite arbitraire pour la nomenclature de la partie nord.

Des efforts de compression venant du sud-ouest ont déformé les roches de la région. Les failles de poussée sont peut-être le genre de déformation le plus commun et le plus ancien. Les plissements peuvent être postérieurs aux premières failles de poussée, mais leurs effets sur les failles ont continué et persisté après la fin des failles de poussée. La plupart de ces failles sont à pendage ouest, mais il y en a à pendage est. L'auteur analyse avec suffisamment de détails la formation d'anticlinaux par entraînement et le mécanisme des failles de poussée à pendage abrupt, qui sont plissées et localisées sur le flanc arrière des plis.

Du point de vue économique, la houille constitue peut-être la matière la plus importante et l'auteur l'étudie par localité et par âge. Le rapport comprend une étude des possibilités de pétrole et de gaz dans la région.

Les annexes contiennent des coupes détaillées et mesurées de la plupart des formations et des plus importantes couches de houille qui affleurent, de même que des coupes des puits d'exploration pour le pétrole établies à partir des notes de forage. Les fossiles sont classés d'après leur âge, les formations qui les contiennent et leur emplacement géographique.

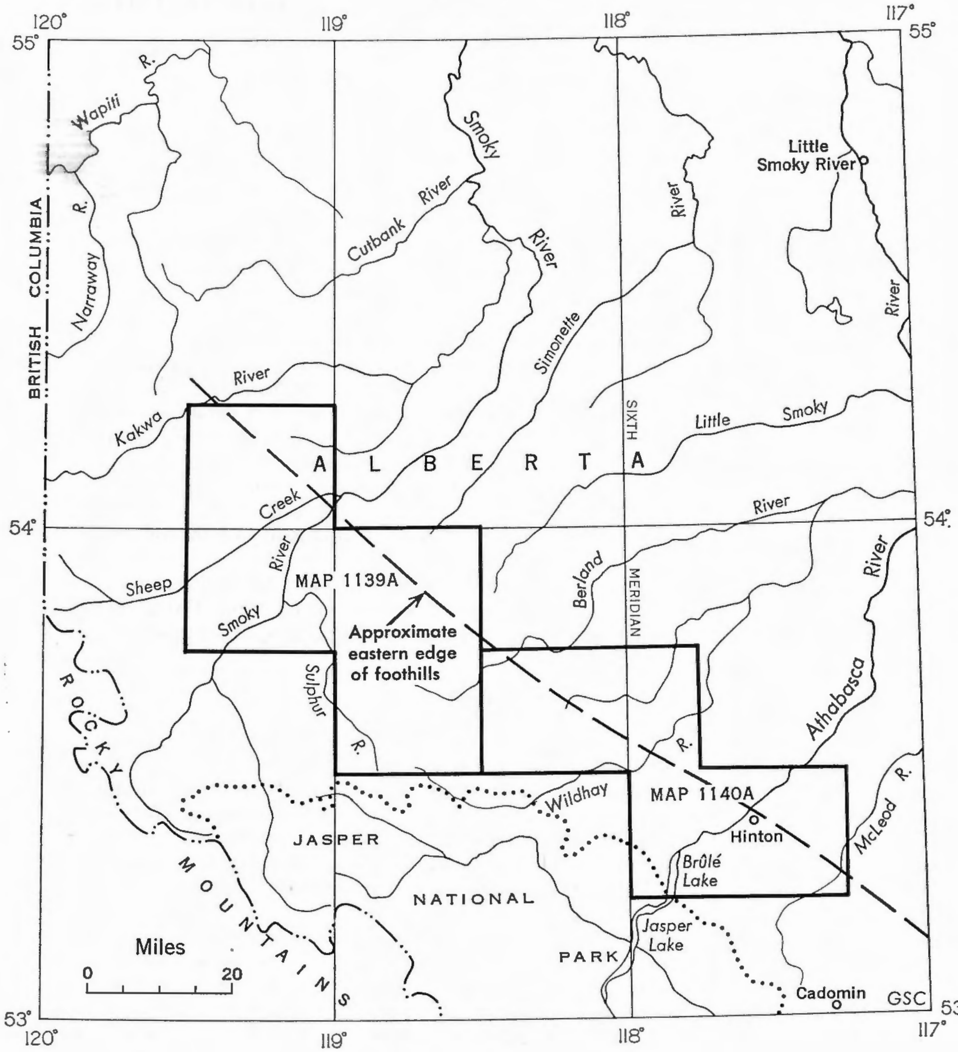


Figure 1. *Index map.*

## *Chapter I*

# INTRODUCTION

The region covered by this report comprises some 2,550 square miles of the Foothills of Alberta. It consists of a relatively narrow, northwest-southeast trending area lying between latitudes 53°15′ and 54°15′ and, for the most part, between the Great Plains on the northeast and the Rocky Mountains on the southwest.

Large reserves of coal are present within the Cretaceous formations from the southern to the northern boundary of the map-area. In past years there has been considerable coal mining at several places near the main line of the Canadian National Railways, and prior to 1925 the area north to Sheep Creek was actively prospected. At present no prospecting is being done for coal and most of the mines are closed.

The oil possibilities of the region have been closely investigated in recent years by geologists representing various oil companies. Wells have been drilled at Solomon Creek, Folding Mountain and Muskeg River. No commercial flows of oil were obtained but the failure of these wells should not condemn the whole region, particularly since there is, as yet, little subsurface information available.

No extensive stands of good timber occur within the map-area but several companies have logged, and are now logging for both lumber and railroad ties for several miles north of Athabasca River. Small isolated stands of good spruce trees occur in several valley bottoms and stands of lodgepole pine large enough for lumber or ties are present in some places. A large part of the region has been burned at various times and is now covered with second-growth trees.

White men inhabit only a very small part of the region. Along the highway and railway in the extreme southern part, small communities have grown up that owe their existence mainly to logging and coal mining. Little real farming is done, though there are several ranches along the Edmonton-Jasper highway and along the valley of Athabasca River. The only white men living in the vast area lying north of Athabasca River are loggers, trappers, and forest rangers. In this region a few Indian families still remain but their numbers are decreasing rapidly. The trapping of fur-bearing animals is still the main occupation of these people.

## Accessibility

The transcontinental line of the Canadian National system follows the Athabasca River valley west and south to Jasper and thence through the Yellowhead Pass into British Columbia. Several stations on this line lie within the southern part of the map-area. The Edmonton-Jasper highway also passes through the southern part of the map-area, just south of the railway. The village of Hinton, located on both the railway and the highway, has a store, hotel and garage. Entrance, about five miles west of Hinton on the railway, is connected to the highway by a branch road three miles long. It has a store, post office, and telegraph service, and has been, for many years, the outfitting point for coal prospectors, forest rangers, hunting parties and, more recently, for geological parties. Field parties of the Geological Survey engaged in mapping most of the area covered by this report were outfitted at Entrance.

Most of the southern part of the area, especially in the vicinity of the villages of Drinnan, Hinton, Entrance and Brûlé, is accessible by numerous bush roads and trails. A good forestry trail extends southward from the old mine near Hinton and follows the crest of High Divide Ridge to avoid the large muskegs in the lower part of this region. A branch of this trail joins the highway near the mouth of Cold Creek.

A large part of the map-area north of Athabasca River has been reasonably accessible since before 1916 by pack trails starting from Entrance. These were originally cut by the Dominion Government but, since the Forest Reserve was transferred to the Province of Alberta, they have been maintained by the Forest Branch of the Department of Lands and Forests of that Province. Several of the trails, lakes and streams named in the following paragraphs lie outside the present map-area but are included here to provide a complete description of the routes of travel.

All traffic into this northern region crosses the Athabasca River on the abandoned Canadian Northern railway trestle bridge near Entrance. This bridge offers the only means, outside of Jasper Park, for pedestrians and vehicles to reach the north side of the river.

The part of the map-area which lies between the Athabasca and Smoky Rivers is traversed by a number of good trails. Two main pack trails extend northwesterly from Entrance to join at the Indian village of Grande Cache. The most easterly of these, known as the Lower Trail, follows the eastern edge of the foothills northwesterly to the point where Muskeg River turns to flow west, then follows the valley of this stream and that of Susa Creek westward to the Indian village of Grande Cache situated on Grande Cache Lake. The Grande Prairie Trail leaves the Lower Trail about six miles east of Grande Cache, follows Muskeg River to its mouth at Daniels Flats on Smoky River, then extends down the northwest side of Smoky River to cross Sheep Creek near its mouth and then proceeds northwesterly again.

The second route to the north, originally known as the Mountain Trail (each part now has a separate name as shown on the map), branches from the Lower Trail about one mile north of Wildhay River. It follows the north side of the river west to Rock Lake, then goes up the valley of Rock Creek for some miles to cross a low divide into the valley of Sulphur River. From this point the trail follows the valley to the upper end of Sulphur River canyon. From here it leads up Walton Creek, crosses Hayden Ridge into the valley of Cowlick Creek, and proceeds down the valley of this creek for some distance before turning north to Grande Cache. At Grave Flats on Sulphur River, a branch trail, the Kvass Creek Trail, goes up Kvass Creek to the divide and then down Wolverine Creek to Smoky River at Clarks Crossing. The Mountain Trail may be reached at Rock Lake by a road from Entrance to Brûlé via the north side of Athabasca River and then up the valley of Solomon Creek.

Besides these two main routes of access there are several intersecting branch trails suitable for pack horses by which most parts of the country can be reached. In some places, however, it was necessary to cut other trails to facilitate the field work.

A road, 72 miles long, was completed in 1947 from Entrance northwest along the route of the old Lower Trail to the site of the Muskeg No. 1 oil well in sec. 24, tp. 57, rge. 6, W. 6th mer. This well was abandoned in 1948, but the road is passable for motor vehicles in dry weather and is now maintained by the Provincial Government. A poor road, maintained by the Forestry Branch, leaves the Muskeg road at Powder Creek and proceeds north and northeast about 12 miles to the Wildhay River ranger cabin. Another road follows the northwest side of Athabasca River to the village of Brûlé and from there a road built for logging leads up the valley of Solomon Creek, crosses the divide to Wildhay River and then follows part of the Mountain Trail up the river as far as Rock Lake. This road is passable for most motor vehicles in dry weather.

The part of the map-area north of Smoky River has fewer trails than the part south of the river and access is more difficult. A good trail, known as the Smoky River Trail, follows up the northwest side of Smoky River from the mouth of Sheep Creek to Clarks Crossing, just west of the mouth of Muddywater River, where it meets the Kvass Creek Trail. From Clarks Crossing the Dry Canyon Trail follows the valley of Muddywater River for some miles then passes through Dry Canyon to Sheep Creek. It continues up the valley of Sheep Creek to connect with the Boundary Trail which roughly follows the interprovincial boundary along the Continental Divide. Both Cecilia and Kakwa Lakes on the British Columbia side of the divide can be reached by branch trails from the head of Sheep Creek. Leaving the Smoky River Trail at Gustavs Flats a good trail crosses the divide into the valley of Sheep Creek and then follows along the top of a high ridge to the headwaters of the east fork of Copton Creek. From here it is possible to cross another divide into Grizzly Creek and thence down into the main valley of Copton Creek to connect with the Copton Creek Trail. The Copton Creek Trail leads down the valley of that stream and meets the Grande Prairie Trail just south of Kakwa River. The Grande Prairie Trail, proceeding northwest from Smoky River, crosses Kakwa River just west of the mouth of Copton Creek, and follows the crest of Nose Mountain to Grayling Creek at the northwest end. From this point one branch goes north and reaches Wapiti River approximately south of the town of Beaverlodge. A second branch proceeds east and north to connect with the ferry on Wapiti River near the settlement of Pipestone Creek. The town of Grande Prairie can be reached by road from either of these two places.

Another route, known as the Two Lakes Trail, leaves the Grande Prairie Trail about one mile north of the Grayling Creek crossing. This trail extends west to Nose Creek and up this stream for a few miles then crosses to the valley of Gunderson Creek. It follows this valley to Stetson Creek where it branches, one branch going approximately south via Torrens River to the upper reaches of Kakwa River and then to the Boundary Trail, and the other branch proceeding southeast to Kakwa River and Copton Creek.

Cabins for the use of the forest rangers are located at Winter Creek and Wildhay River east of the Muskeg road; at Moberly Creek, Little Berland River, Cabin Creek, Muskeg River near the mouth of Lone Teepee Creek on the Muskeg road, and at Grande Cache on the Lower Trail; at Rock Lake, Mile 58, Grave Flats, and at Smoky River at the mouth of Wolverine Creek on the Mountain Trail. There is another cabin on Sheep Creek about three miles above the mouth of Femme Creek. All but the Mile 58, Grave Flats, Smoky River, Sheep Creek and Grande Cache cabins are connected by telephone with headquarters at Old Entrance on the northwest side of Athabasca River. In recent years communication has been improved by the use of portable two-way shortwave radios.

The presence of the Muskeg and Solomon Creek roads as well as the numerous good trails makes the southeastern two-thirds of the map-area more readily accessible from Entrance than from the towns in the Grande Prairie district situated on the Northern Alberta railway but the northwestern one-third is considerably closer to the northern towns.

Light aircraft equipped with floats can be landed on Cecilia and Kakwa Lakes on the British Columbia side of the divide but, in general, pack horses are the only suitable means of transportation both of men and supplies.

Smoky River is difficult and dangerous to cross. The river is swift and can be forded only where and when it is shallow and where horses can obtain good footing. Like all glacier-fed streams, the water is so charged with silt that the bottom is seldom visible. In addition, the position of the sand and gravel bars changes from year to year. It is advisable, therefore, for travellers who are not familiar with the crossings to obtain help from the Indians of the district.

When the water is low Smoky River can be forded satisfactorily at Daniels Flats just below the mouth of Muskeg River but, at times of high water, horses must swim and supplies and equipment must be transported from one side to the other by raft or boat. This applies, also, to other fords on the Smoky River as well as to fords on the Kakwa and Wapiti Rivers. Kakwa River, Sheep Creek, Muskeg River and the other large streams are often difficult to ford but these streams are usually clear so that deep holes can be seen and avoided. Wapiti River can be crossed by ferry just south of the settlement of Pipestone Creek but must be forded at other places.

## General Character of the Region

From northeast to southwest the map-area changes progressively from low, rounded, timbered hills to high, rocky, bare-topped mountain ridges. In general, the region is forested below timber-line but so much of it has been burned by forest fires at various times that very little good timber now remains. Small stands of virgin spruce remain in some places but large parts of the country are now covered with second growth poplar, lodgepole pine and, rarely, white birch. The country is fairly open and grassy where poplar predominates. Wild flowers are varied and abundant and add greatly to the beauty of the hills. Above timber-line the vegetation consists of mosses, lichens, and a great variety of alpine flowers.

The region has a fairly moderate climate with temperatures which are not excessive in either winter or summer. Much of the precipitation occurs as rain in the spring and early summer, the latter part of the summer being generally warm and dry. Although snow accumulates to a considerable depth at most places in the mountains, the Chinook winds which reach the Athabasca and Smoky valleys prevent the accumulation of snow along these rivers and the adjoining uplands in most winters. Because of this, and the fact that the summer rainfall is ample to produce a luxuriant growth of grass and peavine, stock graze out all winter in both valleys.

Hay, oats and vegetables are grown in Athabasca valley for local use and, as much of the district is suitable for grazing, many horses and a few cattle are raised. The Indians living along the Smoky valley show little interest now in agriculture but, in the past, good crops of hay and vegetables were grown by them on the fertile river flats.

## Fauna

Game is plentiful throughout this region, which has long been a favourite hunting ground of the Indians. It is probably one of the last of the good 'big game' territories and each autumn many outfitters and guides from Entrance and other towns along the railway, and from the towns in the Grande Prairie district, head into the mountains with hunters, many of whom come from as far away as the southern and eastern United States. Moose, caribou, elk, deer, Bighorn sheep, mountain goat, black bear, and grizzly bear are to be found. Each spring trappers bring out catches of fur comprising squirrel, fox, lynx, coyote, wolf, marten, bear, weasel, and fisher. Rainbow trout, Rocky Mountain whitefish, Dolly Varden char, and Arctic grayling are found in many streams. Dolly Varden char are particularly plentiful in Muskeg River and A la Pêche Lake, lake char are taken from Rock Lake, and northern pike are caught in Jarvis Lake. Game birds that may be hunted in season include ruffed grouse, spruce grouse and ptarmigan. A few Canada geese and ducks may be seen.

## History of the General Region

The first record of white man in the region is relatively recent. Activity has been confined to the southern part of the area, in particular to the Athabasca Valley which has long been one of the principal fur-trading routes through the Rocky Mountains. Only a few of the main events are outlined to present the general background, although the Athabasca route has had a long and interesting history.

Probably the first important event in the history of the district took place in 1807 when David Thompson, the fur trader employed by the North-West Company, crossed the Rockies by Howse Pass, far south of the Athabasca, and built a trading post on the Columbia River. In 1810 he was returning to this post with a supply brigade when the hostility of the Piegan Indians prevented him from reaching Howse Pass and forced him to try a more northerly route. He travelled by pack train with his party of French Canadian voyageurs from the North Saskatchewan to the Athabasca River. After camping for 25 days in the vicinity of Brûlé Lake where they hunted, put up meat, and made snowshoes and sleds, the party set out on foot up the Athabasca and Whirlpool Rivers and on January 10 and 11, 1811, made a difficult crossing of the Continental Divide in deep snow. The Columbia was reached by descending what is now the Wood River. Dowling (1918) states that Thompson took the Athabasca route to test a report that a trader named J. Henry had previously found a route to the Columbia via the Athabasca, and Thompson's mention of a cabin (Thompson, 1916, p. 442) on an island in Brûlé Lake also suggests that white traders had already penetrated the upper reaches of the Athabasca.

The route blazed by Thompson became one of the main brigade routes for servicing posts on the Pacific slope. Transportation was by pack train, dog team, and also by York boat on the river at least as far as the present site of Devona. A small post was built at Brûlé near the mouth of Solomon Creek prior to the year 1814 and was called by some "Jasper House" after Jasper Hawes, who was in charge, and by others "Rocky Mountain House". This post was moved later to what is now called Jasper Lake. In 1811, when Thompson made his first trip by the Athabasca route, he left William Henry to look after the pack horses and to build a small post called Henry House near the present Henry House station. Both of these posts appear to have been used more as hunting bases than as trading posts.

The Pacific Fur Company, headed by John Jacob Astor, sent a ship around the Horn in 1811 to establish a post called Astoria, near the mouth of the Columbia. In 1814 this company was purchased by the North-West Company and several of Astor's men returned overland to their homes in the East with the brigade of that year. One of these was Gabriel Franchère, a young clerk from Montreal, who recorded his journey in an interesting narrative (1854, p. 297).

David Douglas, the distinguished botanist after whom the Douglas fir is named, accompanied the brigade to Jasper House in 1827. According to him, the post then consisted of three small hovels.

In 1846 two travellers visited Jasper House. One of these, a Belgian missionary named Father de Smet, arrived at the post in a cariole, then continued the difficult journey across Athabasca Pass on foot. The de Smet Range north of Jasper Lake is named in his honour. The second visitor to the post that year was Paul Kane, the noted painter of Indians, who travelled from Fort Vancouver up the Columbia and through Athabasca Pass to Fort Edmonton.

The Palliser Expedition was sent by the British Government in 1857 to report on the resources of the west and the feasibility of a railroad through the mountains. James Hector, geologist to the expedition and discoverer of the Kicking Horse Pass, travelled in 1859 by dog team from Fort Edmonton to a point on the Athabasca west of Henry House. His geological observations were meagre because the trip was made in winter. His reference (1863) to the scarcity of game suggests that the present abundance is comparatively recent.

In 1859 and 1860 a great influx of miners followed the discovery of gold in the Cariboo district of what is now the Province of British Columbia. Most of these arrived by ship at Victoria but many travelled the overland route through the Yellowhead Pass, which had been discovered in 1826. In 1862 a party known as the "Overlanders", consisting of more than one hundred and fifty, including a woman and three children, travelled from Fort Garry, across the Plains, and through the Athabasca and Yellowhead valleys. There the party divided, some going down the Fraser River to Quesnel and others going by way of the North Thompson River to Kamloops (McNaughton, 1896, p. 89).

In the spring of 1863 Viscount Milton and Dr. Cheadle travelled with horses up Athabasca Valley and through Yellowhead Pass. West of the Divide they proceeded down the North Thompson River and, after considerable hardship, reached the post at Kamloops. Their journey, including a description of the country and difficulties of travel, is recorded in two books (Milton and Cheadle, 1865; Cheadle, 1931).

In the years following the Cariboo gold rush there is little recorded travel over the Athabasca route until 1871, the year in which British Columbia entered Confederation, and exploration began for a route for the Canadian Pacific Railway. The Yellowhead Pass was the route selected for the railway and the original survey was completed in 1876. Almost the same route is now followed by the Canadian National Railways. Subsequently, the more difficult southern route was chosen to forestall competition from the railroads in the United States. In 1872, a party headed by Sir Sandford Fleming, Chief Engineer of the Canadian Pacific, travelled with horses to inspect the proposed Yellowhead route and continued to the Pacific. In a book entitled "Ocean to Ocean" (1873), the Rev. G. M. Grant, secretary of the party, wrote an interesting account of the Athabasca Valley.

For some years after the abandonment of the Canadian Pacific surveys and the decline of the fur trade, there was little activity in the district. During this period a few settlers penetrated westward from Edmonton. Among them was James Swift, who established a farm near the present town of Jasper in 1895.

Sometime later Frank Seabolt founded a ranch just south of Entrance near what is now the Edmonton-Jasper highway. This ranch is now operated as a dude ranch.

The most important event that led to the modernization of the region was the building of the rival Grand Trunk Pacific and Canadian Northern Railways which were completed in 1911 and 1914 respectively. Both lines followed the south side of the Athabasca Valley as far as Entrance, where the Canadian Northern crossed to the north side of the river and continued along the northwest side to Brûlé Lake. In 1916, the two railways were amalgamated and became the government-owned Canadian National Railways. At first the Canadian National used the Canadian Northern line through Old Entrance; but to improve the grades, it reverted to part of the Grand Trunk line in 1927 when a new bridge was completed across the Athabasca River. At this time the present village of Entrance was established at what had been Dyke station on the Grand Trunk line.

Jasper National Park was established in 1907. The Indians then residing in the district were given a choice of other areas outside of the park boundary to re-establish themselves. Their choice was Grande Cache just east of the confluence of Sulphur and Smoky Rivers near a lake that now bears the same name. For several years after its establishment the park included Folding Mountain and the valley of Solomon Creek. When the mine and town of Brûlé became large the east boundary of the park was moved westward to its present location at the summit of Roche à Perdrix and the crest of the Boule Range, so that Brûlé would lie outside the park.

Soon after the park was established, the Foothills east of it were constituted a Dominion Forest Reserve. Trails and ranger stations were built and maintained by the Federal Government. Later, the reserve was transferred to the Provincial Government.

The completion of the railways caused fresh interest in the relatively unknown district to the north. Many of the men who had entered the foothills and mountains with the construction of the railways remained to trap fur and prospect for coal in the vast region north of Athabasca River. Some of these men are still living at Entrance and other points west to Jasper.

Probably very few white men had travelled through the territory north of the river prior to the cutting of pack trails by the Federal Government. Between that time and the year 1943 a meagre amount of information had been accumulated and large areas remained relatively unknown.

The Geological Survey of Canada has been engaged since 1943 in a project of systematic mapping of the geology and mineral resources of the Foothills north of Athabasca River. More recently, there has been a renewal of interest in this region because of its oil and gas possibilities.

## Previous Geological Work

Dr. Hector of the Palliser Expedition visited Athabasca Valley during the winter of 1859 (1863). In 1898 James McEvoy of the Geological Survey made a reconnaissance of the route from Edmonton to Tête Jaune Cache (1900). In 1910 and 1911 D. B. Dowling studied the coal deposits of Jasper Park and published brief descriptions of the formations near Brûlé Lake and Moosehorn Creek (1912). In 1917 J. M. MacVicar's work in the Smoky River coal district was published by the Dominion Fuel Board in cooperation with the Geological Survey of Canada. R. L. Rutherford mapped the Foothills belt between McLeod and Athabasca Rivers in 1925, under the auspices of the Research Council of Alberta (1925). His map, published on the scale of 1 inch to 2 miles, includes a small area in the southern part of the present map-area. B. R. MacKay of the Geological Survey made a detailed study of the Brûlé coal deposits in 1927 (1929a), and in 1930 published the results of other coal examinations, including the seams at Folding Mountain (1930). In 1929 L. W. Collett and E. Paréjas, of the University of Geneva, visited Athabasca Valley and their report (1932) is accompanied by a structure-section that includes Boule Range. Also in 1929, C. S. Evans and J. F. Caley of the Geological Survey of Canada made a reconnaissance survey along parts of Wapiti River, Nose Creek and Narraway River (1930). In 1932 J. A. Allan, P. S. Warren, and R. L. Rutherford, of the University of Alberta, published a summary account of the stratigraphy and structure of the mountains near Athabasca River including Folding Mountain (1932). In recent years map-areas in the Foothills belt north of Athabasca River have been mapped by A. H. Lang (1944, 1946, 1947), R. Thorsteinsson (1952), J. K. Eccles (1957), H. R. Greiner (1955), and by E. J. W. Irish (1945, 1946, 1947, 1950, 1951, 1952, 1954, 1955). Much of this region has been investigated by field parties representing various oil companies but few of their results have been published.

Detailed studies of the Jurassic, Mississippian, and Devonian strata have been made in regions adjacent to this area by H. Frebold (1953), P. Harker (1954), and D. J. McLaren (1953, 1955) respectively, of the Geological Survey. In 1956, D. F. Stott, also of the Geological Survey, published a preliminary account of the Alberta group in the Mountains and Foothills of Alberta and this study is being continued.

## Field Work and Acknowledgments

The field work on which this report is based was begun in 1943 and completed in 1954. A. H. Lang mapped the geology of a strip along the Athabasca Valley between Drinnan and Brûlé Lake in 1943. This work was followed in the successive seasons of 1944, 1945 and 1946 by the mapping of the Entrance (1945), Brûlé (1946), and Moberly Creek (1947) map-areas. In 1947 Lang mapped the northern part of Pierre Greys Lakes map-area (1948) and the Muskeg anticline in A la Pêche map-area (1949). These maps were completed by the writer in 1947 and 1948. In 1948 R. Thorsteinsson began work on the east half of the Grande

Cache area and completed this map-area in 1949. J. K. Eccles began mapping the east half of the Adams Lookout map-area in 1954 and completed this work during the field season of 1955. The remainder of the region covered by this report has been mapped by the writer who began the work in 1944. The writer is indebted to E. W. Mountjoy of the Geological Survey who supplied information based on his field mapping within and west of this map-area. These data resulted in some corrections and modifications of the map.

Between 1944 and 1954 the writer was assisted in the field by a number of geological students. It is not feasible to list the names of all these men here but the writer wishes to convey to them his appreciation for satisfactory and often excellent assistance. Special thanks are extended to the late Mr. S. Nelson and Mrs. Nelson who, between 1946 and 1954, held the positions of packer and cook respectively on the writer's field parties. Their whole-hearted cooperation was greatly appreciated. The writer is indebted to many residents of the district for assistance and many courtesies, particularly to the staff of the Alberta Forest Branch, and to Messrs. R. Neighbor, A. E. Davey, A. G. Watt, G. W. Munro, M. F. Truxler, and the late S. H. Clark of Entrance.

The Palaeozoic fossils collected by the writer were identified by R. A. C. Brown, D. J. McLaren, and P. Harker, the Mesozoic invertebrates by F. H. McLearn and J. A. Jeletzky, and the fossil plants by W. A. Bell and W. L. Fry, all of the Geological Survey.

## *Chapter II*

# PHYSIOGRAPHY

The region included within this map-area changes gradually from low hills in the east and northeast to rugged precipitous mountains in the west and southwest. The extreme western and southwestern parts present an approximate accordance of summit level but, in general, altitudes gradually decrease from southwest to northeast.

The detail of the present landscape is considered to be the result of modification by glacial and glacio-fluvial processes when the entire area was occupied by an ice-cover related to the Pleistocene continental glaciers. The land surface left by the regional ice-cover has been subsequently modified by alpine glaciation, frost action and stream action to produce the present land forms. Active erosion by frost and streams continues but no glaciers remain within the map-area.

## Topography

The map-area forms a part of two major physiographic units: the Foothills, and the more easterly ranges of the Rocky Mountains. The division between these two is gradational from northeast to southwest, and irregular from southeast to northwest due to the offset character of the eastern mountain ranges (*see* Fig. 1).

### Foothills

The Foothills, underlain predominantly by rocks of Mesozoic age, are characterized by high northwesterly trending ridges and steep-sided valleys parallel with the strike of the underlying strata. This northwesterly alignment, conspicuous in the more westerly ridges, becomes progressively less well-defined to the northeast until, near the margin of the Plains, the ridges are irregular in shape and show a noticeable change in trend. There the principal ridges strike more to the northeast, parallel with the main streams. This change is probably due to the fact that the strata underlying this part of the map-area are relatively undisturbed and dip gently to the northeast.

The width of the Foothills belt is not constant. Between Athabasca River and Mahon Creek, in the southeast part of the map-area, the belt is approximately 8 miles wide and bounded on the southwest by the Boule and Hoff Ranges south of Wildhay River and by the Berland and Hoff Ranges north of the Wildhay River. The Berland and Hoff Ranges plunge to the northwest and die out just south of Mahon Creek so that, beyond this point, the width of the Foothills is increased to about 16 miles, their southwest boundary now being the more westerly Persimmon Range. This range also plunges to the northwest and dies out just south of Smoky River. North of this point, the Foothills belt reaches its maximum width of about 25 miles and is now bounded on the southwest by the de Smet Range.

The Foothills grade into the Great Plains to the east by progressive decrease in relief, altitude and structural deformation. Also, the transition from foothills to mountains is marked by a gradual increase in altitude and relief, and a change to more open folds of greater amplitude and to much less imbricate faulting.

Summit altitudes of the eastern hills range between 4,000 and 5,000 feet above sea-level but the high ridges to the west reach heights of over 7,000 feet. Maximum relief ranges between 2,500 feet in the east to as much as 3,000 feet in the west. Timber-line is normally between 6,000 and 6,500 feet above sea-level and all ridges rising above this altitude are bare except for grasses, moss and lichens. Below timber-line the ridges and hills are forested except where this cover has been destroyed by fire.

### Mountains

The map-area includes parts of four ranges of the Rocky Mountains. From northeast to southwest these are: the Boule Range and its northwest extension the Berland Range, the Hoff Range, the Persimmon Range, and the de Smet Range. These are underlain, for the most part, by Palaeozoic strata and consist of northwesterly trending ridges with elevations averaging 7,000 to 7,500 feet above sea-level. Maximum relief in the mountain regions reaches as much as 4,800 feet.

Unlike the more rounded summits of the Foothills, the mountain ridges, composed to a large extent of more massive and resistant rocks, are very rugged and exhibit sharp peaks, knife-edge ridges, precipitous faces and deep canyons. These ridges rise as much as 2,500 feet above the timber-line.

Lying between the outlying Boule, Berland and Hoff Ranges and the Persimmon Range to the west is a region exhibiting Foothills characteristics but which, because of its location, cannot accurately be called Foothills. Elevations within this area are about 1,000 feet lower than those of the bordering ranges on either side, and when viewed from these higher elevations it appears as a basin-like depression. The area is about 8 miles wide, and is traversed by well-defined ridges and valleys parallel with the mountain ranges. Most of these ridges rise to, or above, timber-line, but some are lower and are timbered to the top. The area is underlain by Mesozoic formations.

All major valleys trend in a northeasterly direction. These are usually wide, relatively flat-bottomed and have gently sloping sides except where they cut the massive limestone and dolomite of the mountain ranges. Terraces and alluvial fans are conspicuous features of these old valleys. In contrast to these, the inter-montane valleys that parallel the strike of the formations are usually deeply incised with steep valley walls. Gorges and water falls are common in this type. In the eastern and northeastern parts of the area the valleys are wide, irregular and swampy.

One of the major physiographic features is the Athabasca Valley which provides the easiest route through the Canadian Rockies. West of Boule Range, this valley is about seven miles wide and splits into two valleys, one of which is occupied by the present Athabasca River, and the other by the lower parts of Drystone and Maskuta Creeks. These two divisions of Athabasca Valley are separated by a low ridge or series of low hills that trend parallel to the river, across the strike of the bedrock, and were evidently carved at different stages by the ancestral Athabasca River. The two sub-valleys merge near Hinton and extend northeasterly as a single valley about four miles wide. The present course of the river is flanked by a succession of gravel terraces, the highest of which is about 1,000 feet above the present river. West of the mouth of Maskuta Creek these terraces are principally on the north side of the valley. From Old Entrance to the mouth of Maskuta Creek the river flows through a recently cut rock-canyon about 100 feet deep.

## Drainage

Although glacial processes have been responsible for the detailed form of most of the landscape features within the map-area, the basic pattern of mountain ridges and valleys was the result of stream action. Small tributary streams throughout the map-area generally present a dendritic pattern cutting across the structure at various angles but, locally, where creeks are aligned along the strike of the rock formations, a rectangular pattern is being developed. The valleys of the small streams have been carved since the disappearance of the ice.

McLeod River, Wildhay River, Little Berland River, Moon Creek, and Berland River are tributary to the Athabasca and drain the southern half of the map-area while Muskeg River, Little Smoky River, Simonette River, Copton Creek, Sheep Creek, Sulphur River, Muddywater River and Kakwa River are part of the Smoky River system and drain the northern half of the area.

In general, these are swiftly flowing streams occupying wide valleys with gently sloping sides except where they have cut canyons in parts of their courses. The remains of at least two levels of terraces are present along the valley sides of most of these. Small alluvial fans and cones occur and are particularly conspicuous in the valleys of Athabasca and Smoky Rivers. Small stands of good timber remain along the floors of most of these valleys but, in places, fire has destroyed the timber, leaving large grassy flats.

The smaller creeks, particularly in the western parts of the area, occupy narrow, deep valleys, many of which contain falls and gorges. The gradient of these streams is very steep and they become rushing torrents after heavy rains and during the spring run-off.

The water of all streams except Smoky River, Athabasca River, and the lower part of Muddywater River is quite clear except when they are in flood. Athabasca and Smoky Rivers, heading in the Columbia Icefield and glaciers on the north side of Mount Robson respectively, are seldom entirely clear and usually very murky with silt-charged water from the glaciers.

In general, the northeastern parts of the map-area toward the plains are poorly drained. There the gradient of the major streams is much reduced and tributary creeks tend to meander in wide, swampy valleys. Muskegs and swamps are confined mainly to this region, though small muskegs occur throughout the map-area. Swampy and marshy land occurs around the edges of most of the lakes.

Several old valleys now filled with glacial and glacio-fluvial material explain the course of several streams.

The first of these extends in a general northerly direction from Brûlé Lake to Wildhay River. Its southern part is occupied by the lower reaches of Solomon Creek, its central part is undrained except by seepage, and its northern part is occupied by a chain of small lakes of which Jarvis Lake is the largest. The valley is floored by a thick deposit of glacial gravel. A borehole in this valley, near the Black Cat ranch, penetrated 994 feet of gravel before reaching bedrock. Without further information on the depth of bedrock in this valley it is impossible to prove the direction of flow of the river that carved it. It seems probable, however, that the Athabasca, during a long part of Tertiary time, flowed northward through this valley and then down the valley now occupied by Wildhay River.

Another of these drift- and gravel-filled valleys extends in an east-west direction between Smoky River Valley and the valley of Little Smoky River. In the west it is occupied by the lower reaches of Sulphur River, by Grande Cache and Peavine Lakes, and by Susa Creek. Farther east Muskeg River follows it for several miles and, still farther east, it is occupied by the lower part of Lone Teepee Creek and by Little Smoky River.

Most of the major streams in the Foothills flow northeasterly but Muskeg River conforms to this pattern only in part. The river flows northeast across the structural trend to a point just below the fifteenth base line where it enters the wide, flat, east-west valley. At this point it swings and flows westerly, cutting across the strata at a sharp angle. At the point where Susa Creek enters it, Muskeg River turns again and flows northwesterly, parallel with the formational trend.

It is probable that during some part of Tertiary time Smoky River flowed eastward and carved this wide valley. At that time the ancestral Muskeg River joined the Smoky near the present site of Muskeg ranger station. During Pleistocene time ice filled this valley and left it choked with morainal material and outwash gravels. Thus after the ice disappeared, Smoky River was forced to carve its present valley and Muskeg River flowed eastward down the present valley of Little Smoky River. At this time a minor tributary of the Smoky flowed westerly and northwesterly along what is now the lower part of Muskeg Valley. This stream gradually cut back until it tapped the northeasterly flowing Muskeg River, and made the sharp bend in township 57, range 5, and the relatively undrained valley now occupied by Pierre Greys Lakes and Lone Teepee Creek. The capture of Muskeg River increased greatly the amount of water then flowing westerly and resulted in the cutting of the Muskeg River Canyon.

The wide valley in which Cowlick Creek and A la Pêche Lake are now located may be another east-west, moraine and gravel-filled valley, but the pre-Pleistocene drainage pattern is not so clearly indicated here.

## Glaciation

All parts of the map-area were apparently covered by an ice-sheet that moved across mountains and valleys to some extent independent of the local topography. This ice-sheet was probably a part of the complex of ice-fields and glaciers that covered most of the mountainous region of western Canada during periods of Pleistocene glaciation, and which is usually referred to as the Cordilleran ice-sheet.

There is no way of ascertaining the number of advances of the Cordilleran ice-sheet, but there is evidence that the last major movement over the present map-area was toward the east and northeast. Large erratics, composed of Palaeozoic quartzite, limestone and dolomite and weighing many hundreds of pounds, are to be found on the tops of many ridges up to altitudes of 7,100 feet and are found distributed eastward from the mountains as far as the lowermost foothills. This would imply that the ice-sheet covered all ridges at least to an altitude of 7,100 feet above sea-level.

The amount of erosion accomplished by this ice-sheet phase is thought to be slight, and was probably limited to smoothing and rounding existing ridges and peaks without effectively reducing relief.

The physiographic forms lying beneath the ice, controlled to a large extent by southwesterly dipping thrust faults, probably exhibited steep-sided, northeast-facing scarps and relatively gentle dip-slopes to the southwest just as they do today. Thus the topography may have had considerable bearing on the amount of erosion produced. Ice moving northeasterly up the gentle dip-slopes would have had less tendency to 'pluck' the rock than if it had moved southwesterly against the scarp faces. The land forms produced by this ice-sheet have been almost totally obliterated by later valley and mountain glaciation.

Surface features seen within the map-area today are mainly the result of valley and mountain glaciers. These include modified U-shaped valleys, small cirques, out-wash gravels, kettle holes, morainal material, drumlinoid features and dammed stream valleys.

A conspicuous feature of the erosion by mountain glaciers is its asymmetrical character. Because ice and snow melt slower on north-facing than on south-facing slopes, the largest and most active glaciers were concentrated on the north- and northeast-facing slopes. As a result, ice erosion by mountain glaciers has been almost entirely from the north and northeast.

There is no doubt that large glaciers occupied most of the major stream valleys within the map-area. The valleys of Smoky River, Sulphur River, Moon Creek, Berland River, Little Berland River, Wildhay River and Athabasca River all show evidence of having been occupied by ice. All have a U-shaped cross-section at some point, but generally more flaring sides and flatter bottoms than the typical glaciated valley of the more western ranges of the Cordillera. This difference is partly due to the softer and more easily weathered rocks of the Foothills and Rockies. Also it is likely that movement of these glaciers was not great and therefore their erosive power was limited. Truncated spurs and drumlinoid features paralleling the present valley of the south side of Smoky River between Wolverine Creek and Sulphur River are evidence of some movement of the ice. Other features, such as hanging valleys, moraines and kame terraces, formed by ice movement, may have been obliterated by erosion since Pleistocene time. The valleys were probably not deepened much by ice movement.

Glacio-fluvial deposits of outwash gravel and sand occur in all major stream valleys. These range from poorly stratified to well-stratified deposits and are now in various stages of erosion by streams. Much of this material is probably obscured by recent alluvial deposits.

The valleys of Muddywater River and Sheep Creek contain, in places, high banks of poorly sorted to unsorted gravel with some boulder till. Near the mouth of Copton Creek and along Kakwa River are exposures of boulder till. Remnants of well-defined terraces occurring along the valleys of Smoky River, Sulphur River, Wildhay River, Little Berland River and Athabasca River are mantled with coarse gravel which is probably reworked outwash material. Besides the major streams, poorly sorted gravel and sand and small exposures of boulder till are present in the lower reaches of nearly all large creek valleys.

Morainal material occurring high on the sides of the lower hills towards the Plains may have been deposited by the ice-sheet rather than by the valley glaciers.

Water from the melting glacier that filled Athabasca Valley was impounded by a moraine near the present outlet of Brûlé Lake, and built up a body of water wider than the present lake that extended many miles up Athabasca Valley. Evidence of this glacial water is the silt deposited east of Brûlé Lake and wave-cut cliffs at an elevation of 3,500 feet in sandstone outcrops between Brewster and Oldhouse Creeks (MacKay, 1929a, p. 4). The limit of the water-lain silt east of Brûlé Lake cannot be fixed because much of it has been redeposited by wind. The ancient lake evidently broke through its retaining moraine, flooding the eastern part of Athabasca Valley and depositing the rudely sorted gravels which now form terraces.

Several individual or chains of lakes within the map-area occur in large, drift- and gravel-filled preglacial valleys. Grande Cache, Peavine and several smaller ponds occupy the western end of the large east-west trending valleys in which Susa Creek and part of Muskeg River now flow. Pierre Greys Lakes and probably Little Smoky River occupy the eastern part of the same valley. Gregg Lake, Jarvis Lake and several smaller lakes and ponds occupy part of another gravel-filled preglacial valley extending from the northern end of Brûlé Lake to Wildhay River. The large valley in which A la Pêche Lake is situated, is probably another of this type.

Although thick deposits of glacial material now occupy these valleys, kettle holes were observed at only three places within the map-area. Several small, partly destroyed kettles are present along the north side of Smoky River just northeast of the mouth of Muddywater River and at least one kettle about 200 yards across occurs on the northeast side of the mouth of Sheep Creek. In the vicinity of Gregg and Jarvis Lakes numerous small kettle holes are present, many of which contain water.

Cols, arêtes and small, poorly-developed cirques occur in the Boule, Berland, Persimmon and de Smet Ranges. Most of these were developed at the heads of such streams as Little Berland River, Moon Creek, Crescent Creek, Muskeg River, South Muskeg River, North Berland River, Persimmon Creek and West Sulphur River, and were probably formed during the time glaciers occupied these valleys.

Small cirques are also present on the northeast side of the high ridges lying between Muddywater River and Sheep Creek. Some of these are typically developed cirques whose floors have an average altitude of 6,500 feet above sea-level but streams flow in deeply incised, V-shaped valleys on leaving the floor of the cirque. It would seem, therefore, that these belong to a late phase of alpine glaciation that was confined to the formation of cirques only.

There was no evidence to indicate movement of continental ice-sheets from the east.

# *Chapter III*

## STRATIGRAPHY

The map-area is underlain by a succession of marine and non-marine sedimentary strata ranging in age from Cambrian? to Paleocene that have a total thickness of approximately 25,000 feet. The strata have been deformed by folding along northwesterly-trending axes and by thrust faults that roughly parallel the axes of the folds. As a result, the formations are generally exposed as long, relatively narrow, northwest-trending bands.

Except for a small area near the head of the West Sulphur River underlain by probable Cambrian strata, the older formations, composed of Devonian and Carboniferous rocks, are exposed at the surface only in the mountain ranges. Where Devonian beds are exposed they usually form the cores of major anticlinal folds or occur at the base of northeast-facing overthrust blocks. Carboniferous strata form the flanks of folds, or occur on the southwest-dipping side of thrust blocks where they are often repeated by numerous small thrusts. Triassic and Jurassic beds normally outcrop close to the mountains although several areas of Jurassic strata are exposed within folds in the Cretaceous beds underlying the Foothills. Paleocene beds are confined to the eastern and northeastern parts of the map-area.

The formations are well-exposed in the mountain ranges but elsewhere outcrops are found chiefly in canyons, cliffs, and on the higher ridges. They are scarce on the lower, timbered ridges and in the larger areas of muskeg and swamp. In most places outcrops are sufficient to permit reasonably accurate location of geological boundaries, but in parts of the area these positions have had to be inferred from relatively few outcrops and in such places the structure may be more complicated than is indicated on the map.

Most of the formations within the map-area are the approximate counterparts of formations that were first studied and named in southwestern Alberta, 200 to 300 miles to the south. Some formations show remarkable similarity to those of the type areas considering the distances over which they have been traced. Other formations occurring in southern Alberta do not extend as far north as this area; some have changed so much that it is difficult to decide whether to continue the use of the original names or to introduce new ones, and still others occur that are not present farther south. The most noteworthy differences between the stratigraphic succession in this area and that of southern Alberta are: the presence of the Dunvegan Formation; the occurrence of commercial coal seams in the Blairmore equivalent instead of in the Kootenay equivalent; and the absence of the marine shales of the Bearpaw Formation. These shales separate the non-marine Belly River and Edmonton Formations, the undivided rocks being known as the Brazeau Formation.

The stratigraphic succession in the map-area shows analogies to that of the Peace River district of northwestern Alberta and northeastern British Columbia where the sequence is somewhat different and where a different formational nomenclature has been adopted. For this reason explanations regarding the terminology used in this report accompany the description of certain formations.

## Cambrian

*Distribution and lithology.* These strata occur near the head of West Sulphur River in the extreme western part of the map-area. The beds are about 1,000 feet thick and are part of a much thicker succession lying, mainly, west of the region mapped. They have been thrust northeastward on to limestones of Triassic age and now lie, on both sides of the valley, with approximately the same attitude as the underlying beds.

The rocks consist of interbedded, hard, fine-grained, light grey to white quartzite and fine to medium conglomerate with all gradations between these rock types. A little feldspar is present in nearly all beds and in some, including the matrix of the conglomerate, it is present in considerable amounts. The pebbles of the conglomerate are poorly sorted and consist almost entirely of grey and white quartz and white quartzite. They range in size from coarse sand grains to pebbles 2 inches in diameter.

Weathering of the feldspar imparts a speckled appearance to hand samples of the rock and is probably responsible for the typical light orange colour of the mountains underlain by these strata. Individual beds are from 2 to 4 feet thick.

*Age.* No fossils were found in these rocks but their lithological similarity and geographical position relative to probable Cambrian strata to the southeast suggest that they also may be of that age.

## Devonian

It is not proposed to discuss in detail the history of previous work on the Devonian system in the Rocky Mountains. A full discussion of some of the earlier attempts at stratigraphic classification was given by Lang (1947, pp. 15-16) to which the reader is referred.

More recently, deWit and McLaren (1950) published a proposed classification based on extensive stratigraphic and palaeontological studies of Devonian sections in the Rocky Mountains between Crowsnest Pass and Jasper, Alberta. These workers accepted Raymond's Flume and Perdrix Formations in the vicinity of Athabasca River, recognized Beach's Palliser Formation in that region, and divided the beds between into two new formations: the Mount Hawk below and

| ERA | PERIOD OR EPOCH | GROUP OR FORMATION | LITHOLOGICAL SUBDIVISIONS AND FAUNAL ZONES | LITHOLOGY | THICKNESS IN FEET |
|---|---|---|---|---|---|
| CENOZOIC | RECENT | | | *Stream gravels and sands, alluvium, talus* | |
| CENOZOIC | PLEISTOCENE | | | *Boulder till, glacial-fluvial sand and gravel* | |
| CENOZOIC | PALEOCENE | | | *Sandstone, shale, conglomerate, coal (non-marine)* | 4,000 ± |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *BRAZEAU FORMATION* | | *Sandstone, shale, conglomerate, coal (non-marine)* | 6,000 ± |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *SMOKY GROUP* — *WAPIABI FORMATION* | *CHUNGO MEMBER* | *Sandstone, (marine)* | 80–100 |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *SMOKY GROUP* — *WAPIABI FORMATION* | | *Shale, silty shale, siltstone, sandstone (marine)* | 1,000–1,500 |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *SMOKY GROUP* — *BAD HEART FORMATION* | | *Sandstone, shale, conglomerate (marine)* | 50–100 |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *SMOKY GROUP* — *MUSKIKI FORMATION* | | *Shale, silty shale (marine)* | 200–300 |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *SMOKY GROUP* — *CARDIUM FORMATION* | | *Sandstone, argillaceous sandstone, shale, conglomerate (marine and non-marine)* | 50–200 |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *SMOKY GROUP* — *KASKAPAU FORMATION* | | *Shale, silty shale, siltstone, minor amounts of sandstone (marine)* | 1,800–2,000 |
| MESOZOIC | CRETACEOUS — UPPER CRETACEOUS | *DUNVEGAN FORMATION* | | *Sandstone, sandy shale, shale, (marine and non-marine)* | 20–500 |
| MESOZOIC | CRETACEOUS — LOWER CRETACEOUS | FORT ST. JOHN GROUP | | *Shale, sandy shale, minor amounts of sandstone (marine)* | 400 |
| MESOZOIC | CRETACEOUS — LOWER CRETACEOUS | *BLAIRMORE GROUP* — *LUSCAR FORMATION* | | *Sandstone, shale, conglomerate, coal (brackish and non-marine)* | 1,800–2,000 |
| MESOZOIC | CRETACEOUS — LOWER CRETACEOUS | *BLAIRMORE GROUP* — *CADOMIN FORMATION* | | *Conglomerate, minor amounts of sandstone (non-marine)* | 30–200 |
| | | DISCONFORMITY | | | |
| MESOZOIC | CRETACEOUS — LOWER CRETACEOUS | *NIKANASSIN FORMATION* | | *Sandstone, siltstone, sandy shale, carbonaceous shale (marine and non-marine)* | 900–4,000 |

| | | | | | |
|---|---|---|---|---|---|
| | JURASSIC | FERNIE GROUP | | Shale, silty shale, siltstone; minor amounts of sandstone (marine) | 600–1,200 |
| | | | ROCK CREEK MEMBER | Sandstone (marine) | |
| | | | NORDEGG MEMBER | Limestone, calcareous shale (marine) | |
| | DISCONFORMITY | | | | |
| | TRIASSIC | SPRAY RIVER GROUP: WHITEHORSE FORMATION | | Limestone and dolomite, some argillaceous and some arenaceous; sandstone, dolomitic; shale (red, green, ochre) (marine) | 60–1,118 |
| | | SPRAY RIVER GROUP: SULPHUR MOUNTAIN FORMATION | | Shale, silty shale, siltstone, calcareous shale, argillaceous limestone; sandstone, calcareous or dolomitic; limestone, dolomite; (marine) | 900–1,000 |
| PALÆOZOIC | DISCONFORMITY | | | | |
| | LATE PALÆOZOIC | "ROCKY MOUNTAIN" FORMATION | UNIT C | Sandstone (marine) | 0–80 |
| | | | UNIT B | Chert; some dolomite and sandstone (marine) | |
| | | | UNIT A | Sandstone (marine) | |
| | MISSISSIPPIAN | RUNDLE GROUP | | Dolomite, limestone; minor amounts of calcareous shale; some chert (marine) | 600–1,300 |
| | | BANFF FORMATION | | Limestone, argillaceous limestone, calcareous shale; includes dark grey to black shale at base (marine) | 500–600 |
| | DISCONFORMITY | | | | |
| | DEVONIAN | PALLISER AND ALEXO FORMATIONS | | Limestone and dolomite (marine) | 1,200 ± |
| | | MOUNT HAWK FORMATION | | Limestone, argillaceous and silty; dolomite; some shale (marine) | 100 + |
| | | PERDRIX FORMATION | | Limestone, argillaceous; shale, calcareous (marine) | 750 ± |
| | | FLUME FORMATION | | Limestone and dolomite (marine) | 400 + |
| | DISCONFORMITY ? | | | | |
| | CAMBRIAN ? | | | Sandstone, quartzite, conglomerate; much feldspar in some beds (marine) | 1,000 + |

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**Table of Formations**

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the Alexo above. The Flume, Perdrix, and Mount Hawk were shown to be equivalent to the Fairholme, from which the Alexo was split off as a separate unit in the Bow Valley.

In the Jasper area the Palliser and Alexo Formations are recognized as separate units but, instead of Fairholme, Raymond's Flume and Perdrix Formations are employed and Mount Hawk is used for the lower part of his Boule.

McLaren (1953) recognized two major facies in the lower part of the Devonian sequence in the Rocky Mountains. One is a predominantly carbonate sequence consisting of a series of small, broadly lenticular reef bodies and reef detritus beds composed of algae, stromatoporoids, corals, and other organic remains, usually dolomitized. The Fairholme Group of the Bow Valley, restricted to pre-Alexo beds by deWit and McLaren (1950), is an example of this type of facies. The other major facies type contains a higher proportion of non-carbonate clastic material and comprises the Flume, Perdrix, and Mount Hawk Formations, which together are equivalent to the Fairholme.

In the region covered by this report the latter, more clastic facies appears to prevail and the classification proposed by deWit and McLaren is used although the Alexo Formation could not definitely be recognized in the field. No subdivision of the Devonian strata has been made on the accompanying geological map.

### Flume Formation

*Distribution and lithology.* These strata have been recognized at two separate localities. In the Boule Range they occur 2 miles south of Brûlé station, where they form the core of an anticline and consist of about 400 feet of massive limestone and dolomite containing small chert masses and corals. The formation is also exposed in the Persimmon Range to the northwest where Eagles Nest Pass cuts through the range between Rock Creek and Wildhay River about a mile outside the present map-area (*see* Plate I). At the eastern end of this pass Devonian strata have been thrust northeastward over Cretaceous formations and now lie with steep southwest dips forming rugged and precipitous northeast faces. The lower part of this Devonian section consists of thick-bedded to massive, cherty limestone and dolomite that contains a fauna indicative of the Flume Formation.

*Age and correlation.* Specimens of *Spirifer jasperensis* collected by Lang (1947) from the locality near Brûlé station were identified by R. A. C. Brown. Fossils collected from the beds in Eagles Nest Pass by J. K. Eccles were identified by D. J. McLaren and are said to be indicative of the Flume and Waterways Formations, of early Upper Devonian age.

### Perdrix Formation

*Distribution and lithology.* These strata occur in the Boule Range just north of Athabasca River. According to Lang (1947), they overlie the Flume Formation conformably, outcrop in the same anticline that exposes beds of the Flume Formation, and continue northwestward for a short distance near the crest of the

Boule Range. The strata are also exposed near the head of Oldhouse Creek, where they form the core of an anticlinal fold. In Eagles Nest Pass to the northwest several hundred feet of Perdrix beds overlies the Flume Formation conformably but are not well exposed.

In the Boule Range the Perdrix Formation consists of about 750 feet of thin-bedded, relatively soft, black shaly limestone and dark grey, calcareous shale.

*Age and correlation.* No diagnostic fossils were identified from either of these localities so that the correlation of the strata with the Perdrix Formation is based on lithology and stratigraphic position above the Flume Formation. The Perdrix Formation is considered to be of Upper Devonian age.

### Mount Hawk Formation

*Distribution and lithology.* Strata of the Mount Hawk Formation gradationally and conformably overlie those of the Perdrix Formation. The boundary is arbitrarily drawn where limestone beds comprise fifty per cent of the succession.

Lang (1947) did not separate these strata as a distinct formation in the Brûlé area but presumably they are partly included with the underlying Perdrix and partly with his overlying Boule Formation.

To the northwest along the northeast side of the Berland Range only the upper 60 to 100 feet of these beds occur at the surface but in Eagles Nest Pass, and for some distance northwest of the Pass in the Persimmon Range, the whole formation is exposed. The strata consist of dark grey, silty and argillaceous limestone intercalated with grey and buff weathering calcareous shale. In most places the upper part of the formation consists of more massive limestone and dolomite that grades up into the overlying formation. The maximum thickness exposed within the map-area is somewhat more than 100 feet. DeWit and McLaren (1950) assign a thickness of 549 feet to the formation at its type section on Roche Miette in Athabasca Valley.

*Age and correlation.* Collections of fossils were obtained from both localities described above and were identified by D. J. McLaren who states that the fauna is typical of the Mount Hawk Formation of Upper Devonian age. These species are listed in Appendix II.

### Palliser and Alexo Formations

*Distribution and lithology.* The Palliser and Alexo Formations are quite similar in appearance and lithology in the area covered by this report. No satisfactory division could be made in the field between the two and they are treated as a single unit in this report.

Exposures of the Palliser and probably strata representing the Alexo Formation are more numerous than those of the underlying formations and occur locally in all mountain ranges within the map-area. These strata occur in the Boule Range for several miles north of Athabasca River and south of Rock Creek. In the Berland Range, thick-bedded to massive Palliser and Alexo strata occur along the northern half of the northeast side and form the lower part of the towering, precipitous east-facing cliffs of such peaks as Mount Zebra, Tip Top Ridge and Mount Berland but do not extend northwest of Berland River. Small outcrops occur at several places along the Hoff Range where streams have cut down into the anticline far enough to expose the uppermost beds of the Palliser Formation. Palliser strata are exposed in the Persimmon Range from the southern boundary of the map to just south of Berland River. North of this, Devonian beds are obscured by the overlying Mississippian Formations. The most westerly exposure of the Palliser Formation occurs where Sulphur River has cut through the Monoghan anticline, the most easterly fold of the de Smet Range.

Both Palliser and Alexo beds consist of dark grey or dark brown, light grey weathering, fine- to medium-grained limestone with minor amounts of dolomite, and some interbedded, calcareous shale. Small chert masses are common in most beds. The lower strata are well bedded, but, upward in the unit the bedding becomes progressively less distinct and the rock more massive. The uppermost part is again more evenly and distinctly bedded. Most of the Palliser Formation can therefore be described as massive and cliff-forming. Because of this gradation between the lower, bedded strata equivalent to the Alexo Formation, and the upper, massive Palliser Formation, no attempt was made to separate the two.

*Thickness.* In the Boule Range Lang (1947) assigned a total of 1,264 feet of strata to Raymond's Boule Formation. The upper 865 feet of massive limestone and dolomite of this section is probably equivalent to the Palliser and Alexo Formations and the lower 400 feet of thin-bedded, shaly limestone should probably be assigned to the Mount Hawk Formation.

In the Berland Range at the head of Moon Creek 1,200 feet of Devonian strata overlies the Mount Hawk Formation. The lower 400 feet of this unit consists of interbedded, grey to brownish dolomite, argillaceous dolomite and silty dolomite in beds ranging between 1 foot and 10 feet thick. The basal part is predominantly thin-bedded to flaggy, thicker beds becoming more numerous upward in the succession. This unit may be equivalent in age to the Alexo Formation.

Above the strata just described is about 800 feet of thick-bedded to massive, grey to grey-brown, granular to dense limestone and dolomite of the Palliser Formation. Some of these beds are brecciated and many are mottled due to partial dolomitization (Beales, 1953).

*Age and correlation.* The Palliser Formation contains a meagre and scattered fauna. However, collections were obtained at several localities which indicate correlation of these beds with the Palliser Formation of deWit and McLaren (1950). The species collected from these strata are listed in Appendix C, Table 1.

## Devonian and/or Mississippian

The black, non-calcareous shale that overlies the Palliser Formation at many places in the Foothills and mountains of Alberta was first noted by McConnell (1887, pp. 18D-21D). He recorded this shale as occurring at the base of the Banff

Formation, then known as the Lower Banff shale. From then until Warren (1937) raised it to formational status it was included with the Banff Formation. Warren (1937) proposed the name Exshaw Formation for the 30 to 40 feet of black, fissile to platy shale at the base of the Mississippian Banff Formation and immediately overlying the massive limestone of the Palliser Formation in the Banff region. Later, L.M. Clark (1949, p. 627) included within the term Exshaw Formation some of the overlying interbedded calcareous shale and argillaceous limestone beds.

The shale lies on the Palliser beds with a very abrupt contact but is transitional upward into the Banff strata by intercalation of limestone beds and is therefore difficult to separate from the Banff Formation. The shale is widespread but varies in thickness and is not present at all places.

## Basal Shale Unit

*Distribution and lithology.* Within the area covered by this report dark grey to black shale is present above the thick-bedded Palliser Formation wherever the Devonian-Mississippian contact is exposed in the two western mountain ranges. It is best exposed in the Persimmon Range at the head of North Berland River and where the most northeasterly fold of the de Smet Range is cut by Sulphur River. The shale appears to be missing farther to the east in both the Boule and Berland Ranges. Here, Palliser beds are overlain, probably disconformably, by argillaceous limestone of the Banff Formation.

At the head of North Berland River the lower part of the unit consists of between 20 and 40 feet of dark grey to black, fissile to very thin bedded shale, interbedded with harder, dark grey, silty, calcareous shale which is finely banded. This is overlain conformably by about 60 to 80 feet of interbedded dark grey, in part calcareous shale and grey to brownish argillaceous limestone. The limestone beds range in thickness from 2 inches to 6 inches and become progressively more numerous and thicker toward the top of the unit which is consequently transitional upward into the typical, more thickly bedded argillaceous limestones and calcareous shales of the Banff Formation. The unit weathers to soft, grey-buff and brown shaly rubble.

The contact relationships of this shale unit are of some significance. Not only is the shale missing in the Boule and Berland Ranges where the Palliser is directly overlain by typical strata of the Banff Formation but where present farther west, its thickness differs notably between exposures relatively close together. This range in thickness of the shale and its complete absence in some places could be accounted for by erosion of the upper Palliser beds prior to deposition of the shale and/or by erosion of the shale prior to deposition of the typical Banff strata.

In exposures seen by the writer, however, there is no evidence to suggest any erosion at the top of the shale and the upper surface of the top Palliser bed shows only small hollows and protuberances usually less than an inch deep. The upper contact is transitional without any visible break in sedimentation. The lower contact is everywhere very sharp and regular. The bedding both in the underlying limestone and the overlying shale is apparently parallel to the contact and the Palliser beds show no channelling or cutting. The same is true of the contact at places where the black shale is missing.

It would seem, therefore, that little or no erosion of the Palliser beds could have taken place and that the abrupt lithologic change is probably due to a time interval during which no deposition occurred. Non-deposition of sediments is also the most likely explanation for the absence of these black shales in the eastern part of the map-area. It seems probable, however, that this break in the sedimentary record was not of long duration.

*Age and correlation.* In the Mount Greenock map-area at the southeastern end of the de Smet Range in Jasper Park, R.A.C. Brown (1952) reports 30 feet of soft, dark, calcareous shale above the Palliser Formation. This is overlain by 30 feet of alternating, hard, calcareous shale and dark argillaceous limestone. Brown considered that the lower 30 feet of shale might be equivalent to the Exshaw Formation but he could obtain no definite faunal evidence. Harker and McLaren (1958) are of the opinion that no Exshaw is present in this section.

Field work so far seems to indicate that the lithology of the beds between the Palliser Formation and the typical argillaceous limestone and calcareous shale strata of the Banff Formation is similar from Athabasca Valley northwestward perhaps as far as Smoky River Valley. Also, within the present map-area, the black shale is known to be present only west of and including the Bosche and Persimmon Ranges and is missing in the more easterly Boule, Berland and Hoff Ranges.

Based on the similarity of stratigraphic position, part of the shale and interbedded argillaceous limestone occurring within the present map-area may be considered equivalent to the Exshaw Formation as amended by Clark (1949) although none of it appears to be lithologically identical with the typical Exshaw shale of the type section on Jura Creek.

On Halfway River in northeastern British Columbia P. K. Sutherland (1958) records a thick, black shale unit lying between typical Devonian carbonate rocks and the cherty, carbonate strata of his Mississippian Prophet Formation. The upper 275 feet of this succession is described as consisting of interbedded shale and argillaceous limestone with a few chert layers. Above this, another 210 feet of beds is transitional upward into the carbonate beds of the Prophet Formation. These differ from those below in that the proportion of limestone to shale increases upward. Sutherland did not see the lower contact of the shale succession but suggests a total thickness of between 1,500 and 2,000 feet.

From the upper part of this unit he collected a fauna that he considers to indicate an Early Mississippian age and suggests that the lower part may possibly be of Devonian age. No fossils have been collected from the lower part of these shales.

Exposures of these shales seen by the writer, both on Halfway River and at several localities south of the river, have not included the contact with the underlying Devonian carbonate strata. Both calcareous and non-calcareous shales occur and they appear to be similar lithologically to those present above the Palliser beds in the present map-area. Therefore, on the data at present available, and on the basis of their stratigraphic position, the shales at the head of North Berland River and on Sulphur River might be correlated just as satisfactorily with some part of the thick shale succession of northeastern British Columbia as with the Exshaw Formation.

The Exshaw was originally assigned a Devonian age by Warren (1937) based mainly on the identification by Dr. A. K. Miller (1938) of a goniatite. Harker and McLaren (1958), after considering all available evidence, have suggested that the Exshaw Formation be considered of Mississippian age until such time as further palaeontological evidence either disproves or confirms this age. No identifiable fossils were found in the region covered by this report and consequently no additional palaeontological evidence of age was obtained.

## Mississippian

### Summary of Nomenclature

G. M. Dawson (1886) first recognized Carboniferous rocks in the Rocky Mountains and McConnell (1887) recorded them in his reconnaissance along Bow and Kicking Horse Valleys in the southern Canadian Rockies. The earlier evolution of terminology for the Carboniferous in the Rocky Mountains is summarized by Kindle (1924). This begins with McConnell's application of the term Banff to Devonian, Carboniferous, and Triassic strata and ends with Kindle's own column showing Banff shale, Rundle limestone, and Rocky Mountain quartzite.

Laudon (1949), in the Wapiti Lake region, divided the Mississippian into the Banff, Dessa Dawn, and Rundle Formations, and this division was also used by Spreng (1953) in the vicinity of Sunwapta Pass. However, since the threefold division is not readily applicable in the present map-area, the term Dessa Dawn is not used.

Douglas (1953) raised the Rundle to group status in the Mount Head map-area, where he recognized a lower Livingstone Formation, a middle Mount Head Formation, and an upper Etherington Formation. Although Mississippian rocks are well exposed within the present map-area, Douglas' divisions of the Rundle are not obvious and the strata have been mapped simply as the Banff Formation and the Rundle Group.

### Banff Formation

The term Banff Formation was introduced by Shimer (1926) to include about 1,200 feet of calcareous shale containing Mississippian faunas, in the Lake Minnewanka region, Alberta.

In this region, the term is used for beds whose stratigraphic relationships, general lithology and palaeontological content suggest correlation with the Banff Formation of the type area. It includes, also, the basal dark grey shale facies occurring in the western parts of the region and described previously.

*Distribution and lithology.* Banff strata are well exposed in the Boule Range (Appendix A, Section 1) in the south and in both the Hoff and Berland (Appendix A, Section 2) Ranges farther northwest. At these localities the Banff Formation directly overlies Palliser beds (Plate IIB.) To the west, good exposures occur in the Persimmon Range (Appendix A, Section 3), particularly at the head of North Berland River. Still farther west the formation is completely exposed where Sulphur River has cut through the Monoghan anticline of the de Smet Range and, to the west of this, where the formation is repeated by thrust faults.

The strata consist of grey to dark grey, calcareous shale, light to dark grey, thin-bedded limestone ranging from argillaceous and microcrystalline to crinoidal and coarsely crystalline.

Slabby, evenly bedded limestone alternating with shale characterizes a considerable part of the lower Banff. The formation gradually becomes more calcareous upwards until argillaceous and crinoidal limestone beds predominate. The whole formation weathers to buff and light brown colours, and forms gentle slopes of shaly to platy debris. The formation, as a whole, is softer than the underlying Devonian strata and more thinly bedded and shaly than the overlying Rundle beds so that, where the strata dip steeply, the Banff Formation tends to form a saddle or depression. Since the upper contact is gradational into the Rundle it is difficult in most places to map accurately the upper limit of the Banff strata. The contact is placed below the basal unit of massive or thick-bedded limestone at each locality.

*Thickness.* Several sections of the Banff Formation have been measured and these are shown in Appendix A.

The thickness of the Banff Formation changes from southeast to northwest in the Boule, Hoff and Berland Ranges as follows. Near the base of Boule Roche on the north side of Athabasca River 660 feet of strata are recorded. Near the southeast end of the Berland and Hoff Ranges the formation is 600 feet thick, while sections measured toward the northwest end of the latter two ranges measured 470 and 530 feet respectively.

To the west, the formation is 570 feet thick in the Persimmon Range at the head of North Berland River and 540 feet thick in the Monoghan anticline of the de Smet Range. The last two thicknesses include the dark grey shale facies at the base that may be in part of Devonian age.

At the southern end of the de Smet Range in Jasper Park, Brown (1952) measured thicknesses of 603, 710, and 623 feet for the Banff Formation.

These measurements suggest some thinning of the formation both from southeast to northwest and from northeast to southwest. There is faunal evidence to indicate that the Banff-Rundle contact is diachronic (Harker, 1954). As a consequence, upper Banff-type sedimentation in one place was probably synchronous with lower Rundle-type sedimentation in another. This would account for the variation in thickness.

*Age and correlation.* Fossils are relatively scarce in the lower beds, but the upper part of the formation is extremely fossiliferous, especially the upper 200 feet. The fossils are usually restricted to definite beds or horizons and at some localities these beds are composed almost entirely of shell remains. Some thin limestone beds are coquinas of crinoid remains.

All fossil collections from the Banff Formation within this map-area are of Kinderhook age according to R.A.C. Brown and P. Harker and the strata can be correlated with the Banff Formation of the type area. Fossils from the Banff Formation at different localities are listed in Appendix C, Table II.

*Summary.* The Banff Formation, the earlier of the Mississippian formations, represents a steadily changing sedimentary environment. It is characterized by a high percentage of clastic rocks especially in the lower part, with the amount of carbonate increasing toward the top. In the eastern ranges it overlies the Palliser Formation disconformably. In the western exposures it overlies apparently conformably a dark shale facies that may be, in part, of Devonian age.

The Rundle Group, in contrast to the Banff, consists predominantly of clean, non-clastic, carbonate beds. The contact with the underlying Banff strata is gradational.

## Rundle Group

The name Rundle Limestone was proposed by Kindle (1924) for McConnell's Upper Banff Limestone strata in the Bow River section. The entire formation was considered Pennsylvanian by Kindle, but detailed palaeontological work by Shimer (1926), Warren (1927) and Beach (1943) showed the lower part to be of Mississippian age. Still more recent work has raised the Mississippian boundary at least to the top of the Rundle Group (Harker, 1954).

Douglas (1953) raised the Rundle from formation to group status in the Mount Head map-area and divided it into three formations. The writer considers the use of the term "Group" advisable in the present map-area although, at this time, no attempt has been made to define formations.

Rundle Group, as used in this map-area, includes all strata above the Banff Formation and below the lower sandstone unit of the beds designated as Rocky Mountain Formation.

*Distribution and lithology.* The Banff Formation is overlain conformably and, in most places, gradationally by the Rundle Group. In the Hoff Range complete exposures of the group occur at numerous places east of Mumm Creek and in Berland Range at the heads of Little Berland River and Moon Creek (Appendix A, Section 5). In the Persimmon Range sections were measured at the head of

North Berland River (Appendix A, Section 6), Persimmon Creek, and on Phroso Creek (Appendix A, Section 7). The group is also well exposed at several places in the de Smet Range but was measured only on the Monoghan anticline.

The basal beds of the group are massive to thick-bedded and consist predominantly of finely to coarsely crystalline, grey and brown, grey weathering limestone that tends to form craggy outcrops and steep cliffs. Above this the strata consist of more thinly bedded, grey and brown, crystalline limestone and dolomite, the proportion of dolomite increasing upward in the section. Some thin, hard limestone and argillaceous limestone beds are usually intercalated and thin beds of shale, some of which contain plant material, are present at several localities. These strata are rather soft and weather to grey and buff colours. The upper part of the Rundle consists of more thickly bedded, grey to brown, light grey to ash-grey weathering dolomite that contains bands and nodular lenses of chert and is characterized by isolated nodular masses of white calcite. Most of these nodular masses of calcite are between ½ inch and 2 inches in diameter but some are as much as 2 feet across. In the western exposures these beds pass upward into fine-grained to lithographic dolomitic limestone containing small chert masses and lenses. Crinoidal beds are present at different zones within the group and chert occurs in numerous beds above the thickly bedded basal strata and appears to be typical of the uppermost beds.

Sections measured in the Berland Range could be separated into three units of about equal thickness based on the relative hardness and thickness of the beds but lithologic changes are generally gradational both laterally and vertically.

In the eastern Berland and Hoff Ranges an ash-grey weathering, cherty dolomite containing white calcite masses comprises the uppermost beds of the Rundle Group. These are overlain disconformably by strata of Triassic age. In the two more westerly ranges, however, where strata considered to be of post-Rundle and pre-Triassic age are present, the uppermost beds consist of light grey, light grey weathering, hard, flinty, microcrystalline dolomite or dolomitic limestone that, in some places, contains irregular nodules of dark grey chert.

Two features that seem to be common in all sections of the group are: (1) the relatively coarsely crystalline, non-porous and massive to thick-bedded character of the basal 50 to 75 feet and, (2) the presence of porous beds in the middle part.

*Thickness.* Representative measured sections of the Rundle Group are given in Appendix A, Section 4.

The group was measured at several places from southeast to northwest along the Boule, Berland and Hoff Ranges where the most northeasterly exposures occur. At the head of Prine Creek near the southern end of the Boule Range, Lang (1947) measured a total thickness of 945 feet but only 759 feet are recorded in the log of the Jasper No. 1 well on Folding Mountain just south of Athabasca River. To the northwest, in the Berland and Hoff Ranges, thicknesses ranged between 600 and 680 feet.

At the southeastern end of the de Smet Range, Brown (1952) records thicknesses ranging from 782 feet in the eastern exposures to a maximum of 1,154 feet in the western exposures. It should be noted in this comparison of thicknesses that Brown's Greenock Formation includes between 200 and 300 feet of beds that in this area are considered to belong to the Rundle Group. To the northwest, two sections were measured by the writer. One of these is on Phroso Creek where the stream has cut a canyon through steeply dipping Rundle strata in the Persimmon Range. The exposed section is 1,168 feet thick although the lower part is covered. Another measurement was made where Sulphur River transects the Monoghan anticline of the de Smet Range. Here, the Rundle was found to be 1,292 feet thick, although the upper strata are not well exposed.

Based on the above evidence, it seems that there is some erratic variation in the thickness of the Rundle Group from southeast to northwest along the strike and that the group nearly doubles in thickness from northeast to southwest. Much of this difference in thickness is due to post-Rundle erosion of the more eastern part, and some is probably due to a small amount of thinning of the Banff formation from east to west. It does not seem likely, however, on the available evidence, that these two factors alone could compensate for the whole change in thickness. The writer suggests, therefore, that there was a depositional thickening of the Rundle Group from northeast to southwest across this map-area.

*Age and correlation.* All fossils collected from these strata are of Mississippian age and are typical of the Rundle Group of the eastern Rocky Mountains. The group is rather less fossiliferous than the underlying Banff Formation. Crinoidal beds are present and usually yield some bryozoans, brachiopods and gastropods. Other zones containing brachiopods, gastropods, and corals occur throughout most of the group but few fossils, except corals, occur in the upper part. Corals are prolific in some beds.

Two collections from the western part of the map-area yielded specimens of land plants ('*Lepidodendron*' sp.) from both calcareous shale and fine-grained dolomite beds near the middle of the group and these may have some palaeogeographic significance. Harker, in his report on one of these collections states, "The presence of well-preserved land plants (Lepidodendroids) in a fine-grained dolomitic mud is interesting in that it suggests reasonable proximity to a shore-line in late Mississippian times. Some additional support is given by the fact that fossil plants were collected by myself from somewhat earlier Mississippian beds in an area immediately to the south of this region. It seems likely that sedimentation was fairly rapid since the somewhat delicate plant structures are well preserved."

Fossils were obtained from most of the sections within the map-area and are listed in Appendix C, Table II.

## Late Palaeozoic

### Summary of Nomenclature

The Rocky Mountain quartzite was originally included in the Rundle Formation by McConnell (1887), but was later made a distinct formation by Dowling (1909). Warren (1927) described the formation as consisting of about 700 feet of dolomite, quartzite, and chert lying conformably on the Rundle Formation and overlain disconformably by Triassic strata. Subsequently, Warren (1947) divided the Rocky Mountain Formation into two members: the lower Tunnel Mountain Member, consisting of dolomite and sandstone with chert nodules, and the upper Mount Norquay Member, consisting of dolomite, bedded chert, phosphatic shale and a thin phosphate bed.

Beds occupying the same stratigraphic position were measured on Mount Greenock in Jasper Park by Raymond (1930) and were referred by him to the Rocky Mountain Formation of the Bow Valley. Allan, Warren, and Rutherford (1932) also referred these strata to the Rocky Mountain Formation because they occupy the same stratigraphic position and are characterized by similar lithological types. These beds were included by Brown (1952) in his Greenock Formation consisting of three members: a lower cherty dolomite member, a middle massive chert member, and an upper quartzitic sandstone member.

### Rocky Mountain Formation

Within the present map-area late Palaeozoic strata are present in the two western ranges. They consist of rock types similar to the Rocky Mountain Formation of the Bow Valley and occupy a similar stratigraphic position and are therefore tentatively referred to the Rocky Mountain Formation. The formation includes all strata lying between the carbonate beds of the Rundle Group and the dark grey, Lower Triassic shale. The section is thickest in the de Smet Range, somewhat thinner in the Persimmon Range, and has not been recognized in the Boule, Hoff and Berland Ranges.

*Distribution and lithology.* These strata are wholly or partly exposed at numerous places within the Persimmon and de Smet Ranges but are not always readily accessible. Two sections were measured in the de Smet Range, one on the southwest slope of Llama Mountain north of Muddywater River (Appendix A, Section 8), and one in a small cirque just north of the point where Sulphur River cuts through the Monoghan anticline (Appendix A, Section 9). Two sections were measured in the Persimmon Range, one where Phroso Creek has cut into the southwest limb of the anticline (Appendix A, Section 10), and one where the strata are exposed in Rocky Pass (Appendix A, Section 11).

Of these sections the thickest is on Llama Mountain. This has been divided into 3 lithologic units for descriptive purposes and the units designated by the letters A, B, and C (*see* Fig. 2).

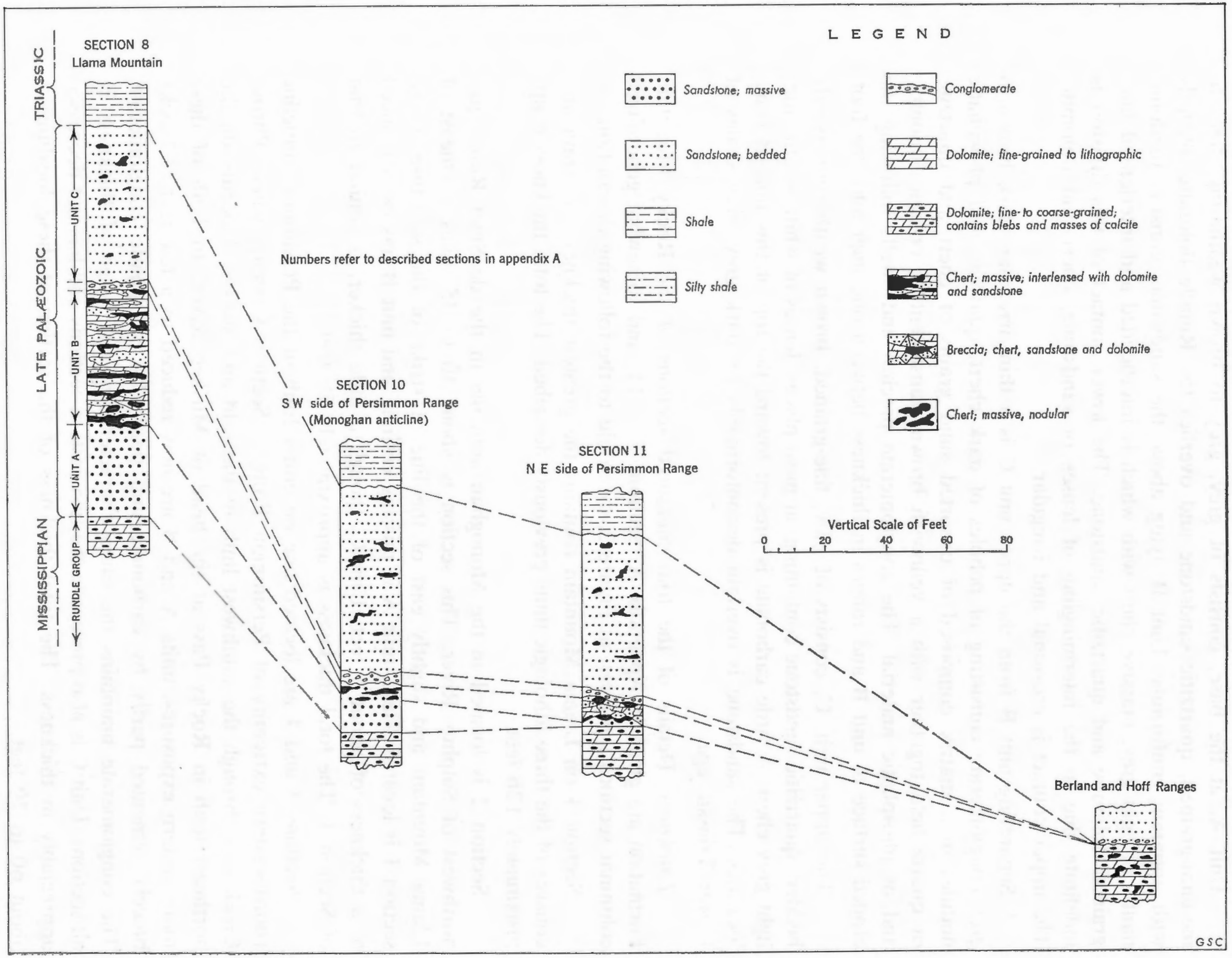


FIGURE 2. Columnar sections of late Palaeozoic, Rocky Mountain Formation.

Unit A, at the base, consists of grey, grey to brown weathering, fine- to medium-grained, quartzitic sandstone and overlies the Rundle dolomite abruptly with apparent conformity. Unit B, lying above the sandstone, consists predominantly of light grey, massive chert with which is interbedded and interlensed fine-grained dolomite and quartzitic sandstone. The lower contact of this division is indefinite due to the intermingling of lenses of sandstone, chert and dolomite. The upper contact is erosional and irregular.

Separating unit B from the upper unit C is a thin, irregular, dark brownish grey conglomerate consisting of pebbles of dark chert, quartzite and phosphatic nodules in a matrix composed of unsorted sand grains of chert and quartzite or quartz held together with a yellowish brown translucent to opaque limonitic and/or phosphatic material. The conglomerate pinches and swells following the eroded surface of unit B and ranges in thickness between one inch and one foot.

The upper unit, C, consists of grey, fine-grained, brown weathering, poorly bedded, quartzitic sandstone containing, at most places, lenses of white weathering, light grey chert. A little carbonate is present toward the top of this unit at some localities. The sandstone is overlain disconformably by dark grey, silty shales of Lower Triassic age.

*Thickness.* Details of the four measured sections of the Rocky Mountain Formation are given in Appendix A, Sections 8 to 11, and somewhat generalized columnar sections are given in Figure 2, as an aid to the following description.

Section 1 on Llama Mountain contains the greatest thickness of strata and consists of the three lithologic units previously described. The total thickness is approximately 126 feet.

Section 2 is located in the Monoghan anticline in the de Smet Range just northwest of Sulphur River. This section is about 30 to 35 miles southeast of Llama Mountain and slightly east of the line of strike of the structure where section 1 is located. Here, unit A is missing entirely and unit B has been reduced to a thickness of about 5 feet. Unit C, though a little thicker, is similar to that of Section 1. The total thickness is approximately 79 feet.

Sections 3 and 4 are located one on either limb of the Persimmon anticline (northwestern extremity of Persimmon Range). Section 3 occurs where Phroso Creek cuts through the southwest limb of the fold and Section 4 occurs on the northeast limb in Rocky Pass at the head of Muskeg River. In both of these more eastern exposures, units A and B are now reduced to a few feet of blocky breccia cemented partly by carbonate and partly by phosphatic conglomerate. The conglomerate maintains the same characteristics and range of thickness in all sections. Unit C is also present in the two eastern sections and has not decreased appreciably in thickness. The total thickness of the section at these localities is about 60 to 70 feet.

*Age and correlation.* As no fossils were found in these strata their age could not be definitely ascertained. Lithologically they are similar to part of the Rocky

Mountain Formation and to the two upper units of the Greenock Formation of Brown (1952), although no erosional interval, as represented by the phosphatic conglomerate, is recorded by Brown in Athabasca Valley.

Rocky Mountain quartzite was the name originally used to designate strata dominantly arenaceous and cherty at the top of the Palaeozoic succession in Alberta and regarded as of Permo-Carboniferous age. Warren (1947) considered his lower, or Tunnel Mountain Member, to be probably of Pennsylvanian age and his upper, or Mount Norquay Member, to be probably of Permian age.

According to Raasch (1956, p. 114), more recent and detailed studies have shown that the term Rocky Mountain has included beds in part mid-Permian in age and in part late Mississippian, separated by an unconformity embracing all of the Pennsylvanian and one-third of the Permian. For this reason he suggested that strata originally part of the Rocky Mountain Formation but now known to be of Mississippian age be included in the Rundle Group and, that the term Rocky Mountain be given group status and restricted to post-Mississippian beds.

McGugan and Rapson (1960), working in the region near Banff, Alberta, divided the Norquay Formation into 5 members. The lower two of these are thought to be of Pennsylvanian age and the upper three are assigned to the Permian.

Brown (1952) included within his Greenock Formation a lower member consisting of fine-grained to lithographic dolomite or dolomitic limestone from the lower part of which he collected Mississippian fossils. This member is transitional downward into typical Rundle beds and could be regarded as part of the Rundle Group as used in the present report.

The same lithologic and stratigraphic relations exist within the present map-area and it seems probable that all carbonate beds below, if not including, the lower sandstone unit, may be of Mississippian age. For this reason it is more logical, in the writer's opinion, to include within the Rundle Group all of the calcareous or dolomitic strata below the sandstone of unit A.

*Summary*. Within the present map-area the Rocky Mountain Formation decreases in thickness from west to east. In the sections studied, this thinning takes place mainly by erosion of units B and A before deposition of unit C. This erosion resulted in an irregular surface on which collected a thin layer of pebbles, sands and phosphatic nodules that is now represented by a thin conglomerate composed of these residual grains and pebbles and partly cemented by a translucent phosphatic material. Above the conglomerate, unit C maintains much the same thickness in both the de Smet and Persimmon Ranges.

In the Berland, Hoff, and Boule Ranges, 10 to 12 miles east of the Persimmon Range exposures, Triassic strata rest directly on an eroded surface of Rundle dolomite (*see* Fig. 2, Section 5). Thus, within this distance the Rocky Mountain Formation has perhaps been removed entirely by erosion.

# Triassic

## Summary of Nomenclature

Kindle (1924) proposed the name Spray River Formation for the Triassic strata in Bow River Valley previously called the upper Banff Shale by McConnell (1887). This name was adopted by Shimer (1926) and Warren (1927), and its use was extended to the Mountain Park district by MacKay (1929) and to Jasper Park by Allan, Warren, and Rutherford (1932). Warren (1945) suggested the division of the Spray River Formation into a lower Sulphur Mountain Member and an upper Whitehorse Member. The former is named after Sulphur Mountain near Banff, where the type section consists of 1,243 feet of interbedded shale and limestone containing Lower Triassic fossils. The Whitehorse Member is named from Whitehorse River near Cadomin, and is described as usually not more than 300 feet thick, consisting of light grey, almost white, chalky limestone, calcareous and dolomitic sandstone, sandstone, and sandy dolomite. No type section was indicated by Warren. Best (1958) has suggested that a well-exposed section at the junction of Whitehorse and Drummond Creeks be considered as the type section of the Whitehorse Member.

Lang (1947), Irish (1947), and Lang and Irish (1948) continued the use of the names Spray River, Sulphur Mountain, and Whitehorse in the Foothills north of Athabasca River.

However, as mapping progressed northwesterly within the eastern Foothills, it became evident that the strata lying below the Whitehorse Member and above the Mississippian Rundle Group, were somewhat different lithologically from the Sulphur Mountain Member of Warren. These beds north of Athabasca River consist predominantly of hard, quartzitic, fine-grained sandstone and siltstone with minor amounts of argillaceous siltstone and shale near the base. They occupy an analogous stratigraphic position to the Sulphur Mountain Member but yielded no diagnostic fossils by which their age might be determined. For these reasons Irish (1951) considered it advisable to drop the name Sulphur Mountain temporarily and to refer to these beds as the Main Part of the Triassic.

On the other hand, the beds lying above the Main Part of the Triassic form a persistent map-unit, in part at least of Middle Triassic age. The formation shows lateral variations in lithology within short distances, but the general character of the sediments is similar to that from the locality near Cadomin, Alberta, northwestward at least as far as Kakwa River. Because this unit is an excellent stratigraphic marker, and because it has been mapped separately for a distance of some 100 miles, it is considered to have more the characteristics of a formation than a member. It is, therefore, called the Whitehorse Formation.

More recent mapping to the west (Irish, 1954, 1955a) has revealed that the lithology of the Triassic here more closely resembles that of the Spray River Formation. It was found, also, that the lower boundary of the Whitehorse Formation was not as well-defined as in sections to the east and southeast, that the formation

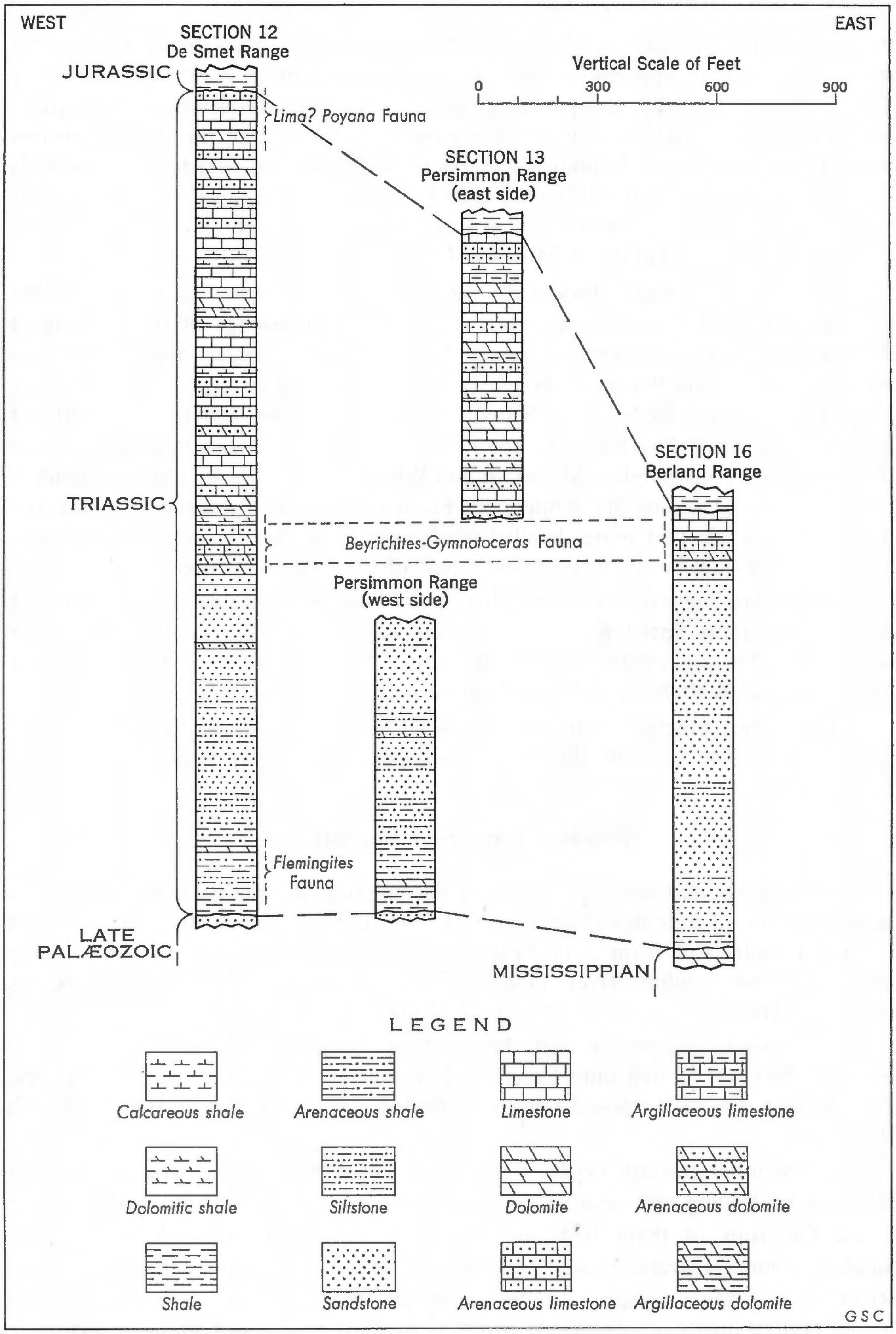


**Figure 3. Diagrammatic columnar sections of the Triassic Spray River Group, from west to east.**

thickens to the west and northwest due to the presence of progressively younger strata, and that its uppermost beds near Llama Mountain contained an Upper Triassic fauna. A further complication occurs in the southwestern part of the map-area where these beds outcrop in the region on both sides of the divide between Rock Creek and South Sulphur River. Here, a brightly coloured, shaly facies is present near the top of the Whitehorse beds. The continuation of this shale facies south of this map-area contains the gypsum deposit lying near the divide between Deer Creek and a tributary of Mowitch Creek.

Thus facies changes throughout the Triassic succession are present within this map-area and it seems very likely that, as our knowledge of the Triassic of the foothills and mountains increases, further facies changes may be demonstrated. It was found that the upper beds at Llama Mountain are equivalent in age to part of the Grey Beds of the Schooler Creek Formation (McLearn, 1920) of the Peace River Valley but it is not known, at this time, just how far west or northwest the terms Sulphur Mountain and Whitehorse can or should be extended. Also, an upper limit to the Whitehorse Formation has not yet been defined and it is quite possible that more detailed work may show that the term "Whitehorse Formation" should be restricted to only part of the calcareous succession.

The writer suggests, therefore, that at least in the mountains and foothills of Alberta, the term Spray River be elevated to group rank and that this group include all Triassic strata. Within the Spray River Group the terms Sulphur Mountain and Whitehorse will be given formational rank.

It was not practicable to show these formations separately on the accompanying map. The Triassic, therefore, has been shown as the Spray River Group (Figure 3).

### Sulphur Mountain Formation

*Distribution and lithology.* Strata of the Sulphur Mountain Formation occupy large tracts in all four mountain ranges. In the de Smet Range, they are repeated by thrust faults and form 3 northwesterly trending bands on both sides of the valley of West Sulphur River. One of the best exposures is that which occurs on Llama Mountain on the north side of Muddywater River.

These rocks outcrop on both flanks of the Persimmon Range. On the northeast side they are faulted onto Fernie and Nikanassin strata and on the southwest side the beds are well exposed but are so folded that a complete section is difficult to measure.

In the more easterly Boule, Berland, and Hoff Ranges the strata have been repeated by folding and faulting and now outcrop as narrow bands and irregular areas. Outcrops of these beds are numerous but complete sections are rare. Sulphur Mountain strata are well exposed on Folding Mountain south of Athabasca River, in the Boule Range 1½ miles southwest of the head of Prine Creek, and in the Hoff Range near the heads of Little Berland River and Moon Creek.

The lower contact of the Sulphur Mountain Formation is disconformable. In the Boule, Berland and Hoff Ranges the formation overlies the eroded surface of the Rundle Group and in the more westerly Persimmon and de Smet Ranges it overlies sandstone of the "Rocky Mountain" Formation. The boundary between the Sulphur Mountain and Whitehorse Formations is transitional and throughout this region is placed arbitrarily where the change takes place from predominantly sandstone and dolomitic sandstone to dolomite and limestone with interbedded argillaceous and arenaceous dolomite and limestone.

In the western exposures (de Smet and Persimmon Ranges), the formation consists of dark grey to bluish black shale and silty shale which grades upward into thin-bedded, finely banded, grey to dark grey siltstone and fine-grained sandstone. Interbedded with the shale and silty shale in the lower part of the succession are thin beds of dark, brownish grey, buff weathering, argillaceous dolomite and fine-grained sandstone. Much of this shale weathers to paper-thin laminae, and the intercalated sandstone and carbonate beds range in thickness from 4 inches to 1 foot. Pyrite is present sporadically throughout the shales and siltstone and in the lower beds pyrite concretions are common.

Above the more shaly beds the formation consists predominantly of evenly bedded, hard, finely banded, fine-grained, grey sandstone and siltstone with interbedded grey silty shale. The thickness of these beds ranges from 2 inches to 1 foot. They weather to platy or slabby talus with a very characteristic red-brown colour. Fine crossbedding occurs in some of the sandstone beds.

The uppermost 140 feet of the formation consists of beds which are thicker and which become progressively more calcareous or dolomitic forming a transition zone with the overlying Whitehorse Formation. These thicker, more massive strata consist of grey and light grey sandstone and dolomitic or calcareous sandstone, with some beds of arenaceous or silty dolomite. They weather to buff, cream, and brown colours and form a blocky rubble.

In the Llama Mountain section (Appendix A, Section 12), where the lower contact of the formation is exposed the relations are disconformable although strata above and below are essentially parallel. No significant erosional features were noted on the upper surface of the underlying Palaeozoic sandstone and no basal conglomerate was seen at this locality (*see* Fig. 3).

In the eastern exposures, which include those in the Boule, Berland and Hoff Ranges, Triassic strata lie disconformably upon the eroded surface of the Rundle Group. The base of the succession is marked by a rusty weathering conglomerate ranging from 2 inches to 2 feet thick and composed, mainly, of sub-angular pebbles of the underlying carbonate rocks in a matrix of calcareous sandstone. Most of the pebbles are about 2 inches in diameter. A few quartzite pebbles and phosphatic nodules have been found and, at one locality, several large, rounded cobbles about 8 inches in diameter were noted. The composition of these cobbles is not known.

The strata above the conglomerate consist of a fairly uniform succession of hard, thin-bedded, slabby, finely banded, grey, red-brown weathering, fine-grained sandstone interbedded with minor amounts of dark grey siltstone and shale. The shale and siltstone is more common near the base but makes up only a small part of the formation. This eastern section contains relatively more sandstone and less shale than those farther to the west. The upper 50 to 75 feet of the formation becomes progressively more calcareous or dolomitic upward forming a transition zone with the overlying formation. The reddish brown colour and thin, slabby nature of these beds when weathered are very distinctive.

*Sulphur Mountain-Whitehorse Contact.* At all localities where this contact was seen it is transitional between the typical dark siltstones and/or shaly siltstones of the Sulphur Mountain Formation and the limestones and dolomites of the Whitehorse Formation. In the eastern exposures this zone is about 30 feet thick but west of and including the Persimmon range, it may be as much as 150 feet thick. At all exposures it consists of relatively thick-bedded, grey, calcareous and dolomitic sandstones with some interbedded sandy or silty carbonates all of which weather readily to somewhat blocky talus having a light buff to cream colour. The zone is rather recessive due to its ease of weathering relative to the strata above and below but the gradual change from dark siltstone below to the dominantly carbonate beds above is such that the contact between the two formations may be placed at a different horizon at different localities.

Ammonites of Anisian age have been collected from this zone at several locations in the area and in most cases the enclosing beds were included at the base of the Whitehorse Formation. However, a collection from the ridge just south of Walton Creek was placed by the writer (Irish, 1955a) near the top of the Sulphur Mountain Formation because, although the fossils occur in a limestone lens, the enclosing calcareous sandstones were considered to resemble the lithology of the Sulphur Mountain Formation more than that of the Whitehorse.

Within this map-area, all fossils identified as of Anisian age were collected from the lower part of the transition beds and, on the basis of lithology it seems now more reasonable to include strata containing this fauna in the Sulphur Mountain Formation as is done in this report. It is interesting to note that none of the Anisian ammonite collections recorded in this report were associated with shale as were those reported by Manko (1960) in his stratigraphic section between Collie Creek and Blue Creek.

*Thickness.* Outcrops and partial sections of the Sulphur Mountain Formation are numerous throughout this map-area but complete sections that can be measured are few. In the western part of the area the formation measured 934 feet on Llama Mountain and is estimated to be about 1,000 feet thick on the northeast side of South Sulphur River. On the northeast flank of the Persimmon Range, the lower 720 feet of the formation are exposed in Rocky Pass.

Farther east, Sulphur Mountain strata were measured by Lang (1947) at the head of Prine Creek in the Boule Range where a total thickness of 1,090 feet was obtained, and by Irish (1949) at the head of Little Berland River where 1,000 feet of beds are assigned to the formation (*see* Appendix A).

*Age and correlation.* Fossils are rare and poorly preserved in the lower part of the formation. In the Llama Mountain section several ammonites as well as some fragmental fish remains were collected from a zone between 25 and 200 feet above the base. Specimens of *Euflemingites* sp. were identified by E. T. Tozer who comments as follows: "*Euflemingites* occurs in the *Meekoceras* zone of Idaho and Ellesmere Island. The fauna of the *Meekoceras* zone is dated early Upper Scythian."

Several very poor ammonite impressions were seen about 700 feet above the base but none could be identified.

In the Persimmon Range no fossils were collected although ammonite impressions were seen in the siltstone about 200 feet above the base.

No diagnostic fossils were collected from the lower part of this formation in the eastern ranges.

In the transition beds near the top of the formation fossils are rare and, where seen, occur in limestone lenses or pods. In the Llama Mountain section poorly preserved ammonites were collected from a zone about 1,034 feet above the base of the Sulphur Mountain Formation. These were identified by Tozer who commented as follows: "The fauna from GSC loc. 23254, although meagre, contain the diagnostic Anisian (Middle Triassic) species *Gymnotoceras blakei* (Gabb). This suggests correlation with the *Beyrichites-Gymnotoceras* fauna described from the Toad Formation by McLearn (1946). Warren (1945) states that this fauna is common in the Whitehorse Member of the Spray River Formation particularly near the base".

The beds above this zone yielded only scattered, poorly preserved gastropods. The upper beds of the Sulphur Mountain Formation underlying most of the ridge just south of Walton Creek and lying above the Mount Russell thrust fault, yielded the following fossils approximately 900 feet stratigraphically above the base of the Triassic succession:

*Ussurites* sp.
*Ptychites* sp.
*Gymnotoceras* sp.
*Beyrichites*? sp.
*Paranautilus*? sp.
Orthoconic nautiloid fragments indet.
*Daonella* sp.

Tozer assigns an Anisian age to these forms.

*Modiola* sp., *Hoernesia* sp. cf. *H. socialis* (Schlotheim), and *Myophoria*? sp. were collected from near the top of the Sulphur Mountain beds on a small creek on the southwest flank of Persimmon Range and flowing into Sulphur River. Tozer's remarks on this fauna are as follows: "*Hoernesia* cf. *socialis* has been reported from the Whitehorse 'Member' by Warren (1945), with the

Anisian *Gymnotoceras*. A Middle Triassic age is therefore suggested for this lot, although the pelecypods probably have a more extended stratigraphic range than the ammonites".

Collections made from the transition beds in the Hoff and Berland Ranges and originally placed in the lower beds of the Whitehorse Formation, include such forms as *Beyrichites* sp., *Gymnotoceras* sp., *Trigonodus* sp., *Leda* sp., *Spiriferina* sp., *Coenothyris* sp., and *Myophoria* cf. *laevigata*. These fossils were identified by F. H. McLearn who assigned a Middle Triassic (Anisian) age to the fauna.

Based on the fossils collected throughout the map-area, at least the upper 300 feet of the Sulphur Mountain Formation is of Middle Triassic Anisian age. These beds can, therefore, be correlated with the lower part of the Whitehorse Member of Warren (1945) and with part of the Toad Formation north of Peace River.

### Whitehorse Formation

*Distribution and lithology*. The distribution of the Whitehorse Formation is similar to that of the underlying Sulphur Mountain strata. It is disconformably overlain by the Fernie Group and its lower contact is arbitrarily placed as previously described.

These strata comprise two facies within this map-area. The formation normally consists of limestone and dolomite beds of which many are argillaceous or arenaceous. In the western part of the map, between the Persimmon Range and South Sulphur River, besides the normal lithology, there is also a highly coloured, dolomitic shale facies which, south of the map-area, is associated with evaporites.

Typical beds of the Whitehorse Formation consist of buff, ash grey and cream-white weathering, dense to very fine grained and medium grained, evenly bedded, grey, brownish grey and dark grey dolomite and limestone, much of which is argillaceous or arenaceous. Interbedded with these are lesser amounts of fine-grained, quartzose sandstone, calcareous or dolomitic shale and breccia. Porous beds and beds containing small calcite-filled cavities are common. Some beds are soft and weather readily; others are hard and resistant. Breccia zones occur locally in the lower part of nearly all exposures of Whitehorse beds. White calcite veins many of the beds and cements some of the breccias.

The coloured shale facies occurs in the Whitehorse Formation along the southwest side of the Persimmon Range and on the mountains situated along the northeast side of South Sulphur River. These shales occur just northwest of, and at a similar stratigraphic horizon to the gypsum beds that outcrop on a small branch of Mowitch Creek just beyond the present map-area. Little or no gypsum occurs within the region covered by this report. Minor amounts of shale are present to the northern end of the Persimmon Range, but none was seen to the northwest at Llama Mountain.

The shale or evaporite facies consists of an alternating succession of red, green and ochre-coloured dolomitic shales; red, green and yellow-buff, soft, argillaceous dolomite; and interbedded dolomitic breccias and beds of dense, grey-brown, sandy dolomite. In general, these strata are soft and weather readily so that exposures become rapidly covered with detritus and only the harder beds remain as outcrops.

*Thickness.* The calcareous strata exposed on Llama Mountain are 1,118 feet thick (*see* Appendix A, section 12). In the Persimmon Range the strata are either too poorly exposed or too contorted for accurate measurement but the formation is estimated to be at least 900 feet thick. An incomplete section exposed on a small creek about 1 mile south of Walton Creek appears to be more than 704 feet thick (*see* Appendix A, section 14). Section 15 (Appendix A), occurring on the northeast side of South Sulphur River, includes the shale facies of the formation. The exposed section here is 941 feet thick and all strata are assigned to the Whitehorse Formation. The Triassic-Jurassic contact is estimated to lie about 50 feet stratigraphically above the top of the measured beds so that the total thickness of Whitehorse here is in excess of 991 feet. The shale facies is about 500 feet thick and is both overlain and underlain by limestone and dolomite beds.

In the Boule Range, Lang (1947) assigned a thickness of 60 feet to the Whitehorse Formation. Farther northwest in the Berland and Hoff Ranges the thickness of Whitehorse strata varies between 80 and 150 feet.

*Age and correlation.* Fossils are rare, poorly preserved, and occur sporadically within the Whitehorse beds. In the Llama Mountain section shell fragments, particularly *'Lingula'*, are present throughout the lower 200 feet. The beds above this yielded only scattered, poorly preserved gastropods.

However, about 3 miles southeast of Llama Mountain the uppermost beds yielded specimens of *Mysidioptera poyana* (McLearn) and *"Terebratula"* cf. *Julica* Bittner. This fauna, according to Tozer, is of Upper Triassic age and is the same as that which characterizes the upper part of the 'Grey Beds' in the Peace River foothills (McLearn, Trans. Roy. Soc. Can., vol. 34, sec. 4, 1940, p. 70). McLearn regards this fauna as representing a part of the Karnian stage of Europe. Tozer comments as follows: "The occurrence of the *Mysidioptera poyana* fauna in this area constitutes the southernmost record of this fauna. McLearn's work in northeastern British Columbia has shown that the *Gymnoceras* and *Mysidioptera poyana* faunas are widely separated stratigraphically and that the *Nathorstites* fauna occurs in the interval. The *Nathorstites* fauna has not yet been found south of Peace River; however, the discovery of the zones that embrace it in the Llama Mountain section suggests that a search for this stratigraphically valuable faunal zone might be rewarded".

## Summary of Triassic

The Triassic succession throughout this map-area is separated by disconformities both from the Palaeozoic strata below and from the Jurassic Fernie Group above. In the western exposures it overlies sandstone, chert or dolomite of "Late Palaeozoic" age and in the most eastern exposures it rests on the eroded surface of the Mississippian dolomite of the Rundle Group.

The succession as a whole thickens from east to west and, probably to some extent from southeast to northwest. The Sulphur Mountain Formation maintains about the same thickness in all exposures, but the thickness of the overlying Whitehorse Formation, which is about 100 feet in the Boule, Hoff and Berland Ranges, increases to more than 1,000 feet in the west and northwest part of the area. This increase is due to the presence of progressively younger beds in these directions, a fact that may be attributed either to non-deposition of the higher beds in the east and southeast or to progressively deeper erosion of the calcareous strata to the east and southeast or, perhaps, to a combination of these causes.

Lithologic changes within each formation have been described in the foregoing paragraphs. In the western exposures, the Sulphur Mountain Formation can be divided into two lithologic units but to the east increasing amounts of siltstone and fine-grained sandstone replace the shale, silty shale and dolomite until, in the Boule, Hoff and Berland Ranges the strata are predominantly siltstone and sandstone. On the other hand, the general character of the Whitehorse remains fairly constant throughout the map-area except for the varicoloured shale (evaporite) facies in the Rock Creek-Mowitch Creek region.

Lower Triassic ammonites were collected from a zone between 25 and 200 feet above the base of the Llama Mountain section, but since no fossils were collected from the lowermost beds it is not known whether or not the Lower Triassic is complete in this map-area. The uppermost beds, at least, of the Sulphur Mountain Formation which include the *Beyrichites-Gymnotoceras* faunal zone are of Middle Triassic age but the boundary between the Lower and Middle Triassic is not known in this area. Middle Triassic fossils have been collected only from a limited stratigraphic range and it is likely that part of the great thickness of carbonate beds lying between those containing the *Beyrichites-Gymnotoceras* fauna and those containing the *Mysidioptera poyana* fauna are also of this age.

The approximate correlation throughout the Foothills and Rocky Mountains of Alberta and British Columbia is shown in Figure 4. This does not include data on the sub-surface Triassic strata.

# Jurassic

The name Fernie shale was applied by Leach (1903) to Jurassic shales in the Crowsnest Pass region that formerly had been grouped with the Kootenay Formation, but the limits were not strictly defined. The Jurassic age of these shales

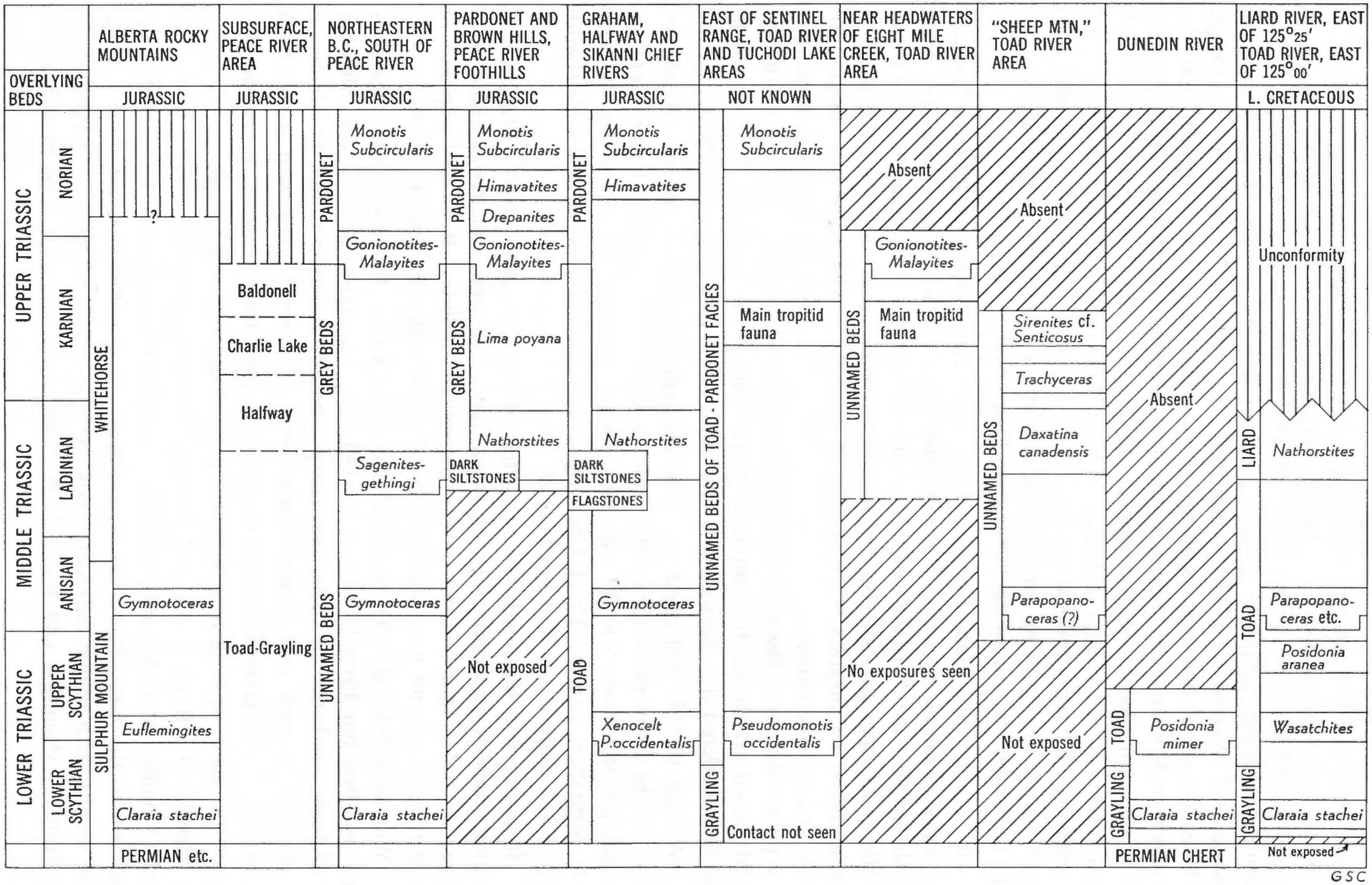


**Figure 4. Correlation chart, Triassic formations of the Eastern Cordillera, Alberta and British Columbia (E. T. Tozer 1961).**

was first established when J.F. Whiteaves (1903) published the description of an ammonite collected by McEvoy (1899). McLearn (1924, 1927, 1930) and Warren (1931, 1932) contributed much of our palaeontological knowledge of the Canadian Jurassic faunas in several papers published by the Royal Society of Canada and Warren (1934) summarized the stratigraphic and palaeontologic evidence known at that time pointing out that the Fernie passes upward into the Kootenay or Kootenay equivalent by the intercalation of sandstone beds. The term Fernie was extended by several workers to designate Jurassic strata as far north as Athabasca River Valley, including beds of different lithological characters and representing different Jurassic epochs. J.F. Henderson (1944) used the term Fernie Group for strata of Jurassic age, but stated that some of the upper sandstone beds might belong to the Nikanassin Formation.

In recent years, Hans Frebold of the Geological Survey of Canada has carried out a systematic faunal and stratigraphic study of the Fernie Group. His work has shown that the Fernie Group is comprised of beds belonging to the Lower, Middle and Upper Jurassic, but because of the absence of index fossils typical of certain stages, he suggests the existence of several hiatuses within the group. No visible angular unconformities occur so that these hiatuses can be recognized only on a palaeontological basis. It is his opinion (1957, p. 2) that the gaps in the faunal record are caused by temporary regressions of the sea, or at least by conditions that hindered the deposition of any appreciable amount of sediment.

Warren (1934) indicated two lithologic units that he considered might be recognized in different sections; these units he defined as the Rock Creek Member, a calcareous sandstone 5 to 30 feet thick occurring 50 to 150 feet above the base of the formation, and the 'Black Chert Member' which consists of black chert with interbedded shaly layers and lies near the base of the formation.

It has been determined, however, that in most places Warren's Black Chert Member consists predominantly of black limestone and calcareous shale with abundant chert fragments and locally phosphatic nodules. It is well exposed in the Nordegg area and was called the Nordegg Member by Spivak (1949).

Warren (1934, p. 59) restricted the Rock Creek Member to a calcareous sandstone bed but Frebold (1957, p. 14) uses the name Rock Creek Member for all beds, sandstone or shale, that carry a middle Bajocian fauna. He defines it as consisting of dark grey, almost black, rusty weathering shale with harder beds of more or less calcareous sandstone. Locally sandstone replaces a considerable part of the shale, or sandstone is replaced by shale with concretions.

Besides the Rock Creek and Nordegg Members, Frebold (1957, p. 6) has listed 13 names of 'beds' and 'Members'. Some of these units, as for example, the Paper shale, the Grey beds, the Green beds and the Passage beds, were recognized locally with minor differentiations, over hundreds of miles (Frebold, 1957 and Frebold, Mountjoy and Reed, 1959) and are also widely used in subsurface geology.

It has been the practice of the Geological Survey to use the term Fernie as designating a group rather than a formation. It is so used in this report and includes most of the Jurassic strata in the Rocky Mountains and Foothills. Faunal evidence at this time indicates an uppermost Jurassic age for part of the Nikanassin Formation and for the lower part of the Kootenay Formation that contains an upper Portlandian ammonite, *Titanites occidentalis* Frebold (Frebold, 1957).

## Fernie Group

*Distribution and lithology.* Fernie strata, though not confined to the mountain ranges, outcrop mainly along their margins as long, narrow bands due mainly to folding and faulting. Several small areas underlain by these beds occur on anticlines within belts of Lower Cretaceous rocks.

South of Rock Creek considerable areas of Fernie beds underlie both sides of the Boule Range. North of Rock Creek, in the Berland Range, Fernie strata occur along the northeast side of Hoff Ridge from Little Berland River northwesterly for about eight miles. Between Hoff and Tip Top Ridges these beds occupy a northwesterly trending strip about 40 miles long and, on the southwest flank of Tip Top Ridge beds of the group underlie a strip from Rock Creek in the south almost as far as Berland River to the northwest. Farther west Fernie strata, for the most part, underlie the valley between the Monoghan and Persimmon anticlines. This same band extending to the northwest is well exposed along the northeast side of Llama Mountain, Faulk Creek, and the lower reaches of Muddy Water River. West of the Monoghan anticline Fernie beds are exposed as another band occurring on both sides of West Sulphur River. Another major band to the northeast occurs from a point just southeast of the junction of Muskeg and South Muskeg Rivers and extends northwesterly to the border of the map. The Cabin Creek anticlinal structure exposes Fernie beds along both limbs from Berland River in the southeast to Mahon Creek in the northwest. Other smaller areas underlain by Fernie strata are shown on the map. These occur as small patches caused either by the erosion of anticlines or by thrust faults. The two small areas shown on the Susa Creek anticline are the most northeasterly exposures of the group within the map-area.

The Fernie Group weathers readily because of its softness and, for this reason, underlies many valleys or forms gentle slopes and saddles within the mountains. The fact that it does underlie low areas or gentle slopes usually results in it being covered to a large extent by vegetation and complete exposures of the group are thus very rare. Also, Fernie strata being relatively incompetent, are at many places severely contorted and faulted.

The lower contact of the group is disconformable. The lowermost Jurassic beds (Hettangian) have not been recognized and the base of the Fernie in the mountains and foothills is not at the same stratigraphic horizon at all places

(Frebold, 1957, p. 7). Fernie strata overlie Middle Triassic sandy dolomite in the eastern exposures and Upper Triassic limestone in the west within the area covered by this report. The upper contact with the Nikanassin is transitional.

There is a general lithological similarity between all sections within this map-area. The lower part of the group consists of hard, dense, black limestone in places interbedded with soft, fissile, black, calcareous shale. The limestone beds may be platy or massive and up to three feet thick. This unit is succeeded by soft, fissile, dark grey to black shale containing numerous bands of buff and red-yellow weathering ironstone ranging between two inches and two feet in thickness. Above this is dark grey shale, mostly fissile or thin-bedded containing continuous or discontinuous ironstone bands and scattered individual concretions up to 3 feet in diameter. Higher still in the section the shale becomes silty and harder with a progressively increasing number of intercalated siltstone bands. The upper part of the group consists of dark grey, silty shale with interbedded hard, grey, buff weathering sandstone beds that may represent the Passage beds (Frebold, 1957). The sandstone beds increase in number and thickness upward forming a gradational contact with the overlying Nikanassin Formation. No two exposures are exactly the same in detail. This is illustrated in the three measured sections given in Appendix A, sections 17, 18 and 19. The thickness of the several units and the composition of each with respect to the proportions of contained limestone, shale, siltstone, and sandstone, changes from place to place. The number and thickness of intercalated ironstone bands, individual concretions, and sandstone beds differs between outcrops and the transition from Fernie Group to Nikanassin Formation is much more abrupt at some places than at others.

The Nordegg Member of Spivak (1949) and Frebold (1957) appears to be present throughout the map-area wherever the lower contact of the group is exposed. For the most part, correlation with the Nordegg Member is based on lithological similarity since fossils representative of this member were collected at only one locality.

The Rock Creek Member could not be recognized as a lithological unit but the representative faunal zone appears to be present in all sections. Neither the upper nor lower limits of this member or zone could be placed with accuracy.

The exposure of the Fernie Group just upstream from the mouth of South Muskeg River contains a 15-foot-thick bed of buff weathering, grey, medium-grained, quartzitic sandstone about 105 feet above the lower contact. Although no fossils were found in the sandstone, a fauna similar to that of the Rock Creek Member was found about 10 feet below it in shale. Exposures farther west, including those of the other two measured sections (*see* Appendix A, Sections 18 and 19) contain no sandstone at this stratigraphic horizon. Typical fossils of the Rock Creek Member occur in black shale west of the Persimmon Range.

East and southeast from the Muskeg River exposures of Fernie beds are generally poor. There are several places, however, such as on the east flank of the Cabin Creek anticline and near the heads of Little Berland River and Moon Creek, where lower Fernie beds are exposed. At none of these localities was a thick sandstone bed present in the lower part of the group.

*Thickness.* No complete or undisturbed exposure of the Fernie Group was located so that the true thickness within the area was not obtained. Three partial sections were measured in detail and approximate thicknesses were obtained at several places by measuring the stratigraphic interval between the uppermost Triassic and the lowermost Nikanassin strata.

Two factors make it difficult to obtain accurate measurements of the thickness of the Fernie Group. One of these is the fact that the strata are faulted and folded to some extent and small faults may be missed or obscured. The other factor is the transitional upper contact. This may be gradual, through a thickness of 200 to 250 feet as in the Llama Mountain section, or it may be relatively abrupt through a thickness of about 50 feet as on Davey Creek above the Mount Russell thrust fault. The upper contact of the Fernie Group is therefore almost certainly placed at different horizons in different localities.

Lang (1947) gave a thickness of 1,300 feet for the group north of Brûlé in the Boule Range. This was estimated by graphical methods and he states that this thickness is probably exaggerated by faulting and folding. To the northwest he gave an approximate thickness of 900 feet for the Fernie at the southern end of Hoff Ridge just east of Mumm Creek. Farther northwest along this ridge the writer assigned a minimum of 750 feet of beds to the Fernie. In this section the lower contact is faulted so that the lower part of the group is not exposed.

Still farther northwest near the head of Cabin Creek the writer obtained an approximate thickness of 700 feet for the group. In this same region Spivak (1949) gives a thickness of only about 600 feet.

Thorsteinsson (1952) states that only the upper 1,000 feet of the Fernie Group is exposed along the Knife Mountain anticline and Mount Russell thrust fault, indicating that the group here is greater than 1,000 feet thick.

The only other place where the Fernie Group may be as thick or thicker than this is at the exposure on the north side of Llama Mountain (*see* Appendix A, Section 18). There is a zone of folding and faulting near the middle of this section and lying stratigraphically below this zone are about 1,200 feet of beds in which no repetitions could be detected. Above the disturbed zone are another 590 feet of beds assigned by the writer to the Fernie. This gives an approximate total of 1,800 feet of beds which, if correct, is by far the thickest Fernie section within the map-area. Fossil evidence indicates that the upper 1,661 feet of this section plus at least the lower 200 feet of the overlying Nikanassin Formation should be assigned to the Upper Jurassic.

It appears that the Fernie Group thickens both from southeast to northwest and from northeast to southwest within this map-area and reaches a maximum in the Llama Mountain region. This increase in thickness coincides with a similar thickening of the overlying Nikanassin Formation in the same general area.

*Age and correlation.* Fossils are not plentiful throughout the group and when found are usually poorly preserved and flattened, especially where they occur in shale. Collections were made at several localities and were identified by Frebold. These fossils, listed in Appendix C, were sufficiently well preserved in most cases to establish the age and faunal zone. Thus, probably the earliest Jurassic strata present in the area belong to the Sinemurian stage of the Lower Jurassic. A fauna, consisting mainly of pelecypods, was collected on a small tributary of Sulphur River on the southwest side of Persimmon Range. This fauna is characteristic of the Oxytoma bed which usually occurs near the top of the Nordegg Member. Above this is a widely distributed fauna representative of Bajocian or lower Middle Jurassic age, and typical of the Rock Creek Member. The Oxfordian stage of the Upper Jurassic is indicated by the presence of *Buchia concentrica* Sowerby.

Thus, enough faunal evidence is on hand to indicate the presence of at least some part of each of the Upper, Middle and Lower Jurassic, lower Sinemurian, middle Bajocian, and Oxfordian-lower Kimmeridgian, but just what zones may be represented by the strata in which no fossils were found cannot be ascertained.

### Summary of Jurassic

The Fernie Group within the area covered by this report includes strata of the Lower, Middle, and Upper Jurassic. It lies disconformably on either Middle or Upper Triassic carbonate rocks and is transitional upward into the Nikanassin Formation. It consists mainly of shale and silty shale with varying amounts of grey sandstone beds and ironstone bands and concretions. Facies changes are not pronounced but evidence obtained from the few good exposures suggests a decrease in sandstone toward the west. Available evidence also indicates a rather sudden thickening of the whole group toward the northwestern part of the area.

## Cretaceous

### Lower Cretaceous

#### *Summary of Nomenclature*

The thick succession of Lower Cretaceous and, in part, uppermost Jurassic sediments overlying the Fernie strata probably partly represents the northern continuation of the Kootenay and Blairmore strata of southwestern Alberta.

G. M. Dawson (1886, p. 162B) gave the name "Kootanie series" to the Lower Cretaceous, coal-bearing rocks of the Crowsnest Pass region, pointing out that the lower beds he included in this series contained marine fossils of probable Jurassic age. Leach (1912) applied the name "Blairmore" to the upper part of this series, which did not contain commercial coal seams, placing the base of the Blairmore at the base of a prominent conglomerate bed subsequently referred to as the Blairmore conglomerate. As work proceeded northward the term Kootenay was applied to Lower Cretaceous coal-bearing strata, but in the central

Foothills it was found that the commercial coal seams lay above a conglomerate bed that seemed equivalent to the Blairmore conglomerate, and palaeobotanical evidence showed that the strata above this conglomerate were of Blairmore age. In the Mountain Park area MacKay (1929a, 1930) named the strata lying between the Fernie Group and the Blairmore conglomerate the Nikanassin Formation and the coal-bearing beds above it, the Luscar Formation. Despite its relative thinness, he named the conglomerate the Cadomin conglomerate because it outcrops prominently and is an important horizon marker for coal prospecting. On later maps he used the term Cadomin Formation. In the same area he gave the name Mountain Park Formation to a series of green, ridge-forming sandstone beds lying above the coal-bearing strata and below the Upper Cretaceous marine strata. The term Blairmore is now used to designate a group composed of the Cadomin, Luscar and Mountain Park Formations or their undivided equivalents.

In 1927, MacKay (1929) mapped a small area at Brûlé and extended the use of the names Nikanassin, Cadomin and Luscar to the predominantly Lower Cretaceous rocks of that area, but was unable definitely to recognize the Mountain Park Formation.

The formational names applied to these strata by MacKay have been extended north and northwest from Brûlé as geological mapping of the Foothills belt has continued. North of Athabasca River no strata have been recognized that have the typical green colour and ridge-forming characters of the Mountain Park Formation at its type locality in the Mountain Park area. However, thick sandstone beds without coal seams do overlie the typical coal-bearing part of the Blairmore Group, and these strata may correspond in age to the Mountain Park Formation. In recent reports on Foothills area north of Athabasca River, strata lying between the Cadomin Formation and Fort St. John Group have been mapped, and referred to, as the Luscar Formation with the understanding that the upper, non-coal-bearing beds may be, in part or wholly, equivalent in age to the Mountain Park Formation (*see* Fig. 5).

In the present map-area, the succession of strata between the Fernie Group and the Cadomin Formation includes, as it does south of Athabasca River, both marine and non-marine strata. The non-marine beds at the top may be of Lower Cretaceous age, but the marine strata occurring below these and grading downward into the underlying Fernie Group are now known to be of Upper Jurassic age. Warren and Stelck (1958) refer to the upper part of this succession, consisting mainly of non-marine strata, as the Kootenay Formation and restrict the term Nikanassin to the lower, marine beds which are of Jurassic age. Ziegler and Pocock (1960) have suggested that the name Minnes Formation replace that of Nikanassin Formation for all beds between the Fernie Group and the Cadomin Formation. Within their Minnes Formation these authors refer to the marine beds as the Nikanassin facies and to the upper, non-marine strata as the Kootenay facies.

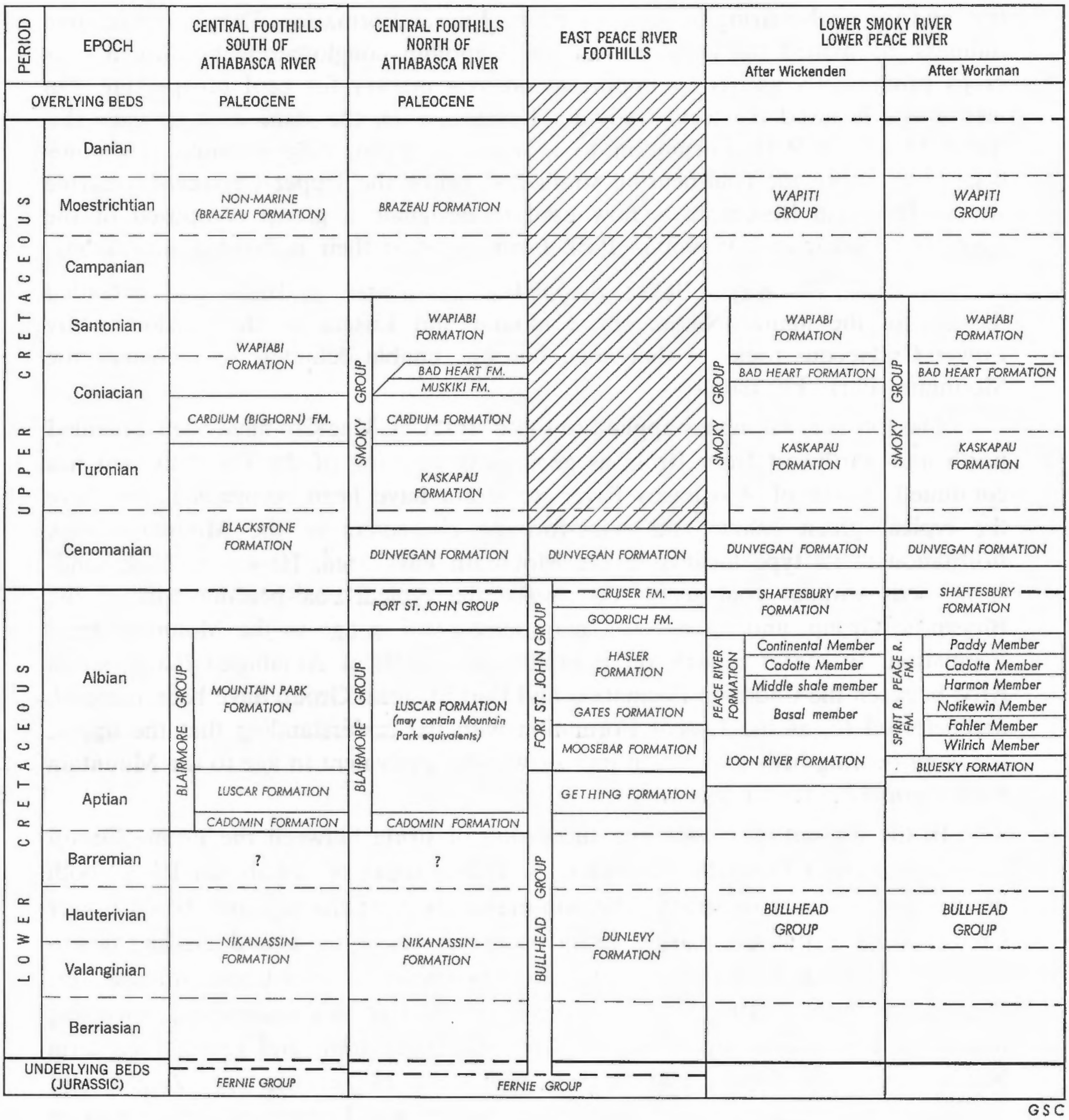


**FIGURE 5. Correlation table of some Cretaceous formations of the Rocky Mountains and Foothills of Alberta and British Columbia.**

The writer agrees that this succession of strata includes both a marine and a non-marine facies, but does not consider it advisable to introduce a new formational name at this time. In this report, therefore, the term Nikanassin Formation refers to all strata occurring between the Fernie Group and the Cadomin Formation.

### *Nikanassin Formation*

*Distribution and lithology.* Lower Cretaceous strata underlie relatively narrow bands on either side of the Boule, Berland and Hoff Ranges. Beyond the northwestern extremities of these ranges, the foothills increase in width to about 25 miles and Lower Cretaceous strata occupy about three-quarters of this region.

Nikanassin rocks make up roughly one-third of the region underlain by the Lower Cretaceous strata. Southeast of Sulphur River they are exposed mainly as narrow bands and irregular areas within the higher ridges of the foothills and in the intermontane valleys. To the northwest of Sulphur River the Nikanassin underlies extensive areas of the higher ridges, particularly in the more western regions between North Berland River and the western border of the map-area. Excellent exposures occur along Turret Ridge on the northeast side of Faulk Creek and on several other ridges north and east of this. Another well-exposed section outcrops where the southeastern end of the Cabin Creek anticline is cut by Berland River.

The Nikanassin Formation overlies the Fernie Group conformably and gradationally, the transition being apparently more rapid at some places than at others. It is overlain disconformably by the Cadomin Formation.

The lower, marine strata consist predominantly of thick-bedded, grey, buff weathering, hard, quartzitic sandstone. Individual beds may be as much as 20 feet thick but they usually measure between ten and fifteen feet. Interbedded with the sandstone are minor amounts of grey shale, silty shale, siltstone and, rarely, beds of yellow weathering sandstone or sandy ironstone. The upper, non-marine strata are more thinly bedded. They consist of fine-grained, hard, grey, grey weathering, quartzitic sandstone and softer, grey-brown to brown, fine-, medium-, and coarse-grained, grey to buff weathering sandstone and argillaceous sandstone. Interbedded with this are thin and thick beds of grey to dark grey shale and silty shale, black, carbonaceous shale, dark grey siltstone, a few thin ironstone beds and, in some places, thin coaly seams. Some of these beds contain carbonized wood fragments and comminuted plant debris. Ripple-marks and crossbedding are common in these upper beds but are virtually lacking in the lower part of the formation.

The relative proportions of the several rock types change laterally, especially in the non-marine part. Silty shale and shale are minor constituents in the lower strata (above the Fernie-Nikanassin transition zone) but are abundant throughout the remainder of the formation. Carbonaceous shale and coal are restricted to the upper part of the formation.

*Thickness.* Although the formation outcrops at many places within the map-area, completely exposed sections are rare. One complete section was measured where Berland River has cut through the northeast limb of the Cabin Creek anticline (Appendix A, Section 20). Here the formation is about 904 feet thick. To the southeast and still east of the first mountain range, Lang (1947) estimated the thickness of the formation near the town of Brûlé to be about 1,000 feet thick and Rutherford (1925) estimated the Nikanassin on Folding Mountain to be 850 feet thick. To the northwest the Nikanassin appears to be considerably thicker. Thorsteinsson estimated a total thickness of 4,000 feet for these strata on Knife Mountain and measured the upper part of the formation where it is exposed in the core of the Sterne Creek anticline on the north bank of Smoky River. Northwest of this locality the Nikanassin is very well exposed on the ridges northeast of Faulk Creek. The thickness here is estimated to be between 3,500 and 4,000 feet.

The Fernie Group is transitional upward into the Nikanassin Formation by the intercalation of an increasing number of sandstone beds. Throughout this map-area an arbitrary boundary between the two was adopted to facilitate field mapping; the boundary was placed at the base of the lowest sandstone bed, which is between 10 and 15 feet thick. It seems improbable, however, that any one sandstone bed maintains the same thickness over a wide area, and it must be assumed that the base of the Nikanassin has been placed at somewhat different horizons in different sections.

The upper contact of the formation is disconformable. At any one place the base of the Cadomin Formation appears to be essentially parallel with the underlying Nikanassin strata but at different localities the uppermost bed of the Nikanassin Formation is not the same. There is, therefore, only a very small discordance between the two formations except locally. Thorsteinsson (1952) observed discordance of dip between the Nikanassin and Cadomin Formations where Sulphur River crosses the northwestern end of Hayden Ridge. The evidence available suggests that the Nikanassin surface was one of gentle relief, yet clearly eroded before the deposition of the Cadomin Formation. Just how much erosion has taken place is not known.

The transitional base and the eroded top of the Nikanassin are two main factors responsible for local changes in thickness of the formation along the structural trend within this area. There seems no doubt, however, that there is a great and quite rapid thickening of these strata from east to west, and to a lesser extent, from southeast to northwest, that appears to take place mainly in the lower marine beds. On the flank of the Cabin Creek anticline the Nikanassin Formation is about 900 feet thick with only a few tens of feet of probable marine beds at the base (Appendix A, Section 20), while 20 miles to the west the thickness of the formation has increased to about four times this figure, more than 600 feet of this being of marine origin.

One complete and several partial sections are given in Appendix A.

*Age and correlation.* Fossils are rare in the Nikanassin Formation. A small species of *Buchia* (formerly known as *Aucella*) ex gp. *B. mosquensis* from the lower part of the Nikanassin is considered by Jeletzky (personal communication) to be of middle Kimmeridgian to early Portlandian age. A collection made by the writer from Turret Ridge on the northeast side of Faulk Creek was tentatively identified by Frebold as of Portlandian age (upper part of Upper Jurassic). Strata from which this fauna was collected occur about 620 feet above the arbitrary top of the Fernie Group in that region, which indicates that at least the lower 620 feet of the Nikanassin Formation is of marine origin and of Jurassic age. Thorsteinsson (1952), who collected the same fauna a few miles to the southeast, suggests that probably a much greater thickness of the lower part of the Nikanassin is of marine origin.

South of Athabasca River, fossil plants found in the upper part of the Nikanassin are considered to be equivalent in age to flora of the Kootenay Formation, most of which is thought by Bell (1956) to be of Lower Cretaceous age. Gussow (1960) suggests that the results of a recent study of ostracods and other microfossils of the Kootenay Formation indicate that there should be further upward revision of the Jurassic-Cretaceous boundary within the Kootenay Formation.

Just northwest of the area covered by this report, Ziegler and Pocock (1960) studied the microfauna and microflora from the Nikanassin (their Minnes Formation). These authors place the Jurassic-Cretaceous boundary 5,000 feet below the top (base of the Cadomin Formation) of their section of Mount Minnes.

In this map-area the marine and non-marine facies were not separated since both types of strata are almost lacking in fossils. Plant stems and wood fragments were seen in the upper beds but no identifiable plants were collected north of Athabasca River. The Nikanassin Formation may be equivalent or partly equivalent to the Dunlevy Formation of the Bullhead Group in Peace River district, and to all or part of the "Marine Bullhead" of the Carbon Creek-Mount Bickford area (Mathews, 1946).

### *Cadomin Formation*

*Distribution and lithology.* The distribution of the Cadomin Formation is similar to that of the underlying Nikanassin. It occurs within the areas underlain by Lower Cretaceous strata where it forms long, narrow, sinuous bands on either flank of, and often also around the noses of folds or as parallel bands due to repitition by thrust faulting. It is distinctive, commonly forms conspicuous outcrops, and is an excellent horizon marker. It forms many persistent hogbacks, which can be traced for long distances and which outline minor structures on major folds. The formation consists of hard, massive conglomerate which is extremely resistant to erosion and consequently has a marked topographic expression (Plate VIIB).

The pebbles are well rounded, commonly ovoid or elliptical, and are closely packed; they consist chiefly of chert and quartzite in about equal proportions. The chert ranges in colour from black to green, red, milky white, light yellow, and greyish white, the relative amounts of each varying from place to place. No pebbles of igneous rocks were observed. Cobbles up to five inches in diameter are not uncommon, but most of them range between one and three inches (Plate VIIA). Chatter marks were observed on many of the cobbles. The matrix is siliceous, and so consolidated that the rock generally fractures across the pebbles rather than around them. Wood fragments and coaly stringers are present at some localities within the interbedded sandstone.

*Thickness.* The formation normally consists of a single band of conglomerate which ranges between 30 and 220 feet in thickness but is usually between 75 and 100 feet. Beds and lenses of medium-grained, light grey, buff weathering sandstone occur locally interbedded with the conglomerate. In some places, notably where Smoky River crosses the Susa Creek anticline and where Sterne Creek crosses the Susa Creek anticline, the formation consists of two distinct conglomerate bands each ranging between 40 and 60 feet thick, separated by 20 to 40 feet of sandstone and sandy shale. There appears to be a tendency for the conglomerate to thicken from northeast to southwest but this is not obvious because of the numerous more local variations in thickness.

In the lower 200 to 300 feet of the overlying Luscar strata, there occur, in some places, conglomerate beds and lenses. These include pebbles smaller than those of the typical Cadomin Formation, but are composed of similar chert and quartzite. These beds are included in the lower part of the succeeding Luscar Formation rather than with the Cadomin.

*Age and correlation.* No fossils were found in the conglomerate within the map-area. It is assigned a Lower Cretaceous age on the basis of its stratigraphic position between the Nikanassin and Luscar Formations and is correlated with the Cadomin Formation of the Mountain Park type area. The formation may also be equivalent in age to all or part of the conglomeratic beds which occur between the Dunlevy and Gething Formations of the western part of the Peace River district.

Bell (1957) gives an Aptian age for the overlying Luscar Formation and to the Gething Formation on Peace River. Warren and Stelck (1958) suggest that the hiatus between the Cadomin and Nikanassin Formations may represent most of the Portlandian, Tithonian and Neocomian stages of the Jurassic and Cretaceous. If this is so the age of the Cadomin Formation would be either late Neocomian or early Aptian.

*Summary.* The Cadomin Formation is remarkable for its length and constant lithology. It extends northeasterly along the Foothills from the Blairmore region of southern Alberta at least as far north as the Peace River, a distance of approximately 520 miles. The formation is very hard and compact and consists predominantly of the same types of chert and quartzite throughout its entire length.

Northeast and east of the present map-area, where the formation thins and finally disappears, it is concealed by younger strata. Limited information regarding the character of this subsurface part of the formation has been obtained from the logs of wells drilled for oil and gas, and it is known that several wells both in Alberta and British Columbia produce gas from a conglomeratic zone that has been correlated with the Cadomin Formation of the Foothills. If this correlation is correct, the massive, non-porous character of the rock does not persist to its eastern limit.

### *Luscar Formation*

*Distribution and lithology.* Luscar strata overlie the Cadomin Formation conformably and occupy about two-thirds of the region underlain by Lower Cretaceous beds. Like the Nikanassin, the Luscar occupies northwesterly trending bands on either side of the Boule, Berland and Hoff Ranges, and wide areas of the Foothills beyond the northwestern extremities of the Persimmon and Berland Ranges. In most places, Luscar strata appear on the map as wider bands than do beds of the Nikanassin Formation.

The formation is usually faulted and folded so that complete exposures of it are rare. Thorsteinsson (1952) records a complete section, well-exposed, below the Grande Mountain thrust on Mount Hamell and facing Smoky River. Two other complete sections recorded by the same author occur where Roddy and Malcolm Creeks cut through the Ambler Mountain anticline on the north side of Smoky River.

Some of the best partial exposures occur where Mason and Sterne Creeks cross the Susa Creek anticline, on several tributaries of Cowlick Creek, on the cliffs on the north side of Smoky River (Goat Cliffs) just north of Gustavs Flats, in the gulch on the north side of Smoky River about two miles above the mouth of Muskeg River, along parts of Sheep Creek, on several tributaries of Nickerson and Caw Creeks, and along the lower reaches of Walton Creek.

Rocks of the Luscar Formation are probably mainly of non-marine and brackish water origin. The upper part of the succession, which may be equivalent in age to the Mountain Park Formation, consists mainly of 300 to 350 feet of fine-, medium-, and coarse-grained, grey and greenish grey, buff and grey-green weathering thick-bedded sandstones. Interbedded with these are minor amounts of fine chert conglomerate, grey shale and siltstone. The sandstone beds of this part of the formation appear to become thinner and softer from southeast to northwest.

Thorsteinsson (1952) records the presence of a bed of unconsolidated, light grey clay, possibly bentonitic, between one and three feet thick, near the top of the Luscar succession. This clay was not recognized elsewhere.

Below the strata just described are the typical Luscar beds, which consist of fine-, medium-, and coarse-grained, grey and brown, buff and grey weathering sandstone and argillaceous sandstone; grey, greenish grey, and dark grey shale; coal seams, ranging in thickness from six inches to about 30 feet; and minor amounts of yellow weathering, concretionary ironstone bands associated with both shale and sandstone. Thin beds of dark chert conglomerate occur in some places but are scarce except towards the base of the section. Some coarse sandstone beds contain scattered pebbles. About three miles above the mouth of Sterne Creek 20 feet of somewhat fissile, dark grey shale containing small, unidentifiable pelecypods is probably of brackish or marine origin.

Ripple-marks are common on the harder sandstone beds and crossbedding is present in the thicker, quartzitic strata. Carbonized plant debris, stems, and pieces of wood occur in sandstone and siltstone at many places throughout the succession. Finely comminuted carbonized material gives a "pepper and salt" appearance to some beds. All gradations occur between grey shale without plant remains through black carbonaceous shale to coal.

At several places within the map-area, a discontinuous, 15- to 20-foot thick zone of conglomerate and pebbly sandstone occurs in the lower 200 to 300 feet of the Luscar Formation. The pebbles are composed of similar materials to those of the Cadomin Formation but are smaller and yield a finer conglomerate. In places where the conglomerate and pebble beds are missing the zone consists entirely of coarse sandstone.

The formation shows lateral variations in lithology within relatively short distances, but the general character of the sediments is maintained throughout the map-area. At some localities, such as near the mouth of Walton Creek, individual beds and groups of beds form lens-like units which interfinger, any one bed or group of beds being of limited lateral extent. Because of these lateral changes, no two sections can be correlated with much certainty. Coal seams are probably the best marker beds within the formation and can be correlated over short distances. Even these, however, occur at different horizons within the succession at different localities.

*Thickness.* According to Thorsteinsson (1952) complete sections of the Luscar Formation occur where Roddy and Malcolm Creeks cross the Ambler Mountain anticline, and below the Grande Mountain thrust facing Smoky River on Mount Hamell. None of these sections is wholly accessible, so detailed measurements of thickness were not made, but the thickness computed by scaling on structure cross-sections is between 2,000 and 2,200 feet. The lack of continuous marker beds or horizons makes it difficult to determine accurately the thickness by correlation between the numerous measured partial sections. Figures obtained by this method ranged between 1,800 and 2,200 feet, suggesting that the Luscar Formation is approximately 2,000 feet thick throughout this map-area, and also that there is little change in thickness from northeast to southwest. Several partial sections of the formation are given in Appendix A.

*Age and correlation.* Plant remains are common in the Luscar Formation, but well-preserved material is difficult to obtain. Fresh or brackish water fossils are scarce but where found consist of a few forms in great abundance. Usually they form coquinas of one or two species and are associated with shale.

The flora and fauna collected from the Luscar are listed in Appendix C. W. A. Bell and W. L. Fry studied the plant remains and dated them as Aptian. The non-marine fauna was studied by E. T. Tozer who made some tentative identifications, but no definite age assignments.

The plant collections are, according to Bell, typical of the Luscar Formation south of Athabasca River and the formation is therefore equivalent in age to the lower part of the Blairmore Group. On the basis of the presence of similar flora (Bell, 1956) it seems likely that these strata are also equivalent in age to the Gething Formation in the western part of the Peace River district.

The upper strata of the Luscar Formation of this map-area may be equivalent in age to part or all of the Mountain Park Formation south of Athabasca River and may be equivalent in age to the lower part of the predominantly marine Fort St. John Group of the Peace River district.

*Summary*. The Luscar Formation is present along the Foothills throughout the entire length of this map-area. It is composed of non-marine sandstones and shales with the possible exception of a 10- to 30-foot thick unit of dark grey, partly fissile shale occurring in the lower part of the formation on Sterne Creek which is probably of brackish or marine origin. It is not known whether this shale occurs in all sections.

The formation is important because of its large reserves of bituminous coal.

### *Fort St. John Group*

Lang (1947), mapping in the valley of Solomon Creek, found that the Luscar Formation was overlain by fissile, black shale and sandy shale, in which no fossils were found and which he mapped as the lower part of the Blackstone Formation. He also noted, near the site of the abandoned Shell Solomon Creek No. 1 well, a bed of sandstone approximately 20 feet thick about 400 feet above the base of the shale.

Subsequent mapping has shown that this sandstone rapidly becomes thicker to the northwest, assuming the attributes of a formation and, on faunal evidence and similarity of lithology, it has been correlated with the Dunvegan Formation of Peace River district. Since the Dunvegan Formation was considered by McLearn (1945) to be of lowermost Upper Cretaceous age it was assumed that the shales below the Dunvegan Formation, due to their stratigraphic position, represented part or all of the Fort St. John Group of Peace River district and were of Lower Cretaceous age. These shales have been referred to as 'Fort St. John' Group in previous reports on map-areas north of Athabasca River Valley.

Fossils collected by Thorsteinsson (1952) and the writer (Irish, 1954) have shown that at least the upper half of the 'Fort St. John' of these map-areas is equivalent in age to the uppermost part of the Fort St. John Group of Peace River district. The shale forms a persistent mappable unit throughout the present map-area and probably also to the northwest, and is called the Fort St. John Group in this report.

*Distribution and lithology*. The Fort St. John Group, in the southeastern part of the map-area, is confined mainly to a narrow, northwesterly trending band parallel to, and from 1½ to 3 miles northeast of the Boule and Berland Ranges. Small areas underlain by the shale also occur within the region underlain by Luscar strata northeast of the Berland Range. To the northwest of this range the group is distributed similarly to the Luscar Formation and underlies many small areas and narrow bands around numerous anticlines and synclines. Five complete sections of the group are exposed between the right-angle bend in Sulphur River just southwest of the Indian village of Grande Cache and its junction with Smoky River.

The lower contact with the Luscar Formation is abrupt, and is invariably marked by a thin bed of shale overlain by a bed of rusty weathering chert-pebble conglomerate between 1 foot and 3 feet thick. The upper surface of this conglomerate is characterized in places by symmetrical ripple-marks with an average wave length of about two feet and an amplitude of roughly 0.7 foot. The constituent pebbles are composed predominantly of dark-coloured chert and are usually between ½ and ¾ inch in diameter. At some places, however, the conglomerate is much finer, the pebbles (granules) averaging about ¼ inch across.

The upper contact with the Dunvegan is transitional and the boundary is drawn at the base of the first thick sandstone bed.

The formation consists mainly of dark grey shale and silty shale with minor amounts of interbedded grey sandstone and yellow weathering concretionary ironstone bands. A sandy and silty zone occurs between 30 and 45 feet above the base of the formation. Usually this zone consists of arenaceous or silty shale with ironstone bands, but at some localities contains beds of grey sandstone up to three feet thick. In one exposure, between the heads of Muskeg and South Muskeg Rivers, 10 to 15 feet of muddy sandstone occurs about 10 feet above the base of the formation.

*Thickness.* The aggregate thickness of Fort St. John strata appears to vary considerably, probably owing to the incompetent character of the beds and the faulting and folding to which they have consequently been subjected. Also, the overlying Dunvegan Formation undergoes lateral changes in thickness which may contribute to the variability in thickness of the underlying shales.

In the valley of Solomon Creek, Lang (1947) determined the thickness to be about 400 feet. On Sulphur River, to the northwest, several complete sections are exposed. Some of these are difficult to examine but the second section upstream from the mouth of the river was measured by Thorsteinsson and its thickness found to be 382 feet (Appendix A, Section 29). He believes this to be a minimum, as graphic measurements elsewhere indicate an average of 450 to 500 feet. Numerous partial sections throughout the map-area have been measured by the writer and the estimated total thickness of the formation is in all cases between 400 and 500 feet. The thickness of the formation indicated by the log of the Muskeg No. 1 oil well is 450 feet.

*Age and correlation.* Samples taken at 5-foot intervals from the second exposed section (Appendix A, Section 29), 2 miles upstream from the mouth of Sulphur River, were examined for microfossils by Thorsteinsson (1952). None were found.

Fish scales are common and are typical of the group within and for at least 100 feet stratigraphically above the silty and sandy zone described previously. The lower part of this zone may represent the "fish scale sand" of Stelck (1954) and other workers. Other fossils are extremely rare, only two collections having been found within the map-area. These collections, though found in widely separated localities, occurred in exactly the same way—as small pods or lenses consisting of a crushed mass of fish scales, bone, wood, ammonites, and fragments of other shells. In both cases, also, these fossils occurred within strata containing numerous fish scales.

Fossils were collected by Thorsteinsson from a zone 217 feet above the base of the formation on Pearl Creek, a tributary of Sulphur River. Thorsteinsson lists the fossils as follows (1952, p. 96):

*Neogastroplites* ex gr. *cornutus* (Whiteaves)
*Neogastroplites* aff. *cornutus* (Whiteaves)
*Neogastroplites* sp. indet.
?*Engonoceras* (sensu lato) sp. indet.
cf. *Inoceramus* sp. indet.
Gastropod, genus and species indeterminate
Barnacles (cf. *Balanus* sp. indet.)
Fish scales (in masses)
Fossil wood (in masses)

Concerning the age of this fauna, Jeletzky comments as follows:

"...All the *Neogastroplites* forms of the Pearl Creek collection are morphologically distinct from any *Neogastroplites* species hitherto described. Nor are there any forms exactly like them in the Geological Survey collections. They are also associated with certain ammonoid forms not known to occur together with the *Neogastroplites* species of the typical localities of this fauna in northeastern British Columbia, nor were any index species, such as *Posidonomya nahwisi,* of the *Neogastroplites* fauna, recognized in the Pearl Creek collection."

Jeletzky (*see* Jeletzky *in* Thorsteinsson, 1952) considered that the fauna from the Pearl Creek locality might represent a new faunal sub-zone.

The second collection was made by the writer (Irish, 1954), 110 feet above the base of the formation on the ridge between the heads of Muskeg and South Muskeg Rivers (GSC loc. 24693). It includes the following forms:

*Neogastroplites* (sensu lato) sp. A
(*Gastroplites*-like in appearance)
*Neogastroplites* (sensu lato) sp. B
(more sturdy, nodose form closer to *Neogastroplites* ex gr. *cornutus* (Whiteaves)
Numerous fish scales
Fragment of vertebrate bone
Pieces of wood

These forms were identified by Jeletzky (*see* Jeletzky *in* Irish, 1954). He commented that this fauna appeared to be the same as that collected by Thorsteinsson, but that like the Pearl Creek collection, it lacked typical *Neogastroplites* forms of the *Neogastroplites cornutus* zone.

More recently, as a result of a study of both Canadian and United States collections of *Neogastroplites,* Dr. John B. Reeside and Dr. W. A. Cobban (1960) have proposed the following subdivision of the generalized *Neogastroplites* zone in ascending order:

(1) *Neogastroplites haasi* Reeside and Cobban
(2) *Neogastroplites cornutus* (Whiteaves)
(3) *Neogastroplites muelleri* Reeside and Cobban
(4) *Neogastroplites americanus* (Reeside and Weimouth)
(5) *Neogastroplites mclearni* Reeside and Cobban

According to Jeletzky (1960) Cobban and Reeside have identified *Neogastroplites americanus* from the locality near the head of Muskeg River, and *Neogastroplites mclearni* from the collection near Pearl Creek.

These collections, then, indicate a zone towards the top of the generalized *Neogastroplites* zone and are of upper Albian age.

Stelck (1949) was first to place the boundary between the Upper Cretaceous and Lower Cretaceous within the upper part of the Fort St. John Group and to use the top of the so-called "fish scale sand" as the boundary's marker over most of the Peace River-lower Athabasca River area. This placement of the Albian-Cenomanian boundary was followed by Gleddie (1954) and many other workers. According to Jeletzky (1960) palaeontological data are sufficient to place all now known *Neogastroplites* zones into the upper Albian stage and to draw the Lower Cretaceous-Upper Cretaceous boundary in the western interior of Canada somewhere between the *Neogastroplites mclearni* and *Acanthoceras athabascense* zones. In the Peace River district therefore, the Cruiser Formation of the Fort St. John Group and that part of the upper Shaftesbury shales above the "fish scale sand" are in part, at least, of Cenomanian (Upper Cretaceous) age.

Evidence based on fossils collected by Thorsteinsson (1952) and Irish (1954) indicates that the upper part of the Fort St. John Group of this area is equivalent to the upper part of both the Cruiser Formation and the Shaftesbury and is therefore of Upper Cretaceous (Cenomanian) age.

## Early Upper Cretaceous

### *Summary of Nomenclature*

In southwestern Alberta the formations of the Blairmore Group are overlain by a thick succession of marine shales with some intercalated sandstone. This succession has been referred to as the 'Benton' or Alberta shale (Hume, 1932) and was divided into Upper and Lower Alberta Formations separated by the relatively thin 'Cardium sandstone'. Malloch (1910), when mapping the Bighorn coal basin, gave the name Bighorn to a sandstone unit that is thicker than the typical Cardium beds but which he considered to occupy the same relative stratigraphic position. He named the shales below the Bighorn the Blackstone, and those above it the Wapiabi. The upper part of the Blackstone is of Colorado age according to American nomenclature, and contains abundant *Inoceramus labiatus* as well as other fossils. The lower part of the formation contains few fossils; it was generally considered to be of early Upper Cretaceous (Colorado) age, though this tentative dating was based on lithological continuity rather than on its meagre fossil content. Above the Blackstone, the relatively sandy Bighorn Formation is also indicative of Colorado time. The succeeding Wapiabi Formation is partly of Colorado and partly of Montana age.

In the years following Malloch's work the terms Blackstone, Bighorn and Wapiabi were extended northwestward along the Foothills by various geologists. The Geological Survey adopted the name Bighorn rather than Cardium, considering it less objectionable than a name derived from a fossil and because there was a type locality designated for the Bighorn but not for the Cardium. However, in recent years, the term Cardium has come into more general use than Bighorn. Geologists working for the various oil companies have extended its use northwestward along the Foothills and eastward in subsurface correlations.

For this reason and to avoid further duplication of names, the Geological Survey conceded to the name Cardium rather than Bighorn. In a recent study of the Alberta Group, Stott (1963) has defined the Cardium Formation and designated a type section.

The Upper Cretaceous succession in the Peace River district of British Columbia, on the northwesterly continuation of the Foothills Belt, varies considerably from that outlined above. There, the lowest Upper Cretaceous strata include some shale near the top of the Fort St. John Group (Stelck, 1949). This shale is succeeded by the Dunvegan Formation and this, in turn, by the Smoky Group (Dawson, 1881; McLearn, 1918). The lower unit of the Smoky Group is the Kaskapau Formation consisting of dark, marine shale. This is overlain by the relatively thin Bad Heart sandstone formation, which is overlain, in turn, by a succession of marine shales generally referred to as Wapiabi. The group is overlain by the non-marine Wapiti Group.

In the Foothills region south of Athabasca Valley, the stratigraphic interval above the Blairmore Group and below the Cardium (Bighorn) Formation is occupied by a succession of mainly dark marine shales to which the name Blackstone Formation has been applied, and which was thought to represent the basal formation of the Upper Cretaceous series in this region. North of the Athabasca, however, the same stratigraphic interval has been found to be occupied by a somewhat different assemblage (*see* Figs. 5, 6). There, a basal section, between 400 and 500 feet thick, overlying the Luscar beds of the Blairmore Group, is composed of black marine shales (Fort St. John Group), now considered to be partly of Lower Cretaceous and partly of Upper Cretaceous age, and equivalent to

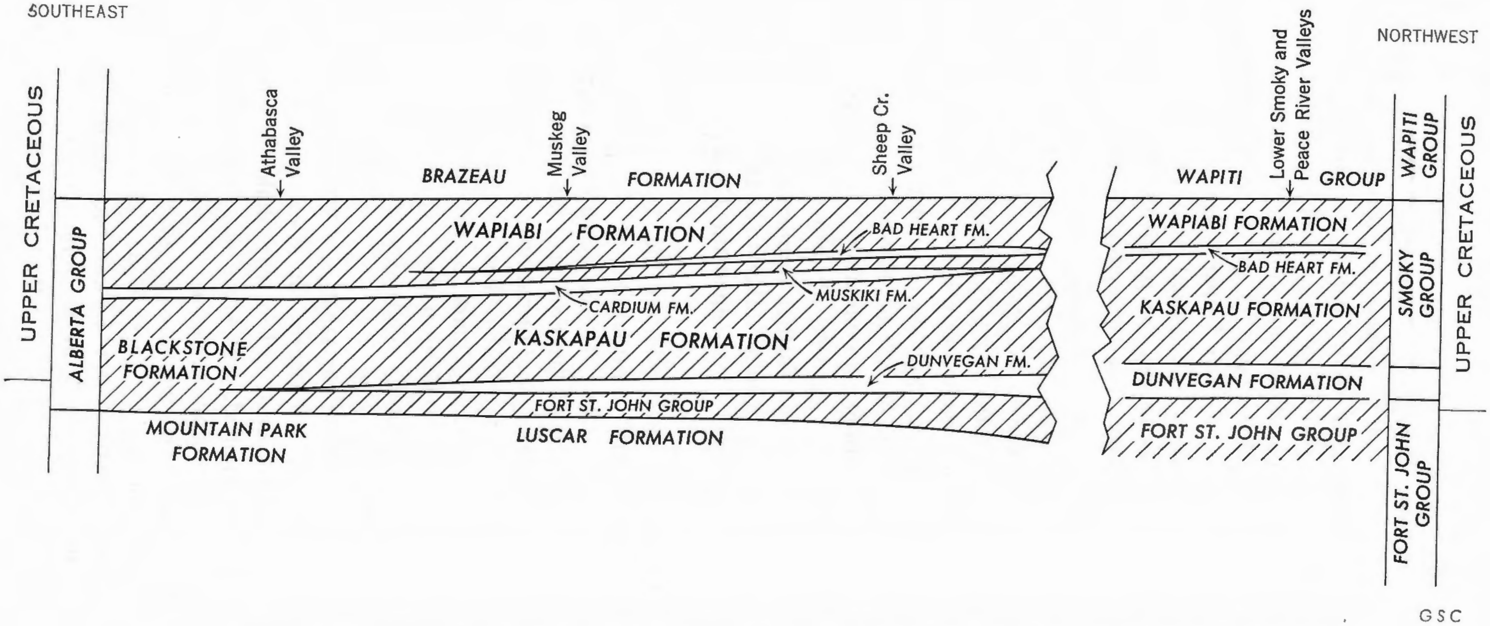


FIGURE 6. *Diagram showing changes in stratigraphy and terminology of Upper Cretaceous formations from Athabasca River to Peace River.*

the upper part of the Fort St. John Group of the Peace River district. Northwest from the Athabasca Valley, this marine shale is overlain by a gradually thickening wedge of sandstone, partly at least of marine origin, and about 400 feet thick where it reaches the northern part of the map-area. From this sandstone, fossils characteristic of the Upper Cretaceous Dunvegan Formation have been collected.

This sandstone is overlain, in turn, by 1,800 to 2,000 feet of mainly black marine shales such as comprise at least most of the Blackstone of more southerly areas. The shales are succeeded by the Cardium Formation. The Fort St. John Group of this map-area appears to maintain a generally uniform thickness southeast to Athabasca Valley. As shales of equivalent age are now known to persist for at least some distance south of the valley, beyond any recognizable extension of the Dunvegan sandstone, their lithological separation from the overlying Blackstone shales is difficult.

Recent work has shown that these Lower Cretaceous strata are present at least as far south as Cadomin, Alberta. According to Jeletzky (1960), C. R. Stelck has collected the ammonite *Neogastroplites* cf. *mclearni* from the "fish scale sand" in this district and these beds are considered to be equivalent in age to the "fish scale beds" containing *N.* cf. *mclearni* in the present area (*see* Jeletzky *in* Thorsteinsson, 1952, pp. 30-31).

The present map-area lies in the southern part of a region in which the geological succession is transitional between the more southerly and more northerly districts. In previous reports the writer continued to use the southern nomenclature when possible pending further stratigraphic and palaeontological evidence to support correlations between the two successions. This necessitated a compromise mixture of the two nomenclatures which was not satisfactory.

New evidence accumulated in recent years gives a much clearer understanding of the relationships between the southern and northern stratigraphic successions so that an effort is made in this report to clarify the earlier nomenclature. For this reason, the stratigraphic nomenclature of the northern succession is used north of Athabasca Valley. In other words, where the Dunvegan Formation can be recognized, the overlying beds are referred to the Smoky Group. The Wapiti Group occupies approximately the same stratigraphic position as the Brazeau Formation of this area and, therefore, the interval between the Dunvegan and Brazeau Formations is about the same as that of the Smoky Group in the Peace River area.

The formational name Smoky River was first used by G. M. Dawson in 1879 for the "upper dark shales" exposed on Smoky River. F. H. McLearn (1918) subdivided this formation into three members which he called the "Lower shale", the "Bad Heart sandstone", and the "Upper shale". In a later paper (1926) McLearn assigned the name Kaskapau to the "Lower shale" member. No name was given at this time to the "Upper shale" unit but in subsequent years it has been referred to as the Wapiabi Formation. Gleddie, (1949, p. 517) proposed that "where applicable, the name Smoky River be raised to group rank to include in ascending order the Kaskapau, Cardium, and Wapiabi Formations." The term Smoky River is now in general use as a group name.

The nomenclature used in this report is that proposed by the Committee on Stratigraphic Nomenclature of the Geological Survey of Canada and is as follows:

(1) The shales lying between the Dunvegan and Cardium Formations should be known as the Kaskapau Formation even though the Kaskapau Formation as originally defined by McLearn (1926, p. 119) extends upward to the base of the Bad Heart Formation and includes beds that are equivalent to and younger than the Cardium Formation. Thus in the more southern areas the Cardium Formation will overlie the Kaskapau while in areas to the north where the Cardium may not be recognized, the Bad Heart Formation will overlie the Kaskapau Formation.

(2) The shales occupying the interval between the Cardium and the Brazeau Formations or between the Bad Heart and Wapiti Formations should be known as the Wapiabi Formation.

(3) Where both the Bad Heart and the Cardium are present and recognizable as formations, the intervening shales (Muskiki Member of Stott, 1961) should be recognized as the Muskiki Formation.

The Bad Heart and Muskiki Formations, which can be recognized as separate units north of Muskeg River, are too thin to show separately on the accompanying map. Where they occur, they are therefore included with the Cardium Formation.

### *Dunvegan Formation*

The name Dunvegan was first used by G. M. Dawson (1881), and applied to what he called the "Lower Sandstones and Shales" of Pine and Peace River Valleys. The type locality is presumably the section described by him and exposed in the cliffs on the north side of Peace River, west of the Hudson's Bay Company trading post at Dunvegan on Peace River.

*Distribution and lithology.* The Dunvegan Formation has been mapped from just north of Athabasca Valley to the northern boundary of the map-area. Outcrops are widely distributed, occurring in characteristic, narrow bands whose distribution approximates closely that of the underlying Fort St. John Group.

In the southern part of the map-area the strata occur mainly as a single, narrow band to the northeast of, and parallel to, the Boule, Berland and Hoff Ranges.

Northeast of the Berland Range, where the Foothills Belt is broader, the Dunvegan continues to underlie a narrow band, but here it occurs also on the limbs of numerous small folds and commonly also around one or both noses of these structures.

Still farther to the northwest, Dunvegan beds underlie extensive areas where the formation caps high, gently folded ridges.

Dunvegan strata lie conformably above the Fort St. John Group and are in turn overlain conformably by the Kaskapau Formation. In all localities where the basal contact is exposed, a transition zone is present, consisting of silty shale with intercalated, thin sandstone beds. This is usually overlain by 30 feet of hard, grey, quartzitic sandstone, the base of which is considered to be the base of the formation for the purpose of field mapping.

Above this sandstone the strata consist of light grey and buff weathering, fine- to medium-grained, flaggy, grey to greenish grey sandstone with interbedded, grey, argillaceous sandstone, grey siltstone and grey to black shale, the relative amounts of each lithologic type varying from one locality to another. In general, thick-bedded to massive sandy beds predominate in the upper and lower parts of the formation although the lithologic units themselves are decidedly lenticular. Most of the sandstone beds are less than ten feet thick. Calcareous sandstones are present throughout the formation but are more numerous toward the top. Cross-bedding is common in the more massive beds, laminations are characteristic, carbonized wood fragments occur in numerous strata and, locally, coal seams less than two inches thick have been noted. Carbonaceous particles and small fragments are characteristic of the formation but are not present in all beds. In general, the siltstones are dark grey, argillaceous and massive. Some of these contain plant remains. Small, reddish brown weathering concretions are fairly common in some of the sandstone and siltstone units and nodular ironstone bands occur in some places. The shales vary considerably in appearance and structure. Some are dark grey, grey to brown weathering, platy to fissile, and others are dark greenish to black and weather rubbly or blocky. Much of the latter type is carbonaceous and contains plant debris.

*Thickness.* The most southerly known exposure of the Dunvegan is that outcropping in the valley of Solomon Creek where the formation consists of a single bed of silty sandstone about 20 feet thick.

To the northwest the formation thickens rapidly so that where it is cut by Little Berland River it is at least 150 feet thick although the section is not complete. On Sulphur River, Thorsteinsson (1952) obtained values of 279 and 281 feet respectively for two measured sections of the complete formation. He considers these to be minimum thicknesses because graphic measurements from structure cross-sections at other places gave values between 325 and 400 feet.

The writer measured the complete formation east of the Sulphur River exposures on a south-flowing tributary of Cowlick Creek. There the Dunvegan is apparently 530 feet thick but may be repeated by faulting since about 230 feet of the section is concealed.

Farther to the northwest complete sections could not be measured, but several partial sections gave values ranging between 350 and 500 feet, while the average obtained for the stratigraphic interval scaled on structure cross-sections was about 400 feet.

It seems, therefore, that throughout the map-area there is considerable lateral variation in the thickness of the Dunvegan strata, but in general the formation thickens progressively from southeast to northwest. To the southeast the formation is gradually replaced by siltstone and shale.

The local changes in thickness of the Dunvegan are probably due to the lenticular nature of the sediments which are in part of non-marine origin and in part of marine or brackish water origin. Detailed sections of the formation are given in Appendix A.

*Age and correlation.* Fossils are not plentiful in the Dunvegan Formation, but numerous small collections have been made throughout the map-area. Several of the species, though typical of the formation, are too long ranging to be of definite stratigraphic value. A list of the collections with the locality from which they were obtained is given in Appendix B. Fossils from the formation were identified by F. H. McLearn as follows:

*Inoceramus* cf. *tenuis* Mantell
*Inoceramus rutherfordi* Warren
*Inoceramus dunveganensis* McLearn
*Brachydontes multilinigera* Meek
*Corbula pyriformis* var. *dunveganensis*
*Corbula* cf. *nematophora* Meek
*Ostrea soleniscus* Meek
*Ostrea* sp.
*Lingula* sp.
*Campeloma* or *Viviparus* sp.
*Yoldia*? sp.
*Exogyra* ex gr. *laeviuscula* Roemer
*Unio* (*Elliptio*) cf. *sulfuriensis* McLearn

*Inoceramus rutherfordi* Warren and *Inoceramus dunveganensis* McLearn are probably the two best guide fossils in the Dunvegan Formation and, it should be noted that throughout this map-area these two forms appear to occur only in the lower part of the formation. *Brachydontes multilinigera* Meek, *Lingula* sp., and *Ostrea* are very common within the formation.

Where the Dunvegan strata outcrop in the valley of Little Berland River a one-foot-thick coquina, composed mainly of oyster shells, occurs 135 feet below the top of the formation. A similar coquina was noted in an exposure on Sheep Creek, but here it occurs about 200 feet below the top of the formation.

In the southeastern part of the map-area Lang (1947) collected the following plants from the Dunvegan Formation:

*Sequoia* sp.
*Pagiophyllum* sp. cf. *Geinitzia reichenbachii*

These were identified by W. A. Bell, who states that *Pagiophyllum* is too poorly preserved to be of any value, and the *Sequoia* by itself does not permit of any age evaluation.

The only other plant collected by the writer was from beds near the head of Little Berland River. This leaf was identified by Bell as *Magnolia* and it was found with a specimen of *Inoceramus rutherfordi*.

Until fairly recently, the age of the Dunvegan according to various authors ranged from earliest Upper Cretaceous (Cenomanian) to Belly River (Campanian); however, most students of Canadian Cretaceous faunas accepted an early Upper Cretaceous age for the formation. Following the work of Warren and Stelck (1940), the Dunvegan Formation was placed in the Upper Cretaceous and is now regarded as belonging to the Cenomanian stage in terms of European chronology.

### *Kaskapau Formation*

The term Kaskapau is in general use as a formational name. Gleddie (1954) restricted the Kaskapau Formation to the shale unit overlying the Dunvegan and overlain by the Cardium Formation when he erroneously considered the Bad Heart to be wholly or in part equivalent in age to the Cardium Formation. Subsequently, Stelck and Wall (1954) also placed the upper limit of the Kaskapau at the base of the Cardium Formation; the overlying shale unit and the Bad Heart being considered as members of the overlying Wapiabi Formation.

On the map accompanying this report the Kaskapau Formation includes all strata between the Dunvegan and Cardium Formations.

*Distribution and lithology.* The Kaskapau Formation has been mapped from southeast to northwest over the whole extent of the present map-area.

The largest region underlain by Kaskapau strata within the area consists of an irregular, northwesterly trending band along the eastern edge of the Foothills, extending from Brûlé Lake in the south to the northwestern corner of the map-area.

Southwest of the band just described, and north of Grande Cache Lake, several small synclines within a complexly folded zone are underlain by Kaskapau. To the southwest of this, the large Sulphur River syncline extends northwesterly across the map-area and is underlain predominantly by Kaskapau beds. Still farther southwest, the Roddy Creek syncline and several small unnamed synclines are underlain by the same strata.

The formation, consisting of soft, easily weathered shales, is generally expressed in the topography by broad valleys with gentle, commonly grass-covered slopes above the small canyons carved by recent streams.

Kaskapau shales overlie the Dunvegan conformably and gradationally and are in turn overlain conformably by the Cardium Formation. The strata consist generally of dark grey, fissile to thin-bedded, in part silty marine shale with numerous interbedded, thin, hard, grey, buff to yellow weathering, concretionary clay-ironstone bands.

The lower part of the formation normally consists of fissile to platy, silty, rusty weathering shale. In some places, the shale is partly calcareous and grey to light grey weathering. Interbedded yellow to buff weathering beds of grey clay-ironstone between 1 foot and 5 feet thick are common.

The upper part of the formation comprises dark grey, silty, rusty weathering shales with some interbedded thin ($\frac{1}{4}$ inch to 1 inch) siltstone beds. These shales are thin bedded to rubbly and contain a few intercalated concretionary bands of ironstone or silty limestone and a few scattered, large, lens-shaped, yellow weathering concretions. Siltstone beds become more numerous toward the top of the formation where a 15- to 25-foot-thick transition zone consists of interbedded sandstone, siltstone, and silty, somewhat concretionary shale. This zone varies throughout the map-area both in thickness and in the number and thickness of the sandstone beds but in general, individual beds range up to five inches in thickness and the number of beds increases upward. On Little Berland River a 6-foot-thick bed of hard, grey quartzitic sandstone lies about 100 feet stratigraphically below the top of the formation. On Muskeg River, a thick siltstone unit occupies approximately the same stratigraphic position.

*Thickness.* Exposures are generally poor because of the softness and ease of weathering of these shales. Also, due to greater incompetence, more complex folds and faults have been produced than in the overlying and underlying sandstone formations. The best exposures occur in canyons such as those of Sulphur River, Sheep Creek and the lower part of Muskeg River. Nowhere within the map-area is a complete section exposed, and intermittent outcrops are usually so contorted that precise measurements are impossible.

In the Brûlé-Entrance region, Lang (1946) estimated a thickness of 1,500 feet for this formation. The writer (Irish, 1947, 1951) measured the stratigraphic interval between the Dunvegan and Cardium Formations on Little Berland River and on Susa Creek and obtained results indicating a thickness for the Kaskapau of between 1,500 and 1,800 feet. The thickness of 1,800 feet is considered to be a maximum and is possibly exaggerated by minor folds and faults.

*Age and correlation.* Fossils have been collected from Kaskapau strata throughout the map-area, but they are not plentiful. Specimens of *Inoceramus labiatus* Schlotheim were collected from the upper middle part of the formation wherever these beds were exposed. Several specimens of *Prionocyclus* (*Collignoniceras*) (originally *Prionotropus*) have been collected from strata somewhat higher than those containing *Inoceramus labiatus*. Lower in the formation, a fossil zone, apparently well-defined and extensive, occurs about 115 to 125 feet above the top of the Dunvegan-Kaskapau contact. *Dunveganoceras albertense* (Warren) is the diagnostic form occurring in this zone, although it may be accompanied by several species of *Inoceramus*.

The presence of *Inoceramus labiatus* Schlotheim and *Prionocyclus* (*Collignoniceras*) indicates a Colorado age for this part of the formation and permits correlation with the middle part of the Blackstone Formation of more southerly areas, and with that part of the Kaskapau Formation of Peace River district lying stratigraphically below the Cardium or Cardium equivalents. In the Pouce Coupé region of Alberta and British Columbia the Cenomanian-Turonian boundary was first placed at, or a few feet above the top of the Pouce Coupé member which contains the *Dunveganoceras* (Late Cenomanian) fauna at that locality (Warren and Stelck, 1940, p. 144). This boundary was subsequently refined on the basis of microfaunal evidence (Stelck and Wall, 1954) and drawn at the top of the *Ammobaculites pacalis* zone, about 100 feet above the Pouce Coupé Member at Spirit River, Alberta, and 150 feet above it in the Pouce Coupé area.

In the region covered by this report and map, the *Dunveganoceras* zone is present in Kaskapau shale about 115 to 125 feet above the Dunvegan Formation. The Cenomanian-Turonian boundary here should be approximately 250 to 275 feet above the Dunvegan Formation. A Turonian age is indicated also for that part of the Kaskapau containing the ubiquitous *Inoceramus labiatus* (Jeletzky, 1960; Stelck and Wall, 1955). The fossil collections with their locations are listed in Appendix B.

### *Cardium Formation*

The term Cardium is used in this report in the restricted sense of Stott (1961) but on the accompanying map, it includes both the Muskiki and Bad Heart Formations north of Muskeg River. The term Bighorn has been used on previous maps of this Foothills region to refer either to the restricted Cardium Formation, or to those strata including the Cardium, Muskiki and Bad Heart Formations, where and when these units could be recognized.

*Distribution and lithology.* The formation has been mapped from the southern to the northern border of the present map-area. Its distribution is similar to, but not as widespread as the Kaskapau Formation. It is confined to a narrow northwesterly trending strip along the eastern side of the Foothills Belt. From Brûlé Lake northwest to about the vicinity of Wildhay River, Cardium beds dip gently and form a relatively wide band; this width is exaggerated in some places due to repetition by thrust faults. From Wildhay River to just south of Cabin Creek the formation dips very steeply and as a result, underlies a single, narrow band. North of Cabin Creek, Cardium strata occur on both limbs and around the southeast nose of the Mahon Creek anticline, along the southwest limb of the Mason syncline, and as a small patch on the crest of the Muskeg anticline just southeast of the site of Muskeg No. 1 well. Farther northwest, Cardium beds underlie bands on both limbs and around both noses of the Copton anticline except for a short distance along the southwest side where they are cut off by the Muskeg fault.

The formation overlies Kaskapau strata conformably and gradationally. The transition zone at the base has been included within the Kaskapau, and the contact between the two formations has been placed at the base of the thickly bedded sandstone. Stott (1961) places the upper contact at the top of the uppermost fine-grained sandstone unit and below the conglomerate or pebbly sandstone beds. He considers these latter beds to belong to the overlying Wapiabi or Muskiki Formation. This boundary is different from that given by Stelck (1955) in his description of the Cardium Formation in the Peace River region to the north. Here, the contact is placed at the top of the conglomerate or pebble beds (Baytree Member).

Cardium strata mainly comprise slabby, light grey, fine-, medium- to coarse-grained quartzitic sandstone; soft, grey to brownish argillaceous sandstone; grey fissile shale; brownish or greenish rubbly shale; black carbonaceous shale; thin coal seams and conglomerate. The formation is characterized by sandstone at top and bottom. The basal sandstone is thick bedded, fine grained and is probably the most persistent unit.

The sandstones are generally hard, fine to medium grained, very finely laminated, well cemented, grey, light grey to buff weathering, platy to massive, and weather to platy or slabby debris. Coarse sandstones occurring in sections near Athabasca River are mainly quartzitic but contain an abundance of dark chert grains. Ripple-marks were noted on bedding planes at some exposures. The interbedded dark grey to brownish, argillaceous sandstone is much softer. Conglomerate beds are not abundant but where present contain pebbles of grey and black chert with minor amounts of white quartzite in a quartzitic sand matrix. The pebbles are generally about the size of peas but in some places grade into a coarse sand.

Cardium shales are dark grey, platy to fissile or greenish grey, brownish to black, and rubbly or blocky. The latter type contain plant remains and some are highly carbonaceous.

The formation includes both marine and non-marine beds. Poorly preserved plant material and thin coaly seams at some localities suggest brackish water or non-marine conditions.

*Thickness.* The ridge-forming character of the Cardium Formation along the Foothills is due to the hardness and resistance to erosion of the sandstone units. On the other hand, the softer sandstone and shale units weather readily, with the result that except in a few places the complete formation is rarely exposed and outcrops are restricted to the harder sandstone. Outcrops of Cardium strata are quite numerous throughout the length of the region underlain by the formation. The formation is completely exposed only on Solomon Mountain, Little Berland River and Sheep Creek, but good partial sections may be seen in the valley of the upper part of Maskuta Creek, on the southwest-facing escarpment along the northeast side of the lower part of Muskeg River Valley, and to the northwest along the Copton anticline.

Sections of the formation in different parts of the map-area show some variation both in the thickness and position of individual sandstone beds and also in the thickness of the formation. On Solomon Mountain the Cardium, measured by Lang (1946), is 808 feet thick but more recent work has shown that the formation here may be repeated by a thrust fault. About 40 miles to the northwest the strata are only 239 feet thick on Little Berland River. It is possible that at this locality the formation is not complete, although no faulting was detected by the writer. Farther northwest on Muskeg River an approximate thickness of 254 feet was obtained, and on Sheep Creek the formation measured about 200 feet.

The thicknesses of these measured sections are in close agreement and since the three localities are roughly along the same strike structurally, little change in thickness is indicated from southeast to northwest. To the west of this band of exposures Cardium beds have been removed by erosion and to the east the Cardium Formation is not exposed at the surface and is known only from subsurface studies. It thins from west to east and the eastern edge may well be comparable with that in the Pembina oil-field.

Measured sections of the Cardium Formation are given in Appendix A.

*Age and correlation.* Few fossils were collected from the Cardium Formation, and none were diagnostic. The age of the formation in this region is therefore based on its stratigraphic position, that is, between the upper part of the *Prionocyclus woolgari* zone (mid-Turonian) above, and the lower part of the *Scaphites ventricosus* sensu stricto zone (Coniacian) below.

### *Muskiki Formation*

Where both the Cardium and Bad Heart Formations are recognized within this area, the Muskiki Member (Stott, 1961) which occurs between them is given formational rank. This formation has been included with the Bighorn Formation on previous maps of this part of the Foothills. It has not been shown separately on the map accompanying this report, but is included with the Cardium Formation.

*Distribution and lithology.* The unit can be recognized as a formation from about Muskeg River northwesterly to the northern border of the map. It consists of dark grey, platy to fissile, in part silty, marine shale interbedded with more rubbly, dark grey shale.

*Thickness.* The thickness of the formation is fairly constant where it is recognized in the present map-area. On Muskeg River about 321 feet of marine shale occurs between the Bad Heart and Cardium Formations and on Sheep Creek the unit is 285 feet thick.

*Age and correlation.* Fossils collected from this formation include *Inoceramus umbonatus* Meek and Hayden, *Inoceramus* sp. indet. (cf. *erectus* Meek), *Scaphites ventricosus* Meek and Hayden, and *Scaphites preventricosus* var. *sweetgrassensis* Cobban. According to Jeletzky this fauna is of early Upper Cretaceous age (latest Turonian-Coniacian).

In the southern part of the map-area, where the unit is not recognized as a formation, this fauna is typical of the lower part of the Wapiabi Formation.

### *Bad Heart Formation*

This unit was included with the Bighorn Formation on previous maps of this region. On the map accompanying this report it is included with the Cardium Formation.

*Distribution and lithology.* The Bad Heart can be recognized as a formation from beyond the northern border of the map at least as far southeast as Muskeg River. It is well exposed on Sheep Creek and at several places along the Copton anticline. The unit is similar lithologically to the Cardium Formation and, like the Cardium, is primarily a ridge-forming, sandstone formation containing minor amounts of shale and conglomerate throughout the region covered by this report. It consists of grey, hard, grey to buff weathering, quartzitic sandstone; argillaceous, dark grey siltstone; grey, rubbly shale and conglomerate composed of chert pebbles up to ½ inch in diameter in a sandstone matrix. The quartzitic sandstones occur in beds up to 1 foot thick.

*Thickness.* The thickness was measured only as the exposure on Sheep Creek and, at this locality, the formation is 185 feet thick. The measured section is given in Appendix A. On Muskeg River the unit is somewhat more than 21 feet thick but is poorly exposed. It probably thins southeastward but was not recognized as an individual unit south of Muskeg River. The measured section is given in Appendix A.

*Age and correlation.* Fossils collected from this formation include *Cardium pauperculum, Scaphites (Clioscaphites) vermiformis, Inoceramus* sp. indet. (? ex gr. *lobatus*). This fauna, though not diagnostic, is considered to be of Santonian age by Jeletzky. Where the Bad Heart is not recognized as a formation, this fauna occurs in the lower but not the lowest part of the Wapiabi Formation.

### *Wapiabi Formation*

The formational name Wapiabi was first used by Malloch (1911). His type section is on the more southerly of the two main branches of Wapiabi Creek which gives the formation its name. The section measured at this locality is 1,135 feet thick but the total thickness of the formation was considered by Malloch (1911, p. 22) to be much greater.

In this report the term Wapiabi refers to the shale succession which, in the southern part of the map-area, lies between the Cardium and Brazeau Formations and which, in the northern part of the map-area, lies between the Bad Heart and Brazeau Formations.

The marine Chungo (Solomon) Member which was included with Brazeau strata on previous maps of this region is in this report considered as a member of the Wapiabi Formation.

*Distribution and lithology.* The formation has been found to be present northwestward along the Foothills from its type area in the Bighorn Basin to the present map-area, within which it has been mapped from the southern to the northern border. Wapiabi strata typically underlie long, narrow belts along the eastern edge of the Foothills. In some places in the southern part of the map-area several narrow bands are present due to repetition by folding or faulting. Northwest of Berland River where the Foothills region is wider, these beds underlie broader belts on the flanks of the Mahon Creek anticline, Mason syncline and along the Muskeg anticline. Still farther north they underlie narrow bands on either flank of the Copton anticline. Because of its soft nature the formation does not outcrop well and therefore its distribution is known chiefly from the position of the underlying Cardium or Bad Heart and overlying Brazeau sandstones, which outcrop prominently.

The lower contact with the Cardium is quite abrupt in most places and may be disconformable although beds above and below the boundary are essentially parallel and no features suggesting erosion were seen at the top of the Cardium beds. Lowermost Wapiabi beds range from silty shale to argillaceous sandstone at different localities.

Several writers have subdivided the Wapiabi into units based on lithological differences. Webb and Hertlein (1934) divided the formation into 4 units: a "lower Concretionary Shale zone", a "Platy Shale", an "Upper Concretionary Shale zone", and a "Transition zone". In 1942, Hake, Willis and Addison published a paper in which five divisions of the Wapiabi are given. Scott (1951) also recognized five divisions which are close to those of Hake, Willis and Addison. More recently Douglas (1956) and Stott (1956) have divided the formation into seven separate lithologic units. In all cases the different units have been given descriptive names based on lithologic or structural features of each. Stott (1961) has renamed some of these units.

The formation is described generally in this report, and for more detailed treatment the reader is referred to the publications of the above authors.

The Wapiabi Formation consists predominantly of dark grey, soft, fissile shale and dark grey, silty or sandy, rubbly shale, with interbedded dark grey siltstone and minor amounts of fine-grained sandstone and ironstone both as thin bands and individual concretionary bodies. The basal part of the formation, about 200 feet thick, consists of platy to fissile shale and grey, rubbly shale. In some places the two types alternate and give a banded appearance where weathered. This unit is overlain by 20 to 50 feet of dark grey, brown weathering siltstone, silty shale, and/or fine-grained, argillaceous, buff weathering sandstone. The sandstone beds are from 1 to 2 feet thick.

The two lower units described above are correlated with the Muskiki and Bad Heart Formations respectively which are present in the northern part of the map-area.

Between the siltstone-sandstone unit and the Chungo (Solomon) Member the formation is composed of dark grey, fissile to platy, grey to rusty weathering shale and silty shale. The lower part of this unit contains minor amounts of thin bands ($\frac{1}{2}$ inch to 2 inches) of siltstone and intercalated yellowish or red-brown weathering, continuous and discontinuous bands of clay ironstone, from one inch to two feet thick. Ironstone also occurs as irregularly shaped individual concretions.

The shales of the middle part of the unit are less silty and, in places, calcareous. They contain scattered, large (up to four feet across), yellowish weathering, lens-shaped and irregular bodies of argillaceous or dolomitic limestone.

The upper part of the unit consists of a more blocky shale or silty shale and is again characterized by banded ironstone or individual reddish or yellowish weathering concretions.

The overlying Chungo (Solomon) sandstone member consists of 80 to 100 feet of hard, fine-grained, greenish grey, buff weathering sandstone that is lithologically much like the Cardium Formation. The upper half of the member is rather massive but the lower half is thin-bedded and typically slabby weathering. The lower contact is gradational and minor amounts of sandy shale are interbedded with the sandstone. Throughout a large part of this map-area the Solomon member is distinctly ridge-forming and is an excellent horizon marker.

Above the Chungo Member are about 75 to 100 feet of dark green and grey, argillaceous sandstone, grey, silty shale, and a few beds of hard, grey sandstone. This unit, which contains much poorly preserved plant material, forms a transition zone between the Wapiabi and the overlying non-marine Brazeau Formation.

*Thickness.* Wapiabi strata are soft, weather readily, are very often contorted due to faulting and folding and usually form gentle slopes covered with grass or other vegetation. For this reason good exposures of the formation are rare. Small scattered outcrops are typical of areas underlain by Wapiabi strata although larger exposures occur, particularly where large streams have cut small canyons through the formation.

Due to incomplete exposure, values for the thickness are based mainly on measurements of the interval between the Cardium and Brazeau Formations and between the Bad Heart and Brazeau Formations. On Maskuta Creek and on Solomon Mountain, Lang (1946) estimated the thickness to be about 1,600 feet and, farther north on Little Berland River, the writer considered the formation to include about 1,500 feet of strata. With the Chungo sandstone and overlying transition units now included with the Wapiabi, these thicknesses are increased respectively to about 1,800 and 1,700 feet. Measurements made north of Sheep Creek were originally recorded as being between 975 and 1,000 feet. The revised thickness, which includes the Solomon and transition members, is between 1,175 and 1,200 feet. Most of this apparent thinning from southeast to northwest is accounted for by the fact that north of Muskeg River the lower boundary of the Wapiabi is taken at the top of the Bad Heart Formation. This is roughly 400 feet higher stratigraphically than the lower contact with the Cardium in areas where the Bad Heart is not recognized as a formation.

*Age and correlation.* Where the Muskiki and Bad Heart Formations are not recognized as such, the faunas typical of those units occur in the lower part of the Wapiabi Formation. Therefore, in the southern half of the map-area the lowermost strata of the Wapiabi are of Coniacian and Santonian ages. A fauna younger than those already described occurs about the middle of the formation in the zone of calcareous shale. This appears to be about the same stratigraphic position as the "Platy Zone" of Stott (1956). This fauna, identified by Jeletzky, includes *Scaphites* (*Clioscaphites*) cf. *montanensis* Cobban, *Inoceramus lobatus* var. *lundbreckensis, Inoceramus cardissoides* Goldfuss cf. var. *pachtii* Arkh., *Inoceramus* cf. *fragilis* Hall and Meek var. *prairiensis* McLearn, and *Baculites* cf. *asper* Morton.

Jeletzky's comments on this fauna are as follows: "These are considered to represent the zone of *Scaphites* (*Clioscaphites*) *montanensis* and are already of the Santonian age in terms of the International standard stages. The occurrence of *Inoceramus* ex gr. *lobatus-cardissoides* confirms the above conclusion and the overlap of the lower parts of *Baculites ovatus* and *Inoceramus* ex gr. *lobatus-cardissoides* zones of McLearn (1937, p. 116) with those of the late members of the *Scaphites ventricosus* species group. These are considered to be correlative with the very late, but not the latest, part of the Wapiabi shale of the southern Foothills and late, but not the latest, part of the upper Alberta shale of the southern plains."

The following fossils, identified by McLearn, were collected from the Chungo Member but are of little value for age determination: *Baculites* sp., *Dosinopsis* sp., *Polinices*? and other gastropods.

Upper Cretaceous formations so far described can be correlated with formations south of Athabasca River and also with the succession in northwestern Alberta and northeastern British Columbia.

The Cardium Formation of this map-area can be traced for many miles southeastward and, although diachronic, is an excellent marker. By means of this unit and because of widespread diagnostic faunas, the Kaskapau Formation can be correlated with most of the Blackstone Formation of the type area (Malloch, 1910). The lower part of the Blackstone south of Athabasca River as far south as Nordegg and Cadomin is equivalent in age to the Fort St. John Group and Dunvegan Formations of this region. The combined Kaskapau, Cardium and Muskiki Formations, as the terms are applied in this report, are equivalent to the Kaskapau of the type area in the Peace River district (McLearn, 1926). The Bad Heart Formation is correlated with the Bad Heart of the type area in the Peace River district (McLearn, 1918) and the overlying Wapiabi Formation in the northern half of this area is equivalent to the "Upper Shale" of McLearn in Peace River district. In the southern half of the present map-area the Wapiabi Formation includes at the base equivalents of the Muskiki and Bad Heart Formations and is equivalent to the Wapiabi of the type area.

The Chungo Member is analogous to all or part of what has been called the "Solomon sandstone" and "Transition Member" in some areas and is probably equivalent in age to the Chinook Member of northeastern British Columbia and northwestern Alberta.

### *Summary of Early Upper Cretaceous*

The early Upper Cretaceous of this region consists of a succession of alternating or interfingering, mainly marine shale and sandstone formations ranging in age from Cenomanian to Santonian. The sandstone units increase in thickness and number from southeast to northwest and thin from west to east. For the most part, these formations occur as narrow bands along the eastern edge of the disturbed belt. The shale units are usually contorted and faulted.

Typical sandstones of the different formations are very similar and are generally composed of quartz and chert in the ratio of about 60 to 70 per cent quartz to 5 to 15 per cent chert; the remainder of the rock is a clayey matrix. The proportion of matrix to sand grains varies in different beds. Rarely, as in some lower beds of the Cardium Formation, silica deposited in optical orientation of the quartz grains has produced an interlocking texture similar to that of quartzite. Usually the rounded outline of the original grains can be seen in a thin section where they are outlined by a film of dust. Feldspar is not a conspicuous constituent but mica, as small flakes, is particularly noticeable along bedding planes. Glauconite is known to occur near the base of the Chungo Member. Carbonate is known to be present in some sandstones at some places, but the extent of its distribution and its relative abundance is not known. The Dunvegan Formation contains much carbonate in some beds.

The conglomerates are similar in all formations. They consist of pebbles composed predominantly of dark chert but with minor amounts composed of white quartz and quartzite and rarely, of sandstone and shale. Normally the pebbles are not closely packed and the amount of matrix may make up about 50 per cent of the rock.

The marine shales and silty shales are quite similar throughout and the rusty colour when weathered is typical of parts of all the shale formations and is probably due to the oxidation of iron. Encrustations of iron-bearing sulphate are also a common feature of the shale. During late summer the concentration of these salts in many streams issuing from the shale is so high that the water is bitter and unpalatable.

The ironstone concretions are similar in each formation. These are usually composed of a mixture of clay and siderite. The characteristic colour when weathered is due to oxidation of the iron carbonate. Many of these contain fossils and some in the Wapiabi Formation have irregular cores of white carbonate.

## Late Upper Cretaceous and Tertiary

### *Summary of Nomenclature*

The Wapiabi Formation is overlain conformably by several thousand feet of non-marine sediments of late Upper Cretaceous and early Tertiary age.

The exact age and terminology of this thick sequence of non-marine strata and the precise delimitation of the Cretaceous-Tertiary boundary in many parts of Alberta are still unsolved problems. The difficulty is caused by the great thickness of strata of fairly similar lithology, the lack of horizon markers, and the scarcity of fossils other than plant remains. Many changes of correlation and revisions of terminology have been made as the study of these strata has progressed.

In the Foothills of southern Alberta the Upper Cretaceous strata above the Upper Alberta or Wapiabi formation have long been divided into the Belly River, Bearpaw, and Edmonton Formations, all of which are of Montana age. The Belly River is non-marine, the Bearpaw is marine, and the Edmonton is non-marine. This is an ideal classification where the Bearpaw occurs, but it disappears to the west and northwest, and where it is not present, the Edmonton has not been satisfactorily separated from the Belly River.

The Edmonton is overlain by the Paskapoo Formation, of Paleocene age, composed of sandstone, shale, and conglomerate, with some coal. In places a disconformity has been observed at the base of the Paskapoo (Allan and Rutherford, 1923, p. 39; Allan and Sanderson, 1945), but where neither this disconformity nor diagnostic fossils are found, it may be difficult to separate the Edmonton from the Paskapoo.

In the Bighorn coal basin Malloch (1911) found that the Bearpaw was absent, and applied the name Brazeau Formation to some 1,700 feet of non-marine beds overlying his Wapiabi Formation. From their lithology and the few fossil remains found in them, he considered them the approximate equivalent of the Judith River (Belly River) Formation. These are the youngest consolidated sediments in the Bighorn area, and therefore the upper limit of the Brazeau Formation was not defined.

In the central Foothills, where the Bearpaw is absent, Allan and Rutherford (1923) and Rutherford (1925) gave the name Saunders Formation to all the strata above the Wapiabi. This was thought to be mainly Upper Cretaceous and to be essentially equivalent in age to the combined Belly River, Bearpaw, and Edmonton strata of more southern areas where the Bearpaw could be identified, though it was suspected that the uppermost beds might be correlative with part of the Paskapoo. Subsequent work by Rutherford (1926) between Athabasca and Embarras Rivers supplemented by the identification by P. S. Warren of many fossil invertebrate and plant collections, indicated that in that area a minimum thickness of 5,300 feet of strata above the uppermost main coal seams of the Coalspur field might be early Tertiary, but older than the Paskapoo. Rutherford concluded, however, that these strata were probably equivalent to the Edmonton Formation.

L. S. Russell, who was the first to describe Paleocene fossils from Alberta, published a general paper on the Cretaceous-Tertiary transition in Alberta (1932), in which he discussed the Saunders Formation in the vicinity of McLeod River. He concluded that the part of the Saunders including and above the McPherson Creek coal seams was Lower and Middle Paleocene, from the evidence of freshwater molluscs and mammalian teeth, and that these strata were overlain by Upper Paleocene beds equivalent to the Paskapoo Formation.

MacKay (1930) traced the Brazeau Formation from the Bighorn area to the Coalspur district where it was found to be equivalent to the Saunders Formation of that district, and the name Brazeau was retained by him on the basis of priority. As used by MacKay on the Cadomin sheet (1929b) the Brazeau Formation included the coal measures of the Coalspur region.

More recently MacKay, in preparing a series of preliminary geological maps of the Wapiabi Creek, George Creek, and Pembina Forks map-areas and the Wawa Creek area, and in compiling a more general preliminary geological map of the Foothills Belt of central Alberta, subdivided the post-Wapiabi strata into a lower or Brazeau Formation, believed to be the approximate equivalent of the Belly River Formation, and an upper or Edmonton Formation, which was considered to be the equivalent of the formation of that name in the western Alberta plains, and which carried important coal measures. In making this separation without the intervening guide furnished by the marine Bearpaw Formation of more southern and eastern areas, he placed the contact at a conglomerate that lay about 900 feet below the lowest main coal seam, a horizon that seemed to correspond approximately with the base of the Edmonton as observed in areas to the southeast where remnants of the marine Bearpaw could still be identified. MacKay recognized that the Edmonton Formation as mapped above the Brazeau may have included strata lithologically like the Paleocene Paskapoo Formation and the base of the Paskapoo was drawn at the bottom of a thick bed or series of beds of massive, hard, brown weathering sandstone that lay about 3,000 feet above the assumed base for the Edmonton. Only in the Wawa Creek map-area was any attempt made to map the Paskapoo separately from the Edmonton; in other areas the combined Brazeau and Edmonton Formations, together with such Paleocene strata as might be present but undifferentiated from the Edmonton, constituted essentially what had been referred to many years earlier by MacKay as the Brazeau Formation of the Mountain Park and Cadomin areas, and as the Saunders Formation in areas mapped by Allan and Rutherford between North Saskatchewan and Athabasca Rivers.

In the early history of the use of the term Saunders Formation, attempts had been made to effect a workable subdivision of the thick series of strata represented. The division proposed was threefold, and consisted of a Lower Saunders Formation, an intermediate or Saunders Coal series, and an Upper Saunders Formation, the lower two divisions regarded as entirely Upper Cretaceous, and the Upper Saunders as in part or entirely Paleocene. Difficulty, however, was experienced in attempts to maintain this subdivision across the various areas being mapped, and in more recent years the subdivision names have not been used, and the succession of post-Wapiabi strata, as proposed by MacKay, into Brazeau, Edmonton, and Paskapoo Formations has been the one most generally employed.

The procedure adopted by MacKay was followed by Lang (1947) in mapping the Entrance area, and the name Entrance conglomerate was given by Lang to a bed of conglomerate considered to be the base of the Edmonton Formation.

In 1945, W.A. Bell of the Geological Survey obtained collections of fossil plants from several localities that he visited in the Foothills. His object was, in part, to place more certainly the boundary between the Upper Cretaceous and the Paleocene. Collections made from the top of the Mynheer, or lowest, coal seam at Coalspur and Sterco were identified by Bell as definitely of Paleocene age. This horizon is well below what had formerly been regarded as the probable upper limit of the Upper Cretaceous succession, and the flora collected was considered to be of approximately the same age as that of the Paskapoo Formation at its type locality. Other collections obtained near Entrance, and not far below the Entrance conglomerate, were identified by Bell as Upper Cretaceous, probably of Edmonton age. On the basis of these determinations it appears reasonably certain that all strata in this region down to the Entrance conglomerate, including both the upper coal-bearing part of the Saunders Formation of Allan and Rutherford, and the Edmonton Formation of MacKay, are of Paleocene age. It appears that the only possible equivalents of the Edmonton Formation would be strata lying stratigraphically below the Entrance conglomerate within what has been mapped as the Brazeau Formation. The inclusion of the coal-bearing strata in the Paleocene corroborates Rutherford's earlier report (1926), in which all beds above the uppermost coal seam of the Coalspur field were regarded as probably Paleocene. Bell's recent work also corroborates Russell's conclusions (1932) regarding the Cretaceous-Tertiary transition in the vicinity of McLeod River. The use of the name "Paskapoo" for these Tertiary strata may not be appropriate, however, because no appreciable quantity of coal is known in the type areas of the Paskapoo.

In this report the term Brazeau is used in the sense originally applied by MacKay (Map 209A, Cadomin sheet) for all post-Wapiabi Upper Cretaceous strata. These are thought to be mainly of Belly River age, but may include some Edmonton equivalents at the top.

### *Brazeau Formation*

The Brazeau Formation was named by Malloch (1911) from the Brazeau River in the Bighorn area and his type section was measured on the more southerly of the two main branches of Wapiabi Creek. This formation, of late Upper Cretaceous age, lies conformably above the Wapiabi and underlies the greater part of the northeastern half of the map-area. The upper part of the formation may contain equivalents of the Edmonton Formation.

*Distribution and lithology*. The Chungo Member of the Wapiabi Formation is overlain by 75 to 100 feet of soft, dark green and grey sandstone and sandy shale which contains much poorly preserved plant material and is transitional between the underlying marine sandstone and the overlying non-marine beds.

Overlying the transition beds are the typical and distinctive pebble beds and conglomerate of the Brazeau formation; the lower of these are massive pebble conglomerate, but above them stratigraphically the amount of conglomerate decreases until sandstone is predominant, with only thin beds and lenses of conglomerate. The beds are composed of pebbles of chert and quartzite, averaging one-half inch in diameter, in a sandy matrix. Some beds contain carbonized wood fragments, and large-scale crossbedding is a conspicuous feature.

Although the zone can be recognized throughout the map-area, individual beds and lenses within it have no great lateral extent. It is about 1,500 feet thick in the southeastern part of the area but appears to be only about 800 feet thick northwest of Copton Creek. The nature of these strata is such that their total thickness probably is different at each locality.

The remainder of the formation consists of about 5,000 feet of interbedded medium- to coarse-grained sandstone and grey shale with minor amounts of black, carbonaceous shale and several hard, grey beds of water-lain ash and thin coal seams. The sandstone is light to dark grey and greenish grey, weathers greenish grey to buff, and much of it is crossbedded. Carbonized wood fragments, zones of shale inclusions, and scattered pebbles are common. The inclusion of minute fragments of lignitic material gives some beds a "pepper and salt" appearance. The shales are mainly grey and greenish grey, but some black, carbonaceous beds occur. Thin, impure, rusty weathering ironstone layers are present in some places. The uppermost stratum classed as Brazeau is a distinctive, massive bed of grey, buff weathering sandstone about 70 feet thick. A railway-cut in this bed three-quarters of a mile west of Entrance exposes a large fossil tree stump.

*Thickness.* No complete section of the formation is exposed within the map-area. Good outcrops occur on McLeod River north of its confluence with Gregg River. Some of the lower beds are exposed on Solomon Mountain, on the ridge near the Athabasca fire lookout tower, on Little Berland River, and on Muskeg River where they occur on the southwest flank of the Mason syncline. Poor exposures, mainly of the lower part of the formation, can be seen on both sides of Smoky River east of the mouth of Muskeg River and along a series of ridges east of the Copton anticline. Scattered outcrops (mainly sandstone) of the higher strata are present on the most easterly hills and ridges.

The best and most complete section of the Brazeau Formation is that exposed along Wildhay River. No attempt was made to measure this accurately because the numerous shale beds are rarely exposed and there is the possibility of repetition by faults and small folds that cannot be recognized. Also, the lack of key horizon markers prevented compilation of an adequate composite section. The thickness of the Brazeau Formation as indicated by structure cross sections is approximately 7,000 feet. Any faulting or sudden change of dip would tend to reduce this graphical estimate of the thickness.

*Age and correlation.* Plant remains are common in both sandstone and shale, and were seen at many places throughout the area, but identifiable fossil plants were collected at only a few localities. These fossils were identified by W. A. Bell and the collections are listed in Appendix C.

Scattered dinosaur bones and teeth occur in these beds at several localities near Entrance. Mr. R. C. Sibley, formerly Canadian National Railways station agent at Entrance, made a large collection of these and sent some specimens to Dr. Barnum Brown of the American Museum of Natural History, who is said to have reported to Mr. Sibley that they were probably wash accumulation; that a tooth was probably from *Gorgosaurus libratus*; and that a toe bone was probably from *Corythosaurus* (*Casuarius*?). *Corythosaurus* is a typical Belly River dinosaur, and *Gorgosaurus* is also found in the Belly River Formation (*see* Lang, 1946, p. 34).

The palaeontological evidence indicates that these strata are of late Upper Cretaceous age, but is not sufficiently definite to indicate whether the entire succession is equivalent to the Belly River or whether the upper part may be equivalent to the Edmonton Formation.

### *Paleocene*

*Distribution and lithology.* Strata along the extreme northeastern border of the map-area may be of Paleocene age. The beds are similar to and conformable with strata that are known to belong to the Brazeau Formation, but it is probable that some are younger than Upper Cretaceous. Where the Entrance conglomerate is known to be present, that is, from the southern border of the map to a point just northwest of Moberly Creek, a rough separation of the Upper Cretaceous and Paleocene strata is possible but north of Moberly Creek, where the conglomerate is either missing or does not outcrop, a division between the two is not practical at this time.

In the southeastern part of the map-area the uppermost massive sandstone bed of the Brazeau Formation is overlain conformably by the Entrance conglomerate. This member has an average thickness of about 20 feet, but is about 50 feet thick at Entrance. It consists of closely packed pebbles of quartzite and chert averaging one to two inches in diameter, although some are as much as six inches. The matrix is sandy, and the rock fractures around the pebbles. In places the bed is all conglomerate; elsewhere sandstone is interbedded, but generally there is little difficulty in recognizing the member, as the pebbles are larger and more closely packed than in the pebble beds of the Brazeau Formation.

The Entrance conglomerate outcrops prominently on both flanks of a broad syncline that plunges to the southeast, causing the conglomerate to form a well-defined "nose" near Entrance. The conglomerate is repeated on the northeast limb of the Prairie Creek anticline, where it is exposed on a ridge 2½ miles north of Entrance. This band is exposed intermittently in a northwesterly direction to a point just north of Moberly Creek. North and northwest of this point the Entrance conglomerate has not been recognized.

Overlying the Entrance conglomerate is a thick succession of relatively soft interbedded sandstone and shale beds, with minor conglomerate, bentonitic beds, and coal seams. The sandstone is generally rather coarse and much of it is crossbedded. It is grey and weathers grey, brown and green. The shale is generally greenish grey and clayey. The conglomerate consists of pebbles and cobbles of waxy-lustred quartzite up to 12 inches in diameter, and ranges from streaks as wide as one pebble or cobble to beds about 10 feet thick. Scattered pebbles ranging in diameter from ½ inch to 4 inches are common in nearly all the sandstone. Carbonized remains of wood fragments are also common.

Strata lithologically and stratigraphically similar to those described above overlie the Entrance conglomerate in the syncline that extends southeast of Entrance and includes High Divide Ridge. The only outcrops on the upper part of this ridge are of cobble-conglomerate, which is loosely cemented and does not outcrop well. The entire ridge is strewn with loose cobbles, which suggests that the upper part is composed essentially of conglomerate that has been folded with the underlying strata. The base of the conglomerate is estimated to be about 3,500 feet above the Entrance conglomerate, and the stratigraphic interval above the base to the summit of the ridge is about 1,500 feet. As there is no evidence of a disconformity between these essentially conglomeratic beds and the underlying strata, they are assumed to be stratigraphically equivalent to the strata lying 3,500 feet and more above the Entrance conglomerate farther to the northwest, which contain more sandstone and shale than conglomerate. The preponderance of conglomerate on High Divide Ridge is consequently believed to be the result of local accumulation.

*Thickness.* Outcrops of these Paleocene beds are scarce, so that no sections could be accurately measured. The strata extends to the east and northeast beyond the border of the present map-area so that no estimate of their total thickness could be obtained. Graphical measurements, however, indicate that there are, within the boundaries of the map, at least 4,000 feet of these beds.

*Age.* Several collections of fossil plants have been obtained from these strata in the southern half of the map-area. This flora was identified by W. A. Bell who concluded that most specimens are indicative of the Paleocene although several genera may be of either Upper Cretaceous or Paleocene age.

These collections are listed with their localities in Appendix C.

### *Summary of Late Upper Cretaceous and Tertiary*

This succession of non-marine strata, thought to be between 10,000 and 11,000 feet thick, underlies most of the map-area east of the disturbed belt. The beds are characterized by gentle dips to the northeast with some local reversals due to gentle folding or warping. Exposures are generally poor so that structures are difficult to define and faults may be obscured.

Sandstone and shale are the two main rock types. Most of the sandstones are softer and more readily weathered than those of the older, underlying, marine formations. They range from thin and evenly bedded to massive and coarsely crossbedded and are very similar, so that no bed is reliable as a marker over any great distance.

Some sandstone beds contain much carbonaceous material as fine particles and these impart a "salt and pepper" appearance to the rock. Other beds contain large and small inclusions of shale, clay and wood. Many sandstone beds weather in the form of "hoodoos". Several grey, hard ash beds occur in the lower part of the formation.

The shales are mainly greenish or greyish in colour, lack fissility and weather rubbly. Some black, carbonaceous shale occurs in the vicinity of coal beds. Both shale and sandstone beds contain much fossilized plant material. Coal seams occur but are usually poorly exposed. Some coal contains small blebs of fossilized pitch.

## Pleistocene and Recent

Glacial gravel and boulder clay mantle a large part of the map-area. Toward the west, boulder clay and poorly sorted to well-sorted sands and gravels form thick deposits confined mainly to the larger stream valleys. Thick deposits of gravel underlie the wide preglacial valleys described in Chapter II. The pebbles and boulders of this material consist of conglomerate, sandstone, limestone, quartzite and chert, all of which rock types are characteristic of the formations of the area.

The large terraces that flank Athabasca River and those along most of the other major streams have been mentioned in Chapter II, in the section on topography. These are composed of reworked glacial debris that was probably transported and deposited by the meltwater at the close of glacial time. Most of this material is coarse gravel that was likely deposited by moving water, but there are also beds of fine gravel, sands and silt. The large deposits of water-lain silt and loess east of Brûlé Lake have already been described, as have the alluvial fans along the shores of the lake.

Large accumulations of talus occur in and close to the mountains. On the slopes of all the mountain ranges are water-courses heaped with slightly rounded talus that is transported periodically by the spring run-off.

Deposits of fine silt and sand cover most of the river flats throughout the area. This accumulation is added to annually, or whenever floodwaters cover the flats.

Small deposits of calcareous tufa occur as coating on gravel or rock in numerous places. They are being deposited by ground water that leaches the calcium carbonate from limestone or, where they are far from limestone bedrock, the source is doubtless in the glacial material.

## *Chapter IV*

# STRUCTURE

## General Statement

Most of the map-area is located in the Foothills Belt, a structurally deformed region of western Alberta which lies along the eastern border of the Rocky Mountains. The southwestern part of the map-area includes parts of four ranges of the Rocky Mountains. Figure 1 shows the geographical and structural setting.

The scale on which the accompanying map is compiled has necessitated some generalization, and for this reason some of the more complex structures have been simplified by the omission of small faults and folds. Some corrections have been made where more recent field studies have shown the original interpretation to be incorrect. For more detailed information the reader is referred to the various individual maps from which the compilation was made.

Relief of diastrophic stresses has resulted in sub-parallel thrust faults and folds, all of which trend generally about north 50 degrees west. In detail, the fold axes tend to be irregular and in places are *en échelon.* Normally the anticlines form ridges and the synclines, valleys, but to some extent the folds are independent of the topography. Most of the anticlines are narrow and compressed relative to the synclines.

The outlying mountain ranges included within the map-area are formed of massive Palaeozoic carbonate rocks thrust relatively to the northeast along southwest-dipping faults. These ranges generally present scarp faces to the northeast (Plate IVB), slope southwest with the dip of the bedrock, and plunge or die out to the northwest. The Mesozoic formations have been more severely contorted than the more massive and relatively more competent Palaeozoic rocks (Plate VA, B).

### Faults

Thrust faulting is the most important type of structural deformation within this map-area, and although a few northeast-dipping faults have been mapped, the large majority dip to the southwest. The more important faults have been named (*see* Structural Map, in pocket).

The faults range from less than a mile to many miles in length, and from minute movements along small fractures to displacements of thousands of feet. The surface traces of all faults are somewhat sinuous along the strike although they maintain a general northwest trend. In detail, however, some parts of a fault trace may be straight and other parts very irregular, a condition which indicates changes in dip of the fault surface. Although some of the thrusts are of considerable length, the relief of stress in most cases appears to have been distributed over two or more shorter breaks. In such cases the faults are *en échelon* in character; that is, as one ends, the movement is taken up on another more or less parallel and adjacent fault.

The actual fault surfaces are rarely exposed, so that their positions are in most places approximate or inferred from the distribution of the strata. Above timber-line in the mountainous regions some faults are readily traceable for limited distances because of the excellent exposure of the strata repeated by the faults. In a few places parts of the fault surface may be seen in section. Where such sections are visible the angle between the bedding and fault surface is rarely more and usually less than 30 degrees. Two very small thrusts of a few feet displacement were seen to pass downward into bedding planes.

The fault surfaces themselves are not conspicuous even where large stratigraphic displacements occur. Where the fault could be observed in section, little or no gouge occurs and in many cases the break is not wider than one inch. Some fracturing is usually present on either side of the fault surface but is confined to a narrow zone only a few feet wide.

## Folds

Within the map-area folds range in size from small drags to large anticlines and synclines more than a mile across. Several of these folds extend unbroken for many miles but the majority are either overridden by faults at one end or the other, are replaced by smaller structures, or are complicated by having smaller folds superimposed on their flanks. Some of the smaller single folds, both anticlines and synclines, are canoe-shaped.

Symmetrical folds occur, but the strike of the anticlines and synclines and the dip of their axial planes commonly change from place to place along the length of the structure. The steeper limb may be to the southeast at one place and to the northeast at another. Overturned folds are not common, but do occur locally immediately in front of the larger thrust faults (Plate I). Strata are here overturned to the northeast.

Both anticlines and synclines are rather compressed, with the synclines usually having more gently dipping limbs than those of the anticlines. Along the eastern edge of the Foothills Belt all folds are gentle and open.

The majority of the folds are underlain by thrust faults along at least a part of their lengths, and at several places some of these faults can be seen to be folded together with both the overlying and underlying strata.

Rock outcrops are relatively few in areas underlain predominantly by shale such as the Lancaster and Sulphur River synclines. It is very probable, therefore, that such structures are more complicated than is indicated on the map.

Thrust faults are the dominant structural features within the map-area. Some of these are larger and more important than others and some divide the area into units for descriptive purposes. With the exception of de Smet Range and parts of the Foothills Belt, each unit is considered to be largely underlain by a major southwest-dipping thrust fault, the name of which is extended to the overlying block of strata as far southwest as the next large thrust. The boundaries of these units are arbitrarily defined, as the large thrusts comprise several smaller *en échelon* segments.

## Boule Thrust Sheet

The Boule thrust sheet is bounded on the northeast by the Boule fault and extends southwest to the edge of the map-area. It includes the Boule Range and part of the Pocahontas-Moosehorn basin.

*Boule Range.* The Boule Range extends from Athabasca River northwesterly to Wildhay River, a distance of about 30 miles. It decreases in width from nearly 4 miles at its southeast end to about 2 miles at Wildhay River. According to Lang (1946) the range consists structurally of a large fan fold about 4 miles wide. The most westerly structural unit is an anticline called the Moosehorn fold which is recumbent toward the west with its axial plane almost horizontal. East of this are several fairly symmetrical folds and still farther east is a large anticline overturned toward the east. The axial plane of this fold dips about 45 degrees to the southwest, and its lower limb dips toward and is truncated by the Boule thrust fault. The upper limb is broken by thrust faults which may be subsidiary to the main fault.

Boule Range has been formed by resistant Devonian beds having been thrust relatively northeast upon Mesozoic rocks. The various structures of the range involve strata of Devonian, Mississippian and Triassic ages.

*Boule Fault.* This fault underlies the Boule Range. It has been mapped from Athabasca Valley northwestward as far as longitude 118° 00′, but probably extends much farther. From Athabasca Valley northwest as far as Boule Roche, a distance of about 8 miles, the northeast limb of the most easterly fold is truncated by the fault, and Devonian strata overlie beds of Jurassic and Lower Cretaceous age. From Boule Roche to the west border of the mapped area, Mississippian, Triassic and Jurassic beds successively overlie the Jurassic Fernie Group and finally, Triassic beds are faulted onto Triassic.

At Athabasca Valley the Boule fault is obscured by glacial-fluvial deposits, but it can be recognized again on the south side of the valley (Mountjoy, 1960). The northwestern extension of the Boule thrust is thought to be one of the several west-dipping thrusts occurring southwest of the Hoff fault.

*Pocahontas-Moosehorn Basin.* That part of the Boule thrust sheet lying southwest of the Moosehorn fold and northeast of the Miette fault underlying the Bosche Range in Jasper Park is called the Pocahontas-Moosehorn basin by Lang (1946, p. 37). Where crossed by Athabasca River, it is 2½ miles wide. It is underlain predominantly by Lower Cretaceous formations, but the rocks are poorly exposed because of the extensive drift cover. Sufficient rock outcrops to indicate close folding, probably accompanied by faults.

## Hoff Thrust Sheet

This unit is defined as the block of strata bounded on the northeast by the Hoff fault and that part of the Mahon fault underlying the Hoff Range, and extending southwest as far as the Tip Top fault north of Wildhay River and as far as the Boule fault south of this stream. A northern limit is arbitrarily placed at the northwestern extremity of the Hoff Range. The unit consists of the Hoff Range and the Thoreau Creek Basin.

*Hoff Range.* Hoff Range, the most easterly of the outlying mountain ranges, was formerly considered to be part of the northern extension of the Boule Range and, as such, is referred to as the Hoff Ridge on earlier maps. More recent work, supported by the results of a study of aerial photographs, indicates that it is a separate thrust fault sheet originating to the east of the Boule Range.

Hoff Range is about two miles wide and extends northwesterly a distance of about 72 miles from just north of Athabasca Valley to just south of Muskeg River. The structures within the range plunge both to the northwest and southeast so that Palaeozoic formations are gradually overlain by progressively younger beds and most of the included structures lose their identity to the southeast and to the northwest. The fault sheet is the result of Palaeozoic formations having been thrust relatively to the northeast over strata of Cretaceous age along the Hoff and Mahon faults. Contrary to the usual situation in the outlying mountain ranges, the Hoff Range lacks a northeast-facing scarp. Structures included within the range are the Hoff anticline and the several faults and repetitions of the beds due to these faults, all of which occur on the southwest limb of the fold.

*Hoff Fault.* Hoff fault forms the northeastern boundary of the fault sheet. It extends from near Brûlé Lake to about two miles north of Moon Creek, a distance of approximately 48 miles. The fault surface dips southwest and movement has resulted in strata of Devonian and Mississippian ages having been thrust relatively to the northeast over Mesozoic strata. Hoff fault truncates the northeast limb of the Hoff anticline so that, along most of its length, northeast-dipping Mississippian and Triassic rocks are in fault contact with beds of Jurassic or Cretaceous age along the trace. This thrust is considered to have been folded to some extent with the Hoff anticline as indicated on structure cross-section E-F. There appears to have been progressively less movement on the fault to the north of Moon Creek and to the south of Wildhay River, the maximum stratigraphic throw occurring between these streams. The dip-slip on the Banff Formation is apparently more than 4,000 feet along the fault surface in the plane of the section (*see* Structure Cross-section E-F).

The Moberly fault, occurring to the east, is thought to be related to the Hoff fault, but will be considered with the Foothills structures.

*Hoff Anticline.* This is the most easterly structure within the Hoff Range south of Moon Creek. Between Prine Creek to the southeast and Moberly Creek to the northwest it is a well-defined, nearly symmetrical fold with strata exposed along the axis being mainly of the Rundle Group. South of Prine Creek, where it plunges to the southeast, the single fold is replaced by two smaller anticlines exposing only formations of Mesozoic age. Northwest of Moon Creek the fold is overridden progressively from the southwest by the Mahon fault until, just north of Moon Creek, it finally disappears beneath this fault. North of Moberly Creek the anticline apparently plunges gently to the northwest and Rundle strata are overlain by beds of Triassic age except where streams have cut into the fold. The Banff Formation is exposed only at the head of Sheba Creek, and where two small southwest-flowing tributaries of Mumm Creek have cut into the fold. The upper beds of the Devonian Palliser Formation also outcrop on the more northerly of these streams.

Good sections of the Rundle Group and of the Banff Formation occur along the valleys of these branch creeks (*see* Plate IVB).

South of Wildhay Valley the structures southeast of the Hoff anticline are not well known. Between Wildhay Valley and Moon Creek the remainder of the Hoff Range consists of several subsidiary or back-limb thrusts that occur on the southwest limb of the fold and that have produced repetitions or a piling up of relatively thin slices of strata involving beds of the Banff Formation, Rundle Group, Sulphur Mountain and Whitehorse Formations. These faults normally cut the strata at a small angle, but both beds and fault surfaces now dip at angles between 45 and 75 degrees, probably due to the rotation caused by movement on successive faults. The stratigraphic throw on these faults ranges from a few feet on the smaller breaks to perhaps several hundred feet on the larger faults.

North of Moon Creek the major movement appears to have been transferred from the Hoff fault to the more westerly Mahon thrust which in the southeast was one of the back-limb thrusts on the southwest flank of the Hoff anticline. Displacement on this fault increases progressively towards the northwest with the result that strata above the fault are gradually thrust farther northeast as the more easterly structures die out.

The Mahon fault replaces the Hoff fault north of Moon Creek as the major thrust underlying the Hoff fault sheet. It is at least 40 miles long and extends northwestward almost to the eastern end of A la Pêche Lake.

The remaining part of the Hoff fault sheet is the region between Hoff Range and the Berland Range. The region is about 2 miles wide, is underlain by Jurassic and Cretaceous strata, and consists of a series of ridges somewhat lower than the Hoff Range. Of the several small faults occurring here at least two are considered to be thrusts on which the overlying beds have moved southwest relative to those below the fault. This strip of country appears to have been squeezed between the Berland and Hoff Ranges with the formation of numerous tight anticlines and synclines, many of which are asymmetrical with the steeper limb to the northeast and some of which, closer to the Berland Range, are overturned to the northeast (Plate IIA).

## Tip Top Thrust Sheet

The Tip Top thrust sheet is bounded on the northeast by the Tip Top fault and on the southwest by the Rocky Pass fault. The southern boundary is placed at the valleys of Wildhay River and Rock Creek, and a northern limit is arbitrarily placed at the valley of Berland River. This unit consists of the Berland Range on the northeast and the Thoreau Creek basin to the southwest.

*Tip Top Fault.* Between Wildhay River and Berland River the Tip Top fault underlies the Berland Range and along this part of the fault, Devonian and Mississippian rocks have been thrust relatively to the northeast over the Cretaceous. To the northwest, beyond the Berland Range, the fault continues as far as Sulphur River, but displacement at the surface is confined to Cretaceous beds. A study of aerial photographs indicates that the fault is continuous to the southeast of Wildhay River and is probably the same break that occurs just southwest of the Boule fault in the Boule Range. If so, Tip Top fault is at least 92 miles long.

Stratigraphic throw on the Tip Top fault is probably at a maximum between the headwaters of Little Berland River and Planet Creek where beds as old as the Mt. Hawk Formation are exposed. The amount of dip-slip movement along the fault here is difficult to determine even approximately but should be several thousand feet according to the writer's interpretation of the structure (*see* Structure Cross-section E-F). Southeast of Little Berland River as far as the Wildhay River the movement on the fault decreases so that first Banff and then Rundle beds rest on the Lower Cretaceous. Beyond the northwestern end of the Berland Range movement on the fault parallel to the dip direction again decreases until the fault involves only the Upper Cretaceous Kaskapau Formation at the surface. As indicated in structure cross-section C-D, a dip-slip displacement of the Nikanassin Formation in the plane of the section is approximately 5,000 feet on the Tip Top fault between 5 and 6 miles north of the Berland Range.

Northeast of the Tip Top fault two unnamed thrust faults have been mapped. One extends just south of Moon Creek northwesterly to about 4 miles north of Berland River and the other extends from Berland River for about 5 miles to the northwest. It is assumed that both of these southwest-dipping thrust faults are related to the Tip Top fault since they appear to merge with that break.

*Berland Range.* North of Wildhay River the mountain range underlain by the Tip Top fault is known as the Berland Range. It lies west of Hoff Range and is separated from it by the narrow area underlain by Mesozoic formations and described previously. Berland Range is about 2 miles wide and extends from Wildhay River northwesterly to Berland River, a distance of 32 miles. Here, it loses its identity as a structural unit although the Tip Top fault continues farther to the northwest.

The thrust sheet in this range results from relative movement northeast of massive Devonian and Mississippian carbonates over beds of Cretaceous age.

These massive strata now present a precipitous scarp face to the northeast and dip to the southwest at from 30 to 50 degrees (*see* Plates IIIA, IIIB). Unlike that of the other mountain ranges, the structure of Berland Range does not include any large folds, but three small anticlines have been mapped south of Tip Top Mountain.

The oldest beds outcropping above the Tip Top fault from the head of Seep Creek northwest as far as Persimmon Creek are Devonian. They rest on Cretaceous formations and are mainly responsible for the precipitous scarp front along which the higher peaks occur (*see* Plates IIIB, IVA).

Still farther southwest within the range two thrust faults, situated fairly close together, repeat strata of Mississippian and Triassic age. The result of this "slice faulting" has been to produce three major repetitions of the same beds, all of which dip to the southwest at angles between 45 and 75 degrees (*see* Plate IIIA). These high dips are considered to be the result of rotation as in the Hoff Range. Several other small thrusts occur but are not shown on the map or structure sections.

North of Persimmon Creek the Palaeozoic formations disappear within a distance of two miles beneath strata of Triassic, Jurassic and Lower Cretaceous ages. The several smaller thrusts also end at or just northwest of the northwest limit of Palaeozoic outcrops but Tip Top fault continues on within the Mesozoic beds.

Southeast of Seep Creek, strata of the Rundle Group are the oldest beds above the Tip Top fault and between Seep Creek and Wildhay Valley, Berland Range has a somewhat lower altitude than farther north. Within this part of the range three small folds are associated with the back-limb thrusts.

*Thoreau Creek Basin.* Between the Berland Range to the northeast and the Persimmon Range to the southwest is a region about 8 miles wide, having the characteristics of the more western foothills. Altitudes here are about 700 feet to 1,000 feet lower than those of the bordering mountain ranges so that the area resembles a depression and is called the Thoreau Creek basin. North of the northwest extremity of the Berland Range the basin merges with the Foothills. To the southeast the Thoreau Creek basin is undoubtedly continuous with the Pocahontas-Moosehorn basin between the Boule and Bosche Ranges.

The Thoreau Creek basin is immediately underlain by rocks of the Fernie Group of Jurassic age and by rocks of both Upper and Lower Cretaceous ages which have all been subjected to intense deformation by thrust faulting and by folding. Previously published maps (963A, 968A, 5-1957, and 54-19) show the complicated structure of this region, but even on these maps, the writer considered the number of faults shown to be a minimum. Most of the region appears as a patchwork of different pieces of the various formations involved in the deformation. Both west- and east-dipping faults are present. It is also probable that folded faults are present within this basin. On the map accompanying this report the structural complexity of the region has been greatly simplified.

Strata underlying the Lancaster syncline, which lies along the extreme southwest edge of the basin, are poorly exposed mainly because of the ease of weathering of the underlying shales. Because of this lack of outcrop, only a minimum of stratigraphic and structural information was obtained and it is very probable that the structure of this syncline is much more complicated than is shown on the map.

## Persimmon Thrust Sheet

The Persimmon thrust sheet extends from the Rocky Pass fault on the northeast of the Rock Creek-Sulphur River Valleys to the southwest and from Rock Creek Valley northwesterly to a few miles beyond longitude 119° 00′. It consists of the Persimmon Range and the valley occupied by the upper reaches of Rock Creek and by Sulphur River.

*Rocky Pass Fault.* The northwestern and southeastern extremities of the Rocky Pass fault have not yet been mapped, so the fault shown on the accompanying map probably extends in both directions for several miles. That part of the fault occurring within this map-area underlies the Persimmon Range and is 32 miles long. The fault surface dips to the southwest and on this surface Devonian and Mississippian formations have been thrust relatively to the northeast over Cretaceous strata. The maximum stratigraphic throw due to movement on the Rocky Pass fault within this map-area is roughly 8,300 feet and occurs between latitude 53° 30′ and a point just north of Persimmon Creek. Along this part of the fault, strata of the Flume Formation overlie beds of the Nikanassin Formation. From Persimmon Creek to Muskeg River strata of the Banff Formation and then the Rundle Group are successively in fault contact with Cretaceous beds. North of Muskeg River, where the Persimmon anticline plunges to the northwest, Triassic beds are thrust over those of the Fernie Group and then onto Triassic as the dip-slip movement decreases.

Along most of its length the fault cuts the northeast limb of the Persimmon anticline.

*Persimmon Range.* Persimmon Range extends for 50 miles from its southeastern end at Rock Creek Valley to its northwestern extremity just west of longitude 119° 00′ where it loses its identity as a separate structural unit. The continuation of these structures to the southeast between Rock Creek and Athabasca Valleys is known as the Bosche Range.

Persimmon Range is underlain by Devonian and Mississippian strata which have been thrust relatively northeast over Cretaceous formations on a major southwest-dipping thrust called here the Rocky Pass fault.

The southeastern two-thirds of the part of the range which lies within this map-area presents a precipitous scarp to the northeast. Along this scarp Devonian strata form cliffs that are more than 1,500 feet high in places.

Within the Persimmon Range, from about 3 miles northwest of latitude 53° 30′, Devonian and Mississippian formations are exposed. No folding occurs here and the strata are repeated only once by thrust faulting. Farther northwest numerous folds develop within the Palaeozoic formations, and the northwestern end of the range is formed by a single anticlinal fold known as the Persimmon anticline.

The southwestern slope of the Persimmon Range is largely underlain by Triassic strata folded into numerous small sub-parallel anticlines and synclines. The crest of each successive anticline becomes progressively lower in altitude from the summit of the range southwesterly toward the valley occupied by Sulphur River and the upper part of Rock Creek. These small folds, though not overturned, are asymmetrical, with the axial planes dipping steeply to the northeast.

The valley between Persimmon and de Smet Ranges is underlain by both Triassic and Jurassic strata, but outcrops are scarce. The northwestern end of this valley appears to be a normal syncline with no large thrust fault underlying de Smet Range. Farther southeast where the valley is wider the shales of the Fernie Group are highly contorted, sheared and broken by numerous small faults, suggesting that faulting probably becomes more important southeast of the region mapped.

## De Smet Range

In the corners of the map-area bounded by latitude 53° 30′, longitude 119° 00′, latitude 53° 45′ and longitude 119° 30′, are two parts of a mountain region occurring west of Persimmon Range. These are considered to be parts of the northwestern extension of the de Smet Range of Jasper Park.

The more northerly of these triangular areas occurring southwest of Faulk Creek and the lower part of Muddywater River is underlain by rocks of Mississippian, Late Palaeozoic and Triassic ages. The structure here is a series of anticlines and synclines, the most important of which is the Llama Mountain anticline. Several small thrust faults have been mapped but there appears to be no major thrust fault underlying these folds.

To the southeast and lying southwest of Persimmon Range is another part of the same mountainous unit. No evidence was obtained here to indicate an underlying major thrust fault although the exposed strata underlying the upper part of Rock Creek Valley are contorted and broken by many small faults.

*Monoghan Anticline.* In this part of the map-area the most northeasterly structure within the de Smet Range is the Monoghan anticline. The part of the anticline inside the map-area is about 3 miles wide at the southeast end, but narrows to 2 miles where it crosses the northwest border. The anticline is somewhat asymmetrical with the steeper limb to the northeast. Beds on the northeast limb dip between 70 and 75 degrees and on the southwest limb, between 35 and 50 degrees.

Strata of the Rundle Group are exposed along the crest of the fold within this map-area. Rocks of the Banff Formation outcrop where several northeasterly flowing streams have eroded through the Rundle Group and the upper beds of the Devonian Palliser Formation are exposed only where the anticline is cut by the valleys of Monoghan Creek and West Sulphur River. Triassic strata occur on both flanks of the anticline.

*Other Structures.* Southwest of the Monoghan anticline a southwest-dipping fault of relatively small stratigraphic throw has brought Triassic beds northeast relative to underlying Jurassic Fernie strata. About a half mile still farther southwest, a larger thrust repeats strata of the Mississippian formations, rocks of the Banff Formation having been thrust northwest onto Triassic beds. This thrust fault has been called the West Fork fault. A syncline within Rundle strata lies above the West Fork thrust fault, northeast of the West Fork anticline. Several smaller folds are associated with the larger structures. Southwest of the anticline another southwest-dipping thrust fault is present which repeats part of the Banff Formation, the Rundle Group and the Whitehorse and Sulphur Mountain Formations.

Quartz and quartz-feldspar sandstones and quartzites, some of which are conglomeratic, occur west of this to the borders of the map-area. These beds have been thrust relatively to the northeast and now lie above strata of Triassic age. The part of this fault occurring within the map-area is about 3 miles long, but little is known about its continuation either to the northwest or to the southeast. It is, however, a major thrust fault on which has occurred a minimum stratigraphic displacement of 6,000 feet.

## Foothills Structures South of Latitude 53° 30′

*Pedley Fault.* This thrust, the surface of which dips northeasterly, occurs along the northeast side of the Entrance syncline. The position of lower Brazeau strata on the northeast side, in contact with strata high in the Edmonton-Paskapoo succession, suggests a steeply dipping thrust. The fault extends from the southeast corner of the map-area to Athabasca River, but has not been located north of the river.

*Entrance Syncline.* This is a broad, open syncline extending northwestward from the southern border of the map-area as far as the pre-glacial valley in which is situated Jarvis Lake. The fold plunges gently to the southeast and is bounded on the northeast by a faulted anticline (Pedley fault). Strata of Tertiary age occur in the trough of the syncline. High Divide Ridge, occurring along the axis of the fold is capped by 50 to 100 feet of weakly-cemented cobble conglomerate.

*Other Structures.* Southwest of the Entrance syncline and south of Athabasca Valley two more east-dipping thrusts repeat beds of the Brazeau and Wapiabi Formations. These faults appear to merge near the location of the Edmonton-Jasper highway. Most of the region west of these faults and bounded by Athabasca River Valley and the south border of the map-area is covered by outwash deposits of sand and gravel. Bedrock is exposed only along the south border of the map and the structures here, which include the Folding Mountain anticline, have not been traced across the Pleistocene deposits to the north side of Athabasca Valley.

In the region north of Athabasca Valley between the northern extension of the Entrance syncline and the Hoff fault, the main fold appears to be a syncline complicated by both east- and west-dipping faults. The Cardium Formation occurring around the northwest nose and along the southwest flank of the syncline is about twice its normal thickness as now shown on the map. It is suggested that this formation is repeated by an east-dipping thrust that may be folded. The writer feels, however, that to explain several discrepancies, a re-interpretation of the structures here is required, necessitating more detailed field work. The structure in this region has been simplified to some extent for the purposes of the accompanying map.

## Foothills Structures Between Latitude 53° 30′ and the Muskeg River Valley

*Wildhay Fault.* This is the most easterly structure mapped in this region and it extends from just south of Wildhay River northwesterly as far as Muskeg River, a distance of about 64 miles. Wildhay fault can be mapped with reasonable accuracy from Muskeg River southeast as far as Little Berland River and can be located where it crosses Wildhay River. Between Little Berland and Wildhay Rivers, the information available is not sufficient to show the structure accurately, so for the purposes of this map, it has been shown as a single break. The validity of this has yet to be proved. Strata of the Wapiabi Formation have been thrust relatively to the southwest over Brazeau beds along almost the entire length of the Wildhay fault. To the south it ends in Brazeau beds and to the northwest within the Cardium Formation. Immediately southwest of the Wildhay fault Brazeau strata are imbricated by several faults.

West of the imbricate zone the Wapiabi, Cardium, Kaskapau and Dunvegan Formations, all of Upper Cretaceous age, and the Fort St. John Group, of mainly Lower Cretaceous age occur in order from northeast to southwest. The strata of these formations are either vertical or dip steeply to the northeast. The region between these steeply dipping strata and the Moberly fault is underlain by Lower Cretaceous Luscar beds and consists mainly of a series of small anticlines and synclines. The most easterly of these folds is the southeastern limit of the Cabin Creek anticline which reaches its culmination just north of this division.

*Moberly Fault.* This fault extends northwesterly from Wildhay River to the vicinity of Mahon Creek, a total distance of about 42 miles. It is a southwest-dipping thrust that occurs about one mile northeast of the Hoff and Mahon faults, and that appears to merge at its extremities with the Hoff and Mahon faults respectively. Just south of Moon Creek, two branches develop, one on either side of the main break, and are assumed to continue northwest of Moon Creek for three or four miles. The fault forms the northeastern limit of the highly contorted zone in front of the Hoff and Mahon thrusts.

Cretaceous, mainly Lower Cretaceous formations are displaced at the present surface by the Moberly fault. The stratigraphic throw is probably about 1,500 feet.

## Foothills Structures North of Muskeg River Valley

This division includes all of the remainder of the map-area except the small part southwest of Faulk Creek and the lower reaches of Muddywater River. In this division the Foothills have their maximum width of about 35 miles.

*Muskeg Anticline.* This anticline lies along the extreme eastern edge of the disturbed belt and is the most northeasterly fold mapped in the northern part of the map-area. It can be traced a distance of about 18 miles, but scarcity of outcrops prohibits an accurate determination of its southeastern limit.

The anticline is not as compressed as are the folds farther to the southwest. It is nearly symmetrical at its northwestern extremity, but toward the southeast, the attitude of the beds suggests a slight asymmetry, for the southwest limb is somewhat steeper than the northeast side. Dips on the northeast limb range between 15 and 20 degrees, while those on the southwest limb range between 30 and 50 degrees. Wapiabi strata are exposed at the centre of the fold, except just southeast of the Muskeg well site where a small patch of Cardium sandstone outcrops. It should be noted here that 3,200 feet of rock assigned to the Kaskapau Formation was penetrated in the Muskeg No. 1 well. Even allowing for a considerable inclination of the beds, this thickness is about 1,000 feet more than that measured at surface exposures. This increased thickness may be due to squeezing of the shale into the anticline between the more competent Dunvegan and Cardium Formations, but is more likely due to a repetition of the Kaskapau strata by thrust faulting. If a fault is present it should occur at the surface to the northeast of the fold. Evidence for such a fault has not yet been obtained.

*Copton Anticline.* This is a narrow rather compressed fold along the northeastern edge of the disturbed belt northwest of the Muskeg anticline. It extends northwesterly from just south of Smoky River almost to the west border of the map-area, a distance of approximately 34 miles. The anticline is nearly symmetrical and one of the longest and most regular of the anticlines within the map-area. The southwest limb is bounded by the Muskeg fault.

Kaskapau strata are exposed along the axis of the fold over most of its length, with the Cardium, Wapiabi and Brazeau Formations occurring along the northeastern flank. These formations are almost entirely obscured on the southwest flank by older strata above the thrust fault.

### Muskeg Thrust Sheet

*Muskeg Fault.* This fault, extending a distance of nearly 65 miles, is the most easterly of the large west-dipping thrust faults in the northern part of the map-area. The southeastern part of the fault extends along the northeast limb of the Mason syncline to the southwest end of the Copton anticline where it is folded anticlinally over the Copton anticline and synclinally beneath the Mason syncline.

*Mason Syncline.* This is the principal structure above the Muskeg fault west of the Muskeg anticline. It is a broad open fold about 20 miles long and 4 to 5 miles wide, with gently dipping limbs.

Northwest of the Mason syncline the structures occurring above the Muskeg fault and northeast of the Mason fault consist of a number of sub-parallel anticlines and synclines underlain mainly by Lower Cretaceous formations and ranging in length from 4 to 24 miles.

## Mason Thrust Sheet

*Mason Fault.* Mason fault lies between 4 and 6 miles southwest of the Muskeg thrust and is approximately 65 miles long. It extends from just south of Berland River to a point about 5 miles south of Smoky River. Here the fault bifurcates, the more easterly branch apparently dying out just north of Smoky River, and the more westerly branch extending northwestward to within a few miles of the western border of the map-area. For several miles from its southwestern extremity the Mason fault follows close to the northeast limb of the Cabin Creek anticline. It then swings more northerly and parallels the northeast limb of the Susa Creek anticline to the point where it forks. The fault surface is exposed in the deep valleys of two small streams where it is folded with the strata above and below. The more western branch is thought to extend northwestward within the Luscar Formation.

The fault is a thrust that has moved Lower Cretaceous Luscar and Nikanassin beds relatively to the northeast over those of the Lower Cretaceous Fort St. John and the Upper Cretaceous Dunvegan and Kaskapau Formations. The maximum stratigraphic throw, about 2,800 feet, occurs where the fault truncates part of the northeast limb of the Susa Creek anticline. Here Nikanassin strata lie above beds of the Kaskapau Formation.

*Cabin Creek Anticline.* This anticline is the largest structure within the Mason thrust sheet. It extends as a single fold from just north of Moberly Creek northwesterly to near the headwaters of Cabin Creek. Here, at its culmination and where it starts to plunge to the northwest, the single fold is gradually replaced by three anticlines with two intervening synclines. Two of these subsidiary folds die out just north of Muskeg River, but the most westerly of the three, called the Sterne Creek anticline, extends northwest as far as Sheep Creek. The total length of the Cabin Creek and Sterne Creek anticlines is about 72 miles.

At the culmination of the structure near the head of Cabin Creek, strata of the Rundle Group are exposed along the axis for about 4 miles. The southeast plunge of about 1,200 feet per mile brings younger formations successively over the axis of the fold until southeast of Moon Creek only Luscar strata are exposed. Near the head of Cabin Creek subsidiary folds develop on the flanks of the main anticline with all three folds plunging gently northwest.

The Cabin Creek anticline itself is somewhat compressed and asymmetrical, with the northeast limb being steeper than the southwest limb. The dip of the beds ranges between 60 and 75 degrees northeast and between 36 and 60 degrees southwest.

*Sterne Creek Anticline.* The axis of the Sterne Creek anticline is sinuous and the fold lies close to the southwest limit of the Mason fault sheet. It occurs mainly within Luscar strata north of Muskeg River, but elongated areas of Nikanassin beds are exposed within the fold where it crosses Grande Cache Valley, Smoky River Valley and the valley of Sheep Creek.

*Susa Creek Anticline.* The Susa Creek anticline, a relatively narrow irregular fold, lies near the eastern margin of the Mason fault sheet and is underlain by the Mason fault. The axis of the fold, along most of its length, is roughly parallel to the trace of the fault except where the fault truncates the southeast end of the fold. The anticline extends northwest from Muskeg River nearly as far as Smoky River, a distance of about 24 miles. It is irregular in shape and ranges in width between one and two miles. Strata on the flanks dip between 45 and 70 degrees, being locally asymmetric northeastward or southwestward. The fold bifurcates just south of Susa Creek and forms a small subsidiary anticline and syncline.

Nikanassin strata are exposed at the core of the anticline except where two small areas of the Fernie Group outcrop where the fold is cut by the valleys of Susa Creek and the more westerly branch of Mason Creek.

The remainder of this fault block is characterized by numerous small anticlines and synclines and also several short west-dipping thrust faults. It is underlain by both Upper and Lower Cretaceous formations.

### Cowlick Thrust Sheet

The Cowlick thrust sheet is bounded on the northeast by the Cowlick fault and on the southwest by the Sulphur River thrust fault.

*Cowlick Fault.* The Cowlick fault extends from Mahon Creek to beyond the northwest border of the map-area. Its length of 65 miles makes it one of the longest faults within the map-area. The surface of this thrust dips to the southwest and movement northeastward has brought Nikanassin strata up over those of the Luscar Formation. Throughout its length, the stratigraphic throw on the fault is probably not more than 2,500 feet.

The southeastern end of the Cowlick fault overlaps and occurs just northeast of the northwestern end of the Mahon fault. It is probable that transfer of movement takes place from the Mahon to the Cowlick fault where this overlap occurs, and the Cowlick fault can then be considered as a northwestern extension of the Hoff fault-Mahon fault zone.

The largest structure within the Cowlick thrust sheet is the Sulphur River syncline.

*Sulphur River Syncline.* Near the confluence of Cowlick Creek and Sulphur River, the Sulphur River syncline is about 4 miles wide, but from here both to the northwest and to the southeast it becomes gradually narrower. At some places minor folds and small thrust faults occur along both limbs giving to the major syncline an irregular outline. The largest fault affecting the structure is the northern extension of the Tip Top fault which cuts the southeastern 16 miles of the southwest limb of the fold. The meagre data obtained from exposures of the Kaskapau shales within the syncline indicate many minor structures not shown on the map.

*Roddy Creek Syncline.* This is a small, roughly canoe-shaped syncline occurring 2 miles west of the Sulphur River fold and separated from it by a faulted anticline. The syncline is 16 miles long and about one mile wide. Like the Sulphur River fold it is mainly underlain by the Kaskapau shales with rocks of both the Dunvegan Formation and the Fort St. John Group occurring around the rim.

Besides the two folds just described, the thrust sheet includes numerous small anticlines and synclines as well as several small thrust faults. Some of the latter dip northeasterly.

### Sulphur River Thrust Sheet

This includes the Sulphur River fault and those structures between it and the Mt. Russell fault to the southwest.

*Sulphur River Fault.* The Sulphur River fault lies southwest of the Roddy Creek syncline and extends northwest from just southeast of Smoky River to the west border of the map-area at longitude 119°00′ and beyond. From its southeastern end the trace bifurcates, the two branches changing direction from N40°W to N60°W and then back to N40°W. The two faults then remain roughly parallel between one-quarter and three-quarters of a mile apart to the border of the map-area. The stratigraphic throw may be as much as 1,000 feet where Luscar strata have been thrust over beds of the Fort St. John Group.

*Other Structures.* Between the Sulphur River thrust and the Mt. Russell thrust to the southwest there are several small folds and minor west-dipping thrust faults involving Lower Cretaceous strata. The Mt. Stearn fault is notable, however, because it is the longest east-dipping thrust fault in this part of the map-area. It may be related to the Sulphur River thrust.

### Mount Russell Thrust Sheet

All the structures between the Mt. Russell fault and the Palaeozoic exposures southwest of Faulk Creek are included in this unit.

*Mount Russell Fault.* This fault is apparently continuous from the Thoreau Creek basin northwesterly to the vicinity of Sheep Creek, a distance of 72 miles. Over most of this distance the fault maintains a gently sinuous surface trace, but just west of longitude 119°15′ and on the north side of Smoky River, the dip of the fault surface suddenly flattens. From this point to the northwestern end of the thrust the trace is very irregular. The change in dip of the fault surface can be seen in the cliffs at the head of Davey Creek where Fernie strata overlie those of the Nikanassin Formation.

At most places along the Mt. Russell fault Nikanassin beds have been thrust relatively to the northeast onto either Nikanassin or Luscar strata but between Muskeg River and the border of the map-area at 119°00′ longitude, beds of

Jurassic, Triassic, and Mississippian ages overlie the Nikanassin. Also, for about 4 miles both north and south of Smoky River, Fernie shales of Jurassic age are exposed above the fault in contact with Lower Cretaceous Nikanassin beds below the fault.

The Mt. Russell thrust is a long fault with a maximum stratigraphic throw of about 6,400 feet where the upper strata of the Rundle Group have been thrust relatively to the northeast over Nikanassin beds.

The region southwest of the Mt. Russell fault and northeast of the Llama Mt. anticline is a topographically high area cut by deep creek-valleys and underlain mainly by the Lower Cretaceous Nikanassin Formation. The strata here have been subjected to intense crumpling. Only axes of the larger anticlines and synclines are shown on the accompanying map but it should be noted that all such folds have numerous plications superimposed upon them. The Knife Mt. anticline is probably the most noteworthy of these larger folds. This anticline has Jurassic Fernie beds exposed along its axis over most of its length.

*Whistler Fault.* The Whistler fault, more than 20 miles long, lies northeast of or in front of the Rocky Pass fault and it inclines to the southwest. Its northwestern limit is not yet known, but to the southeast it merges with the Rocky Pass fault near Persimmon Creek. Along the Whistler fault the Nikanassin Formation, and in the northwest, the Fernie Group have been thrust relatively northeast over Lower Cretaceous and Upper Cretaceous formations which occur on both limbs of the northwest end of the Lancaster syncline.

## Discussion

### Temporal Relationships of Faults and Folds

Within the part of the Rocky Mountains and Foothills covered by this report the strata have yielded to compressive stresses mainly by northeasterly movement on thrust faults and through folding. It is the writer's opinion that in most cases these thrust faults were initiated prior to the folding that is now seen, although it is possible that broad, regional folds may have existed before the faulting. Most of the folds shown on the accompanying map are considered to have originated subsequent to the initiation of major thrust faults; the two processes of deformation then proceeded contemporaneously. It may be that some folding continued after all movement on the thrusts had stopped.

### Bedding Plane Slippage

There is little surface evidence in this map-area to indicate the existence of large bedding plane thrusts such as have been shown to occur in more southern parts of the mountains and foothills. However, in the mountains small thrusts with a stratigraphic throw of only a few feet were seen to pass downward into bedding planes and it is assumed that parts of most of the thrust faults within the map-area occur within zones of bedding plane slippage.

## Folds

It is thought that most of the anticlines and synclines in the map-area formed by differential compressive stress during and/or later than movement on the underlying thrust faults. Folding within each thrust sheet was an additional means of relieving differential stress and toward the end of the mountain-building movements it may have been the most important means if conditions were such that the stress was more easily relieved by folding of the strata than by the formation of more thrusts or continued movement on established faults. For discussion of the probability that some of this folding took place later than movement on the faults, see section later in this chapter on Evidence of Folding Subsequent to Faulting.

Anticlinal folds that commonly occur in the overthrust strata at the advance edge of a thrust sheet are considered to have, in part, a somewhat different origin. These are thought to have been initiated as drag folds caused by frictional resistance to the relative northeasterly movement. Since a uniform dip of the fault surface is not likely these drag folds would be emphasized wherever the fault surface changes from a gentle to a steeper dip as for example where it passes upward to a stratigraphically higher and relatively more competent rock unit or from one zone of bedding plane slippage to a stratigraphically higher one through more competent and more massive formations.

As eastward movement of the thrust sheet continues, these anticlines gradually enlarge and become asymmetrical with a steep northeast flank and a more gentle southwest flank.

## Thrust Faults

Relief of differential stress throughout the map-area was probably accomplished mainly by the formation of faults on the surfaces of which large masses of strata were thrust relatively to the northeast. As the angle between these fault surfaces and the bedding surfaces was nowhere observed to be much greater than 30 degrees, it is assumed that all such faults can be classed as low-angle thrusts. The fact that some of these faults and the strata they cut dip very steeply is due to counterclockwise rotation of the beds caused by movement on successive faults. This rotational movement is described more fully in a later paragraph.

## Back-Limb Thrusts

The steeper limb in a series of simple, parallel and somewhat asymmetrical folds is referred to as the 'front limb' of the anticline. The other, less steeply dipping limb is called the 'back limb'. Back-limb thrusts are normally those that repeat the strata of the back limb of an anticlinal fold as contrasted with those that break the front limb. The drag anticlines described previously are formed in such a way that the fold is asymmetrical with the steeper limb to the northeast (*see* Fig. 7). Therefore in the map-area under discussion here, the 'back limb' is normally the gentler, southwest flank of the anticline.

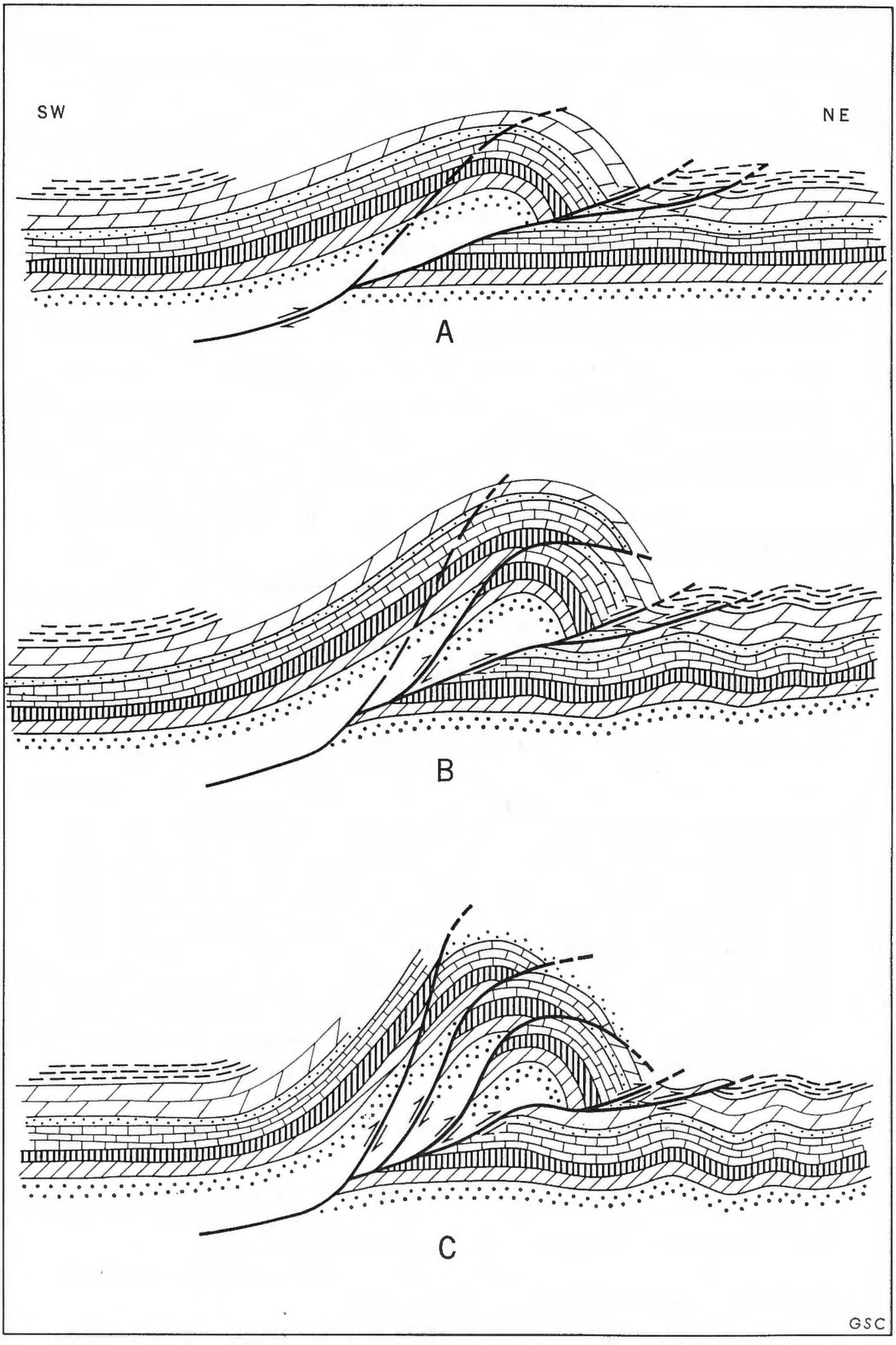


**Figure 7.** *Diagram showing progressive evolution of a major thrust fault, a drag anticline, and back-limb thrusts. Strata initially flat-lying.*

The use of the term 'back limb' has been extended in this report to include the southwest-dipping strata above a major thrust fault where erosion may have partly or wholly removed all evidence of the original drag fold.

Other writers have presented their ideas on the mechanics involved in the formation of these back-limb thrusts, so it is only necessary here to state generally that relief of differential stress in the back limb of an asymmetrical fold is partly accomplished by the formation of one or more thrust faults. If more than one fault is required a number of superimposed fault slices results. Such faults are, by the nature of their formation, roughly curved and concave to the southwest. They may or may not merge with the major fault at depth.

Any thrust faults occurring on the more gentle, southwest limb of an anticlinical fold are back-limb thrusts. They are conspicuous only where they occur on the back limbs of sharp folds and in such numbers as to have broken the strata into a series of thrust slices. Such faults are used here to illustrate the steepening of thrust surfaces and the folding of thrust faults. Back-limb thrusts occur in the Hoff and Berland Ranges east of the Hoff and Tip Top thrust faults (*see* Structure Cross-section E-F).

## Rotation of Back-Limb Thrusts

In the map-area under discussion most of the back-limb thrusts have now very steep dips to the southwest (*see* Plate IIIA; Structure Cross-section E-F). That this was not always so is indicated by the relatively small angle between the bedding and the fault surface. Some back-limb thrusts have become folded over the drag anticline as may be seen on the Hoff anticline (*see* Structure Cross-section E-F).

Figure 7 illustrates the writer's idea of the sequence of events that have produced both folded and steeply dipping back-limb thrust faults.

Figure 7A shows the initiation of a major thrust fault (A) and subsidiary thrust (A′) in originally flat-lying strata. Thrusting of the overlying strata to the northeast has caused the beginning of a drag fold. (B) shows the likely position for the formation of the first back-limb thrust before movement.

Figure 7B illustrates further movement on faults (A) and (A′). Movement on fault (B) has been accompanied by an enlarging and tighter folding of the anticline resulting in the folding of the upper part and steepening of the lower part of fault (B). Movement on fault (B) together with the tightening of the fold has increased the dip of strata above the fault; (C) is the probable position of the next fault. Overthrusting on faults (A) and (A′) has produced some crumpling in the beds below the faults.

Figure 7C shows further folding of faults (B) and (C) with consequent steepening of their lower parts. Movement on fault (D) has further increased the dip of the beds overlying it. It is assumed here that subsequent to movement on the earlier-formed faults, differential stress has folded together the anticline and the underlying faults (A) and (A′).

During this deformation a rotation of fault slices steepened the dips of both faults and strata. Two factors appear to have caused this rotation.

(1) *Temporal relationships of a series of back-limb thrusts.* It is not known at this time whether these subsidiary back-limb thrusts formed in time sequence from northeast to southwest, from southwest to northeast, or in no definite directional order. The writer feels, however, that the formation of these faults in time sequence from northeast to southwest would help to explain the present very steep dips of both faults and strata. Under these circumstances each successive thrust must rotate the beds more to the southwest because it cuts strata that have already been rotated by the previous fault. This does not mean that all movement stops on previously formed faults when a new break occurs. It is conceivable that movement may take place on all faults simultaneously or only on some of them.

(2) *Rotation caused by the formation of a drag fold.* Back-limb thrusts occur on the southwest limb of the anticline. If these faults were initiated relatively early in the evolution of the fold, the subsequent enlarging and gradual steepening of its southwest flank must be reflected in the attitude of both the strata and the faults occurring on that limb.

## Folding of Back-Limb Thrusts

The same enlarging of the drag anticline that causes steepening of subsidiary faults that occur on the southwest limb may also produce folding of some back-limb thrusts. If a considerable amount of movement takes place on the faults before the folding of the drag (or other) anticline is complete, those faults that occur over the anticline, and the strata above them, will be involved in any further compression of the fold. Such faults and the overlying beds must be folded to some degree, the more eastern faults being bent more than those farther west (*see* Figs. 7B and 7C).

## Evidence of Folding Subsequent to Faulting

Several structural features in the map-area indicate that some folding took place after most of the movement on the thrust faults had ceased. Such late folding is suggested by the following illustrations:

(1) The Muskeg fault overlies the Copton anticline and underlies the Mason syncline. It seems unlikely that the “S” curve in the surface trace of this fault could occur except by the formation of these folds during the later stages of, or after the thrust movement.

(2) Figure 8 shows two diagrammatic structure cross-sections involving part of the Mason fault where some of the strata above and below the fault are exposed in two small creek valleys. In these valleys the fault is visible in cross-section and it can be seen to be folded with the strata above and below it.

(3) In the Hoff Range two back-limb thrusts have been folded over the Hoff anticline such that the faults and strata above them change in attitude from a southwest dip to a northeast dip over the major drag fold. These two thrusts have probably been folded to some extent

in the development of the drag fold but it seems doubtful that this alone could account for the present attitudes. The writer considers that the faults above the anticline, the anticline itself and, therefore, the underlying Hoff fault have all been folded simultaneously to some extent during the latter stages of, or after the thrust movements. This later folding has steepened the limbs of the Hoff anticline, completed the folding of the overlying fault slices and probably has caused some folding of the Hoff fault itself.

### East-Dipping Faults

*A.* In the Alberta Foothills Belt, major east-dipping thrust faults are fairly common along the eastern limit of the disturbed strata. Such faults occur in this map-area from the southern border northwest as far as Muskeg River. The Wildhay fault, extending northwest between Wildhay and Muskeg Rivers, forms the eastern border of an extremely imbricate zone occurring just east of the steeply dipping northeast limb of a large anticline. Pedley fault, south of the Athabasca River, lies on the northeast flank of the Entrance syncline. West and northwest of the Pedley fault several other east-dipping thrust faults have been mapped and here also the structure west of the faults is complex.

Both the Pedley and Wildhay faults occur on the western margin of the large Alberta syncline and it is likely that relief of differential stress was most easily accomplished by the formation of east-dipping thrust faults on its western flank rather than by an eastward movement of the whole syncline on underlying west-dipping faults.

*B.* Within the more contorted part of the foothills and mountains, small east-dipping thrusts are present but the relationship of such faults to major structures is not always clear. Those faults that occur west of a major west-dipping thrust and have steeply dipping strata east of them are thought to be related to that fault. The formation of this type of fault may be due to the fact that the fault surfaces of the several west-dipping faults to the east finally become so steep that further differential stress is more easily released by the formation of an east-dipping break. Examples of this type occur on the southwest flanks of the Berland, Hoff, and Persimmon Ranges (*see* Structure Cross-sections C-D and E-F).

The Stearn fault (*see* Structure Cross-section A-B) occurs west of and above the Mount Russell thrust in a highly folded region. Its origin may be related to formation of the Mount Russell fault.

Assuming that the reason given for the formation of these small, east-dipping faults is correct, they must have developed somewhat later than the underlying west-dipping thrusts to which they may or may not be joined. Their location was probably determined by a change in attitude of the underlying west-dipping thrust surface (Hume, 1931). The east-dipping fault may have been initiated where the dip of the underlying fault changes from relatively steep to less steep.

# *Chapter V*

# ECONOMIC GEOLOGY

## Oil and Gas

The region covered by this report has been actively investigated by numerous geological survey parties working for various oil companies as a part of a general exploratory program along the Foothills. Three wells have been drilled without encountering commercial quantities of oil and gas. Logs of these wells are included as Appendix D.

The Shell-Solomon Creek No. 1 well drilled on Solomon Creek anticline in 1942-43 was spudded near the top of the Luscar Formation, and abandoned at a depth of 4,774 feet when the great thickness of Luscar strata penetrated indicated structural complexities not evident at the surface (Lang, 1946). Later the well was deepened by New Superior Oils of Canada Limited and Associates but was finally abandoned on March 21, 1953 at a depth of 11,321 feet.

The Anglo-Canadian Oil Company drilled the Jasper No. 1 well on the west flank of the Folding Mountain anticline in 1944-45. The well was spudded in the Fernie Group, encountered a fault at a depth of 4,900 feet, and entered upper Blairmore strata. It was abandoned at a depth of 5,096 feet.

Muskeg No. 1 well was drilled jointly by the Gulf, Imperial, McColl-Frontenac, Shell, and Socony-Vacuum companies under a compact known as the Northern Foothills Agreement (N.F.A.). The hole was spudded in near the axis of the Muskeg anticline in the Wapiabi Formation and ended in the Banff Formation of Mississippian age at a total depth of 10,709 feet. Drilling commenced on April 13, 1947 and ended on October 19, 1948. No oil was found and the only show of gas was from a drill stem test in the Rundle Formation between 9,867 and 9,897 feet. From this test 200 feet of gas-cut mud and 2,590 feet of sulphurous salt water were obtained.

Rocks of the Rundle Group perhaps have the most promising petroleum possibilities within this area. Thin zones showing scattered porosity were noted throughout the group. In most places where the upper Rundle beds outcrop in the Boule and Berland Ranges, at least one porous zone about 25 feet thick occurs within the upper 200 feet of the group. Porosity conditions, however, are only considered to be fair in the exposed strata. Little or no porosity was seen in Devonian outcrops. The Folding Mountain well was drilled through 1,960 feet of the Devonian section above the thrust fault and the section was completely penetrated in the Solomon Creek well. Very little encouragement in the way of porosity was found in either of these wells. The calcareous part of the Triassic shows some porosity in outcrop sections.

The three largest structures, the Folding Mountain anticline, the Solomon Creek anticline and the Muskeg anticline, have already been tested with disappointing results. Within most of the major folds along the western side of the map-area the prospective reservoir rocks, the Triassic limestone and the Rundle Group, are exposed.

Various sandstone horizons of Cretaceous age have produced oil and gas in western Canada; where these formations or members outcrop they show little porosity but it is not known whether this condition holds throughout the eastern and northeastern parts of the map-area where the formations dip gently to the northeast and are covered by younger strata.

## Coal

Considerable coal mining has been done in the southern part of the area but the collieries are now idle. The abandoned mine at Brûlé was one of the largest in Canada, producing nearly 2,000,000 tons between 1914 and 1928. Good steam coal was mined at Hinton until 1941 and domestic coal has been and is being mined intermittently at Drinnan. These coal measures occur near the main line of the Canadian National Railways and the Edmonton-Jasper highway.

Coal seams were known to exist as far to the northwest as Smoky River and Sheep Creek, and were prospected as early as 1909. Between 1909 and about 1925 there was considerable prospecting throughout the area and many good, workable seams were opened up.

J. MacVicar investigated the coal deposits between Athabasca and Smoky Rivers for the Geological Survey of Canada in 1916, 1919 and 1923. His reports contain analyses of many of these seams and also a map showing the route surveyed at that time by the Canadian National Railways for a branch line into these coalfields. Due to inaccessibility and lack of markets for the coal, interest in the area waned and no mining was done. Geological mapping of this region has shown that these strata with their included coal seams continue beyond the northwest boundary of the map-area and has provided information that should assist future prospecting for coal.

### Age of Coal Seams

Coal seams occur in strata of Lower Cretaceous, Upper Cretaceous and Tertiary ages. Workable seams are confined to the Luscar Formation of Lower Cretaceous age, the Brazeau Formation of Upper Cretaceous age and to Paleocene beds of Tertiary age, but thin stringers and lenses of coal and coaly shale beds occur locally in non-marine parts of the Nikanassin, Dunvegan and Cardium Formations. The Luscar Formation contains the largest reserves of good coal.

For purposes of description the coal-bearing strata have been divided into three geographic divisions based on their position relative to the three mountain ranges. The Eastern Division comprises the Cretaceous and Tertiary strata lying east of the Boule, Hoff and Berland Ranges; the Western Division comprises the Cretaceous strata lying betwen the Bosche and Persimmon Ranges on the west and the Boule, Hoff, and Berland Ranges on the east; and the Northern Division lies north of the Berland, Hoff and Persimmon Ranges and comprises all Cretaceous strata east of the de Smet Range.

## Eastern Division (Luscar)

*Brûlé.* From 1914 to 1928, 1,836,742 tons of bituminous and semi-bituminous coal are reported to have been mined at Brûlé by the Brûlé Coal Company and the Blue Diamond Coal Company. MacKay (1929) reports that the Luscar Formation there contains six or more coal seams, three of which, 5, 7, and 9 feet thick respectively, were mined, and estimated that the No. 3, or lowest seam, was 700 feet above the Cadomin Formation.

Some development took place where the Luscar Formation is crossed by Scovil Creek and two branches of Prine Creek and a small tonnage was mined at Prine Creek by Mount Cavell Collieries, Limited. The seams at Prine Creek were 3, 9, and 7 feet thick.

*Folding Mountain.* What appear to be the same seams as those at Brûlé occur at the east side of Folding Mountain. These were first explored by open-cuts and adits when the property was known as the "Drinnan Prospect" but more recent drilling was done by Sterling Collieries, Limited. According to MacKay (1930), the earlier work indicated four seams with average thicknesses of 5, 10, 12, and 13 feet. The later drilling indicated a 24-foot seam 1,000 feet above the Cadomin Formation, and, at another locality, a 14-foot seam that may be the same as the 24-foot one, lying 900 feet above the Cadomin.

*Athabasca River to Berland River.* In the northern part of the Eastern Division coal outcrops in the Luscar are scarce. The region is heavily covered by drift and this lack of outcrop may not be entirely due to the absence of seams. Where Moberly Creek crosses the formation considerable coal float has been observed but no exposures were seen. On Little Berland River a 1-foot seam is exposed in the east bank about ¼ mile upstream from the Luscar-Fort St. John contact. Also, near the head of Little Berland River and on the divide between this stream and Mumm Creek a few seams up to 6 inches thick were noted in gullies. Coal occurs, also, in a fault zone in the east bank of Moon Creek about 1 mile upstream from the Luscar-Fort St. John contact.

## Eastern Division (Brazeau and Paleocene)

*Drinnan.* At Drinnan a mine was operated on a 300-ton a day basis for several years by the Jasper Coal Company, but was abandoned about 1939. The seam worked has a total thickness of 18 feet but is divided by clay bands. It is about 1,600 feet stratigraphically above the Entrance conglomerate and is therefore classed as Paleocene in age.

In 1943 mining was begun on a small scale by Jasper Coals, Limited on a 4-foot seam about 800 feet above the Entrance conglomerate, and in 1944 this mine produced about 40 tons of good domestic coal a day. Several other seams were located by drilling.

*Hinton.* Steam coal of good grade was mined at Hinton by Hinton Collieries, Limited, but the mine was abandoned in 1941. Lack of rock exposures in the vicinity made it impossible to prove the stratigraphic position of the seam, but the evidence available indicated that it is in the upper part of the Upper Cretaceous Brazeau Formation.

*McLeod River and McPherson Creek.* Southeast of Hinton and Drinnan several seams are known to occur both in the Brazeau Formation and in Paleocene strata.

Numerous thin coal seams of Brazeau age outcrop along McLeod River between the mouth of Anderson Creek and the confluence of Gregg and McLeod Rivers. Several of these are about 3 feet thick, but most of them are less than 2 feet. It is possible that other seams are present but are not exposed.

For some years coal has been known to outcrop on Coal Creek, a small south-flowing tributary of McPherson Creek. Prospecting was carried on in the vicinity of McPherson Creek during the spring of 1925, and several pits were dug. When the writer examined these prospects in 1944 the pits and trenches were caved and filled with water so that only approximate thicknesses could be obtained.

Prospect No. 1, 1,000 feet upstream from the mouth, showed 4 feet of coal. No lower contact was visible and the upper contact was eroded and drift-covered. The seam is reported by prospectors to be 14 feet thick.

Another large seam occurs between 260 and 300 feet stratigraphically above No. 1 seam. It was partly exposed in the creek bed and in the banks, 2,000 feet up from the mouth of the creek. No. 2 seam was 7 feet thick where exposed, but the top had been eroded. Fifty feet downstream from No. 2 prospect, and separated from it by a 10-foot thick zone consisting of sandstone and clay shale with thin coal seams, is a seam 11 feet thick. The 11-foot seam may be a downfaulted part of seam No. 2. Below the 11-foot seam and separated from it by 12 feet of sandstone is a seam 2½ feet thick.

The seams on Coal Creek occur in Paleocene strata, and No. 1 seam was estimated graphically to be 3,000 feet above the Entrance conglomerate.

*Athabasca River to Berland River.* North and northwest of Athabasca River the Brazeau and Paleocene strata are for the most part poorly exposed and coal outcrops are rare.

Along Wildhay River several thin seams and coaly shale beds are present but none more than 5 inches thick was found. MacVicar (1924) reports two 18-inch seams near the point where the trail crosses the river. These seams could not be located by the writer but may now be covered. Lang (1947) reports a 7-foot seam exposed at the confluence of Teitge and Pinto Creeks and at what may be the same horizon on Berland River. This horizon is roughly 2,000 feet above the base of the Paleocene succession.

### Western Division (Luscar)

This division comprises the Cretaceous strata lying between the Bosche and Persimmon Ranges on the southwest and the Boule, Hoff, and Berland Ranges on the northeast. It contains the Pocahontas-Moosehorn basin in Jasper Park and is probably a continuation of the measures mined at Mountain Park. All seams in this division occur in the Luscar Formation. Old analyses given by MacVicar (1924) rank the coal of this district as high grade bituminous.

*Ronde Creek.* Coal was mined at the Bedson Mine near Ronde Creek by Jasper Park Collieries when they operated their main mine at Pocahontas, on the south side of Athabasca River. The seams are described by Dowling (1912) and MacKay (1930).

*Upper Wildhay River Area.* Good coal has been known to exist in this district since 1909 and for a number of years after 1916 prospecting was active on the upper part of Wildhay River, Seep Creek, Carson Creek and Thoreau Creek. A few seams were traced for short distances but no coal was mined. Most of the old trenches and pits are now caved and overgrown, but a few were reopened by the writer in 1946 and 1947 and the seams measured. The region is one of intense folding and faulting and the distance that a seam can be traced is controlled by the faulting. All seams dip very steeply.

Two seams, 7 and 22 feet thick, occurring on the east side of Carson Creek were located by trenches on the east side of the creek and traced part way down the hillside toward the stream. They should cross Carson Creek about 2,500 feet above its confluence with Wildhay River. The seams are between 1,000 and 1,200 feet stratigraphically above the base of the Luscar Formation (*see* Appendix E, Section 5).

Another seam was exposed by trenching in a saddle of the ridge on the west side of Carson Creek. This may be a continuation of the seam described above as its stratigraphic position is similar. The approximate thickness of this seam is 35 feet. It strikes south 45 degrees east and dips at 65 degrees to the northeast.

On the south bank of Wildhay River opposite the mouth of Fault Creek a seam or seams had been exposed previously by a trench about 100 feet long. No estimate of the thickness could be obtained but the seam could be followed to the southeast by means of old pits and trenches. It is apparently the northwest continuation of one of two seams that are exposed in a small creek just south of the map-area and to which MacVicar (1924) has assigned thicknesses of 18 and 24 feet.

In the west bank of Thoreau Creek, about three-quarters of a mile above its mouth, a thick seam is exposed which strikes south 65 degrees east across the valley and has a dip of 82 degrees to the northeast. It lies about 1,000 feet above the base of the Luscar Formation (*see* Appendix E, Section 6).

Northeast of the Thoreau Creek seam, on the ridge between Thoreau Creek and Fault Creek at an elevation of between 6,500 feet and 6,600 feet above sea-level, are two coal seams. The upper seam, lying about 1,200 feet above the base of the Luscar Formation, consists of 27 feet of coal, strikes south 45 degrees east and is vertical. A second seam lies about 400 feet lower in the formation and is exposed in a pit higher on the hill. The thickness of this seam could not be measured. Adjacent strata strike south 45 degrees east and dip at 80 degrees to the southwest.

## Northern Division (Luscar)

This includes approximately that part of the map-area lying north of the northwestern extremities of the Berland and Persimmon Ranges and extends from the eastern border of the map-area to the de Smet Range. In this northern division the area underlain by the coal-bearing strata is not divided by upthrust Palaeozoic ranges so the Eastern and Western Divisions have now become one.

*Berland River to Smoky River.* Few seams are exposed south of Smoky River. On Sterne Creek, a 6-foot thick seam is exposed on both sides of the creek about 2½ miles above its mouth (Appendix E, Section 7).

Two seams are exposed on the south-flowing branch of Cowlick Creek just east of longitude 119° 00′. The upper seam is 2 feet 3 inches thick and occurs about 506 feet below the top of the formation. The lower seam is 1 foot 10 inches thick and occurs about 890 feet below the top of the formation.

Another coal outcrop was observed on the north-flowing tributary of Cowlick Creek just east of the Mountain Trail. This 5-foot thick seam is about 725 feet above the base of the Luscar Formation.

Near the confluence of Sulphur and Smoky Rivers, where the Sulphur meets the Cadomin Formation to flow down the upper contact of this conglomerate to the Smoky, a 17-foot thick seam is partly exposed, probably within 400 feet of the base of the Luscar Formation.

*Smoky River and Sheep Creek.* The Smoky River region has long been known to contain high-grade bituminous coal seams. Three coal seams measuring 1 foot 6 inches, 13 feet 6 inches, and 4 feet outcrop in the east bank of Muskeg River about one-half mile above its confluence with Smoky River (Appendix E, Section 8). An exposure of the Luscar Formation in a gulch on the northwest side of Smoky River and about 1½ miles above the mouth of Muskeg River reveals three coal seams. The largest of these, about 1,243 feet below the top of the formation, is 18 feet 6 inches thick. The second seam, about 1,000 feet below the top of the formation, consists of 7 feet 6 inches of coal with a 2-inch clay parting near the top. The uppermost of the three seams is about 879 feet below the top of the formation and is 8 feet thick, but only the upper 5 feet was considered to be clean coal. On Sheep Creek coal is exposed in both banks just southwest of the Luscar-Blackstone fault contact. The coal there is crushed but the seam appears to be about 6 feet thick.

About ½ mile up Sheep Creek from the fault-contact a mixture of coal and carbonaceous shale outcrops in the south bank at the mouth of a small stream (Appendix E, Section 4). Three-quarters of a mile upstream from the fault-contact a seam 22 feet 6 inches thick with a 3-inch thick shale parting near the middle is exposed near water-level in the south bank. About 200 feet stratigraphically above this another seam is well exposed in the northwest bank (Appendix E, Section 2).

On the northwest side of Sheep Creek at about latitude 53°59′ and longitude 119°15′, a 12- to 14-foot-thick seam is exposed between two falls on a small southeasterly flowing creek. It appears to be good, hard, bituminous coal. This seam is presumably on the old Campbell claim (McEvoy, 1925).

Perhaps the same seam as that described above outcrops about one mile to the southwest on another southeasterly flowing tributary of Sheep Creek. This seam is 10 feet thick and is exposed at an elevation of 4,100 feet.

Numerous coal showings occur on the southwest-facing slope of the ridge on the northeast side of Horne Creek, and at least 3 seams are present on the ridge at the head of Corydalis Creek. The middle one of these, about 10 feet thick, is well exposed at several places and can be traced along the strike for nearly a mile.

Along the face of the high cliffs (Goat Cliffs) lying between Hells Creek and Gustavs Flats on the north side of Smoky River, the upper 908 feet of the Luscar Formation is exposed. Within this section, between 327 and 846 feet below the upper contact, are 18 seams of coal more than 1 foot thick; the two thickest seams measure 28 feet 8 inches and 11 feet respectively (*see* Appendix A, Section 22).

A 5-foot-thick seam of coal is exposed in the valley of Smoky River along Hells Creek, which drains the southeastern slopes of Mount Hamell. This seam occurs 50 feet above the base of the formation. On the south side of Smoky River an 8-foot-thick seam is exposed in a small creek opposite Gustavs Flats. Its stratigraphic position within the formation was not determined.

*Upper Part of Caw Creek.* Still farther to the northwest, coal occurs on tributaries of Nickerson and Copton Creeks. On a small southwest-flowing branch entering Nickerson Creek just east of longitude 110°25′, a seam is exposed at the crest of an anticlinal fold. It lies about 1,000 feet stratigraphically below the top of the Luscar Formation and is 12 feet thick. The coal is banded, breaks into large blocks and seems to be quite resistant to weathering. On a northerly-flowing branch entering Caw Creek at approximately longitude 119°28′ coal seams 15 feet 11 inches, 2 feet 1 inch and 1 foot thick are exposed. The 15 foot 11 inch seam is 225 feet above the base of the formation (*see* Appendix E, Section 9).

At least three seams, 12 feet, 5 feet 4 inches, and 23 feet thick are exposed at an elevation of 6,500 feet on a small creek forming part of the headwaters of

Caw Creek. These seams are exposed above timber-line and are considerably weathered, but no significant partings were noticed. Their thickness may be somewhat exaggerated at this locality, which is close to the crest of an anticlinal fold. The 23-foot seam lies about 1,000 feet above the base of the Luscar Formation (Appendix E, Section 10).

Numerous other indications of coal occur in the area around the headwaters of Caw Creek. Many of these are probably due to the same seams being repeated by folding.

### Northern Division (Brazeau and Paleocene)

Throughout the Northern Division large areas are underlain by strata of Upper Cretaceous and Paleocene age but these rocks are poorly exposed due to their gentle northeast dip. Because of this, only one coal seam more than 2 inches thick was seen although it is quite probable that seams of workable size are present. The one seam noted outcrops in the north bank of Daniel Creek about 2 miles above its mouth and is about 2 feet thick.

### Summary

It is evident from the foregoing description that the Lower Cretaceous Luscar is by far the most important coal-bearing formation within the map-area. The areal extent of any one seam cannot be known until detailed work is done but from the evidence available at this time, the seams appear to form an *en échelon* pattern and the number of seams present differs from one locality to another. In fact, at several places there may be almost complete absence of coal. According to Thorsteinsson (1952) two complete sections of the Luscar Formation are exposed where Roddy Creek and Sterne Creek cut through the Ambler Mountain anticline, but no coal seams more than 1 foot thick were seen.

Coal outcrops are more numerous in the western and northwestern parts of the Northern Division. It may be that this is due in part to the presence of a larger number of seams than farther east, but to a large extent it is due to repetition because of the larger amount of faulting and folding of the strata and the resulting steeper dips. The extreme fracturing of the seams in the Western Division make it possible to trace them for only short distances. Usually this coal is more crushed and friable than that of the seams in the Northern Division where the intensity of deformation was not as great.

The demand for coal is small at the present time and the reserves in the more inaccessible parts of this map-area may not be needed in the near future. However, it is known that part of the Foothills included in this map-area contains large reserves of high-grade bituminous coal that can be made available when required.

## Gypsum

Gypsum associated with red and yellow shales occurs just beyond the southwest border of this map-area on the divide between Deer Creek and Mowitch Creek, a tributary of Snake Indian River. The deposit has been known for some years and has been described by Allan (1933).

The writer made a hurried visit to the Mowitch Creek deposit in 1954 and traced the shales northwestward. But although the coloured shale facies extends into this map-area for some distance, no gypsum was recognized. The northern limit of the deposit appears to be south of the U-shaped bend of Deer Creek.

No fossils could be found in these strata so that their age and that of the gypsum itself could not be definitely established. A comparison with sections to the northwest suggests that it is of Upper Triassic age.

In the event that this deposit becomes of commercial value in the future, a road from Rock Lake via Wildhay River Valley and Eagles Nest Pass into and up the valley of Rock Creek would be the best means of access.

The only other gypsum noted within this area occurs on Llama Mountain. Here the shale equivalent of the Rock Creek Member of the Fernie Group contains a thin zone about 2 feet thick consisting of mixed shale, fossil remains and selenite.

## Phosphate

The phosphatic conglomerate within the "Rocky Mountain" Formation has already been mentioned. The phosphate appears to be present both as dark grey nodules and as a yellowish translucent material that in thin section is seen to include grains of sand and fragments of fossils such as bryozoa and foraminifera. The phosphate appears to be confined to the conglomerate which ranges in thickness between 1 inch and 1 foot.

A sample of this material contained 18 per cent $P_2O_5$ but it is not likely that the average $P_2O_5$ content would be as high as that given by this assay.

Occurrences of phosphatic limestone at the base of the Fernie Group have been reported along the Foothills southeast of this area. Tests for phosphate were made at several places within the map-area where basal Fernie strata are exposed. These were negative in all cases. However, samples from this zone in the Jasper No. 1 well are reported to have contained about 0.5 per cent $P_2O_5$.

## Limestone

The Palaeozoic formations along the western side of the map-area contain a vast amount of limestone and dolomite. The occurrences near Athabasca Valley may be of commercial importance at some future date because of their proximity to rail transportation. These rocks have been described by Goudge (1946, p. 118).

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# APPENDIX A

## Measured Sections

## Measured Sections of the Banff Formation

*Section 1. Near the base of Boule Roche, southeast end of Boule Range, on a ridge 1½ miles southwest of the head of Prine Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Rundle Formation | | |
| 15 | Shale, calcareous, black, fissile; buff to grey weathering | 20 | 660 |
| 14 | Limestone, lead-grey, cherty, massive | 30 | 640 |
| 13 | Shale, black, crumbly | 2 | 610 |
| 12 | Shale, grey, calcareous, fissile, soft | 3 | 608 |
| 11 | Limestone, argillaceous, grey, thick-bedded; (containing fossil lot L370) | 120 | 605 |
| 10 | Limestone, argillaceous, grey, fissile, thin-bedded | 200 | 485 |
| 9 | Shale, calcareous, grey, very soft | 30 | 285 |
| 8 | Limestone, crinoidal, lead-grey, massive, buff weathering | 15 | 255 |
| 7 | Shale, grey, fissile, calcareous; weathering to paper-thin laminae; contains a few 1- to 2-inch beds of more massive, calcareous shale | 20 | 240 |
| 6 | Limestone, lead-grey, coarse-grained, massive | 10 | 220 |
| 5 | Shale, grey, calcareous, fissile; weathering to paper-thin laminae, with a few 1- to 2-inch beds of more massive calcareous shale | 20 | 210 |
| 4 | Shale, dark grey, calcareous, fissile, light grey weathering; contains fossil lot L371 | 140 | 190 |
| 3 | Limestone, black, argillaceous, massive | 10 | 50 |
| 2 | Limestone, black, argillaceous, soft, fissile | 25 | 40 |
| 1 | Limestone, dark grey, soft; (contains fossil lot L372) | 15 | 15 |
| | TOTAL THICKNESS | 660 | |
| | Underlying beds: Palliser (Boule) Formation | | |



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*Section 2. On the ridge on the west side of Moon Creek near its source in the Berland Range.*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Rundle Formation | | |
| 15 | Limestone, shaly, dark grey, thin-bedded; weathering buff-grey and reddish brown | 9 | 500 |
| 14 | Limestone, dark grey; weathering dark grey; in beds from 3 inches to 3 feet thick; thin ribbons of grey chert near top | 35 | 491 |
| 13 | Limestone, crinoidal, light grey, weathering light grey; beds from 1 inch to 1 foot thick; brachiopods in 2-foot zones near base | 24 | 456 |
| 12 | Limestone, dark grey, hard, nodular; weathering light grey; in beds from 1 inch to 3 inches; some interbedded soft, grey-buff, shaly limestone in beds from 1 inch to 2 feet | 50 | 432 |
| 11 | Limestone, light grey, coarse-grained; weathering brownish; beds from 1 inch to 1 foot; brachiopods in zone about 10 feet from top | 50 | 382 |
| 10 | Limestone, dark grey, fine-grained, buff weathering; containing numerous chert nodules up to 3 inches in diameter; some nodules lined with quartz crystals; thin-bedded | 46 | 332 |
| 9 | Limestone, dark grey, crinoidal, coarse-grained, buff weathering; contains some brachiopods | 19 | 286 |
| 8 | Shale, grey, calcareous and interbedded limestone, dark grey, fine-grained; some chert nodules in the upper limestone beds | 45 | 267 |
| 7 | Limestone, thin-bedded, dark grey, weathering brown; networks of calcite stringers | 23 | 222 |
| 6 | Limestone, dark grey, with chert nodules and large calcite crystals; beds 6 inches to 2 feet; much interbedded calcareous shale | 28 | 199 |
| 5 | Limestone, coarse-grained, dark grey, brown and grey weathering; beds from 6 inches to 1 foot; much white calcite present | 20 | 171 |
| 4 | Limestone, grey, fine-grained; contains chert nodules; beds from 1 foot to 2 feet in thickness | 27 | 151 |
| 3 | Shale, calcareous, dark grey, brown weathering; a few thin, grey limestone beds; much white calcite present | 18 | 124 |
| 2 | Limestone, dark grey, fine-grained; contains chert nodules; beds from 8 inches to 2 feet; weathers buff | 34 | 106 |
| 1 | Limestone and calcareous shale; fine-grained, brownish grey limestone interbedded with grey, calcareous shale; beds between 1 foot and 4 feet thick; both types weather light buff; many small cavities in the limestone, some filled with pyrite | 72 | 72 |
| | TOTAL THICKNESS | 500 | |
| | Underlying beds: Palliser (Boule) Formation | | |

*Section 3. At the head of North Berland River in the Persimmon Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Rundle Formation | | |
| 16 | Limestone, argillaceous, dense, buff to yellow weathering; beds up to 1 foot thick; dark grey | 6 | 566 |
| 15 | Limestone, brownish grey, fine-grained; grey weathering | 3 | 560 |
| 14 | Limestone, dark grey, very fine-grained, buff weathering; beds up to 1 foot thick | 8 | 557 |
| 13 | Shale, calcareous, dark grey, buff weathering; fissile to thin-bedded | 35 | 549 |
| 12 | Limestone, dark grey, coarsely crystalline brown-grey weathering; contains crinoid and brachiopod remains; beds up to 1 foot thick | 13 | 514 |
| 11 | Limestone, argillaceous, dark grey, dense, very hard, nodular; buff weathering; beds up to 3 feet thick; contains scattered brachiopod remains (GSC loc. 24698) | 16 | 501 |
| 10 | Limestone, dark grey, shaly, brown weathering; somewhat banded | 3 | 485 |
| 9 | Limestone, dark grey, dense, hard, brownish weathering; weathers shaly to nodular; contains scattered brachiopods | 15 | 482 |
| 8 | Limestone, dark grey, grey weathering, medium-grained | 7 | 467 |
| 7 | Limestone, dark grey, dense, brownish weathering; nodular; contains corals | 22 | 460 |
| 6 | Limestone, grey, coarsely crystalline, grey weathering; beds up to 4 inches thick | 11 | 438 |
| 5 | Limestone, argillaceous, dark grey to black, grey-weathering; weathers blocky | 20 | 427 |
| 4 | Limestone, dark grey to black, grey weathering, blocky; contains crinoidal remains; some beds composed entirely of crinoidal material; numerous brachiopods along bedding surfaces; scattered corals (GSC loc. 24697) | 86 | 407 |
| 3 | Limestone, dark grey, dense, grey weathering, argillaceous; beds from ¼ inch to 1 inch; contains irregular rounded concretions; buff-weathering; upper 10 feet in nodular beds; scattered brachiopods and corals | 203 | 321 |
| 2 | Limestone, grey, light grey weathering, medium-grained; main part crinoidal and sugary | 15 | 118 |
| 1 | Shale, dark grey, finely banded; some calcareous and some not; light buff weathering; weathers to thin plates, paper-thin in the lower part; thin brown-grey limestone beds increase in number towards the top | 103 | 103 |
| | TOTAL THICKNESS | 566 | |
| | Underlying beds: Palliser Formation | | |



95036—10½

## Measured Sections of the Rundle Group

*Section 4. Exposed 1½ miles southwest of the head of Prine Creek in the Boule Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Triassic (Spray River Formation) | | |
| 8 | Limestone and dolomite, thick-bedded, lead-grey, ash-grey weathering; containing small, angular chert fragments and some white calcite masses; beds average 1 foot thick | 460 | 945 |
| 7 | Limestone, grey, porous, rubbly | 30 | 485 |
| 6 | Limestone, lead-grey, slightly porous | 200 | 455 |
| 5 | Limestone, argillaceous, black, grey weathering | 50 | 255 |
| 4 | Limestone, grey, porous | 5 | 205 |
| 3 | Limestone, grey | 50 | 200 |
| 2 | Limestone, grey, porous | 30 | 150 |
| 1 | Limestone, grey, thick-bedded; containing much chert as small fragments and as streaks 1 inch thick | 120 | 120 |
| | TOTAL THICKNESS | 945 | |
| | Underlying beds: Banff Formation | | |

*Section 5. On the ridge between the headwaters of Carson and Moon Creeks in the Berland Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Triassic (Spray River Formation) | | |
| 27 | Dolomite, dark grey, light grey weathering, thick-bedded; beds average 3 feet in thickness; much white calcite in small cavities and as veinlets | 50 | 665 |
| 26 | Dolomite, grey, buff-weathering, fine-grained | 4 | 615 |
| 25 | Dolomite, grey, grey weathering, thick-bedded; numerous lenses and nodules of dark grey chert; a few, thin, shaly weathering beds | 21 | 611 |
| 24 | Limestone, dolomitic, dark grey, dark grey weathering; contains large and small nodules of white calcite; corals and brachiopods present | 11 | 590 |
| 23 | Dolomite, light grey, light grey weathering, fine-grained | 11 | 579 |
| 22 | Dolomite, dark grey, buff to brown weathering, very hard, fine-grained; numerous calcite-filled cavities; weathered rock presents a honeycomb appearance | 63 | 568 |
| 21 | Dolomite, calcareous, thin-bedded, fine-grained, dark grey, cream weathering, shaly; numerous small cavities filled with calcite and some with pyrite; beds up to 1 foot thick | 18 | 505 |
| 20 | Dolomite, fine-grained, dark grey, brown weathering; many small calcite-filled cavities | 15 | 487 |
| 19 | Dolomite, dark and light grey interbedded; some calcareous shale beds up to 1 foot thick; many small calcite-filled cavities | 21 | 472 |
| 18 | Dolomite and shaly dolomite; dolomite, fine- to medium-grained, brownish grey; beds up to 3 feet but averaging 6 inches to 1 foot; interbedded with thin limestone beds and beds of argillaceous limestone; mostly buff to brown weathering; some beds porous; many masses of white calcite up to 1 foot in diameter | 195 | 451 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 17 | Limestone, grey, extremely fine-grained, dark brownish grey weathering; many patches and veinlets of white calcite | 6 | 256 |
| 16 | Limestone, grey, buff-grey weathering, fine-grained, dolomitic, networks of white calcite stringers | 7 | 250 |
| 15 | Dolomite, grey, shaly, fine-grained, buff weathering | 10 | 243 |
| 14 | Limestone, grey, ash-grey weathering, fine-grained, massive; speckled with calcite crystals in places; some pyrite | 10 | 233 |
| 13 | Dolomite, light grey, light grey weathering, fine-grained | 6 | 223 |
| 12 | Limestone, brownish grey, grey weathering, thin-bedded | 21 | 217 |
| 11 | Dolomite, grey, buff-weathering, fine-grained, brittle | 6 | 196 |
| 10 | Limestone, dark-grey, fine-grained, light grey weathering | 24 | 190 |
| 9 | Limestone, grey, fine-grained, light grey weathering; speckled with minute calcite-filled cavities; very porous when weathered | 10 | 166 |
| 8 | Limestone, dolomitic, brownish grey, fine-grained, grey weathering; minute calcite-filled cavities; porous; some fossil remains | 12 | 156 |
| 7 | Limestone, grey, ash-grey weathering, hard; weathers slaty; thin fossil zone containing brachiopods and crinoid remains | 7 | 144 |
| 6 | Shale, dolomitic, dark grey, buff weathering, soft | 2 | 137 |
| 5 | Limestone, light to dark grey, grey weathering, fine- to medium-grained, thin-bedded | 26 | 135 |
| 4 | Limestone, grey, light grey weathering, hard, very fine grained, thick-bedded; large calcite-filled vugs; 2-foot zone at the top containing brachiopods and crinoid remains | 30 | 109 |
| 3 | Limestone, grey to brown, brownish weathering, soft; in part crinoidal with some bryozoans and brachiopods | 4 | 79 |
| 2 | Limestone, grey, light grey weathering, fine-grained, hard, thick-bedded to massive | 25 | 75 |
| 1 | Limestone, grey, light grey weathering, hard, fine- to medium-grained, thick-bedded to massive; numerous bands and irregular masses of dark grey chert | 50 | 50 |
| | TOTAL THICKNESS | 665 | |
| | Underlying beds: Banff Formation | | |

*Section 6. At the head of North Berland River in the Persimmon Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds covered | | |
| 42 | Limestone, light brownish grey, buff weathering, finely crystalline; some beds mottled light and dark grey; unit includes 4 feet of dark brownish grey, dense limestone containing much calcite near the top | 38 | 921 |
| 41 | Limestone, dark brownish grey, grey weathering, fine-grained, contains many calcite blebs | 30 | 883 |
| 40 | Limestone, brown, brown-grey weathering, dense, porous; becomes pitted or honeycombed when weathered; scattered brachiopods | 22 | 853 |
| 39 | Limestone, grey-brown, brown weathering, dense; beds averaging 2 inches in thickness | 2 | 831 |
| 38 | Dolomite, calcareous, pinkish grey, light grey to cream weathering, fine-grained, porous | 55 | 829 |
| 37 | Limestone, grey, grey weathering; contains numerous calcite veinlets | 10 | 774 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 36 | Limestone, brownish grey, light grey weathering, fine-grained; pin-point porosity; contains 2 zones of fragmental limestone | 92 | 764 |
| 35 | Limestone, dolomitic, pinkish grey, cream weathering | 4 | 672 |
| 34 | Limestone, mottled brown and grey, brown weathering speckled with calcite blebs | 19 | 668 |
| 33 | Limestone, grey to dark grey, medium-grained, light grey weathering; contains much calcite in blebs and small vugs; beds up to 1 foot thick | 52 | 649 |
| 32 | Limestone, or calcareous dolomite, dark grey, dense, cream weathering, brittle; beds up to 1 foot thick | 8 | 597 |
| 31 | Limestone, oolitic, brown, grey-brown weathering; beds up to 3 inches thick | 8 | 589 |
| 30 | Limestone, argillaceous and shale, calcareous; pinkish grey, cream weathering, soft | 15 | 581 |
| 29 | Limestone, grey, grey weathering, very fine grained; contains many blebs of white calcite | 50 | 566 |
| 28 | Limestone, grey, light grey weathering, very fine grained | 2 | 516 |
| 27 | Limestone, calcareous; brown-grey, grey weathering, dense; blebs and veinlets of white calcite; porous on weathered surface | 6 | 514 |
| 26 | Limestone, grey, light grey weathering, finely crystalline; beds up to 3 inches thick | 3 | 508 |
| 25 | Limestone, argillaceous; or shale, calcareous; brown-grey, brownish grey weathering, mostly fine-grained but with scattered patches of more coarsely crystalline calcite; beds up to 2 feet thick | 32 | 505 |
| 24 | Limestone, dark grey, cream weathering, dense; in part argillaceous; weathers shaly | 4 | 473 |
| 23 | Limestone, brown-grey, brownish grey weathering, dense; fine-grained with scattered patches of more coarsely crystalline calcite; in part shaly and calcareous | 34 | 469 |
| 22 | Limestone, grey to dark grey, light grey weathering, fine-grained to lithographic | 2 | 435 |
| 21 | Limestone, brown, grey weathering, dense; contains patches of clear calcite; pitted surface when weathered | 43 | 433 |
| 20 | Limestone, dark grey, dense, cream weathering, shaly | 3 | 390 |
| 19 | Limestone, dark brownish grey, dark grey weathering, dense; numerous calcite veinlets; beds up to 1 foot thick; weathers blocky | 15 | 387 |
| 18 | Limestone; as above but weathers shaly rat er than blocky | 15 | 372 |
| 17 | Limestone, light grey, ash-grey weathering, dense to finely crystalline; beds up to 2 feet thick | 40 | 357 |
| 16 | Limestone, grey to dark grey, grey weathering, dense, argillaceous limestone | 4 | 317 |
| 15 | Limetsone, dark grey, cream weathering, dense; shaly weathering | 2 | 313 |
| 14 | Limestone, dark grey to black, grey weathering, dense; numerous caclite veinlets; breaks into small blocky fragments | 17 | 311 |
| 13 | Limestone, light grey, dense, grey weathering; cut by numerous calcite veinlets | 15 | 294 |
| 12 | Limestone, dark grey to black, light grey weathering, dense; numerous blebs of clear calcite; breaks into small fragments | 23 | 279 |
| 11 | Limestone, dark grey to black, grey weathering, dense, very brittle; breaks into small fragments; argillaceous | 2 | 256 |
| 10 | Limestone, grey, light grey weathering; in part argillaceous, contains numerous brachiopods | 18 | 254 |
| 9 | Limestone, brown, grey weathering, dense; somewhat argillaceous; beds up to 2 feet thick | 21 | 236 |
| 8 | Limestone, grey, grey weathering, fine-grained; beds about 1 foot thick | 7 | 215 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 7 | Limestone, grey, grey weathering; dense to oolitic; beds about 6 inches thick | 4 | 208 |
| 6 | Limestone, grey, grey weathering, dense to fine-grained beds about 2 feet thick | 5 | 204 |
| 5 | Limestone, dark brownish grey, brown weathering, dense; contains remnants of crinoidal parts; weathers shaly | 5 | 199 |
| 4 | Limestone, brown, light grey weathering, dense; contains numerous blebs of white calcite | 78 | 194 |
| 3 | Limestone, brownish grey, brownish weathering, fine- to medium-grained; scattered crinoid fragments | 21 | 116 |
| 2 | Limestone, grey, light grey weathering, coarsely crystalline; upper 20 feet is crinoidal with scattered brachiopods; beds up to 4 feet thick | 77 | 95 |
| 1 | Limestone, grey, light grey weathering, fine- to medium-grained; some beds crinoidal; thick-bedded; 9 feet above the base of the unit is an 18 inch bed containing numerous gastropods; corals (GSC loc. 24699) | 18 | 18 |
| | THICKNESS MEASURED | 921 | |
| | Underlying beds: Banff Formation | | |

*Section 7. On Phroso Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Late Palaeozoic | | |
| 29 | Dolomite, grey, light grey weathering, compact to lithographic; scattered small chert nodules; a few white calcite blebs becoming more numerous toward the base | 130 | 1177 |
| 28 | Dolomite and chert interbedded; fine-grained, grey limestone interbedded with thin bands of light and dark grey chert | 6 | 1047 |
| 27 | Dolomite, grey, compact; contains blebs of white calcite | 39 | 1041 |
| 26 | Dolomite, greenish grey, buff weathering, calcareous; contains numerous tiny calcite-filled vugs | 16 | 1002 |
| 25 | Dolomite, dark grey, grey weathering, fine-grained; much white calcite as filling in vugs and as narrow veinlets | 21 | 986 |
| 24 | Limestone, light grey to greenish grey, grey weathering; contains large masses of white calcite toward the base of the units | 10 | 965 |
| 23 | Dolomite, argillaceous, dark grey and dark grey weathering; very brittle; breaks into small angular blocks; cut by white calcite veinlets | 3 | 955 |
| 22 | Limestone, dark grey to black, grey-brown weathering, compact, brittle; beds from 6 inches to 2 feet thick | 25 | 952 |
| 21 | Shale, grey, calcareous | 10 | 927 |
| 20 | Limestone, grey to dark grey, grey weathering; compact and very fine grained; massive | 24 | 917 |
| 19 | Limestone, shaly or shale, calcareous; brownish grey, fine-grained; (contains plant fragments) | 2 | 893 |
| 18 | Dolomite, grey, calcareous, fine-grained; speckled appearance due to numerous white calcite-filled vugs (pin point to ½ inch) | 60 | 891 |
| 17 | Limestone, dark grey to black, argillaceous, grey weathering, compact | 7 | 831 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 16 | Limestone, grey to brownish grey, grey weathering; finely crystalline: some vugs up to ¼ inch | 76 | 824 |
| 15 | Limestone, grey to brownish, grey weathering, coarsely crystalline; several zones containing crinoid and brachiopod remains; corals occur from 85 feet above the base to the top | 166 | 748 |
| 14 | Limestone, grey and brown, grey to buff weathering, fine-grained to compact; vugs from pin point to ½ inch usually lined or filled with calcite | 344 | 582 |
| 13 | Limestone, brownish grey, grey weathering, argillaceous; large crystals in a fine-grained matrix | 43 | 238 |
| 12 | Limestone, brown, buff weathering, fine-grained; some crystals up to ¼ inch; large calcite-filled vugs | 30 | 195 |
| 11 | Shale, calcareous or limestone, argillaceous; dark grey | 2 | 165 |
| 10 | Limestone, argillaceous, dark grey; weathers shaly; cut by veinlets of white calcite | 3 | 163 |
| 9 | Shale, calcareous or limestone, argillaceous; dark grey | 3 | 160 |
| 8 | Limestone, dark grey, grey weathering; probably argillaceous, contains veinlets of white calcite | 3 | 157 |
| 7 | Shale, calcareous or limestone, argillaceous; dark grey | 1 | 154 |
| 6 | Limestone, grey, hard; contains much white calcite | 6 | 153 |
| 5 | Shale, dark grey, calcareous | 1 | 147 |
| 4 | Limestone, dark grey, hard; contains much calcite | 2 | 146 |
| 3 | Limestone, dark grey, grey weathering, compact to finely crystalline; 64 feet above base of unit is a 6-foot band containing solitary corals | 100 | 144 |
| 2 | Limestone, brownish grey, buff weathering, compact to finely crystalline; contains numerous white calcite veinlets | 14 | 44 |
| 1 | Limestone, grey, grey weathering, fine- to medium-grained, massive | 30 | 30 |
| | THICKNESS EXPOSED | 1,177 | |
| | Underlying beds covered | | |

## Measured Sections of the Rocky Mountain Formation(?)

*Section 8. On the southwest side of Llama Mountain*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Lower Triassic | | |
| 6 | Sandstone, fine-grained, quartzitic, very hard, light grey, thin-bedded in part; in part massive | 3 | 126 |
| 5 | Sandstone, fine-grained, grey, calcareous, soft, brown weathering; massive; cut by a network of calcite veinlets | 8 | 123 |
| 4 | Sandstone, fine-grained, brownish grey, grey-brown weathering, very hard, quartzitic; contains lenses of grey chert up to 1 foot thick | 40 | 115 |
| 3 | Conglomerate, dark grey; lensy and irregular; composed of grains and pebbles of quartzite, chert, and of phosphatic nodules; cemented with iron-stained, phosphatic material | 0–2 | 75 |
| 2 | Chert, light and dark grey; interbedded with grey dolomite and quartzitic sandstone | 43 | 73 |
| 1 | Sandstone, fine-grained, grey, grey weathering, hard | 30 | 30 |
| | APPROXIMATE THICKNESS | 126 | |
| | Underlying beds: Rundle Group | | |

*Section 9. In anticline just northwest of the junction of Sulphur and West Sulphur Rivers*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Lower Triassic | | |
| 3 | Sandstone, grey, quartzitic, brown weathering; contains lenses and beds of grey, light grey weathering chert | 60 | 74 |
| 2 | Conglomerate, dark grey to black, coarse and fine, lensy, rusty weathering; composed of grains and pebbles of chert, quartzite, and phosphatic nodules; all cemented by a transluscent phosphatic material | 2–4 | 19 |
| 1 | Sandstone, chert and dolomite; interlensed and interbedded; upper 2 to 4 feet brecciated into large and small blocks | 15 | 15 |
| | APPROXIMATE THICKNESS | 79 | |

*Section 10. Along Phroso Creek on the southwest flank of the Persimmon Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Lower Triassic | | |
| 3 | Sandstone, grey, grey-brown weathering, medium-grained, massive; in part calcareous; contains lenses of grey chert up to 1 foot thick; chert weathers light grey to white | 45 | 59 |
| 2 | Conglomerate, black, dirty, lensy; composed of grains and pebbles of chert and quartzite and of small phosphatic nodules; cemented with a translucent phosphatic material | 0–4 | 14 |
| 1 | Sandstone, chert and dolomite; breccia of large and small blocks; in part cemented by the overlying phosphatic material but mainly by carbonate | 10 | 10 |
| | APPROXIMATE THICKNESS | 59 | |
| | Underlying beds: Rundle Group | | |

*Section 11. In Rocky Pass on the northeast flank of the Persimmon Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Lower Triassic | | |
| 3 | Sandstone, grey-brown, buff to brown weathering, quartzitic; contains nodular bands of grey chert up to 3 feet thick; massive | 50 | 66 |
| 2 | Conglomerate, dark grey to black; composed of grains and pebbles of quartzite, chert, some dolomite, and small phosphatic nodules all cemented by a translucent phosphatic material | 2–4 | 16 |
| 1 | Sandstone and chert; a breccia of large and small blocks of quartzitic sandstone, grey chert and dolomite | 2–12 | 12 |
| | APPROXIMATE THICKNESS | 53 | 66 |
| | Underlying beds: Rundle Group | | |

# Measured Sections of the Spray River Group

*Section 12. On Llama Mountain in the northwestward extension of the de Smet Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | WHITEHORSE FORMATION | | |
| | Overlying beds: Fernie Group | | |
| 59 | Dolomite, calcareous, fine-grained, grey; contains blebs and veinlets of white calcite; light grey weathering beds up to 3 feet thick | 29.0 | 2030.0 |
| 58 | Dolomite, calcareous, fine-grained, dark grey to black; veinlets of white calcite; beds up to 1 foot thick | 5.3 | 2001.0 |
| 57 | Limestone, dolomitic, medium-grained, grey; some patches of coarse-grained rock; veinlets and blebs of white calcite; weathers mottled dark grey and buff; beds up to 4 feet thick | 16.8 | 1995.7 |
| 56 | Limestone, dark grey, fine-grained, argillaceous, finely banded; weathers shaly | 3.9 | 1978.9 |
| 55 | Dolomite, dark grey, dense, argillaceous, buff weathering; blebs and veinlets of white calcite; beds up to 3 feet thick; weathers shaly | 56.2 | 1975.0 |
| 54 | Dolomite, grey, dense to fine-grained, argillaceous, buff weathering; weathers shaly | 63.0 | 1918.8 |
| 53 | Limestone, dolomitic mottled grey and brown, fine- to coarse-grained, brownish weathering; hackly; numerous white calcite veinlets | 3.8 | 1855.8 |
| 52 | Limestone, grey-brown, dark grey weathering, fine-grained; rock contains large crystals of calcite; beds up to 5 feet thick | 49.2 | 1852.0 |
| 51 | Limestone, grey, weathers mottled grey and brown; brecciated | 2.0 | 1802.8 |
| 50 | Limestone, dark grey, medium-grained; weathers mottled grey and grey-brown; contains calcite crystals up to ¼ inch in diameter; fine network of calcite veinlets and blebs; beds up to 3 feet thick | 109.0 | 1800.8 |
| 49 | Limestone, hard, dark grey, grey weathering; larger crystals in a finer groundmass | 15.0 | 1691.8 |
| 48 | Limestone, light grey, grey weathering, fine-grained; calcite-filled vugs up to 1½ inches across; beds up to 6 inches thick | 30.0 | 1676.8 |
| 47 | Dolomite, calcareous and argillaceous, grey, fine-grained; network of calcite veinlets; vugs up to 1 inch across, some filled and some lined with calcite crystals | 36.5 | 1646.8 |
| 46 | Dolomite, arenaceous, compact, grey, light grey weathering | 34.0 | 1610.3 |
| 45 | Limestone, breccia composed of dark grey and medium-grey angular fragments; numerous vugs, some calcite-filled; weathers nodular and gives a large scale 'honeycomb' appearance; fine-grained | 66.7 | 1576.3 |
| 44 | Dolomite, grey, grey weathering, fine-grained, hard, compact; numerous calcite veinlets; weathers rusty along joints; beds up to 2 feet thick | 16.7 | 1509.6 |
| 43 | Limestone, arenaceous and siltstone, calcareous, brownish grey, buff weathering, fine-grained, vuggy to cavernous; beds up to 2 feet thick | 22.6 | 1492.9 |
| 42 | Limestone, argillaceous, grey, light grey weathering, hard, fine-grained; some veinlets of calcite and some small vugs; beds up to 2 feet thick | 8.0 | 1470.3 |
| 41 | Dolomite, arenaceous, grey, buff to brown weathering, dense | 51.7 | 1462.3 |
| 40 | Limestone, dolomitic, brownish grey, buff weathering, hard, dense | 10.0 | 1410.6 |
| 39 | Dolomite, argillaceous, grey, buff weathering, fine-grained, soft and weathers shaly | 2.0 | 1400.6 |
| 38 | Limestone, brownish grey, light grey weathering, fine-grained, compact; porous when weathered; some calcite veinlets; beds from 6 inches to 2 feet thick | 60.6 | 1398.6 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 37 | Limestone, banded light and dark grey; bands up to ½ inch thick; banding more conspicuous on weathered surface; very compact; cut by some calcite veinlets; weathers buff; beds up to 2 inches thick | 3.0 | 1338.0 |
| 36 | Limestone, same rock as above but brecciated giving a 'marble cake' effect; may be intraformational breccia; some vugs lined with calcite | 4.2 | 1335.0 |
| 35 | Limestone, light grey, light grey weathering, hard, compact; numerous calcite-filled vugs; beds between 2 and 3 feet thick; some gastropod remains | 59.0 | 1330.8 |
| 34 | Limestone, dark brownish grey, light grey weathering, fine-grained, hard; some calcite veinlets; a few small vugs; beds up to 2 feet thick; fossil moulds of gastropods; brachiopods, and ammonites | 11.9 | 1271.8 |
| 33 | Limestone, brecciated; fragments from 1/16 inch to 1½ inches, angular, dark fragments in light grey matrix; may be intraformational breccia or conglomerate | 16.0 | 1259.9 |
| 32 | Limestone, arenaceous, light grey, light grey weathering, fine-grained, hard; vuggy and porous; beds up to 1 foot thick | 4.7 | 1243.9 |
| 31 | Limestone, dark grey, brown weathering, fine-grained, sugary textured; beds up to 2 feet thick | 42.4 | 1239.2 |
| 30 | Limestone, arenaceous, light grey, ash-grey weathering, fine-grained; small calcite-filled vugs from ⅛ to ¼ inch across; numerous white calcite veinlets | 3.0 | 1196.8 |
| 29 | Limestone, dolomitic and argillaceous, dark grey, buff to yellow-brown weathering, fine-grained; honeycomb structure when weathered; calcite-filled vugs; beds from 2 inches to 2 feet thick | 98.0 | 1193.8 |
| 28 | Limestone, argillaceous, grey, buff-grey weathering; fine-grained; small to pin-point pores or vugs; thin-bedded; numerous calcite veinlets | 25.0 | 1095.8 |
| 27 | Limestone, dark grey, argillaceous, brownish to yellow-brown weathering, fine-grained; numerous calcite veinlets; large and small vugs partly filled with calcite; beds up to 2 feet thick | 15.9 | 1070.8 |
| 26 | Limestone, light grey, ash-grey weathering, dense; many small calcite-filled pores or vugs | 24.7 | 1054.9 |
| 25 | Limestone, arenaceous, brownish grey, dark grey weathering, dense; innumerable tiny pores up to ⅛ inch; contains a few calcite veinlets | 7.4 | 1030.2 |
| 24 | Limestone, silty, light brownish grey, brown or grey weathering, dense, hard; weathers shaly; mottled appearance in places; contains some vugs up to ¼ inch; calcite veinlets numerous; beds up to 6 inches thick | 5.9 | 1022.8 |
| 23 | Limestone, argillaceous or silty, dark brownish grey, dark grey weathering, hard, dense; weathers shaly; contains some vugs up to ¼ inch; calcite veinlets numerous; beds up to 3 inches thick | 1.7 | 1016.9 |
| 22 | Limestone, arenaceous, light grey, buff and grey weathering, fine-grained, dense, vuggy; many calcite-filled veinlets and vugs; beds from 2 inches to 2 feet thick | 67.1 | 1015.2 |
| 21 | Limestone, arenaceous, light to medium grey, yellow-brown weathering, fine-grained; contains vugs filled or lined with calcite and some calcite veinlets | 14.4 | 948.1 |
| | THICKNESS OF WHITEHORSE FORMATION | 1,096.3 | |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | SULPHUR MOUNTAIN FORMATION | | |
| 20 | Sandstone, calcareous, light brownish grey, buff weathering, very fine grained, hard, thin-bedded; breaks into thin slabs; a siliceous limestone in places | 40.0 | 933.7 |
| 19 | Limestone, arenaceous, light grey, fine-grained; weathers mottled buff and grey with a rough surface; contains calcite veinlets and calcite-filled vugs | 15.0 | 893.7 |
| 18 | Sandstone, dolomitic or calcareous, grey-brown, yellow-brown weathering, hard, tough; white calcite along joints; joints contain some double-ended quartz crystals up to ¾ inch long; thin-bedded; some fine ripple-marks | 4.0 | 878.7 |
| 17 | Sandstone, dolomitic, grey-brown with dark grey bands, cross-laminated, hard, fine-grained, yellow-brown weathering; alternating thick and thin beds, some finely banded and some not; beds between ½ inch and 1 foot thick | 50.0 | 874.7 |
| 16 | Dolomite, arenaceous, light greyish brown, fine-grained; weathers yellow-brown and slabby; vugs, some lined with calcite; beds up to 1 foot thick; some fossil imprints | 5.0 | 824.7 |
| 15 | Dolomite, arenaceous, greyish brown, fine-grained; weathers yellow-brown and slabby; beds up to 1 foot thick; some fossil remains | 3.0 | 819.7 |
| 14 | Siltstone, calcareous, or a very fine calcareous sandstone; fine-grained, grey-brown with dark grey bands; cross-laminated; beds from ½ inch to 2 inches thick; weathers light brown; alternating thick and thin beds | 6.0 | 816.7 |
| 13 | Dolomite, fine-grained, light grey-brown, hard; weathers yellow-brown and slabby; contains a few calcite-lined vugs and stringers; beds up to 1 foot thick | 4.0 | 810.7 |
| 12 | Dolomite, arenaceous, dark grey, light brown or buff weathering, calcareous in part, fine-grained; contains vugs up to 1 foot thick; some brachiopod remains | 10.0 | 806.7 |
| 11 | Sandstone, dolomitic, grey, light grey weathering, fine-grained; some calcite veinlets and calcite-filled vugs; beds from 2 inches to 1 foot thick; contains numerous fossil fragments | 4.0 | 796.7 |
| 10 | Sandstone, calcareous or limestone, arenaceous; fine-grained, grey-brown, yellow weathering; some calcite-filled vugs; beds from 6 inches to 2 feet thick | 67.0 | 792.7 |
| 9 | Dolomite, silty, brownish grey, fine-grained, hard; some thin veinlets of white calcite; fragments of '*Lingula*' | 3.0 | 725.7 |
| 8 | Sandstone, calcareous or dolomitic, dark grey to black, fine-grained; thin beds from ½ inch to 2 inches thick | 125.0 | 722.7 |
| 7 | Sandstone, brownish grey, hard, fine-grained, very calcareous; beds up to 6 inches thick interbedded with siltstone beds up to ½ inch thick; some ammonite impressions | 113.0 | 597.7 |
| 6 | Sandstone, dolomitic, dark grey; interbedded with dolomite and dolomitic siltstone, fine-grained, dark grey | 195.0 | 484.7 |
| 5 | Siltstone and interbedded sandstone, dark grey; sandstone beds weather buff and brown and contain pyrite and carbonate; in beds up to 2 feet thick; siltstone beds from paper thin to ¼ inch thick | 24.8 | 289.7 |
| 4 | Siltstone, dark grey, sandy; two small sandstone beds near the centre of unit; some non-pyritiferous concretions near the top; beds from ⅛ to ½ inch thick | 12.9 | 264.9 |
| 3 | Dolomite, argillaceous, grey-brown, yellow-brown weathering, hard; interbedded with dolomitic siltstone | 2.0 | 252.0 |
| 2 | Siltstone, dark grey, sandy; in beds ⅛ to ½ inch thick | 50.0 | 250.0 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 1 | Siltstone, dark grey to black and bluish black, hard; interbedded with shale and silty shale; unit is more shaly toward the base; calcareous in places; grades in places into siliceous or argillaceous dolomite; weathers brownish; beds from paper thinness to 2 inches thick which are finely banded; 22 feet above the base of the unit is a bed of hard, black rock ranging from calcareous siltstone to siliceous dolomite; this band contains cigar-shaped and ovoid concretionary bodies, some of which contain pyrite; ammonite impressions occur just above this band in softer shale | 200.0 | 200.0 |
| | THICKNESS OF SULPHUR MOUNTAIN FORMATION | 933.7 | |
| | TOTAL THICKNESS OF TRIASSIC SECTION | 2,030.0 | |
| | Underlying beds: Late Palaeozoic | | |

*Section 13. In Rocky Pass on the northeast side of the Persimmon Range*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | SULPHUR MOUNTAIN FORMATION | | |
| | Overlying beds covered | | |
| 6 | Sandstone, grey, red-brown weathering; uppermost beds up to 4 feet thick; some beds calcareous or dolomitic; 3 or 4 beds of dolomite and siliceous dolomite toward the top of the unit | 415.0 | 730.0 |
| 5 | Siltstone, dark grey, finely banded, reddish brown weathering; containing sandstone bands; sandstone, grey, fine-grained, buff weathering; these very numerous toward top of unit | 20.0 | 315.0 |
| 4 | Siltstone, dark grey, reddish brown weathering, finely banded; intercalated fine-grained, grey sandstone bands up to 1 inch thick; a few ammonite impressions | 16.5 | 295.0 |
| 3 | Siltstone, dark grey, brown weathering, finely banded; several thin concretionary layers | 35.5 | 278.5 |
| 2 | Shale, silty and siltstone, dark grey to black; finely banded; weathers brown; weathers to thin plates, some paper-thin; several ammonite impressions | 223.0 | 243.0 |
| 1 | Shale and silty shale, dark grey to black, brown weathering, fissile to paper-thin laminae | 20.0 | 20.0 |
| | THICKNESS EXPOSED | 730.0 | |
| | Underlying beds: Late Palaeozoic | | |

*Section 14. On a small westward-flowing creek located one mile south of Walton Creek and just east of longitude 119°00′*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | WHITEHORSE FORMATION | | |
| | Overlying beds: Fernie Group | | |
| 49 | Limestone, black, dense; in beds 3 feet thick; contains irregular chert lenses from 0 to 4 inches thick; weathers brown grey; contains calcite veinlets | 6.0 | 709.5 |
| 48 | Shale, grey, dolomitic or calcareous, yellow-brown weathering, thin-bedded | 0.4 | 703.5 |
| 47 | Limestone, dark grey, finely crystalline; weathers light grey | 0.3 | 703.1 |
| 46 | Dolomite, dark grey, finely crystalline; weathers light grey, contains many calcite veinlets up to 1/16 inch | 1.0 | 702.8 |
| 45 | Dolomite, grey brown, finely crystalline, thin-bedded; weathers light grey | 0.5 | 701.8 |
| 44 | Dolomite, light grey; weathers very light grey with reddish tint; dense | 0.6 | 701.3 |
| 43 | Dolomite, grey, grey weathering; thin-bedded; beds from ¼ inch to 1 inch thick | 1.1 | 700.7 |
| 42 | Limestone, dolomitic; mottled grey and dark grey | 2.7 | 699.6 |
| 41 | Dolomite, grey; weathers light grey; finely crystalline; beds ¼ inch to 6 inches thick; alternating with beds one foot thick | 4.0 | 696.9 |
| 40 | Dolomite, dark grey, very finely crystalline; weathers light grey to buff | 2.0 | 692.9 |
| 39 | Dolomite, grey to dark grey, finely crystalline, thinly bedded | 1.5 | 690.9 |
| 38 | Dolomite, very finely crystalline, dark grey; weathers light grey to buff | 2.8 | 689.4 |
| 37 | Dolomite, as above; much disseminated pyrite; weathers buff | 3.5 | 686.6 |
| 36 | Dolomite, grey, dense; weathers grey; in beds about 2 inches thick | 1.6 | 683.1 |
| 35 | Dolomite, argillaceous, dark grey, buff weathering; in beds from ¼ inch to 1 inch thick | 9.0 | 681.5 |
| 34 | Dolomite, as above; weathers to concretionary masses | 0.5 | 672.5 |
| 33 | Dolomite, as above; concretionary masses up to 4 inches | 0.9 | 672.0 |
| 32 | Dolomite, as above but more shaly | 5.0 | 671.1 |
| 31 | Limestone, banded grey and dark grey; bands up to ¼ inch thick; beds about 5 inches thick | 1.8 | 666.1 |
| 30 | Mostly covered; rubble of yellowish brown dolomitic material | 6.8 | 664.3 |
| 29 | Limestone, brecciated, dark grey; weathers dark grey | 3.3 | 657.5 |
| 28 | Covered; rubble, yellowish weathering, calcareous material | 14.0 | 654.2 |
| 27 | Dolomite, grey; one bed; contains irregular, alternating zones of dark grey dolomitic limestone up to 1/16 inch thick; weathers yellowish brown to grey-brown | 7.6 | 640.2 |
| 26 | Sandstone, medium-grained, light grey, porous, calcareous cement; quartz grains well-rounded; bedding from ¼ inch to 4 inches thick | 5.0 | 632.6 |
| 25 | Limestone, breccia, light grey matrix; some quartz grains present; dark grey fragments up to 2 inches long; contains lenses of fine-grained sandstone as above | 4.9 | 627.6 |
| 24 | Limestone; alternating bands of grey and dark grey limestone; weathers dark grey; contains many calcite veinlets | 2.9 | 622.7 |
| 23 | Limestone, dolomitic; in beds 6 inches thick; dark grey; weathers grey | 2.9 | 619.8 |
| 22 | Limestone, breccia; light grey and grey with some quartz grains | 0.5 | 616.9 |
| 21 | Sandstone, dolomite cement; fine-grained; beds from 1 inch to 2 inches | 3.0 | 616.4 |
| 20 | Covered; alternating light and dark grey sandstone as above | 1.3 | 613.4 |
| 19 | Sandstone, calcareous; or sandy limestone; quartz grains rounded | 4.5 | 612.1 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 18 | Covered; rubble of light yellowish brown, dolomitic material containing rounded quartz grains | 6.7 | 607.6 |
| 17 | Sandstone, yellowish brown, very fine grained, soft, noncalcareous; weathers lighter than above | 3.7 | 600.9 |
| 16 | Limestone, dark grey, dark grey weathering | 0.8 | 597.2 |
| 15 | Sandstone, dolomitic; contains quartz grains; light yellow-brown; weathers to the same colour | 2.5 | 596.4 |
| 14 | Sandstone, light grey, light grey to yellow-brown weathering beds about 1 inch thick; calcareous cement; a few specks of pyrite | 2.3 | 593.9 |
| 13 | Sandstone, as above; beds up to 5 inches thick | 14.3 | 591.6 |
| 12 | Covered | 6.0 | 577.3 |
| 11 | Limestone, arenaceous, light yellow-grey; weathers yellow-brown with a pitted surface; beds from ½ inch to 4 inches thick | 2.0 | 571.3 |
| 10 | Limestone as above but light grey; some disseminated pyrite | 1.6 | 569.3 |
| 9 | Dolomite, sandy, very fine grained, yellowish brown weathering; beds about 1 inch thick | 8.0 | 567.7 |
| 8 | Dolomite, dense, light grey, light grey weathering; contains calcite blebs up to ¼ inch; beds about 5 inches thick | 2.2 | 559.7 |
| 7 | Limestone, dark grey, dark grey weathering, dense; upper 3 feet in beds about 5 inches thick; lower 7 feet is one bed; contains calcite veinlets and small calcite blebs | 11.0 | 557.5 |
| 6 | Dolomite, light grey, light grey weathering; two beds about 8 inches thick | 1.6 | 546.5 |
| 5 | Dolomite as above | 2.0 | 544.9 |
| 4 | Dolomite, light grey and dark grey interbedded; beds about 1 foot thick | 3.5 | 542.9 |
| 3 | Same as above but darker in colour | 6.5 | 539.4 |
| 2 | Covered; lower part underlain by sandy material, yellow-grey in colour | 51.7 | 532.9 |
| 1 | Breccia; dolomitic matrix with limestone fragments up to ¼ inch; beds up to 6 feet thick; some unbrecciated beds of limestone are included | 73.2 | 481.2 |
| | Covered | 408.0 | 408.0 |
| | TOTAL THICKNESS EXPOSED | 709.5 | |
| | Underlying beds: Triassic arenaceous dolomite, sandstone and siltstone | | |

*Section 15. At head of small branch of Rock Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | WHITEHORSE FORMATION | | |
| | Overlying beds covered | | |
| 7 | Limestone, grey and dark grey, grey to ash-grey weathering, hard; dolomite, grey and brown-grey, grey and buff weathering; interbedded argillaceous limestone and dolomite | 170.0 | 941.0 |
| 6 | Limestone, grey to dark grey, grey weathering; some interbedded dolomite and argillaceous dolomite; a 1-foot thick bed contains gastropods | 20.0 | 771.0 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 5 | Limestone and dolomite, dark grey to brown; grey and buff weathering; some soft, argillaceous beds that weather shaly | 20.0 | 751.0 |
| 4 | Shale and dolomitic shale, soft; weathers to red-brown, greenish and ochre colours; several feet of argillaceous limestone and dolomite at base; contains several brecciated zones; unit partly obscured | 440.0 | 731.0 |
| 3 | Dolomite, dark grey, grey weathering; interbedded limestone that weathers light grey; beds up to 2 feet thick | 26.0 | 291.0 |
| 2 | Shale, and dolomitic shale, soft, grey to brown; weathers to reddish and ochre colours; 20-foot thick brecciated zone at the top | 40.0 | 265.0 |
| 1 | Limestone and dolomite, argillaceous and siliceous, dark grey and grey-brown, light grey and buff weathering | 225.0 | 225.0 |
| | THICKNESS EXPOSED | 941.0 | |
| | Underlying beds covered | | |

*Section 16. Composite section of the Triassic strata in the Berland Range near the head of Moon Creek and Little Berland River*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | WHITEHORSE FORMATION | | |
| | Overlying beds: Fernie Group | | |
| 7 | Limestone and dolomite, grey, dark grey and brown-grey, buff, ash-grey and cream-white weathering, hard; some interbedded softer argillaceous dolomite and limestone that weathers shaly; includes at least 2 brecciated zones; beds become arenaceous limestone and dolomite and dolomitic sandstone near the base | 100.0 | 1151.0 |
| 6 | Limestone, arenaceous or silty, grey, buff weathering; interbedded dolomite, dark grey; and arenaceous or argillaceous dolomite | 50.0 | 1051.0 |
| | THICKNESS EXPOSED | 150.0 | |
| | SULPHUR MOUNTAIN FORMATION | | |
| 5 | Sandstone, grey, buff weathering; siltstone, dark grey, grey weathering; dolomite and arenaceous dolomite; dolomite content increases upward; beds in upper half of unit are from 1 foot to 6 feet thick; lower half consists of beds from 6 inches to 2 feet thick | 100.0 | 1001.0 |
| 4 | Covered | 300.0 | 901.0 |
| 3 | Sandstone, grey, fine-grained, red-brown weathering; forms platy talus; thin-bedded and finely banded; unit contains a few sandstone beds up to 2 feet thick | 100.0 | 601.0 |
| 2 | Sandstone, grey to dark grey, finely banded, very fine grained, red-brown weathering; interbedded with dark grey siltstone toward the base of unit | 500.0 | 501.0 |
| 1 | Conglomerate; composed of sub-angular limestone and dolomite fragments in a calcareous sandstone matrix | 1.0 | 1.0 |
| | THICKNESS EXPOSED | 1,001.0 | |
| | Underlying beds: Rundle Group. | | |
| | TOTAL THICKNESS EXPOSED | 1,151.0 | |

## Measured Sections of the Fernie Group

*Section 17. On a small creek 1 mile south of Walton Creek and just east of longitude 119°00′*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | FERNIE GROUP | | |
| 26 | Overlying beds covered | | |
| 25 | Shale, black fissile to thin-bedded; contains numerous ironstone bands from 2 inches to one foot thick; some of these contain disseminated pyrite. This unit is contorted and faulted | 300.0 to 400.0 | 510.9 to 610.9 |
| 24 | Shale, black, fissile; ironstone bands occur at 3.6, 14.4, 21.4, 28.6 and 34.5 feet respectively from the top of the unit; these bands contain numerous specimens of an *Aucella* of the *bronni* group and range in thickness from 2 inches to 1 foot | 35.0 | 210.9 |
| 23 | Shale, dark grey to black, fissile | 6.6 | 175.9 |
| 22 | Covered; mostly black silty shale with some ironstone concretions; contains specimens of belemnites | 11.2 | 169.3 |
| 21 | Mostly covered; upper 1 foot consists of thin-bedded, dark grey siltstone, weathering light yellow-brown; contains some belemnites in a sandy zone. Concretionary bands near the top contain ammonites about 1 foot in diameter, pelecypods up to 6 inches across, and numerous belemnites | 15.0 | 158.1 |
| 20 | Shale, black, fissile. At 0.8, 14.6, 16.6, 18.7, 23.6 and 29.5 feet respectively from the top of the unit are dark grey siltstone bands about ¼ inch thick. Some belemnites are present | 37.3 | 143.1 |
| 19 | Covered; contains large concretionary masses up to 3 feet in diameter, no fossils found in them; beds contain irregularly shaped masses of fine-grained pyrite | 48.9 | 105.8 |
| 18 | Limestone, black, dense; forms oblong concretionary masses on weathering, up to 9 inches long; some fossil fragments present (belemnites and pelecypods) | 0.5 | 56.9 |
| 17 | Covered | 6.4 | 56.4 |
| 16 | Limestone, black, finely crystalline; weathers medium to dark grey; contains many calcite veins up to ¼ inch | 2.5 | 50.0 |
| 15 | Shale, black, silty, thin-bedded | 3.7 | 47.5 |
| 14 | Limestone, black, fine-grained; many calcite veinlets up to ½ inch thick; weathers light brownish grey | 0.6 | 43.8 |
| 13 | Limestone, black, dense | 1.5 | 43.2 |
| 12 | Limestone, black, thin-bedded; in beds about ¼ inch thick | 0.4 | 41.7 |
| 11 | Shale, calcareous, black, fissile | 1.4 | 41.3 |
| 10 | Limestone, black; beds up to ¼ inch | 0.3 | 39.9 |
| 9 | Shale, calcareous, black, fissile | 0.4 | 39.6 |
| 8 | Limestone, black; beds about 2 inches thick | 0.5 | 39.2 |
| 7 | Shale, calcareous, black, fissile | 1.3 | 38.7 |
| 6 | Limestone, black; beds up to ½ inch thick | 0.8 | 37.4 |
| 5 | Shale, calcareous, black, fissile | 3.6 | 36.6 |
| 4 | Limestone, black; beds up to 1 inch thick | 1.8 | 33.0 |
| 3 | Limestone, black; beds about ¼ inch thick | 3.5 | 31.2 |
| 2 | Limestone, black, thin-bedded | 27.2 | 27.7 |
| 1 | Sandstone, conglomeratic, containing quartz grains up to ¼ inch in diameter, angular fragments of grey and black shale and limestone. This bed ranges in thickness but averages about 6 inches | 0.5 | 0.5 |
| | Underlying beds: Triassic limestone | | |

*Section 18. On the northeast side of Llama Mountain in creek valleys*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Nikanassin Formation | | |
| 25 | Siltstone, sandy, grey; interbedded with sandstone, fine-grained, light grey; beds average 7 inches in thickness and weather brown. Siltstone weathers grey. Sandstone bands laminated light and dark grey. At 120 feet from base of this unit is a calcareous sandstone bed 2 feet thick, dark grey, hard, yellow-brown weathering. At 149 feet from base of this unit is an 8 inch band of sandstone same as above. At 177 feet from base of unit is a band of calcareous sandstone 2 feet thick, buff weathering | 258.0 | 1794.2 |
| 24 | Siltstone, dark grey, thin-bedded; interbedded with dark grey, banded fine-grained sandstone. Siltstone weathers grey; sandstone weathers buff to brown. Siltstone beds up to 1 inch thick; sandstone in beds up to 8 inches thick; the thicker sandstone beds are cross-bedded | 31.0 | 1536.2 |
| 23 | Shale, silty; containing brown weathering, fine-grained, grey sandstone beds about every 6 feet. These sandstone beds are up to 6 inches thick | 25.0 | 1505.2 |
| 22 | Sandstone, grey, hard; in beds up to 8 inches thick; interbedded with silty shale | 6.0 | 1480.2 |
| 21 | Shale, silty, dark grey; interbedded with thin (up to 3 inches thick) sandstone and siltstone beds. Sandstone beds increase in number and thickness toward top of unit. Some sandstone beds near top are 5 inches thick | 71.0 | 1474.2 |
| 20 | Shale, silty, dark grey; with interbedded, grey, siltstone ribbons up to 3 inches thick. Several thin, yellow-weathering, hard concretionary bands | 45.3 | 1403.2 |
| 19 | Siltstone, dark grey, hard, thin-bedded; interbedded with thin sandstone beds up to 3 inches thick. Siltstone and sandstone about equal quantities | 20.0 | 1357.9 |
| 18 | Siltstone, shaly, dark grey; beds up to ¼-inch thick; interbedded with thin sandstone ribbons. In this unit there are 2 6-inch thick, yellow weathering concretionary bands | 30.0 | 1337.9 |
| 17 | Sandstone, grey, fine-grained, weathering grey; thin-bedded (up to 2 inches thick) | 2.0 | 1307.9 |
| 16 | Shale, silty; with sandstone ribbons | 30.0 | 1305.9 |
| 15 | Ironstone, grey, hard, tough, yellow weathering | 3.0 | 1275.9 |
| 14 | Shale, silty, dark grey; with thin, ribbon-like, grey sandstone bands (up to 3 inches thick); these are brown weathering | 70.0 | 1272.9 |
| 13 | Contorted zone containing several folds and small faults. Possibly some overlap between last measured section and next lower measured section | | |
| 12 | Shale, silty, dark grey; with minor amounts of interbedded, thin (up to 2 inches) beds of fine-grained grey sandstone; sandstone weathers brown; shale weathers dark grey; a few dark grey, scattered, spherical concretions containing pyrite | 260.0 | 1202.9 |
| 11 | Siltstone, dark grey; contains some irregular bands of fine-grained, light grey sandstone up to ¼ inch thick. Bedding up to 2 inches thick; this material is mottled due to lighter sandstone mixed with darker shaly siltstone | 53.0 | 942.9 |
| 10 | Shale, silty; dark grey to black; contains siltstone bands (¼ to 1 inch thick); siltstone bands occur at intervals of about 4 feet | 90.0 | 889.9 |
| 9 | Shale, silty; interbedded with thin, dark grey, siltstone bands (¼ to 1 inch thick); these bands occur at intervals of 3 inches to 6 inches apart | 252.0 | 799.9 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 8 | Shale, some silty, dark grey to black; with occasional interbedded, ribbon-like siltstone bands up to ½ inch thick; a zone about middle of this unit contains almost spherical, individual, dark grey to black concretions which usually have a core of pyrite | 50.0 | 547.9 |
| 7 | Shale, dark grey to black, fissile; contains continuous and discontinuous concretionary ironstone bands (2 inches to 1 foot thick) about 6 to 10 feet apart. Also, some scattered individual concretions of ironstone (round and oval shapes) up to 3 feet in diameter. The lower 70 feet of this zone contains fossils including ammonites, and pelecypods. Fossils in shale are flat impressions only. Concretionary bands weather yellow to brown | 375.0 | 497.9 |
| 6 | Ironstone, calcareous, compact, hard, grey, brown-yellow weathering; containing harder, grey concretionary bodies | 4.0 | 122.9 |
| 5 | Shale, black, soft, fissile | 38.6 | 118.9 |
| 4 | Coquina, fossil fragments of belemnites, pelecypods and gypsum | 2.0 | 80.3 |
| 3 | Shale, dark grey to black; fissile, soft; some slightly calcareous; containing numerous bands of ironstone from 2 inches to 2 feet thick; these are about 10 to 20 feet apart and are concretionary | 50.0 | 78.3 |
| 2 | Limestone, dolomitic, black, probably argillaceous, very fine-grained; hard; interbedded with shale, calcareous, black, fissile rock cut by calcite veinlets up to ½ inch thick | 18.3 | 28.3 |
| 1 | Limestone, black, very fine grained, thin-bedded; and shale, calcareous, black, fissile | 10.0 | 10.0 |
| | APPROXIMATE THICKNESS | 1,794.2 | |
| | Underlying beds: Triassic limestone | | |

*Section 19. In banks of South Muskeg River about 300 yards upstream from mouth*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds covered | | |
| 4 | Shale and silty shale; with interbedded ironstone bands and individual concretions | 50.0 | 167.0 |
| 3 | Sandstone, grey, quartzitic, medium-grained, buff weathering, in part calcareous | 15.0 | 117.0 |
| 2 | Shale, black, fissile; lower 20 feet is calcareous; contains two black limestone beds about 1 foot thick; upper 67 feet not so fissile and contains ironstone beds between 2 inches and 6 inches thick about every 10 feet; contains pelecypods, belemnites and ammonoids in upper 70 feet | 87.0 | 102.0 |
| 1 | Limestone, black, hard; contains several beds (2 inches to 1 foot) of black calcareous shale; *Pecten*, *Ostrea* and *Rhynchonella* sp. indet. were collected from the upper 5 feet | 15.0 | 15.0 |
| | THICKNESS EXPOSED | 167.0 | |
| | Underlying beds: Triassic Whitehorse Formation | | |

## Measured Sections of the Nikanassin Formation

*Section 20. On Berland River just east of the mouth of Adam's Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Cadomin Formation | | |
| 15 | Sandstone, brownish and grey sandstone, weathering light brown, with interbedded grey shale; two 3-foot ironstone beds at 20 and 74 feet below the top | 148.0 | 904 |
| 14 | Sandstone, grey, hard, quartzitic, dark grey weathering | 17.0 | 756 |
| 13 | Sandstone and shale, grey, buff weathering sandstone with interbedded greenish, silty shale | 52.0 | 739 |
| 12 | Sandstone, hard, thin-bedded, grey, brown weathering | 58.0 | 687 |
| 11 | Shale, dark grey, with interbedded sandstone bands up to 2 feet thick | 27 | 629 |
| 10 | Sandstone, hard, grey, thick-bedded, light brown weathering, medium-grained with minor thin, grey shale partings | 159 | 602 |
| 9 | Shale and sandstone, interbedded brownish grey, grey-buff weathering sandstone and grey-green shale in beds about 6 feet thick | 58 | 443 |
| 8 | Sandstone, thick-bedded to massive, grey, buff weathering, with minor thin shale partings | 253 | 385 |
| 7 | Shale, grey, silty | 4 | 132 |
| 6 | Sandstone, hard, brown, yellow weathering | 2 | 128 |
| 5 | Shale, black, fissile | 6 | 126 |
| 4 | Sandstone, thin-bedded, grey, quartzitic, grey weathering | 46 | 120 |
| 3 | Shale, dark grey to black, silty | 5 | 74 |
| 2 | Sandstone, thin-bedded, grey-brown, dark grey to brown weathering | 49 | 69 |
| 1 | Sandstone, light grey, grey weathering, hard, quartzitic, massive | 20 | 20 |
| | TOTAL THICKNESS | 904 | |
| | Underlying beds: Fernie Group | | |

*Section 21. Exposed where Smoky River crosses the Sterne Creek anticline (Thorsteinsson, 1952)*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Cadomin Formation | | |
| 99 | Siltstone, dark grey, crumbly weathering | 3.0 | 1278.1 |
| 98 | Sandstone, grey, fine-grained, in part carbonaceous, finely bedded | 3.0 | 1275.1 |
| 97 | Siltstone, dark grey, crumbly weathering; interbedded with thinly bedded carbonaceous sandstone | 5.0 | 1272.1 |
| 96 | Sandstone, brown, crossbedded, medium-grained, carbonaceous | 5.0 | 1267.1 |
| 95 | Siltstone, grey, hard; with intercalated fine-grained sandstone beds | 12.0 | 1262.1 |
| 94 | Sandstone, buff, crossbedded, carbonaceous; with occasional interbedded siltstone | 26.6 | 1250.1 |
| 93 | Sandstone, grey to brown, crossbedded locally, interbedded with massive quartzitic sandstone beds ranging up to 3.5 feet in thickness | 55.6 | 1223.5 |
| 92 | Siltstone and sandstone; dark grey, calcareous siltstone interbedded with fine-grained, tan-coloured, crossbedded sandstone with fragmentary plant remains | 20.0 | 1167.9 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 91 | Siltstone, dark grey, hard; with minor, intercalated, light grey, fine-grained sandstone | 15.0 | 1147.9 |
| 90 | Siltstone, dark grey, hard, containing large ironstone concretions and numerous plant remains | 15.5 | 1132.9 |
| 89 | Sandstone and siltstone; grey, crossbedded sandstone interbedded with dark grey siltstone, each in beds approximately 1 foot thick | 33.0 | 1117.4 |
| 88 | Siltstone, dark grey, hard | 3.4 | 1084.4 |
| 87 | Sandstone, grey, fine-grained, crossbedded, weathers buff, thinly bedded at top, becoming more thickly bedded towards base | 14.6 | 1081.0 |
| 86 | Siltstone, dark grey, hard, carbonaceous | 2.1 | 1066.4 |
| 85 | Sandstone, light grey to buff, minutely crossbedded, carbonaceous, very hard, massive | 2.2 | 1064.3 |
| 84 | Siltstone, dark grey, crumbly weathering | 3.2 | 1062.1 |
| 83 | Sandstone, grey, fine-grained, crossbedded, carbonaceous, buff weathering | 2.8 | 1058.9 |
| 82 | Siltstone, dark grey | 3.0 | 1056.1 |
| 81 | Sandstone, buff, thinly bedded, carbonaceous, buff weathering | 7.2 | 1053.1 |
| 80 | Sandstone, dark grey, highly carbonaceous, thinly bedded, grading into siltstone | 18.0 | 1045.9 |
| 79 | Sandstone, buff to grey, quartzitic, minutely crossbedded | 2.3 | 1027.9 |
| 78 | Siltstone and sandstone; lenses of grey siltstone in crossbedded, fine-grained, buff sandstone containing carbonaceous fragments | 7.0 | 1025.6 |
| 77 | Sandstone, dark grey, fine-grained, quartzitic, massive | 4.9 | 1018.6 |
| 76 | Sandstone, brown, fine-grained, minutely crossbedded, carbonaceous, thinly bedded, buff weathering | 7.4 | 1013.7 |
| 75 | Siltstone, grey; containing lenses of crossbedded, fine-grained, carbonaceous sandstone | 18.0 | 1006.3 |
| 74 | Sandstone, dark grey, fine-grained, thinly bedded, carbonaceous, buff weathering | 0.7 | 988.3 |
| 73 | Sandstone, light brown, minutely crossbedded, quartzitic, carbonaceous, yellow to orange weathering | 1.4 | 987.6 |
| 72 | Siltstone, light to dark grey | 9.6 | 986.2 |
| 71 | Sandstone, dark grey, thinly bedded, crossbedded, carbonaceous | 0.5 | 976.6 |
| 70 | Siltstone, dark grey, crumbly weathering | 2.4 | 976.1 |
| 69 | Sandstone, light yellow, thinly bedded, crossbedded, carbonaceous | 0.5 | 973.7 |
| 68 | Siltstone, dark grey, crumbly weathering | 5.7 | 973.2 |
| 67 | Sandstone, light brown, fine-grained, minutely crossbedded, carbonaceous; minor interbeds of grey siltstone | 8.3 | 967.5 |
| 66 | Siltstone and sandstone; crumbly weathering dark grey siltstone interbedded with minutely crossbedded, fine-grained, carbonaceous rusty weathering sandstone | 35.0 | 959.2 |
| 65 | Sandstone, dark grey, medium-grained, crossbedded, hard; siltstone partings | 3.0 | 924.2 |
| 64 | Sandstone, light brown, fine-grained, crossbedded, carbonaceous | 1.0 | 921.2 |
| 63 | Sandstone, dark grey, medium-grained, crossbedded, quartzitic | 14.6 | 920.2 |
| 62 | Sandstone, buff, fine-grained, quartzitic, minor siltstone interbeds; plant fragments | 9.6 | 905.6 |
| 61 | Siltstone and sandstone; intergrading and interfingering, dark grey siltstone and fine-grained, grey, carbonaceous sandstone | 29.5 | 896.0 |
| 60 | Sandstone, light brown, crossbedded, carbonaceous | 0.6 | 866.5 |
| 59 | Siltstone and sandstone, alternating in beds about 1 foot thick; sandstone, grey to buff, fine- to medium-grained; siltstone, dark grey and crumbly weathering, carbonaceous | 51.0 | 865.9 |
| 58 | Sandstone, dark grey, grey weathering, fine-grained, hard, dense | 3.0 | 814.9 |
| 57 | Siltstone, dark grey, thinly bedded, hard, contains fragments of plant stems | 15.0 | 811.9 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 56 | Sandstone, grey, quartzitic; carbonaceous bedding planes | 1.5 | 796.9 |
| 55 | Sandstone, light brown, fine-grained, crossbedded, massive | 6.5 | 795.4 |
| 54 | Sandstone and siltstone alternating in beds about 1 foot thick; sandstone, light brown, fine-grained, crossbedded; siltstone, dark grey to grey, hard | 20.8 | 788.9 |
| 53 | Siltstone, black, arenaceous, fissile | 19.5 | 768.1 |
| 52 | Sandstone, light brown, medium-grained, crossbedded; carbonaceous bedding planes | 1.0 | 748.6 |
| 51 | Siltstone, dark grey, arenaceous, crumbly weathering | 9.0 | 747.6 |
| 50 | Sandstone and siltstone alternating in thin beds about 3 feet thick; sandstone, dark grey with carbonaceous fragments; siltstone, black, fissile | 18.8 | 738.6 |
| 49 | Siltstone, black, hard, crumbly weathering; numerous ironstone concretions | 13.6 | 719.8 |
| 48 | Siltstone, dark grey, hard, fissile; contains numerous thin beds of very fine grained, dark grey sandstone | 22.2 | 706.2 |
| 47 | Sandstone, dark grey, fine-grained; in thin and irregular beds | 10.6 | 684.0 |
| 46 | Siltstone, dark grey, arenaceous, hard; contains minor, fine-grained, carbonaceous sandstone beds | 36.0 | 673.4 |
| 45 | Sandstone, dark grey, fine-grained, thinly bedded, rusty weathering | 2.6 | 637.4 |
| 44 | Sandstone, dark grey, fine-grained, crossbedded, weathers brown | 23.0 | 634.8 |
| 43 | Siltstone, dark grey to grey, hard, arenaceous, thinly bedded | 5.3 | 611.8 |
| 42 | Sandstone, fine-grained, greyish brown, crossbedded, uniformly carbonaceous | 29.0 | 606.5 |
| 41 | Siltstone, dark grey, fissile; grading into thinly bedded, grey, fine-grained sandstone | 6.0 | 577.5 |
| 40 | Sandstone, brown, thinly bedded, brown weathering; with carbonaceous bedding planes | 1.7 | 571.5 |
| 39 | Sandstone, dark brown, fine-grained, uniformly carbonaceous, thick to thin irregularly bedded, grey weathering; minor siltstone | 20.3 | 569.8 |
| 38 | Siltstone, dark grey, arenaceous, fissile, in beds 2 to 3 feet thick; intercalated sandstone beds a few inches thick; carbonaceous matter along the bedding planes | 47.0 | 549.5 |
| 37 | Sandstone, dark brown, carbonaceous, especially along bedding planes, thickly bedded, yellow weathering | 3.6 | 502.5 |
| 36 | Siltstone and sandstone interbedded in beds about 1 foot thick; sandstone, brown, uniformly carbonaceous, fine-grained, massive; worm burrows | 45.5 | 498.9 |
| 35 | Sandstone, dark brown, fine-grained, carbonaceous | 14.3 | 453.4 |
| 34 | Siltstone and sandstone interbedded in beds about 1 foot thick; siltstone, black, fissile and arenaceous; sandstone, fine- to medium-grained, dark and carbonaceous, brown weathering; crossbedded sandstone beds occur as lenses | 30.9 | 439.1 |
| 33 | Sandstone, brown, fine-grained; carbonaceous matter concentrated along bedding planes | 4.6 | 408.2 |
| 32 | Sandstone, brown, fine-grained, crossbedded, weathering yellow; platy weathering; carbonaceous material along bedding planes; minor amounts of siltstone interbeds a few inches thick | 33.3 | 403.6 |
| 31 | Siltstone, dark grey, crumbly; with thin, yellow, carbonaceous, crossbedded sandstone interbeds | 8.5 | 370.3 |
| 30 | Sandstone, fine-grained, argillaceous, carbonaceous, crossbedded, yellow weathering; with interbeds of fissile siltstone about 5 feet thick | 29.5 | 361.8 |
| 29 | Siltstone, dark grey, fissile; contains minor streaks of sandstone | 5.4 | 332.3 |
| 28 | Sandstone, light brown, fine-grained, crossbedded | 1.5 | 326.9 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 27 | Sandstone and siltstone in alternating beds; sandstone, fine-grained, tan weathering, carbonaceous; siltstone, dark grey, fissile | 4.0 | 325.4 |
| 26 | Sandstone, fine-grained, argillaceous, highly crossbedded; carbonaceous bedding planes; light brown to dark grey, thin siltstone interbeds | 56.0 | 321.4 |
| 25 | Siltstone and sandstone, carbonaceous; in alternate, equal beds about an inch thick | 2.6 | 265.4 |
| 24 | Sandstone, fine-grained, crossbedded, weathering yellowish brown; in some places with carbonaceous bedding planes; siltstone partings | 33.0 | 262.8 |
| 23 | Sandstone and siltstone; sandstone, dark brown, fine-grained, with carbonaceous bedding planes in beds about 1 foot thick; siltstone, dark grey, crumbly, in beds of same thickness | 58.0 | 229.8 |
| 22 | Siltstone, black; with minor sandstone partings | 2.0 | 171.8 |
| 21 | Sandstone, medium-grained, grey, massive, tan weathering | 6.6 | 169.8 |
| 20 | Sandstone, brown or black, fine-grained, massive, hard, with carbonaceous bedding planes | 3.1 | 163.2 |
| 19 | Sandstone, silty, crossbedded, light brown; carbonaceous bedding planes | 7.8 | 160.1 |
| 18 | Sandstone, dark grey, fine-grained, carbonaceous; massive to thin-bedded, hard, siltstone, partings of little horizontal extent; ripple-marked | 35.0 | 152.3 |
| 17 | Siltstone, black, fissile, arenaceous; minor interbeds of dark sandstone | 3.7 | 117.3 |
| 16 | Sandstone, dark grey, fine-grained, hard, with carbonaceous fragments | 1.8 | 113.6 |
| 15 | Sandstone, brown to dark grey, fine-grained, crossbedded; with many carbonaceous bedding planes; intercalated siltstone beds a few inches thick | 28.4 | 111.8 |
| 14 | Siltstone, sandstone, and shale, interbedded, dark grey | 1.6 | 83.4 |
| 13 | Sandstone, dark brown, fine-grained, crossbedded; with carbonaceous bedding planes; siltstone partings about 3 inches thick | 15.0 | 81.8 |
| 12 | Siltstone, arenaceous, dark grey to black, fissile | 0.8 | 66.8 |
| 11 | Sandstone, dark brown, fine-grained, crossbedded; carbonaceous bedding planes; thinly bedded | 11.0 | 66.0 |
| 10 | Siltstone, arenaceous, dark grey to black, fissile | 1.8 | 55.0 |
| 9 | Sandstone, fine- to medium-grained, dark grey, crossbedded; with carbonaceous bedding planes | 7.1 | 53.2 |
| 8 | Siltstone, dark grey, arenaceous, fissile | 1.2 | 46.1 |
| 7 | Sandstone, fine-grained, dark brown, crossbedded; with carbonaceous bedding planes and fragments; some siltstone partings | 6.6 | 44.9 |
| 6 | Siltstone, arenaceous, dark grey, crossbedded | 0.9 | 38.3 |
| 5 | Sandstone, brown to grey, very fine grained, crossbedded, massive, grey weathering | 16.5 | 37.4 |
| 4 | Covered | 12.0 | 20.9 |
| 3 | Sandstone, brown to grey, fine-grained, crossbedded; carbonaceous bedding planes | 4.2 | 8.9 |
| 2 | Siltstone, dark grey, fissile; with some black shale | 1.3 | 4.7 |
| 1 | Sandstone, grey, fine-grained, thin-bedded; carbonaceous bedding planes; brown weathering | 3.4 | 3.4 |
| | TOTAL THICKNESS EXPOSED | 1,278.1 | |
| | Underlying beds covered | | |

## Measured Sections of the Luscar Formation

*Section 22. Exposed at Goat Cliffs on north side of Smoky River just east of Gustavs Flats (Thorsteinsson, 1952, p. 17)*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Grande Cache Formation | | |
| 170 | Volcanic ash, light greenish grey to white, unconsolidated | 1.4 | 938.1 |
| 169 | Sandstone, grey, fine- to medium-grained; limonitic stains in upper part; carbonaceous fragments scattered throughout | 2.0 | 936.7 |
| 168 | Shale, grey, silty | 0.9 | 934.7 |
| 167 | Siltstone, grey; carbonaceous fragments scattered throughout | 3.0 | 933.8 |
| 166 | Siltstone or very fine grained, well-cemented, hard, grey sandstone; some ironstone concretions; some grey, silty shale partings and bands | 13.6 | 930.8 |
| 165 | Shale, grey to dark grey, silty; contains carbonaceous fragments | 1.0 | 917.2 |
| 164 | Ironstone, grey | 0.8 | 916.2 |
| 163 | Shale, grey; fragments of carbonaceous material | 1.5 | 915.4 |
| 162 | Siltstone, grey; containing a large amount of iron carbonate and carbonaceous material | 2.0 | 913.9 |
| 161 | Shale, grey to dark grey, thinly bedded, fissile; contains carbonaceous material | 2.6 | 911.9 |
| 160 | Siltstone, grey, non-calcareous; carbonaceous fragments some irregular, fine partings of grey silty shale | 5.1 | 909.3 |
| 159 | Shale, grey, fissile, slightly calcareous; some fragments of carbonaceous material | 4.5 | 904.2 |
| 158 | Limestone, grey, massive, impure; contains fragments of carbonaceous material; may be highly calcareous siltstone; much veining with secondary calcite | 1.2 | 899.7 |
| 157 | Impure limestone or calcareous siltstone, grey; some grains of carbonaceous material; some secondary calcite veins | 1.4 | 898.5 |
| 156 | Siltstone, shaly, grey; some fragments of carbonaceous material | 2.8 | 897.1 |
| 155 | Siltstone, brownish grey, calcareous; containing plant fragments; bands of dark grey shale, with ironstone concretions becoming more abundant towards the base | 2.8 | 894.3 |
| 154 | Siltstone, calcareous, grey with dark grey shale finely and irregularly interbedded; plant fragments throughout | 6.9 | 891.5 |
| 153 | Shale, light to dark grey; in part, highly carbonaceous; ironstone concretions and bands; some parts silty; plant remains scattered throughout | 1.6 | 884.6 |
| 152 | Impure limestone or calcareous siltstone, grey; carbonaceous material and plant fragments | 0.6 | 883.0 |
| 151 | Shale, grey to dark grey; in part carbonaceous | 1.0 | 882.4 |
| 150 | Siltstone or impure limestone, as above | 0.8 | 881.4 |
| 149 | Shale, light grey to dark grey; in part highly carbonaceous | 1.8 | 880.6 |
| 148 | Siltstone or impure limestone, grey; some fine, irregular bands of dark grey shale | 3.4 | 878.8 |
| 147 | Shale, grey to dark grey, non-calcareous; carbonaceous fragments and some ironstone nodules | 2.0 | 875.4 |
| 146 | Siltstone or impure limestone, as above | 1.8 | 873.4 |
| 145 | Shale, grey to dark grey; in part carbonaceous; some ironstone bands and concretions | 2.6 | 871.6 |
| 144 | Siltstone or very fine grained sandstone, grey, 'salt and pepper' appearance; calcareous cement; sandstone becoming coarser grained toward base; some fragments of carbonaceous material | 8.4 | 869.0 |
| 143 | Shale, grey to dark grey; contains fragments of carbonaceous material | 2.0 | 860.6 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 142 | Sandstone, grey, in part shaly; very fine to fine-grained; containing considerable iron carbonate | 2.0 | 858.6 |
| 141 | Shale, dark grey; uppermost 6 inches highly carbonaceous; some ironstone bands and concretions | 2.4 | 856.6 |
| 140 | Siltstone or impure limestone, grey; small fragments of carbonaceous material | 1.6 | 854.2 |
| 139 | Shale, grey to dark grey; in part highly carbonaceous, contains ironstone bands and nodules | 1.4 | 852.6 |
| 138 | Siltstone or impure limestone, brownish grey; fine; irregular partings of dark grey silty shale | 1.9 | 851.2 |
| 137 | Shale, dark grey; in part, carbonaceous | 1.5 | 849.3 |
| 136 | Siltstone, grey, non-calcareous; containing fragments of carbonaceous material | 1.6 | 847.8 |
| 135 | Shale and siltstone, interbedded; shale, grey to dark grey; siltstone, light grey to grey | 1.8 | 846.2 |
| 134 | Shale, dark grey, highly carbonaceous; some bands of grey to dark grey calcareous silt containing plant fragments; shale is in part, coaly | 4.5 | 844.4 |
| 133 | Covered | 5.7 | 839.9 |
| 132 | Shale and siltstone; shale is grey to dark grey, fissile, contains carbonaceous fragments; siltstone is grey | 6.5 | 834.2 |
| 131 | Sandstone, very fine grained, grey, 'salt and pepper'; contains carbonaceous fragments | 7.5 | 827.7 |
| 130 | Sandstone, grey to buff, fine- to medium-grained, 'salt and pepper'; carbonaceous fragments; some grey silty bands; limonite stain; some white material that may be kaolinite | 4.0 | 820.2 |
| 129 | Shale, silty; carbonaceous fragments scattered throughout, grey to dark grey; ironstone bands and concretions | 13.4 | 816.2 |
| 128 | Sandstone, grey, fine-grained, 'salt and pepper'; calcareous cement; some limonitic spots; weathers buff to grey | 4.5 | 802.8 |
| 127 | Shale, grey to dark grey; in part, silty; containing fragments of plant remains, and ironstone bands and nodules | 7.7 | 798.3 |
| 126 | Sandstone, grey to buff; in part, shaly; 'salt and pepper', non-calcareous cement, platy; some banded, grey siltstone | 4.3 | 790.6 |
| 125 | Shale, grey to dark grey; finely interbedded with siltstone; nodules of ironstone | 1.0 | 786.3 |
| 124 | Sandstone, grey, fine-grained, 'salt and pepper'; carbonaceous fragments scattered throughout; a little calcareous cement; some interbeds of grey shale and siltstone | 10.1 | 785.3 |
| 123 | Shale, grey to dark grey; carbonaceous fragments scattered throughout; bands of grey siltstone; ironstone bands and concretions | 26.7 | 775.2 |
| 122 | Sandstone, grey, 'salt and pepper', fine-grained; calcareous cement; becoming coarser grained toward the base; some thin bands of grey shale | 110.0 | 748.5 |
| 121 | Conglomerate, grey; pebbles of black chert and quartz up to ½ inch in diameter; matrix of medium- to coarse-grained sandstone containing much black chert | 2.0 | 638.5 |
| 120 | Sandstone, grey, 'salt and pepper'; with calcareous cement; some bands non-calcareous; veins of calcite; band of conglomerate at base 1.5 feet thick; pebbles of chert up to ¼ inch in diameter | 20.2 | 636.5 |
| 119 | Shale, light grey to dark grey, non-calcareous; carbonaceous fragments scattered throughout; in part silty | 3.6 | 616.3 |
| 118 | Shale, same as above except for ironstone concretions | 16.6 | 612.7 |
| 117 | Siltstone, grey, non-calcareous; carbonaceous grains scattered throughout | 0.7 | 596.1 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 116 | Coal, lignitic, with one band of grey, fissile, carbonaceous, non-calcareous shale 4 inches thick | 1.8 | 595.4 |
| 115 | Shale, silty, grey to dark grey | 2.5 | 593.6 |
| 114 | Siltstone, grey to dark grey; numerous ironstone nodules; limonitic stains | 0.7 | 591.1 |
| 113 | Shale and siltstone, interbedded; shale, grey and fissile; siltstone, dark grey; some limonitic stains in the siltstone | 9.4 | 590.4 |
| 112 | Sandstone, light grey to grey, fine- to medium-grained, 'salt and pepper'; becoming silty in part; quartz grains subangular to subrounded; sandstone grades to siltstone at base | 1.5 | 581.0 |
| 111 | Shale, grey to dark grey, fissile; some ironstone concretions; some carbonaceous material; shale, silty; band of concretionary ironstone 1 inch thick at base | 7.3 | 579.5 |
| 110 | Sandstone, grey, medium-grained, hard, well-cemented, 'salt and pepper'; traces of a green mineral; some limonitic stains between grains; grains subangular to subrounded; weathers buff to green; in part well-banded; one band of dark grey shale | 6.4 | 572.2 |
| 109 | Shale, light grey to grey, fissile; some carbonaceous material scattered throughout | 10.0 | 565.8 |
| 108 | Sandstone, grey, fine-grained, 'salt and pepper'; in part silty, with partings of grey shale; grains subrounded; weathers buff to brown | 1.0 | 555.8 |
| 107 | Shale, grey, fissile; some carbonaceous fragments; in part silty; occasional ironstone bands; some interbedded grey siltstone at base | 17.0 | 554.8 |
| 106 | Sandstone, grey to light grey, fine-grained, 'salt and pepper'; trace of green mineral; limonitic stains between grains; non-calcareous cement; platy, weathers buff to brown; shaly partings near base | 3.0 | 537.8 |
| 105 | Shale and siltstone, interbedded; shale, light grey to grey, fissile, non-calcareous; some carbonaceous fragments scattered throughout; siltstone, grey; a few shaly partings; weathers green and buff; carbonaceous particles in siltstone; siltstone, in part, grades into fine-grained sandstone; nodules and bands of ironstone scattered throughout | 3.6 | 534.8 |
| 104 | Sandstone, light grey,'salt and pepper', medium- to coarse-grained; quartz is subrounded; a few small grains of carbonaceous material; traces of pyrite; finely bedded, calcareous cement | 1.5 | 531.2 |
| 103 | Sandstone, grey to buff,'salt and pepper', medium- to coarse-grained; limonitic stains; quartz grains subrounded; many grains of carbonaceous material; outcrop shows good joint system, with many joints filled with secondary calcite | 1.5 | 529.7 |
| 102 | Sandstone, grey, 'salt and pepper', medium-grained; quartz grains subangular, with some frosting; limonite stains; calcareous | 1.7 | 528.2 |
| 101 | Sandstone, grey, medium-grained, 'salt and pepper'; calcareous cement; platy; some greenish grey shale interbeds | 1.2 | 526.5 |
| 100 | Shale, light to dark grey, finely bedded; interbedded with silt; carbonaceous fragments scattered throughout; some bands of grey siltstone; bands of coaly shale; numerous ironstone bands and concretions | 8.7 | 525.3 |
| 99 | Coal | 3.1 | 516.6 |
| 98 | Shale, dark grey, in part brownish, carbonaceous | 5.0 | 513.5 |
| 97 | Coal; with some interbedded carbonaceous shale | 3.6 | 508.5 |
| 96 | Shale, dark grey, fissile; carbonaceous fragments scattered throughout | 2.7 | 504.9 |
| 95 | Coal | 1.7 | 502.2 |
| 94 | Siltstone, brownish grey, calcareous; carbonaceous fragments scattered throughout | 1.6 | 500.5 |
| 93 | Shale, grey to dark grey; in part silty; with carbonaceous specks | 2.4 | 498.9 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 92 | Siltstone, grey, non-calcareous; carbonaceous bands | 1.6 | 496.5 |
| 91 | Coal with interbedded carbonaceous shale | 3.0 | 494.9 |
| 90 | Siltstone, grey, calcareous; a little carbonaceous material interbedded with some dark grey shale | 3.8 | 491.9 |
| 89 | Shale, carbonaceous and coal; shale, dark grey | 2.6 | 488.1 |
| 88 | Shale, dark grey, carbonaceous | 9.0 | 485.5 |
| 87 | Siltstone, grey, calcareous; interbedded with some grey shale and grey carbonaceous shale; some carbonaceous fragments scattered throughout; ironstone concretions | 10.0 | 476.5 |
| 86 | Shale, grey, silty in part; ironstone bands and nodules; carbonaceous material scattered throughout | 3.0 | 466.5 |
| 85 | Coal | 1.6 | 463.5 |
| 84 | Carbonaceous shale and siltstone; shale, dark grey; siltstone, grey, hard; contains considerable carbonaceous material | 1.0 | 461.9 |
| 83 | Coal | 4.0 | 460.9 |
| 82 | Shale and sandstone; shale, grey to dark grey, fissile; sandstone, buff, fine-grained, well-cemented; both contain carbonaceous material | 1.5 | 456.9 |
| 81 | Coal | 1.2 | 455.4 |
| 80 | Shale, grey to dark grey, fissile; in part silty; thin ironstone bands and nodules; some fine interbeds of siltstone | 5.0 | 454.2 |
| 79 | Coal | 0.8 | 449.2 |
| 78 | Shale, grey to dark grey, fissile; considerable carbonaceous material; some thin bands of siltstone; some ironstone bands and nodules | 4.8 | 448.4 |
| 77 | Sandstone, light grey, 'salt and pepper'; calcareous cement; fine- to medium-grained; considerable carbonaceous material; parts of outcrop slumped | 6.0 | 443.6 |
| 76 | Siltstone and shale, interbedded; shale, grey to dark grey, with carbonaceous material; siltstone, grey; some ironstone concretions | 2.0 | 437.6 |
| 75 | Sandstone, grey, 'salt and pepper'; carbonaceous flakes scattered throughout; some calcareous cement | 2.7 | 435.6 |
| 74 | Shale, grey to dark grey, fissile, greenish | 2.0 | 432.9 |
| 73 | Sandstone, buff, 'salt and pepper', fine- to medium-grained, thinly bedded; carbonaceous fragments scattered throughout; calcareous cement; ironstone concretions | 1.3 | 430.9 |
| 72 | Siltstone and shale, interbedded, grey to dark grey; carbonaceous particles scattered throughout; ironstone concretions | 1.3 | 429.6 |
| 71 | Sandstone, buff, fine-grained, 'salt and pepper'; carbonaceous material; calcareous cement | 1.0 | 428.3 |
| 70 | Shale, siltstone, and sandstone, interbedded; shale, grey to dark grey; contains carbonaceous fragments and ironstone concretions; siltstone, grey and contains carbonaceous fragments; sandstone, grey to buff, very fine grained, 'salt and pepper', well-cemented | 12.5 | 427.3 |
| 69 | Siltstone, grey, calcareous; carbonaceous flakes scattered throughout; some plant fragments; some calcite veins | 2.0 | 414.8 |
| 68 | Sandstone and shale irregularly and finely interbedded; sandstone, buff, 'salt and pepper'; calcareous cement; shale, grey to dark grey; some calcite veins | 8.0 | 412.8 |
| 67 | Siltstone and shale, interbedded; siltstone, grey, somewhat shaly, with fine flakes of carbonaceous materials; shale grey, to dark grey, fissile | 3.0 | 404.8 |
| 66 | Shale, grey to dark grey, very fissile; some bands of grey siltstone or very fine grained sandstone; some ironstone bands and concretions | 10.7 | 401.8 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 65 | Sandstone, buff, very fine grained; shaly partings; calcareous cement; interbedded with grey to dark grey shale; ironstone bands and concretions | 4.6 | 391.1 |
| 64 | Shale and siltstone, finely interbedded; shale, dark grey; siltstone, calcareous, grey; some grey shale; ironstone bands scattered throughout | 5.9 | 386.5 |
| 63 | Coal | 7.8 | 380.6 |
| 62 | Shale, dark grey, highly carbonaceous | 1.0 | 372.8 |
| 61 | Coal | 1.0 | 371.8 |
| 60 | Shale, grey and dark grey; numerous ironstone bands; dark grey shale, in part, highly carbonaceous | 6.0 | 370.8 |
| 59 | Coal | 8.0 | 364.8 |
| 58 | Shale, grey, fissile, in part dark grey; ironstone bands scattered throughout | 2.6 | 356.8 |
| 57 | Shale, grey to dark grey; finely interbedded grey to buff-grey sandstone; sandstone, very fine grained; shale, silty; both contain carbonaceous fragments and plant remains; ironstone bands and concretions | 7.4 | 354.2 |
| 56 | Sandstone, grey, very fine to fine-grained, 'salt and pepper'; many specks of carbonaceous material; calcareous cement | 1.0 | 346.8 |
| 55 | Shale, silty, grey; finely interbedded with the shale; carbonaceous fragments scattered throughout; a few beds of grey, fine-grained, 'salt and pepper' sandstone, with calcareous cement; ironstone bands and concretions | 2.0 | 345.8 |
| 54 | Sandstone, ash grey, quartzitic, fine-grained; quartz appears subangular; many flakes and grains of carbonaceous material; sandstone somewhat shaly | 1.0 | 343.8 |
| 53 | Sandstone, buff, fine-grained, 'salt and pepper'; much limonite staining between grains; some calcareous cement; calcite veins | 1.0 | 342.8 |
| 52 | Shale, grey to dark grey; in part silty; carbonaceous fragments scattered throughout | 4.9 | 341.8 |
| 51 | Siltstone, grey; carbonaceous fragments scattered throughout; ironstone concretions | 1.8 | 336.9 |
| 50 | Sandstone, grey, very fine grained; calcareous cement; carbonaceous fragments; some ironstone concretions | 1.0 | 335.1 |
| 49 | Shale, grey to dark grey; interbedded with grey, shaly siltstone; cement contains considerable iron carbonate | 1.8 | 334.1 |
| 48 | Shale, grey to dark grey; interbedded with siltstone; siltstone, grey and shaly; shale, very fissile; contains fragments of carbonaceous material | 2.9 | 332.3 |
| 47 | Siltstone, grey, highly calcareous; fragments of carbonaceous material; contains iron carbonate; possibly an impure limestone | 3.0 | 329.4 |
| 46 | Shale, grey to dark grey; contains siltstone or limestone as above; carbonaceous material | 2.7 | 326.4 |
| 45 | Sandstone, fine-grained, 'salt and pepper'; contains carbonaceous material; calcareous cement | 1.4 | 323.7 |
| 44 | Shale, grey to dark grey; carbonaceous fragments; ironstone bands and concretions | 2.0 | 322.3 |
| 43 | Coal | 4.4 | 320.3 |
| 42 | Shale, grey; contains carbonaceous fragments; ironstone bands; more carbonaceous towards base | 4.0 | 315.9 |
| 41 | Coal | 2.0 | 311.9 |
| 40 | Siltstone, grey; interbedded with grey shale; carbonaceous fragments scattered throughout | 0.8 | 309.9 |
| 39 | Shale, dark grey to black, highly carbonaceous | 0.8 | 309.1 |
| 38 | Shale, grey, fissile; carbonaceous fragments; ironstone concretions | 0.8 | 308.3 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 37 | Coal | 11.0 | 307.5 |
| 36 | Siltstone, grey, shaly, sandy, soft | 2.0 | 296.5 |
| 35 | Sandstone, light grey, 'salt and pepper', fine-grained; in part, shaly; some interbeds of grey siltstone | 2.0 | 294.5 |
| 34 | Shale, grey to dark grey; fragments of carbonaceous material; some bands of grey siltstone containing carbonaceous material; some bands of fine-grained, 'salt and pepper' sandstone; ironstone bands and concretions | 7.6 | 292.5 |
| 33 | Sandstone, light grey, 'salt and pepper', fine-grained calcareous cement, some calcite veins | 4.1 | 284.9 |
| 32 | Sandstone, very shaly; interbedded with dark grey shale; poorly cemented | 1.6 | 280.8 |
| 31 | Sandstone, buff to grey, fine-grained, 'salt and pepper'; calcareous cement; some bands of grey siltstone | 3.7 | 279.2 |
| 30 | Shale, dark grey, fissile, carbonaceous | 1.0 | 275.5 |
| 29 | Shale, grey to dark grey; interbedded with grey siltstone; carbonaceous fragments scattered throughout; ironstone bands and concretions | 12.3 | 274.5 |
| 28 | Shale and siltstone, interbedded; siltstone, grey, somewhat sandy, calcareous; containing fragments of carbonaceous material; shale, grey, silty; containing carbonaceous fragments; becoming less silty towards base | 7.2 | 262.2 |
| 27 | Sandstone, grey, medium-grained, 'salt and pepper'; quartz grains subangular to subrounded; some stains between grains; calcareous cement; some limonitic thin beds of dark grey shale and grey siltstone; some calcite veins | 9.6 | 255.0 |
| 26 | Shale and siltstone, interbedded; shale, grey, fissile, and silty; in part sandy and containing carbonaceous fragments; siltstone, grey; some shaly partings and carbonaceous fragments; some bands of ironstone concretions | 9.9 | 245.4 |
| 25 | Coal | 3.1 | 235.5 |
| 24 | Shale, grey, in part brownish, carbonaceous | 1.9 | 232.4 |
| 23 | Coal | 2.5 | 230.5 |
| 22 | Shale, brownish grey, in part carbonaceous | 2.0 | 228.0 |
| 21 | Coal | 1.8 | 226.0 |
| 20 | Shale, brownish grey, carbonaceous | 1.7 | 224.2 |
| 19 | Coal | 3.8 | 222.5 |
| 18 | Shale, grey, silty; carbonaceous fragments; some bands of grey siltstone | 5.9 | 218.7 |
| 17 | Siltstone, grey, highly calcareous, possibly an impure limestone; carbonaceous fragments scattered throughout | 2.0 | 212.8 |
| 16 | Sandstone, grey, buff weathering, fine to very fine grained; some fine irregular partings of grey shale; calcareous cement; platy in part; becoming medium-grained towards base | 76.0 | 210.8 |
| 15 | Shale, grey; some interbedded grey siltstone; both calcareous and containing carbonaceous material | 16.0 | 134.8 |
| 14 | Coal | 9.0 | 118.8 |
| 13 | Shale, grey; interbedded, grey siltstone; both calcareous; some carbonaceous fragments; calcite veins | 3.0 | 109.8 |
| 12 | Sandstone, brownish grey, very fine grained; calcareous cement; carbonaceous fragments; shaly partings, becoming more silty and shaly at base; upper surface of sandstone covered with asymmetrical ripple-marks | 5.5 | 106.8 |
| 11 | Shale and siltstone, interbedded; shale, grey, somewhat calcareous; siltstone, brownish grey, calcareous; both contain carbonaceous fragments | 2.6 | 101.3 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 10 | Shale, grey, fissile; carbonaceous fragments; becoming more carbonaceous at base; some thin beds of brownish grey shale | 4.3 | 98.7 |
| 9 | Siltstone, grey to brownish grey, shaly, calcareous; carbonaceous fragments | 0.6 | 94.4 |
| 8 | Shale, grey to dark grey; band of lignitic coal 4 inches thick at base | 1.6 | 93.8 |
| 7 | Sandstone, brownish grey, medium- to coarse-grained, 'salt and pepper'; quartz grains subangular to subrounded; calcareous cement; becoming more silty towards base; calcite veins | 7.0 | 92.2 |
| 6 | Shale and siltstone, interbedded; shale, grey to dark grey, calcareous; siltstone, grey, calcareous | 20.8 | 85.2 |
| 5 | Shale, grey to dark grey, slightly calcareous, carbonaceous; some ironstone concretions | 13.8 | 64.4 |
| 4 | Sandstone, grey to brownish grey, very fine grained, shaly; ironstone concretions; some poorly preserved fossil fragments, including pelecypods | 2.0 | 50.6 |
| 3 | Shale, dark grey, fissile; in part carbonaceous and coaly | 8.4 | 48.6 |
| 2 | Sandstone, grey, 'salt and pepper', fine-grained, in part shaly; non-calcareous cement; carbonaceous fragments | 1.0 | 40.2 |
| 1 | Sandstone, brownish grey, fine-grained, 'salt and pepper'; a few irregular partings of grey shale; calcareous cement; some calcite veins | 39.2 | 39.2 |
| | TOTAL THICKNESS EXPOSED | 937.9 | |
| | Underlying beds covered | | |

*Section 23. In the large gulch on the north side of Smoky River about 2 miles above the mouth of Muskeg River*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Grande Cache Formation | | |
| 43 | Grit and fine conglomerate; composed of dark coloured chert; rusty weathering | 2 | 1365 |
| 42 | Covered | 180 | 1363 |
| 41 | Sandstone, hard, grey, fine-grained | 8 | 1183 |
| 40 | Covered | 90 | 1175 |
| 39 | Sandstone, hard, grey, fine-grained; some thin, grey, shale partings | 200 | 1085 |
| 38 | Sandstone, hard, greenish grey, medium-grained, platy | 82 | 885 |
| 37 | Siltstone, dark grey | 6 | 803 |
| 36 | Sandstone, grey, medium-grained, crossbedded; contains carbonized wood remains | 28 | 797 |
| 35 | Shale, black carbonaceous; coaly streaks | 10 | 769 |
| 34 | Sandstone, grey, medium-grained | 40 | 759 |
| 33 | Shale, grey, silty; some carbonaceous shale | 8 | 719 |
| 32 | Sandstone, soft, light grey, medium-grained; contains carbonaceous fragments | 74 | 711 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 31 | Shale, grey, silty; some carbonaceous and coaly material | 34 | 637 |
| 30 | Sandstone, grey, medium-grained | 52 | 603 |
| 29 | Sandstone, grey; some silty sandstone | 5 | 551 |
| 28 | Sandstone, grey; some interbedded silty sandstone | 5 | 546 |
| 27 | Shale, grey | 4 | 541 |
| 26 | Shale, black, carbonaceous | 1 | 537 |
| 25 | Coal | 3 | 536 |
| 24 | Shale, grey, somewhat silty | 25 | 533 |
| 23 | Sandstone, grey, fine-grained, thin-bedded | 6 | 508 |
| 22 | Sandstone, hard, light grey, fine-grained | 50 | 502 |
| 21 | Shale, grey; some carbonaceous shale; numerous ironstone concretionary bands up to 2 feet thick; a few thin sandstone bands; 3 feet of coal near the top | 100 | 452 |
| 20 | Sandstone, grey, fine- to medium-grained, massive, crossbedded | 19 | 352 |
| 19 | Sandstone, grey, medium-grained; interbedded siltstone beds up to 3 feet thick | 8 | 333 |
| 18 | Shale, black, carbonaceous | 4 | 325 |
| 17 | Sandstone, brownish grey, fine-grained, thin-bedded | 8 | 321 |
| 16 | Shale, black, carbonaceous; some yellow weathering, concretionary, ironstone bands; some silty shale | 32 | 313 |
| 15 | Shale, grey, silty; some interbedded, black carbonaceous shale; a few yellow weathering ironstone bands | 20 | 281 |
| 14 | Sandstone, grey, hard, fine-grained, platy | 6 | 261 |
| 13 | Shale, grey, some carbonaceous shale | 8 | 255 |
| 12 | Sandstone, and siltstone, interbedded, brownish grey, fine-grained, thin-bedded | 40 | 247 |
| 11 | Sandstone, grey, fine- to medium-grained; some carbonized wood remains; a few ironstone concretions | 52 | 207 |
| 10 | Shale, grey; some interbedded, grey, fine-grained sandstone | 20 | 155 |
| 9 | Shale, black, carbonaceous | 2 | 135 |
| 8 | Coal | 18 | 133 |
| 7 | Shale, black, carbonaceous; somewhat silty | 10 | 115 |
| 6 | Sandstone, hard, brown-grey, fine-grained; poorly preserved pelecypods at upper contact with shale | 14 | 105 |
| 5 | Shale, dark grey to black; one regular ironstone band 4 inches thick | 13 | 91 |
| 4 | Sandstone, grey, fine-grained, platy; some poorly preserved plant remains and pelecypods | 10 | 78 |
| 3 | Shale, grey; interbedded with dark grey, shaly sandstone; thin partings of carbonaceous shale | 50 | 68 |
| 2 | Sandstone, grey, hard, fine-grained | 8 | 18 |
| 1 | Shale, silty, dark grey | 10 | 10 |
| | TOTAL THICKNESS EXPOSED | 1,365 | |
| | Underlying beds covered | | |

*Section 24. On a southwest-flowing tributary of Caw Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Grande Cache Formation | | |
| 48 | Conglomerate, fine, cherty, rusty weathering | 0.3 | 944.1 |
| 47 | Sandstone, hard, medium-grained, dark brownish grey | 13.0 | 943.8 |
| 46 | Sandstone, hard, fine- to medium-grained, grey to dark grey; some silty sandstone | 13.3 | 930.8 |
| 45 | Sandstone, hard, fine-grained, grey, finely banded | 1.5 | 917.5 |
| 44 | Shale, dark grey; interbedded with grey sandstone in beds up to 6 inches thick | 9.5 | 916.0 |
| 48 | Sandstone, hard, fine-grained, greenish grey | 4.0 | 906.5 |
| 42 | Sandstone, medium-grained, brownish; interbedded with dark grey shale | 34.2 | 902.5 |
| 41 | Sandstone, hard, fine- to medium-grained, grey-brown, finely banded | 32.3 | 868.3 |
| 40 | Sandstone, fine-grained, grey; contains poorly preserved plant remains | 1.0 | 836.0 |
| 39 | Sandstone, medium- to coarse-grained, grey; contains lenses of fine chert-conglomerate up to 3 inches thick | 10.0 | 835.0 |
| 38 | Shale, dark grey | 2.0 | 825.0 |
| 37 | Sandstone, hard, fine-grained, brownish grey, buff weathering; some of it is finely banded | 16.0 | 823.0 |
| 36 | Shale, dark grey, silty | 5.0 | 807.0 |
| 35 | Shale, silty; contains poorly preserved plant material | 3.7 | 802.0 |
| 34 | Sandstone, fine-grained, brown-grey, buff weathering; has a muddy appearance | 42.7 | 798.3 |
| 33 | Sandstone, fine-grained, brown, buff weathering, slightly calcareous | 33.0 | 755.6 |
| 32 | Sandstone, coarse-grained, grey, calcareous; contains scattered pebbles and dark grey shale fragments; some carbonate stringers | 10.0 | 722.6 |
| 31 | Sandstone, medium- to coarse-grained, grey, slightly calcareous, rusty weathering | 19.0 | 712.6 |
| 30 | Conglomerate, fine; and sandstone, very coarse, grey, cherty, rusty weathering | 3.0 | 693.6 |
| 29 | Shale, grey, silty; interbedded with fine-grained, brownish sandstone; much carbonized plant material | 56.0 | 690.6 |
| 28 | Sandstone, hard, fine-grained, buff-grey, buff weathering; carbonized plant remains | 3.0 | 634.6 |
| 27 | Covered | 50.0 | 631.6 |
| 26 | Shale, grey | 10.0 | 581.6 |
| 25 | Shale, grey; minor thin beds of soft, grey sandstone | 14.0 | 571.6 |
| 24 | Sandstone, hard, fine- to medium-grained, grey, buff weathering; in beds from 1 foot to 3 feet thick | 30.0 | 557.6 |
| 23 | Sandstone, fine-grained, grey, soft, concretionary | 7.0 | 527.6 |
| 22 | Shale, grey and dark grey; minor interbedded thin, grey sandstone bands | 41.0 | 520.6 |
| 21 | Sandstone, fine-grained, grey, crossbedded | 5.3 | 479.6 |
| 20 | Shale, grey | 6.0 | 474.3 |
| 19 | Sandstone, hard, fine-grained, dark grey, yellowish weathering | 2.0 | 468.3 |
| 18 | Shale and sandy shale, grey | 24.0 | 466.3 |
| 17 | Sandstone, fine- to medium-grained, grey; beds up to 2 feet thick, minor grey shale partings | 29.5 | 442.3 |
| 16 | Conglomerate and coarse, grey sandstone | 3.0 | 412.8 |
| 15 | Sandstone, medium- to coarse-grained, grey | 31.5 | 409.8 |
| 14 | Sandstone, very coarse, grey | 2.0 | 378.3 |
| 13 | Shale, grey; interbedded with 2- to 6-inch beds of black carbonaceous shale | 21.0 | 376.3 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 12 | Shale and sandy shale, grey; contains yellow weathering ironstone bands about 2 inches thick | 37.4 | 355.3 |
| 11 | Sandstone, fine-grained, grey weathering; weathers platy | 21.0 | 317.9 |
| 10 | Shale, dark grey | 8.3 | 296.9 |
| 9 | Sandstone, fine- to medium-grained, brownish grey, brown weathering; thin-bedded with carbonaceous partings | 31.0 | 288.6 |
| 8 | Shale, grey; contains concretionary sandstone bands up to 4 inches thick | 13.5 | 257.6 |
| 7 | Coal, sheared and weathered | 3.5 | 244.1 |
| 6 | Shale, grey; with interbedded sandstone | 37.0 | 240.6 |
| 5 | Sandstone, hard, medium-grained, grey; in beds up to 4 feet thick; some shaly sandstone; contains plant remains | 56.6 | 203.6 |
| 4 | Sandstone, soft, fine-grained, brown, buff weathering, finely banded; contains some plant remains | 65.0 | 147.0 |
| 3 | Sandstone, fine-grained, brown, brownish weathering | 25.0 | 82.0 |
| 2 | Covered (this interval contains a coal seam 13 feet thick) | 50.0 | 57.0 |
| 1 | Sandstone, fine-grained, brown, buff weathering | 7.0 | 7.0 |
| | TOTAL THICKNESS EXPOSED | 944 | |

Underlying beds covered

*Section 25. Measured on a northeasterly-flowing tributary of Caw Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 13 | Sandstone, fine-grained, grey, buff weathering | 20.0 | 267.4 |
| 12 | Sandstone, fine-grained, grey, buff weathering; weathers platy and contains plant remains | 4.0 | 247.4 |
| 11 | Shale, grey; interbedded black, carbonaceous shale and thin coal stringers | 2.5 | 243.4 |
| 10 | Coal, sheared and weathered; apparently no shale partings | 15.9 | 240.9 |
| 9 | Sandstone, fine-grained, grey; interbedded with grey shale; plant remains in shale and sandstone; large wood fragments in sandstone | 5.3 | 225.0 |
| 8 | Sandstone, fine- to medium-grained, grey, brown weathering; some plant remains | 6.1 | 219.7 |
| 7 | Shale, dark grey to black, carbonaceous | 5.0 | 213.6 |
| 6 | Sandstone, fine- to medium-grained, grey, brown weathering | 17.2 | 208.6 |
| 5 | Shale, grey; some black carbonaceous shale | 3.0 | 191.4 |
| 4 | Coal, broken and weathered | 2.1 | 188.4 |
| 3 | Shale, grey | 0.7 | 186.3 |
| 2 | Coal, weathered | 1.0 | 185.6 |
| 1 | Covered | 184.6 | 184.6 |
| | TOTAL THICKNESS EXPOSED | 267.4 | |

Underlying beds: Cadomin Formation

*Section 26. On the first north-flowing tributary of Cowlick Creek east of the Mountain Trail*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds covered | | |
| 34 | Sandstone, fine-grained, hard, dark grey; weathers light grey to buff, thin-bedded, calcareous | 8.3 | 763.6 |
| 33 | Shale, silty, grey, grey weathering; carbonaceous in places; 2-foot coal seam near top | 28.5 | 755.3 |
| 32 | Coal | 5.0 | 726.8 |
| 31 | Shale, silty, grey-brown, grey weathering; 8-inch ironstone bed near top | 25.1 | 721.8 |
| 30 | Sandstone, hard, medium- to coarse-grained, grey-buff to brown weathering; thin-bedded to platy; some finely laminated | 10.0 | 696.7 |
| 29 | Shale, siltstone, and sandstone; interbedded, mostly grey weathering; some bands brown weathering; plant remains | 73.6 | 686.7 |
| 28 | Sandstone, fine and coarse bands interbedded; grey, grey and buff weathering | 74.7 | 613.1 |
| 27 | Covered; mainly silty sandstone with some yellow weathering ironstone bands | 94.1 | 538.4 |
| 26 | Shale, silty shale, and siltstone, interbedded, dark grey, dark grey weathering; beds from 1 inch to 8 inches; one or two 2-foot bands of yellow weathering ironstone bands | 76.3 | 444.3 |
| 25 | Sandstone, hard, fine-grained, dark grey, yellow weathering, very calcareous | 13.9 | 368.0 |
| 24 | Sandstone, hard, fine-grained, greyish brown, buff weathering, calcareous | 4.6 | 354.1 |
| 23 | Sandstone, hard, fine-grained, grey, buff weathering, finely laminated and crossbedded, very calcareous; no plant remains | 13.1 | 349.5 |
| 22 | Sandstone, fine-grained, brownish grey; buff weathering | 12.1 | 336.4 |
| 21 | Conglomerate; pebbles of chert and quartzite up to ½ inch | 0.5 | 324.3 |
| 20 | Sandstone, fine-grained, brownish grey, buff weathering | 6.0 | 323.8 |
| 19 | Sandstone, medium- to coarse-grained, brownish grey, buff weathering; thin-bedded, hard | 16.6 | 317.8 |
| 18 | Shale, silty, dark grey to black | 9.2 | 301.2 |
| 17 | Sandstone and shale, in beds up to 3 feet thick; brown weathering | 31.1 | 292.0 |
| 16 | Sandstone, medium-grained, grey, buff weathering, thin-bedded to platy | 27.4 | 260.9 |
| 15 | Shale, dark grey; some silty bands; brackish-water pelecypods | 17.7 | 233.5 |
| 14 | Sandstone, fine-grained, grey; a few thin shale bands | 11.6 | 215.8 |
| 13 | Sandstone, fine-grained, grey, hard, laminated | 11.9 | 204.2 |
| 12 | Shale, silty, brownish grey to chocolate-brown; a few thin, grey sandstone bands | 17.9 | 192.3 |
| 11 | Sandstone, fine-grained, platy, brownish grey, buff weathering; some interbedded dark grey shales; plant stems common | 11.4 | 174.4 |
| 10 | Sandstone, fine-grained, grey; in beds up to 4 feet thick; interbedded, dark grey, shaly and silty sandstone in beds up to 6 inches thick; abundant plant remains | 19.8 | 163.0 |
| 9 | Sandstone, fine-grained, hard, grey, grey weathering | 12.1 | 143.2 |
| 8 | Shale, silty, grey to black; some carbonaceous | 12.6 | 131.1 |
| 7 | Sandstone, fine-grained, very hard, grey, grey weathering, slightly calcareous | 23.1 | 118.5 |
| 6 | Covered | 19.6 | 95.4 |
| 5 | Siltstone, fine-grained, brownish grey and brown weathering; contains plant remains | 21.8 | 75.8 |
| 4 | Shale, silty, brownish grey; interbedded carbonaceous shale | 3.7 | 54.0 |
| 3 | Siltstone, fine-grained, brownish grey, brown weathering, finely laminated and platy weathering, slightly calcareous | 3.9 | 50.3 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 2 | Sandstone, silty, fine-grained, grey and grey weathering; carbonized plant remains throughout and 2 feet of dark grey carbonaceous shale with ¼-inch coal lenses near the base | 15.4 | 46.4 |
| 1 | Sandstone, grey, grey to buff weathering, fine-grained; small conglomerate lenses with pebbles up to ½-inch in diameter; scattered wood fragments; slightly calcareous | 31.0 | 31.0 |
| | TOTAL THICKNESS EXPOSED | 763.6 | |
| | Underlying beds: Cadomin Formation | | |

*Section 27. On a south-flowing tributary of Cowlick Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Grande Cache Formation | | |
| 30 | Sandstone, fine- to medium-grained, grey, grey to buff weathering; interbedded siltstone and minor grey shale partings; one or two yellow weathering concretionary bands; some plant stems | 138.7 | 1814.2 |
| 29 | Sandstone, hard, massive siliceous, crossbedded, medium- to coarse-grained, grey, grey weathering; some carbonized plant stems and a few scattered pebbles | 83.3 | 1675.5 |
| 28 | Sandstone, with interbedded shale; greenish grey, buff weathering sandstone beds up to 4 feet thick interbedded with grey, silty shale in beds up to 2 feet thick | 72.4 | 1592.2 |
| 27 | Sandstone, coarse-grained, thick-bedded, grey, grey weathering; carbonized plant stems; scattered pebbles | 30.0 | 1519.8 |
| 26 | Shale, silty, greenish grey, greenish grey weathering; minor, interbedded, black, carbonaceous shale | 36.2 | 1489.8 |
| 25 | Covered | 30.0 | 1453.6 |
| 24 | Sandstone, fine-grained, grey, grey weathering | 10.2 | 1423.6 |
| 23 | Shale, silty, greenish, grey-green weathering; 1 foot of coaly shale at top; poorly preserved plant remains | 10.0 | 1413.4 |
| 22 | Sandstone, fine-grained, grey, buff weathering; with interbedded silty sandstone and shale; plant remains common | 63.4 | 1403.4 |
| 21 | Shale, grey-green; somewhat concretionary | 27.8 | 1340.0 |
| 20 | Shale, coaly | 3.8 | 1312.2 |
| 19 | Coal | 2.4 | 1308.4 |
| 18 | Shale, silty, dark grey; minor grey sandstone beds up to 1 foot thick | 26.4 | 1306.0 |
| 17 | Sandstone, coarse-grained, hard, grey, light grey weathering; zones and lenses up to 1 foot thick of small chert pebbles; clay pellets in some zones; numerous plant stems | 345.0 | 1279.6 |
| 16 | Siltstone, fine-grained, grey; interbedded with grey-green, silty shale | 11.0 | 934.6 |
| 15 | Coal | 1.8 | 923.6 |
| 14 | Sandstone, and interbedded shale; sandstone, fine-grained, grey; shale, greenish | 56.5 | 921.8 |
| 13 | Sandstone, grey to brownish, grey and buff weathering, fine-grained; beds up to 5 feet thick; interbedded grey and black shale containing concretionary, yellow weathering ironstone bands up to 6 inches thick | 225.0 | 865.3 |



95036—12½

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 12 | Shale, silty, dark grey to black, containing three coal seams about 1 foot thick | 7.0 | 640.3 |
| 11 | Sandstone, medium- to coarse-grained, hard, grey, buff weathering; very calcareous; poorly preserved plant remains | 30.0 | 633.3 |
| 10 | Covered; probably silty shale | 18.9 | 603.3 |
| 9 | Sandstone, fine-grained, hard, dark grey, grey to buff weathering, very calcareous | 36.8 | 584.4 |
| 8 | Shale, with interbedded sandstone; sandstone, fine-grained, grey, grey weathering; beds up to 2 feet thick; shale, dark grey to greenish; one 2-foot, yellow weathering ironstone band | 19.0 | 547.6 |
| 7 | Covered | 67.2 | 528.6 |
| 6 | Shale, grey; some thin, grey siltstone bands | 12.0 | 461.4 |
| 5 | Covered | 104.3 | 449.4 |
| 4 | Sandstone, fine-grained, dark grey, grey weathering, carbonaceous in places | 10.3 | 345.1 |
| 3 | Covered | 49.5 | 334.8 |
| 2 | Sandstone, coarse-grained, hard, massive, grey, grey weathering | 24.6 | 285.3 |
| 1 | Sandstone, silty, fine-grained, grey to dark grey interbedded with grey shale; all very poorly exposed | 260.7 | 260.7 |
| | TOTAL THICKNESS EXPOSED | 1,814.2 | |
| | Underlying beds covered | | |

*Section 28. On the northeast side of Nickerson Creek at approximately latitude 54°02′ longitude 119°26′.*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Grande Cache Formation | | |
| 55 | Sandstone, dark brownish grey, medium-grained, hard | 13.0 | 978.3 |
| 54 | Sandstone, grey, soft with interbedded dark grey siltstone | 13.2 | 965.3 |
| 53 | Sandstone, grey, fine-grained, finely banded, hard | 1.5 | 952.1 |
| 52 | Shale, dark grey; with interbedded grey sandstone bands up to 6 inches thick | 9.5 | 950.6 |
| 51 | Sandstone, greenish grey, fine-grained, hard | 4.0 | 941.1 |
| 50 | Sandstone, brownish grey, medium-grained, argillaceous; interbedded with shale, dark grey, silty | 34.2 | 937.1 |
| 49 | Sandstone, brownish grey, fine- to medium-grained, hard, finely banded | 32.3 | 902.9 |
| 48 | Sandstone, grey, buff weathering, fine-grained; contains plant remains | 1.0 | 870.6 |
| 47 | Sandstone, grey, medium- to coarse-grained; contains streaks of very coarse sand | 10.0 | 869.6 |
| 46 | Shale, dark grey, silty | 2.0 | 859.6 |
| 45 | Sandstone, brownish, fine-grained, hard, finely banded; weathers buff | 16.0 | 857.6 |
| 44 | Shale, dark grey; contains some silty bands | 5.0 | 841.6 |
| 43 | Siltstone, grey-brown, buff weathering; contains some plant remains | 3.9 | 836.6 |
| 42 | Sandstone, greenish grey, fine-grained, buff weathering; muddy appearance | 43.0 | 832.7 |
| 41 | Sandstone, grey-brown, fine-grained, buff weathering | 33.0 | 789.7 |
| 40 | Sandstone, grey, coarse-grained; contains scattered small pebbles and fragments of dark grey shale; numerous carbonate veinlets | 10.0 | 756.7 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 39 | Sandstone, grey, medium- to coarse-grained, rusty weathering | 19.0 | 746.7 |
| 38 | Sandstone, grey, cherty, very coarse and conglomerate, very fine-grained | 3.0 | 727.7 |
| 37 | Shale, grey, chunky; with interbedded grey, fine-grained, sandstone and silty shale; contains much carbonized plant material | 56.0 | 724.7 |
| 36 | Sandstone, brownish grey, fine-grained, grey weathering, contains carbonized plant remains | 3.0 | 668.7 |
| 35 | Covered | 50.0 | 665.7 |
| 34 | Shale, grey | 10.2 | 615.7 |
| 33 | Sandstone, dark grey, hard, brittle, yellow weathering | 3.0 | 605.5 |
| 32 | Sandstone, brown, fine-grained, argillaceous, chunky | 2.0 | 602.5 |
| 31 | Shale, grey | 12.0 | 600.5 |
| 30 | Sandstone, grey, fine-grained, platy | 4.0 | 588.5 |
| 29 | Shale, grey, and argillaceous, soft sandstone | 13.0 | 584.5 |
| 28 | Sandstone, grey, fine-grained, crossbedded, grey weathering | 3.0 | 571.5 |
| 27 | Shale and sandy shale, grey; with interbedded sandstone beds about 1 inch thick | 27.0 | 568.5 |
| 26 | Sandstone, grey, medium-grained, hard, platy | 17.0 | 541.5 |
| 25 | Sandstone, brown-grey, soft; interbedded with grey shale | 10.0 | 524.5 |
| 24 | Shale, grey; with minor beds of soft friable sandstone | 14.0 | 514.5 |
| 23 | Sandstone, dark grey, buff weathering, hard; in beds between 1 foot and 3 feet thick | 30.0 | 500.5 |
| 22 | Sandstone, brown-grey, soft, concretionary | 7.0 | 470.5 |
| 21 | Shale, grey; some dark grey, carbonaceous shale; some grey sandstone beds | 41.0 | 463.5 |
| 20 | Sandstone, grey, grey-weathering, crossbedded, fine-grained | 5.5 | 422.5 |
| 19 | Shale, grey | 6.0 | 417.0 |
| 18 | Sandstone, dark grey, yellow weathering, concretionary | 2.0 | 411.0 |
| 17 | Shale and shaly sandstone, grey | 24.0 | 409.0 |
| 16 | Sandstone, grey, fine- to medium-grained, grey weathering; some thin grey shale partings | 29.5 | 385.0 |
| 15 | Conglomerate, fine | 3.0 | 355.5 |
| 14 | Sandstone, grey, shaly | 31.0 | 352.5 |
| 13 | Sandstone, very coarse; and conglomerate, fine | 2.0 | 321.5 |
| 12 | Shale, grey; several zones of black, carbonaceous shale | 21.0 | 319.5 |
| 11 | Shale, grey, and sandy shale; contains several yellow weathering ironstone bands about 2 inches thick | 37.4 | 298.5 |
| 10 | Sandstone, grey, fine-grained, grey and platy weathering | 21.0 | 261.1 |
| 9 | Shale, dark grey | 8.0 | 240.1 |
| 8 | Sandstone, grey to brown, fine- to medium-grained, thin-bedded, carbonaceous partings | 31.0 | 232.1 |
| 7 | Shale, grey; with thin concretionary sandstone bands up to 4 inches thick | 13.5 | 201.1 |
| 6 | Coal, sheared | 3.6 | 187.6 |
| 5 | Sandstone, grey, soft and silty shale; partly covered | 37.0 | 184.0 |
| 4 | Sandstone, grey, hard, grey weathering; in beds about 4 inches thick; contains carbonized plant stems; interbedded with fine-grained, brown-grey shaly sandstone | 57.0 | 147.0 |
| 3 | Sandstone, brown, fine-grained, buff weathering, soft, finely banded | 55.0 | 90.0 |
| 2 | Sandstone, brownish grey, fine-grained; contains much carbonized plant material | 10.0 | 35.0 |
| 1 | Sandstone, brownish grey, argillaceous, concretionary | 25.0 | 25.0 |
| | TOTAL THICKNESS EXPOSED | 978.3 | |

Underlying beds covered

## Measured Section of the Fort St. John Group

*Section 29. On Sulphur River about 2 miles above its confluence with Smoky River*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Dunvegan Formation | | |
| 4 | Shale, arenaceous shale, dark grey, buff to grey weathering, fissile; shale grades upward into siltstone | 36.0 | 382.0 |
| 3 | Shale, dark grey, yellow stained, friable | 100.0 | 346.0 |
| 2 | Shale, dark grey, rusty weathering, arenaceous, hard, fissile; twelve ironstone concretionary bands or ellipsoidal layers occur between 260 and 380 feet | 244.0 | 246.0 |
| 1 | Conglomerate and shale; dark grey weathering; chert and quartzite pebbles in a fine-grained quartzitic matrix; one foot thick overlying a bed of dark grey, fissile shale 0.5 foot thick | 2.0 | 2.0 |
| | TOTAL THICKNESS | 382.0 | |
| | Underlying beds: Luscar Formation | | |

## Measured Sections of the Dunvegan Formation

*Section 30. On the first south-flowing tributary of Cowlick Creek 1½ miles east of longitude 119°00′*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Kaskapau Formation | | |
| 6 | Sandstone, fine-grained, light grey, grey weathering; beds up to 1 foot thick | 15 | 403 |
| 5 | Covered | 107 | 388 |
| 4 | Shale, silty, dark grey; a few bands of hard, grey sandstone up to 4 feet thick | 130 | 281 |
| 3 | Sandstone, very hard, fine-grained, grey, grey weathering, platy; beds up to 2 feet thick; minor amounts of interbedded shale | 36 | 151 |
| 2 | Shale, silty, dark grey to black; a few thin, grey sandstone beds | 61 | 115 |
| 1 | Sandstone, hard, fine- to medium-grained, grey, grey to buff weathering; in beds up to 3 feet thick; minor amounts of interbedded grey shale | 54 | 54 |
| | TOTAL THICKNESS | 403 | |
| | Underlying beds: Fort St. John Group | | |

*Section 31. On the north side of Sheep Creek about half-way between Nickerson Creek and Horne Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds covered | | |
| 27 | Sandstone, medium- to coarse-grained, grey | 1.5 | 358.0 |
| 26 | Shale, dark grey, silty; with interbedded soft sandstone | 40.0 | 356.5 |
| 25 | Sandstone, medium- to coarse-grained, grey; with carbonaceous remains; thick-bedded; buff weathering; crossbedded | 8.6 | 316.5 |
| 24 | Shale, dark grey, silty | 3.8 | 307.9 |
| 23 | Sandstone, fine-grained, grey; contains large fragments of wood | 1.5 | 304.1 |
| 22 | Shale, grey, interbedded with shaly sandstone | 10.8 | 302.6 |
| 21 | Sandstone, fine- to medium-grained, grey to brown; crossbedded in part; weathers platy; much carbonaceous material along partings | 15.6 | 291.8 |
| 20 | Sandstone, grey; some fine-grained and some coarse-grained; crossbedded; buff weathering | 14.2 | 276.2 |
| 19 | Sandstone, fine-grained, greenish grey; weathers light grey and crumbly | 10.6 | 262.0 |
| 18 | Sandstone, fine-grained, hard, grey, finely crossbedded; contains some dark bands; buff weathering | 13.0 | 251.4 |
| 17 | Covered | 21.0 | 238.4 |
| 16 | Sandstone, fine-grained, grey, very hard, thick-bedded; weathers buff | 12.0 | 217.4 |
| 15 | Shale, dark grey, silty | 2.0 | 205.4 |
| 14 | Sandstone, grey, thick-bedded; weathers platy; contains fossil leaves and stems | 18.2 | 203.4 |
| 13 | Sandstone, fine-grained, grey-brown, hard; interbedded with grey shale; some plant remains; minor thin ironstone bands up to 2 inches thick | 77.0 | 185.2 |
| 12 | Sandstone, medium-grained, hard, grey; beds up to 2 feet thick; wood remains common | 35.0 | 108.2 |
| 11 | Shale, dark grey, silty; some plant remains | 4.5 | 73.2 |
| 10 | Sandstone, medium-grained, grey; nodular and buff weathering | 2.0 | 68.7 |
| 9 | Shale, dark grey, contains carbonaceous material | 0.5 | 66.7 |
| 8 | Sandstone, medium-grained, dark grey, flaggy; banding due to carbonaceous material | 4.0 | 66.2 |
| 7 | Sandstone, carbonaceous; interbedded with carbonaceous shale | 5.0 | 62.2 |
| 6 | Shale, dark grey, silty; contains much plant material | 8.4 | 57.2 |
| 5 | Sandstone, fine-grained, grey-brown weathering; contains much plant material | 1.0 | 48.8 |
| 4 | Shale, grey to green; contains leaf remains | 6.0 | 47.8 |
| 3 | Sandstone, grey, hard; beds up to 1 foot thick; micaceous; contains several thin ironstone bands; some ostrea remains | 13.3 | 41.8 |
| 2 | Sandstone, fine-grained, brownish grey, silty; looks muddy; contains ostrea fragments | 12.0 | 28.5 |
| 1 | Sandstone, medium-grained, grey, thinly banded, flaggy; buff weathering; crossbedded | 16.5 | 16.5 |
| | THICKNESS EXPOSED | 358.0 | |
| | Underlying beds: Fort St. John Group | | |

*Section 32. On Little Berland River*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Kaskapau Formation | | |
| 8 | Sandstone, hard, quartzitic, slabby, grey-green, grey weathering.... | 50 | 190 |
| 7 | Sandstone, silty, brown, light brown weathering | 10 | 140 |
| 6 | Shale, soft, dark grey, grey weathering | 8 | 130 |
| 5 | Sandstone and silty shale, grey, greenish weathering; interbedded with dark grey silty shale | 32 | 122 |
| 4 | Sandstone, hard, quartzitic, grey, grey weathering | 4 | 90 |
| 3 | Shale, grey, nodular in part; with interbedded, hard, grey, sandstone; carbonized wood fragments | 20 | 86 |
| 2 | Sandstone, fine-grained, hard, silty; containing a 1-foot thick ostrea coquina | 16 | 66 |
| 1 | Sandstone, quartzitic, hard, grey-green, slabby, grey weathering | 50 | 50 |
| | THICKNESS EXPOSED | 190 | |
| | Underlying beds: Fort St. John Group (probable fault contact) | | |

*Section 33. Exposed 1 mile north of Grande Mountain (Thorsteinsson, 1952)*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Kaskapau Formation | | |
| 40 | Sandstone, grey, very fine grained, shaly, quartzitic; numerous finely disseminated carbonaceous fragments throughout; becomes more shaly and silty toward base | 8.6 | 280.9 |
| 39 | Shale, grey, silty; some carbonaceous fragments | 1.3 | 272.3 |
| 38 | Siltstone, or very fine grained sandstone, grey, hard; some calcareous and siliceous cement; shaly partings; some calcite veins; some carbonaceous fragments | 0.6 | 271.0 |
| 37 | Shale and siltstone, interbedded; shale, silty, contains carbonaceous fragments; siltstone, grey to brownish grey; contains carbonaceous fragments; ironstone bands and concretions | 29.5 | 270.4 |
| 36 | Sandstone, grey, fine-grained, quartzitic; some black chert; carbonaceous flakes scattered throughout | 0.9 | 240.9 |
| 35 | Sandstone, grey to buff, medium-grained, 'salt and pepper' quartz grains subangular to subrounded; some limonitic stains between grains; calcareous cement; becoming fine-grained and less carbonaceous towards the base | 6.5 | 240.0 |
| 34 | Shale, grey; specks of finely disseminated carbon scattered throughout; in part interbedded with grey siltstone; some ironstone nodules | 1.4 | 233.5 |
| 33 | Siltstone, brown; with irregular partings of dark grey shale; siltstone and shale, calcareous | 0.5 | 232.1 |
| 32 | Shale, grey, silty, slightly calcareous | 0.4 | 231.6 |
| 31 | Siltstone, grey, well-cemented, calcareous; fine fragments of carbonaceous material | 0.6 | 231.2 |
| 30 | Shale, grey to dark grey, fissile, non-calcareous; carbonaceous fragments scattered throughout; some thin beds of brownish grey siltstone up to 1 inch in thickness | 2.7 | 230.6 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 29 | Siltstone, brownish grey, irregularly interbedded with grey shale; calcareous cement; some nodules of ironstone, and bands of grey to dark grey, fissile, non-calcareous shale with siltstone; siltstone becoming more shaly and non-calcareous at base | 3.4 | 227.9 |
| 28 | Shale, grey to dark grey, fissile; in part, with brownish tinge | 3.6 | 224.5 |
| 27 | Siltstone and shale, interbedded; carbonaceous fragments scattered throughout; some bands of dark grey shale; some calcite veins; siltstone, grey, slightly calcareous to non-calcareous, with some shaly partings; shale, mainly non-calcareous, but becoming more calcareous towards base | 2.5 | 220.9 |
| 26 | Shale, grey to dark grey; in part with brownish tinge; carbonaceous fragments scattered throughout | 4.5 | 218.4 |
| 25 | Siltstone, brownish grey, calcareous; containing some carbonaceous fragments; some bands of grey shale; siltstone, sandy in part; some irregular partings of grey shale; becoming more shaly toward base | 1.8 | 213.9 |
| 24 | Shale, grey to dark grey; in part, highly carbonaceous; fragments scattered throughout | 3.7 | 212.1 |
| 23 | Sandstone, grey, very fine grained, 'salt and pepper', non-calcareous, well-cemented; some calcite veins; carbonaceous fragments | 0.8 | 208.4 |
| 22 | Sandstone, light buff to light grey, quartzitic; carbonaceous fragments scattered throughout; calcareous cement; some calcite veins; numerous shell fragments, including pelecypods | 4.2 | 207.6 |
| 21 | Shale, grey to dark grey, calcareous; carbonaceous fragments; some brownish grey siltstone bands | 0.9 | 203.4 |
| 20 | Siltstone, brownish grey, calcareous; some irregular partings of grey silty shale; calcite veins; 30 per cent of this section is shale | 6.3 | 202.5 |
| 19 | Siltstone, brownish grey, calcareous; partings of grey silty shale; shale composes 20 per cent of this section | 3.8 | 196.2 |
| 18 | Shale, grey, non-calcareous; in part silty; carbonaceous fragments scattered throughout | 1.1 | 192.4 |
| 17 | Coal | 1.4 | 191.3 |
| 16 | Siltstone, grey, hard, massive, weathers rusty on surface, non-calcareous; contains iron carbonate | 2.1 | 189.9 |
| 15 | Shale, grey, somewhat fissile; carbonaceous fragments; somewhat silty in part; some bands of grey to brownish grey siltstone, and some ironstone concretions | 50.1 | 187.8 |
| 14 | Sandstone, grey, very fine grained, shaly; carbonaceous fragments | 2.0 | 137.7 |
| 13 | Shale, silty, grey; carbonaceous fragments | 2.9 | 135.7 |
| 12 | Sandstone, silty, very fine grained, brownish grey; shaly in part; shaly partings | 3.2 | 132.8 |
| 11 | Shale and siltstone, interbedded, grey to brownish grey; carbonaceous fragments scattered throughout | 11.0 | 129.6 |
| 10 | Sandstone, brownish grey, massive, medium-grained, 'salt and pepper'; carbonaceous fragments scattered throughout; calcareous cement | 7.7 | 118.6 |
| 9 | Shale, silty, grey, finely interbedded with lighter grey silt | 2.1 | 110.9 |
| 8 | Sandstone, very fine grained to fine-grained, grey, 'salt and pepper'; some medium-grained; some calcareous cement; ironstone concretions, casts of fossils, and carbonaceous fragments; some irregular partings of dark grey shale | 33.4 | 108.8 |
| 7 | Shale, grey to dark grey, interbedded with grey siltstone; some ironstone concretions | 26.4 | 75.4 |
| 6 | Siltstone, brownish grey, interbedded with grey shale; carbonaceous fragments; ironstone concretions | 10.3 | 49.0 |
| 5 | Sandstone, very fine grained, brownish grey; calcareous cement; some carbonaceous flakes | 1.0 | 38.7 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 4 | Shale, grey to dark grey, silty; ironstone concretions | 4.4 | 37.7 |
| 3 | Sandstone, brownish grey, fine to very fine grained; silty in part; numerous bands of grey shale | 10.3 | 33.3 |
| 2 | Shale, grey to dark grey; carbonaceous fragments; bands of grey siltstone | 22.6 | 23.0 |
| 1 | Sandstone, grey, very fine grained, may be siltstone calcareous cement; carbonaceous fragments | 0.4 | 0.4 |
| | TOTAL THICKNESS | 280.9 | |

Underlying beds: Fort St. John Group

## Measured Sections of the Cardium Formation

### *Section 34. On the west side of Solomon Mountain*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds covered | | |
| 8 | Sandstone, grey, buff weathering, hard | 4.0 | 808.0 |
| 7 | Covered, probably shale | 121.0 | 804.0 |
| 6 | Sandstone, grey, buff weathering, hard, laminated | 80.0 | 683.0 |
| 5 | Covered; faults in this zone | 420.0 | 603.0 |
| 4 | Shale, dark grey to black; contains *Scaphites ventricosus* | 2.0 | 183.0 |
| 3 | Sandstone, grey, buff weathering, crossbedded | 6.0 | 181.0 |
| 2 | Chiefly covered, but containing a few small exposures of black shale with coaly fragments | 160.0 | 175.0 |
| 1 | Sandstone, grey, buff weathering, crossbedded | 15.0 | 15.0 |
| | TOTAL THICKNESS | 808.0 | |

Underlying beds covered

### *Section 35. On Little Berland River near the mouth of Evans Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Wapiabi Formation | | |
| 13 | Sandstone, greenish grey, hard, slabby, quartzitic, fine-grained; contains *Cardium pauperculum* near the top | 61.0 | 239.0 |
| 12 | Sandstone, buff-brown, thin-bedded, fine-grained | 20.0 | 178.0 |
| 11 | Conglomerate, pebbles up to 2 inches in diameter | 0.8 | 158.0 |
| 10 | Sandstone, dark grey, silty, grey weathering | 6.0 | 157.2 |
| 9 | Coal, soft, dirty | 0.2 | 151.2 |

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| 8 | Shale, dark grey, soft | 4.0 | 151.0 |
| 7 | Sandstone, light grey, fine-grained, quartzitic | 3.0 | 147.0 |
| 6 | Sandstone, grey-brown, light brown weathering, medium-grained, with grey shale partings | 50.0 | 144.0 |
| 5 | Shale, grey, hard | 7.0 | 94.0 |
| 4 | Shale, greenish grey, clay-like | 10.0 | 87.0 |
| 3 | Sandstone, grey, grey weathering, hard, quartzitic | 8.0 | 77.0 |
| 2 | Sandstone and shale, soft, brownish grey, medium-grained sandstone interbedded with grey, silty shale | 11.0 | 69.0 |
| 1 | Sandstone, greenish grey, grey weathering, hard, slabby, quartzitic | 58.0 | 58.0 |
| | TOTAL THICKNESS | 239.0 | |
| | Underlying beds: Kaskapau Formation | | |

*Section 36. On the ridge on the east side of Evans Creek near the divide between Evans Creek and Moberly Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Wapiabi Formation | | |
| 5 | Sandstone, green-grey, fine-grained, slabby | 69.0 | 232.0 |
| 4 | Sandstone, shaly, slabby; a few pebbles at base | 60.0 | 163.0 |
| 3 | Shale, lumpy and clay-like | 28.0 | 103.0 |
| 2 | Sandstone, quartzitic, medium-grained, white | 16.0 | 75.0 |
| 1 | Sandstone, reddish and greenish weathering; slabby; some shaly partings | 59.0 | 59.0 |
| | TOTAL THICKNESS | 232.0 | |
| | Underlying beds covered | | |

*Section 37. On Muskeg River just east of the mouth of Susa Creek*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Muskiki Formation | | |
| 6 | Conglomerate; with some sandstone and pebbly sandstone | 10.0 | 254.0 |
| 5 | Sandstone, hard, platy, grey, grey to buff weathering | 75.0 | 244.0 |
| 4 | Sandstone, siltstone, and shale; poorly exposed | 100.0 | 169.0 |
| 3 | Sandstone, massive, platy, hard, grey, grey and buff weathering | 60.0 | 69.0 |
| 2 | Conglomerate; pebbles of black, grey, and grey chert | 6.0 | 9.0 |
| 1 | Sandstone, hard, medium-grained, slabby, grey and grey weathering | 3.0 | 3.0 |
| | TOTAL THICKNESS | 254.0 | |
| | Underlying beds: Kaskapau Formation | | |

*Section 38. On the south side of Sheep Creek about four miles above its mouth*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Muskiki Formation | | |
| 9 | Conglomerate; pebbles up to 3 inches in diameter | 1.0 | 200.0 |
| 8 | Sandstone, hard, grey, quartzitic, slabby | 2.0 | 199.0 |
| 7 | Shale, grey, silty | 2.0 | 197.0 |
| 6 | Sandstone, hard, grey, quartzitic; interbedded with grey, silty shale | 22.0 | 195.0 |
| 5 | Shale, light grey, clayey, soft; some weathers yellowish | 44.0 | 173.0 |
| 4 | Sandstone, hard, grey; minor amounts of grey shale as thin partings | 36.0 | 129.0 |
| 3 | Shale, dark grey, silty; some carbonaceous | 21.0 | 93.0 |
| 2 | Sandstone, light grey, very fine grained; contains carbonized wood | 28.0 | 72.0 |
| 1 | Sandstone, hard, grey, quartzitic; in beds up to 2 feet thick | 44.0 | 44.0 |
| | TOTAL THICKNESS | 200.0 | |
| | Underlying beds: Kaskapau Formation | | |

## Measured Section of the Bad Heart Formation

*Section 39. On the south side of Sheep Creek about four miles above its mouth*

| Unit | | Thickness (feet) | Height above base (feet) |
|---|---|---|---|
| | Overlying beds: Wapiabi Formation | | |
| 4 | Sandstone, hard, grey, quartzitic; beds up to 1 foot thick | 21.0 | 185.0 |
| 3 | Conglomerate; composed mainly of chert pebbles up to ½ inch in diameter | 2.0 | 164.0 |
| 2 | Sandstone, hard, grey, quartzitic; almost massive | 12.0 | 162.0 |
| 1 | Sandstone, grey, hard; interbedded with grey siltstone and shaly sandstone | 150.0 | 150.0 |
| | TOTAL THICKNESS | 185.0 | |
| | Underlying beds: Muskiki Formation | | |

# APPENDIX B

## Fossil Localities

| Loc. No. | GSC Loc. | | |
|---|---|---|---|
| 1 | T37 | Devonian | Head of west fork of Solomon Creek, Boule Range (lat. 53° 21′, long. 117° 59′ approx.) |
| 2 | W154 | Devonian | Head of north fork of Supply Creek, Boule Range (long. 117° 53′ and just south of lat. 53° 15′ approx.) |
| 3 | W162 | Devonian | On ridge west of Brûlé Lake near lat. 53° 15′ |
| 4 | M137 | Devonian | On ridge west of Brûlé Lake near lat. 53° 15′ (just south of map boundary) |
| 5 | T41 | Devonian | On ridge west of Brûlé Lake 1,000 feet north of C.N. tunnel (just south of map boundary) |
| 6 | L223 | Devonian | In railway-cut head at Brûlé Lake 1,000 feet north of tunnel (just south of map boundary) |
| 7 | 12696 | Devonian | Base at northeast face of Zebra Mountain, Berland Range |
| 8 | 12697 | Devonian | In cirque on northwest side of Tip Top Ridge, Berland Range |
| 9 | 15976 | Devonian | ⅛ mile northwest of Crescent Creek and ½ mile east of long. 118° 30′ |
| 10 | 12697 | Banff | In cirque on northwest side of Tip Top Ridge, Berland Range |
| 11 | 12699 | Banff | Head of small southwest-flowing branch of Mumm Creek on Hoff Range near long. 118° 15′ |
| 12 | 12698 | Banff | On ridge about one mile southeast of Zebra Mountain, Berland Range (lat. 53° 34′, long. 118° 26′ approx.) |
| 13 | 12694 | Banff | In cirque on northwest side of Tip Top Ridge, Berland Range |
| 14 | 4404 | Banff | On ridge at head of North Berland River (lat. 53° 30′, long. 118° 49′ approx.) |
| 15 | 23495 | Banff | Northwest bank of Smoky River, 2 miles above Clarks Crossing (just south of map border) |
| 16 | 24697 | Banff | Ridge at head of North Berland River (lat. 53° 30′, long. 118° 49′ approx.) |
| 17 | 24698 | Banff | Ridge at head of North Berland River (lat. 53° 30′, long. 118° 49′ approx.) |
| 18 | 24699 | Banff or Rundle | Ridge at head of North Berland River (lat. 53° 30′, long. 118° 49′ approx.) |
| 19 | 24696 | Banff | Monoghan Anticline, de Smet Range, north side of Sulphur River |
| 20 | 24700 | Rundle | Monoghan Anticline, de Smet Range, north side of Sulphur River |
| 21 | 12693 | Rundle | On hill northwest of confluence of Moon Creek and Planet Creek, Hoff Range |
| 22 | 12695 | Rundle | On ridge about 1¼ miles west of long. 118° 20′ and ¼ mile south of lat. 53° 35′ |
| 23 | 12694 | Rundle | Cirque in northwest side to Tip Top Ridge (lat. 53° 34′, long. 118° 26′ approx.) |
| 24 | 23255 | Rundle | Llama Mountain, west side (lat. 53° 48′ 30″, long. 119° 29′ approx.) |
| 25 | | Triassic | Ridge on southeast side of Little Berland River, Hoff Range (lat. 53° 34′, long. 118° 21′ approx.) |
| 26 | | Triassic | Small northwest-flowing branch of Little Berland River, Hoff Range (lat. 54° 34′, long. 118° 23′) |
| 27 | | Triassic | Hoff Range, head of south-flowing branch of Mumm Creek (lat. 53° 32′, long. 118° 13′) |
| 28 | 25118 | Triassic | About 900′ above base of formation on ridge south of Walton Creek (lat. 53° 45′, long. 118° 48′) |
| 29 | 25121 | Triassic | 10′ below base of Whitehorse Formation, Zenda Creek, Persimmon Range (lat. 53° 34′, long. 118° 51′) |
| 30 | 25123 | Triassic | 4′ to 10′ below Whitehorse Formation, on southwest-flowing branch of Sulphur River, Persimmon Range about lat. 53° 37′, long. 118° 56′ |

| Loc. No. | GSC Loc. | | |
|---|---|---|---|
| 31 | 25124 | Triassic | About 60′ below Whitehorse Formation, just north of 14th baseline about lat. 53° 32′, long. 118° 47′ |
| 32 | 23489 | Triassic | Northeast side of Llama Mountain (lat. 53° 49′, long. 119° 28′ approx.) |
| 33 | 23490 | Triassic | Northeast side of Llama Mountain (lat. 53° 49′, long. 119° 28′ approx.) |
| 34 | 23494 | Whitehorse | Top of scarp, west and southwest of Clarks Crossing |
| 35 | 23486 | Fernie | Northeast side of Llama Mountain (lat. 53° 49′, long. 119° 28′ approx.) |
| 36 | 23486a | Fernie | Northeast side of Llama Mountain (lat. 53° 49′, long. 119° 28′ approx.) |
| 37 | 23487 | Fernie | Northeast side of Llama Mountain (lat. 53° 49′, long. 119° 28′ approx.) |
| 38 | 23488 | Fernie | Northeast side of Llama Mountain (lat. 53° 49′, long. 119° 28′ approx.) |
| 39 | 24701 | Fernie | 10′ above base in canyon of South Muskeg River about ½ mile above confluence with Muskeg River |
| 40 | 13106 | Fernie | Southeast end of low saddle one mile east of divide between Little Berland River and Mumm Creek |
| 41 | L379 | Fernie | Tributary of Moosehorn Creek, 970′ downstream from lat. 53° 15′ |
| 42 | 25392 | Nikanassin | North Berland River about lat. 53° 37′, long. 118° 44′ |
| 43 | 25400 | Nikanassin | On ridge at approx. lat. 53° 34′, long. 118° 30′ |
| 44 | 25402 | Nikanassin | North Berland River about lat. 53° 37′, long. 118° 44′ 30″ |
| 45 | 13736 | Nikanassin | Thoreau Creek, north of Wildhay River (lat. 53° 31′, long. 118° 30′ approx.) |
| 46 | 17301 | Luscar | 2,400′ up Franks Creek from mouth (lat. 53° 46′, long. 119° 02′ approx.) |
| 47 | 24594 | Luscar | 69′ above base of formation on Walton Creek ½ mile above mouth (lat. 53° 45′, long. 118° 59′ approx.) |
| 48 | 17300 | Fort St. John | Pearl Creek about 1,900′ upstream from confluence with Sulphur River (lat. 53° 48′, long. 119° 02′ approx.) |
| 49 | 24693 | Fort St. John | On ridge between Muskeg and South Muskeg Rivers (lat. 53° 37′ 30″, long. 118° 52′ approx.) |
| 50 | 17307 | Dunvegan | Upper 20′ of formation, about 1,200′ upstream from junction of Cowlick and Shale Creeks (lat. 53° 50′, long. 119° 01′) |
| 51 | 17308 | Dunvegan | North side of Smoky River, about lat. 53° 52′, long. 119° 10′ |
| 52 | 17312 | Dunvegan | Muskeg River ½ mile west of long. 119° 00′ and about 2 miles south of lat. 54° 00′ |
| 53 | 17305 | Dunvegan | Basal 3 feet of formation on Shale Creek (lat. 53° 51′, long. 119° 01′ approx.) |
| 54 | 19171 | Dunvegan | 20′ above base of formation where it crosses Nickerson Creek (lat. 54° 01′, long. 119° 24′ approx.) |
| 55 | 19172 | Dunvegan | On small branch at Nickerson Creek near lat. 54° 01′, long. 119° 25′ |
| 56 | 19173 | Dunvegan | 1¼ miles east of long. 119° 30′ and about ½ mile north of lat. 54° 00′ |
| 57 | 19174 | Dunvegan | Lower 50′ of formation on ridge south of Copton Creek near lat. 54° 06′, long. 119° 25′ |
| 58 | 20108 | Dunvegan | North side of Copton Creek, about lat. 54° 08′, long. 119° 23′ |
| 59 | 14968 | Dunvegan | North fork of Cowlick Creek (lat. 53° 51′, long. 118° 59′ approx.) |
| 60 | 13734 | Dunvegan | Thoreau Creek (lat. 53° 32′, long. 118° 00′ approx.) |
| 61 | 13105 | Dunvegan | Creek flowing northeast on north side of Tip Top Ridge, Berland Range (lat. 53° 35′, long. 118° 26′ approx.) |
| 62 | 900 | Kaskapau | Road-cut near Solomon Creek 1 mile below mouth of west fork |

| Loc. No. | GSC Loc. | | |
|---|---|---|---|
| 63 | T653 | Kaskapau | Upper part of Maskuta Creek (lat. 53° 18′ 30″, long. 117° 43′ approx.) |
| 64 | T502 | Kaskapau | West side of Solomon Mountain just below Bighorn Formation (lat. 53° 23′ 30″, long. 117° 51′) |
| 65 | W95 | Kaskapau | Upper part of Maskuta Creek (lat. 53° 16′, long. 117° 43′ approx.) |
| 66 | 14964 | Kaskapau | Muskeg River at McDonald Flats (lat. 53° 57′, long. 118° 56′ approx.) |
| 67 | 25401 | Kaskapau | North-flowing branch of North Berland River, about lat. 53° 36′, long. 118° 44′ |
| 68 | 17306 | Kaskapau | Sulphur River about lat. 53° 52′, long. 119° 06′ |
| 69 | 17311 | Kaskapau | Gustavs Creek about lat. 53° 56′, long. 119° 12′ |
| 70 | 18454 | Kaskapau | 100′ above Dunvegan Formation near lat. 54° 00′, long. 119° 00′ |
| 71 | M176 & W50 | Cardium | On ridge northeast of locality of Shell Solomon Creek No. 1 well (lat. 53° 23′, long. 117° 53′ approx.) |
| 72 | L207 & L215 | Cardium | Solomon Mountain (lat. 53° 23′ 30″, long. 117° 51′ approx.) |
| 73 | L140 | Cardium | Upper part of Maskuta Creek (lat. 53° 16′, long. 117° 42′ approx.) |
| 74 | 13104 | Wapiabi | Moon Creek about lat. 53° 42′, long. 118° 21′ |
| 75 | 13103 | Wapiabi (Chungo Member) | Moon Creek about lat. 53° 41′, long. 118° 22′ |
| 76 | W80 | Wapiabi | Ice Water Creek at the 6th Meridian (lat. 53° 29′, long. 118° 00′ approx.) |
| 77 | T670 | Wapiabi | Maskuta Creek just south of lat. 53° 15′ and near long. 117° 42′ |
| 78 | M207 | Wapiabi | Solomon Mountain; 100′ NW of the northwest corner of sec. 6, tp. 51, rge. 26 |
| 79 | 333 | Wapiabi (Chungo Member) | At mouth of Paradise Creek (lat. 53° 29′, long. 117° 59′ approx.) |
| 80 | 14965 | Wapiabi | First south-flowing creek east of McDonald Flats (lat. 53° 57′, long. 118° 54′ approx.) |
| 81 | 14963 | Muskiki | Scarp on east side of McDonald Flats near lat. 53° 57′, long. 118° 54′ approx. |
| 82 | 20103 | Muskiki or Lower Wapiabi | Small creek flowing east and entering Copton Creek at the right angle bend near long. 119° 17′ |
| 83 | 20104 | Muskiki or Lower Wapiabi | Small branch entering Adelade Creek from the north (lat. 54° 08′, long. 119° 21′ approx.) |
| 84 | 20105 | Bad Heart | On point where Copton Creek changes course from east to north (lat. 54° 08′, long. 119° 17′ approx.) |
| 85 | 20106 | Muskiki or Lower Wapiabi | Beaverdam Creek (lat. 54° 07′, long. 119° 17′ 30″ approx.) |
| 86 | 20110 | Wapiabi (Chungo Member) | Head of small branch flowing south into Copton Creek (approx. lat. 54° 09′, long. 119° 22′) |
| 87 | 18440 | Muskiki or Lower Wapiabi | About 2 miles above the mouth of Sheep Creek (lat. 54° 03′, long. 119° 06′) |
| 88 | 18441 | Muskiki or Lower Wapiabi | About 2 miles above the mouth of Sheep Creek (lat. 54° 03′, long. 119° 06′) |
| 89 | 18442 | Wapiabi | About 2 miles above the mouth of Sheep Creek, 600′ above Bighorn at lat. 54° 03′, long. 119° 06′ |
| 90 | 18445 | Wapiabi | Small creek entering Smoky River at Daniels Flats (lat. 54° 02′, long. 119° 02′) |
| 91 | 18446 | Wapiabi | Small creek entering Smoky River at east end of Daniels Flats (lat. 54° 03′, long. 119° 02′) |
| 92 | 18448 | Wapiabi | Cutpick Hill, 1½ miles north of Sheep Creek (lat. 54° 03′, long. 119° 08′) |
| 93 | 3723 | Luscar | Forty-one Mile Creek (lat. 54° 31′, long. 118° 25′) |
| 94 | 4537 | Luscar | South Berland River, 1½ miles below the mouth of Persimmon Creek (lat. 53° 35′, long. 118° 38′ approx.) |

| *Loc. No.* | *GSC Loc.* | | |
|---|---|---|---|
| 95 | 4405 | Luscar | Walton Creek, $1\frac{1}{2}$ miles above mouth (lat. 53° 45′, long. 118° 58′ approx.) |
| 96 | 3361 | Luscar | Oldhouse Creek about 3,000′ upstream from crossing of road to upper Prine Creek (lat. 53° 31′, long. 117° 53′ approx.) |
| 97 | 3362 | Luscar | Solomon Creek, 500′ downstream from Shell Solomon Creek No. 1 well |
| 98 | 3530 | Luscar | Prine Creek, 1,200′ upstream from abandoned coal mine (lat. 53° 22′, long. 117° 57′ approx.) |
| 99 | 3531 & 3532 | Luscar | Prine Creek, at abandoned coal mine (lat. 53° 22′, long. 117° 57′ approx.) |
| 100 | 4536 | Dunvegan | Persimmon Creek about $2\frac{1}{2}$ miles above the mouth (lat. 53° 34′, long. 118° 42′ approx.) |
| 101 | 3274 & 3275 | Upper Cretaceous | Abandoned railway grade, $\frac{1}{2}$ mile east of Entrance (lat. 53° 23′, long. 117° 41′ approx.) |
| 102 | 3272 | Upper Cretaceous | Trail Creek (Pedley Creek) about lat. 53° 27′ 30″, long. 117° 27′ 30″ |
| 103 | 3477 | Paleocene | North bank of Wildhay River, about lat. 53° 37′, long. 117° 47′ |
| 104 | 3478 | Paleocene | Pinto Creek, about lat. 53° 38′, long. 117° 59′ 30″ |
| 105 | 3479 | Paleocene | Twelve Mile Creek, about 5,000′ up from junction with Wildhay River (lat. 53° 33′, long. 117° 54′) |
| 106 | 3271 | Paleocene | Fish Creek about lat. 53° 28′, long. 117° 38′ |

# APPENDIX C

## Fossil Identifications

## Table I—*Devonian*

| Fauna Species | Locality Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| *Syringopora* sp. | – | – | – | – | – | – | – | x | – |
| *Thamnopora* sp. | – | – | – | – | x | – | x | – | – |
| *Disphyllum colemanense* (Warren) | – | – | – | – | – | x | – | – | – |
| *Disphyllum* sp. | – | x | – | – | – | – | – | – | x |
| "*Streptelasma*" sp. | – | – | – | – | – | – | – | – | x |
| *Tabulophyllum* cf. *T. magnum* Fenton and Fenton | – | – | – | – | – | – | – | – | x |
| *Schizophoria* sp. | – | – | – | – | – | – | – | – | x |
| *Gypidula* sp. | – | – | – | – | – | – | – | x | x |
| *Schuchertella* sp. | x | – | – | – | – | – | – | – | – |
| *Chonetes* sp. | x | – | – | – | – | – | – | x | x |
| *Productella lata* Warren | – | – | – | – | – | – | – | x | – |
| *Productella* sp. | – | – | – | x | – | – | – | – | – |
| Productid indet. | – | – | – | – | – | – | – | – | x |
| *Camarotoechia* sp. | – | – | x | – | – | – | – | x | – |
| *Calvinaria albertensis* (Warren) | – | – | – | – | – | – | – | – | x |
| *Leiorhynchus* sp. | – | – | – | x | – | – | – | – | – |
| *Pugnoides calvini* Fenton and Fenton | – | – | – | – | – | – | – | – | x |
| *Pugnoides solon* Thomas and Stainbrook | – | – | – | – | – | – | – | – | x |
| *Atrypa borealis* var. *lata* Warren | – | – | – | – | – | – | – | – | x |
| *Atrypa devoniana* Webster | – | – | – | – | – | – | – | – | x |
| *Atrypa* sp. | – | – | – | – | x | – | – | – | x |
| *Cyrtiopsis standlyensis* (Shimer) | – | – | – | – | – | – | – | x | – |
| *Cyrtospirifer animasensis* (Girty) | – | – | – | – | – | – | – | x | – |
| *Cyrtospirifer* cf. *C. whitney* (Hall) | – | – | – | – | – | – | – | – | x |
| "*Spirifer*" sp. | x | – | x | – | – | – | – | – | – |
| *Martinia*? sp. | – | x | – | – | – | – | – | – | – |
| *Cyrtina* cf. *C. hamiltonensis* Hall | – | – | – | – | – | – | – | – | x |
| *Athyris* sp. | – | – | – | – | – | – | – | x | – |
| *Conocardium* sp. | – | – | – | – | – | – | – | x | – |
| *Bellerophon* sp. | – | – | – | x | – | – | x | x | – |
| *Euomphalus* sp. | – | – | – | – | – | – | – | x | – |
| *Euomphalus eurekensis* Walcott | – | – | – | – | – | – | x | – | – |
| *Halopea* sp. | – | – | – | – | – | – | – | – | x |
| *Porcellia* sp. | – | – | – | – | – | – | – | – | x |
| *Geisonoceras* sp. | – | – | – | – | – | – | – | – | x |
| "*Gomphoceras*" sp. | – | – | – | – | – | – | – | – | x |
| *Michelinoceras* sp. | – | – | – | – | – | – | – | – | x |

# Table II—*Mississippian*

| Fauna Species | Locality Number | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Banff Formation | | | | | | | | Rundle Group | | | | | | |
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| *Pleurodictyum placenta* White | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Syringopora aculeata* Girty | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Syringopora pennsylvanica* Shimer | – | – | – | – | – | – | – | – | – | x | – | – | x | – | – |
| *Triplophyllum minnewankensis* Shimer | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – |
| *Koninckophyllum* sp. | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |
| *Lithostrotion* cf. *L. mutabile* Kelly | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Lithostrotion* sp. | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Ekvasophyllum* sp. | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Pseudozaphrentoides* ? sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – |
| *Rhipidomella* cf. *R. diminutiva* Rowley | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Schizophoria* sp. | x | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Dictyoclostus* cf. *D. burlingtonensis* Hall | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Dictyoclostus* sp. | – | – | – | – | – | x | x | – | – | – | – | x | – | – | – |
| *Linoproductus ovatus* (Hall) | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Linoproductus* sp. | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| "*Productus*" aff. *minnewankensis* Shimer | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Productus* sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – |
| *Camarotoechia* sp. | – | – | x | – | – | x | – | – | – | – | – | x | – | – | – |
| *Camarotoechia* cf. *C. tuta* (Miller) | – | x | x | – | – | x | – | – | – | – | – | – | – | – | – |
| *Camarotoechia chouteauensis* Weller | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Camarotoechia allani* Warren | – | x | x | – | – | – | x | – | – | – | – | – | – | – | – |
| *Dielasma chouteauensis* Weller | x | – | – | – | – | – | – | – | – | – | – | x | – | – | – |
| *Platyrachella*? *rutherfordi* (Warren) | x | – | x | – | – | – | – | – | – | – | – | x | – | x | – |
| *Spirifer cascadensis* Warren | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Spirifer* sp. (*Spirifer bifurcatus* type) | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Spirifer esplanadensis* Brown | x | x | x | – | x | – | x | – | – | – | – | x | – | x | – |
| *Spirifer* cf. *S. logani* Hall | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Spirifer greenockensis* Brown | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – |
| *Spirifer marionensis* Shumard | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Spirifer minnewankensis* Shimer | – | – | – | – | – | – | x | – | x | – | – | – | – | – | – |
| *Spirifer* cf. *S. missouriensis* Swallow | – | – | – | – | – | – | – | – | – | – | x | – | – | x | – |
| *Spirifer platynotus* Weller | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Spirifer* ex gr. *S. rowleyi* Weller | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – |
| *Spirifer shepardi* Weller? | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Brachythyris chouteauensis* Weller | x | x | x | – | – | – | x | – | – | – | – | x | – | – | – |
| *Brachythyris suborbicularis* (Hall) | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Martinia* sp. | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Martinia rostrata* Girty | x | x | – | – | – | – | – | – | – | – | – | x | – | – | – |
| *Reticularia pseudolineata* (Hall) | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – |
| *Reticularia cooperensis* (Swallow) | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Reticularia* sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – |
| *Syringothyris* sp. | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Cliothyridina* sp. | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – |
| *Cliothyridina lata* Shimer | – | x | x | – | – | – | – | – | x | – | – | x | – | x | – |
| *Cliothyridina obmaxima* McChesney | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Composita* sp. | – | – | – | – | x | – | x | – | – | – | – | – | – | x | – |
| *Composita athabascensis* Warren | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Composita immatura* Girty | x | x | x | – | – | x | – | – | – | – | – | x | – | – | – |
| *Composita humilis* Girty | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| cf. *Composita sulcata* Weller | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – |
| *Eumetria verneuiliana* (Hall) | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – |
| *Proetus* sp. | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |
| *Lepidodendron* sp. | – | – | – | – | – | – | – | – | – | x | – | – | x | – | – |
| *Schellwienella*? sp. | – | x | x | – | – | – | – | – | – | – | – | x | – | – | – |
| *Straparollus* sp. | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – |

## Table III—*Triassic*

| Fauna Species | Locality Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Spray River Group | | | | | | | | | |
| | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| *Spiriferina* sp. | – | x | – | – | – | – | – | – | x | – |
| *Coenothyris* sp. | – | x | – | – | – | – | – | – | – | – |
| "*Terebratula*" cf. *T. julica* Bittner | – | – | – | – | – | – | – | – | – | x |
| *Leda* sp. | – | x | – | – | – | – | – | – | – | – |
| *Daonella* sp. | – | – | – | x | – | – | – | – | – | – |
| *Hoernesia* cf. *H. socialis* (Schlotheim) | – | – | – | – | – | – | – | – | – | – |
| *Bakevillia* sp. | – | – | – | – | – | – | x | x | – | – |
| *Lima* sp. | – | – | – | – | x | – | – | – | – | – |
| *Mysidioptera poyana* McLearn | – | – | – | – | – | – | – | – | – | x |
| *Modiola* sp. | – | – | – | – | x | x | – | – | – | – |
| *Myophoria* cf. *M. laevigata* (Ziethen) | – | x | – | – | – | – | – | – | – | – |
| *Myophoria* sp. | – | – | – | – | – | x | x | x | – | – |
| *Trigonodus* sp. | x | – | – | – | – | – | – | – | – | – |
| Orthoceraconic cephalopod indet. | – | – | – | x | – | – | – | – | – | – |
| *Paranautilus*? sp. | – | – | – | x | – | – | – | – | – | – |
| *Euflemingites* sp. | – | – | – | – | – | – | – | x | – | – |
| *Ussurites* sp. | – | – | – | – | – | – | – | – | – | – |
| *Beyrichites* sp. | x | – | – | x | – | – | – | – | – | – |
| *Gymnotoceras* cf. *G. blakei* (Gabb) | x | – | x | x | – | – | – | – | x | – |
| *Ptychites* sp. | – | – | x | x | – | – | – | – | – | – |
| *Sturia* sp. | – | – | – | – | – | – | – | – | – | – |

## Table IV—*Jurassic*

| Fauna Species | Locality Number | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fernie Group | | | | | | | Nikanassin Formation | | | |
| | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| *Rhynchonella* sp. indet. | – | – | – | – | – | – | – | x | – | – | – |
| "*Stephanoceras*" sensu lato | – | – | – | – | – | – | – | – | – | x | – |
| *Chondroceras*? sp. | – | – | – | – | – | – | – | – | – | x | – |
| *Cardioceras*? sensu lato | – | x | x | – | – | – | – | – | – | – | – |
| *Belemnites* sp. | x | – | – | – | – | – | – | – | x | x | – |
| *Buchia* sp. indet. | x | – | – | – | – | – | x | – | x | – | – |
| *Buchia* ex gr. *B. piochii* (Gabb) or | – | – | – | – | – | – | – | – | – | – | – |
| *Buchia* ex gr. *B. mosquensis* (Buch) | – | – | – | – | x | x | – | – | – | – | x |
| *Buchia concentrica* Sowerby | – | x | x | – | – | – | – | – | – | – | – |
| *Pecten* n. sp. | – | – | – | – | x | – | – | – | – | – | – |
| *Ostrea* sp. indet. | – | – | – | – | x | – | – | – | – | – | – |
| *Gryphaea* cf. *cadominensis* Warren | x | – | – | – | – | – | – | – | – | – | – |

## Table V—*Lower and Upper Cretaceous*

| Fauna Species | Locality Number | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Luscar Formation | | Fort St. John Group | | Dunvegan Formation | | | | | | | | | | | |
| | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
| ? *Viviparus* sp. indet. | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Melania*? sp. indet. | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – |
| *Neogastroplites* ex gr. *cornutus* (Whiteaves) | – | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Neogastroplites* sp. indet. | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Neogastroplites* (sensu lato) nov. sp. A | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Neogastroplites* (sensu lato) nov. sp. B | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – |
| ?*Engenoceras* (*Metengenoceras*) sp. indet. | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| cf. *Inoceramus* sp. indet. | – | – | x | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Inoceramus rutherfordi* Warren | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | x |
| *Inoceramus dunveganensis* McLearn | – | – | – | – | – | – | x | – | – | – | – | x | x | – | – | – |
| *Exogyra* ex gr. *laeviuscula* Roemer | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – |
| *Corbicula* cf. *durkeei* (Meek) | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – |
| *Corbula pyriformis* var. *dunveganensis* | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Corbula* sp. | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Corbula* cf. *nomatophora* Meek | – | – | – | – | – | x | – | – | – | x | – | – | – | – | x | – |
| *Ostrea* sp. | – | – | – | – | – | – | – | – | x | – | x | x | – | – | – | – |
| *Yoldia* sp. | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – |
| *Brachydontes* cf. *multilinigera* Meek | – | – | – | – | – | x | – | – | x | – | – | x | – | – | – | x |
| cf. *Unio* ex gr. *lacombi* McLearn | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Unio* (*Elliptio*) aff. *blairmorensis* Russell | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Unio* ex gr. *lacombi* McLearn | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Unionid? indet. | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Unio* (*Elliptio*) cf. *sulphuriensis* | – | – | – | – | – | – | – | – | x | – | – | – | – | – | x | – |
| cf. *Balanus* sp. indet. | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Lioplacoides* sp. indet. | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

# Table VI—*Upper Cretaceous*

| Fauna Species | Locality Number | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kaskapau Formation | | | | | | | | | Cardium Formation | | | Wapiabi Formation (or equivalents) | | | | | | | | | | | | | | | | | |
| | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 |
| *Polinices*? | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| '*Prionocyclus*' sp. | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Prionotropis*? | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Scaphites ventricosus* Meek and Hayden | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | x | x | – | – | – | – | x | x | – | – | – | – |
| *Scaphites* (*Clioscaphites*) cf. *montanensis* Cobban | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | x | x | x | x |
| *Scaphites preventricosus* Cobban | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| cf. var. *sweetgrassensis* Cobban | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – |
| *Scaphites* ex gr. *ventricosus* Meek and Hayden | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Sensu lato (resembles *S. depressus* Reeside) | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Scaphites* sp. | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Baculites* sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | x |
| *Placenticeras* sp. indet. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |
| *Dunveganoceras* sp. indet. | – | – | – | – | – | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus lobatus* var. *lundbreckensis* McLearn | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus labiatus* Schlotheim | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus capulus* Shumard | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus leylandensis* var. *bighornensis* McLearn | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus leylandensis* McLearn | – | – | – | – | – | – | – | – | – | x | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus* cf. *selwyni* McLearn | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus inconstans* Woods | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus umbonatus* Meek and Hayden | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | x | – | – | – | – | – |
| *Inoceramus corpulentus* McLearn | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus* ex gr. *fragilis* Hall and Meek | – | – | – | – | – | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | x |
| *Inoceramus lamarki* Park | – | – | – | – | – | – | x | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Inoceramus lamarki* Park cf. var. *apicalis* Woods | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Cardium* sp. | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | x | – | – | x | – |
| *Oxytoma nebrascensis* Ewans and Shumard | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | x | x | x | – |
| *Tellina* sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – |
| '*Dosiniopsis*' sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – |
| *Panopea* cf. *gurgitis* (Brongniart) | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – |
| ? *Arctica* sp. indet. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | x | – | – | – | – | – | – | – | – |
| *Nucula* sp. indet. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |



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# Table VII—*Cretaceous and Paleocene*

| Flora Species | Locality Number | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Luscar Formation | | | | | | | Upper Cretaceous | | | | Paleocene | | | |
| | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 |
| *Equisetites lyelli* (Mantell) Unger | x | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Equisetites* sp. (rhizome) | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Cladophlebis oerstedi* (Heer) Seward | – | – | – | – | x | – | – | – | – | – | – | – | – | – | – |
| *Klukia canadensis* Bell | x | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Cladophlebis virginiensis* Fontaine | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Sphenopteris latifolia* Fontaine | – | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Onoclea hebridica* (Forbes) Bell | – | – | – | – | – | – | – | – | – | x | x | – | – | – | – |
| *Ptilophyllum speciosum* (Heer) Seward | x | – | – | – | – | – | x | – | – | – | – | – | – | – | – |
| *Pseudocycas dunkeriana* (Goeppert) Florin | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – |
| *Pseudocycas unjiga* Dawson | – | – | – | – | – | – | – | x | – | – | – | – | – | – | – |
| *Sagenopteris williamsoni* (Newberry) Bell | – | x | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Sagenopteris mclearni* Berry | x | – | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Sagenopteris* sp. | – | – | – | – | – | x | x | – | – | – | – | – | – | – | – |
| *Nilssonia serotina* Heer | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |
| *Nilssonia* sp. | – | – | – | – | – | x | – | – | – | – | – | – | – | – | – |
| *Ginkgo adiantoides* (Unger) Heer | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |
| *Ginkgo pluripartita* (Schimper) Heer | x | – | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Athrotaxites berryi* Bell | x | – | x | – | – | x | x | – | – | – | – | – | – | – | – |
| *Athrotaxites* sp. | – | x | x | – | – | – | – | – | – | – | – | – | – | – | – |
| *Elatocladus* (*Sequoia*?) *smittiana* (Heer) Seward | x | – | – | x | x | – | x | – | – | – | – | – | – | – | – |
| *Elatocladus* sp. cf. *E. dicksoniana* (Heer) Seward | – | – | x | – | – | – | – | – | – | | – | – | – | – | – |
| *Taxodites intermedius* Hollick | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |
| *Thuja interrupta* Newberry | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |
| *Elatides curvifolia* (Dunker) Nathorst | – | x | x | – | – | – | x | – | – | – | – | – | – | – | – |
| *Metasequoia occidentalis* (Newberry) Chaney | – | – | – | – | – | – | – | – | – | x | x | x | x | x | – |
| *Elatocladus nordenskiöldi* Heer (Bell) | – | – | – | – | – | – | – | – | – | – | x | – | x | – | – |
| *Trochodendroides arctica* (Heer) Berry | – | – | – | – | – | – | – | – | – | x | – | – | – | x | – |
| *Trochodendroides arctica* Heer (Berry) forma *rotundifolia* Newberry | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Trochodendroides* sp. | – | – | – | – | – | – | – | – | x | – | x | – | – | – | – |
| *Ulmus wardii* Knowlton and Cockerell | – | – | – | – | – | – | – | – | – | – | x | – | – | – | – |
| *Viburnum antiquum* (Newberry) Hollick | – | – | – | – | – | – | – | – | – | – | – | x | – | x | – |
| *Celastrinites insignis* (Heer) Bell | – | – | – | – | – | – | – | – | – | x | – | – | – | – | – |
| *Nymphaeites angulatus* (Lesquereux) Bell | – | – | – | – | – | – | – | – | x | x | – | – | – | – | – |
| *Platanus* sp. | – | – | – | – | – | – | – | – | – | – | – | x | – | – | – |
| *Dombeyopsis* sp. | – | – | – | – | – | – | – | – | x | – | – | – | – | – | – |

# APPENDIX D

## Logs of Wells

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## Shell Solomon Creek No. 1—Superior *et al.* Solomon Creek No. 1 Well

The following log was prepared by Mr. I. Cook and is included in this report by kind permission of the Petroleum and Natural Gas Conservation Board of Alberta.

### *Shell Solomon Creek No. 1*

MOUNTAIN PARK-LUSCAR

| Depth (feet) | |
|---|---|
| 0–180 | No samples |
| 180–190 | Sandstone, fine-grained, greyish green, slightly calcareous; some buff coloured sandstone and grey shale |
| 190–200 | Shale and sandstone; dark grey shale with some greyish green and brownish sandstone |
| 200–220 | Shale and sandstone; greenish grey shale with some greyish green and brownish sandstone |
| 220–230 | Sandstone, fine-grained, grey, non-limy |
| 230–240 | Shale, greenish grey |
| 240–250 | Sandstone, fine-grained, greyish green and grey, non-limy |
| 250–270 | Sandstone, fine-grained, salt and pepper, non-limy, micaceous; some coaly material |
| 270–280 | Sandstone, fine-grained, greenish grey |
| 280–290 | Shale and sandstone; dark grey and greenish grey shale with some sandstone as above |
| 290–300 | Sandstone, coarse-grained, salt and pepper, limy |
| 300–310 | Sandstone, medium-grained, greyish green |
| 310–330 | Sandstone, medium- to coarse-grained, greyish buff, limy |
| 330–340 | Sandstone and shale; sandstone as above with grey shale |
| 340–350 | Sandstone and shale; fine-grained, greyish green sandstone and grey shale |
| 350–370 | Sandstone as above |
| 370–380 | Shale, greenish grey, bentonitic (?) |
| 380–410 | Shale, as above with brown and dark grey |
| 410–430 | Sandstone, fine-grained, grey, non-limy |
| 430–440 | Missing sample |
| 440–480 | Sandstone, as above |
| 480–490 | Sandstone, medium-grained, greyish buff, very limy |
| 490–500 | Shale, grey |
| 500–510 | Sandstone and shale as above |
| 510–520 | Sandstone as above |
| 520–530 | Sandstone, medium-grained, salt and pepper, slightly limy |
| 530–540 | Sandstone, medium-grained, greyish buff, limy |
| 540–550 | Coal, with fine-grained, non-limy sandstone |
| 550–560 | Shale, greenish grey |
| 560–570 | Shale, as above; some medium-grained, salt and pepper, slightly limy sandstone |
| 570–580 | Shale and sandstone as above |
| 580–620 | Sandstone as above |
| 620 | *Mountain Park-Luscar contact?* |
| | NOTE: The contact between the Mountain Park and Luscar Formations is almost impossible to place accurately. Descriptions of the formations give the Mountain Park as containing green shales and thin coal seams, while the Luscar contains grey shales, salt and pepper sandstones and commercial coal seams. The contact between the formations is placed at the first coal below the last greenish grey shale. |
| 620–630 | Coal and shale; coal and carbonaceous shale with some sandstone as above |
| 630–640 | Shale, carbonaceous; some limy sandstone as above |
| 640–650 | Shale, grey |
| 650–660 | Shale and sandstone; shale as above with some slightly limy, salt and pepper sandstone |
| 660–670 | Sandstone and shale as above |
| 670–680 | Shale and sandstone as above |

| Depth (feet) | |
|---|---|
| 680–740 | Sandstone as above |
| 740–750 | Sandstone as above with fine-grained, grey, limy sandstone |
| 750–770 | Sandstone, fine-grained, grey, limy |
| 770–780 | Sandstone as above with coarser grained, grey, limy sandstone |
| 780–820 | Sandstone, coarse-grained, greyish green, limy |
| 820–830 | Sandstone and shale; sandstone as above with grey shale |
| 830–850 | Shale and sandstone; grey shale and fine-grained, grey sandstone |
| 850–860 | Sandstone, fine-grained, grey, slightly limy |
| 860–890 | Sandstone, coarse-grained, greyish buff, limy, some sandstone as above |
| 890–940 | Shale, grey, with small amounts of sandstone as above |
| 940–950 | Shale and sandstone; shale as above with fine-grained, grey sandstone |
| 950–980 | Sandstone, fine-grained, grey, limy |
| 980–990 | Sandstone and shale; sandstone as above with grey shale |
| 990–1,000 | Sandstone as above |
| 1,000–1,010 | Sandstone, medium-grained, salt and pepper, limy |
| 1,010–1,020 | Sandstone, medium-grained, greyish buff, limy |
| 1,020–1,050 | Shale, grey |
| 1,050–1,060 | Shale, carbonaceous |
| 1,060–1,070 | Shale, grey |
| 1,070–1,080 | Shale and sandstone; grey shale and fine-grained, grey sandstone |
| 1,080–1,100 | Sandstone, fine-grained, grey, limy |
| 1,100–1,130 | Sandstone, medium-grained, salt and pepper, limy |
| 1,130–1,140 | Shale and sandstone; dark grey, slickensided shale with sandstone as above |
| 1,140–1,150 | Shale, carbonaceous, slickensided |
| 1,150–1,160 | Sandstone, medium-grained, greyish buff, slightly limy |
| 1,160–1,170 | Sandstone, medium-grained, salt and pepper, slightly limy |
| 1,170–1,180 | Shale and sandstone; grey shale and sandstone as above |
| 1,180–1,200 | Sandstone and shale; salt and pepper sandstone with carbonaceous shale, slickensided; some coal |
| 1,200–1,210 | Sandstone, medium-grained, grey-buff, limy |
| 1,210–1,270 | Sandstone, fine-grained, grey; some limy |
| 1,270–1,290 | Sandstone, medium-grained, salt and pepper, slickensided; dark grey shale; carbonaceous |
| 1,290–1,310 | Coal |
| 1,310–1,330 | Shale, dark grey; some coal and slickensiding |
| 1,330–1,340 | Shale as above with some fine-grained, grey sandstone |
| 1,340–1,370 | Shale as above. |
| 1,370–1,380 | Shale, dark grey |
| 1,380–1,390 | Shale and sandstone; dark grey shale and fine-grained sandstone |
| 1,390–1,430 | Sandstone as above |
| 1,430–1,440 | Sandstone as above with some coal |
| 1,440–1,470 | Sandstone as above |
| 1,470–1,480 | Sandstone as above with some coal |
| 1,480–1,510 | Sandstone as above |
| 1,510–1,530 | Sandstone and coal; coarse-grained, grey-buff sandstone; some coal |
| 1,530–1,540 | Sandstone as above |
| 1,540–1,560 | Sandstone and shale; sandstone as above with dark grey shale |
| 1,560–1,570 | Shale, grey |
| 1,570–1,620 | Shale and sandstone; shale as above with coarse-grained, salt and pepper, limy sandstone |
| 1,620–1,630 | Sandstone, medium-grained, greyish buff, limy |
| 1,630–1,660 | Shale and sandstone; dark grey shale and sandstone as above; some non-limy, coarse-grained, pepper and salt sandstone |
| 1,660–1,680 | Sandstone and shale; medium-grained, non-limy, pepper and salt sandstone and dark grey shale |
| 1,680–1,690 | Shale and sandstone; dark grey, silty shale and fine-grained, dark grey, non-limy sandstone; some medium-grained, light grey, pepper and salt sandstone |
| 1,690–1,700 | Shale and sandstone; dark grey, silty shale and fine-grained, dark grey, non-limy sandstone |

| Depth (feet) | |
|---|---|
| 1,700–1,710 | Shale and sandstone as above with some medium-grained, non-limy, pepper and salt sandstone |
| 1,710–1,720 | Coal and medium-grained, light buff sandstone |
| 1,720–1,730 | Sandstone and shale; coarse-grained (conglomeratic) light grey, pepper and salt sandstone, dark grey, silty, shale, some coal |
| 1,730–1,740 | Coal and medium-grained, non-limy, pepper and salt sandstone |
| 1,740–1,750 | Sandstone and coal and shale; coarse-grained, dark greyish buff sandstone; very limy and coarse-grained (mostly loosely cemented or conglomeratic). Light-coloured, pepper and salt, non-limy sandstone; some coal and dark shale |
| 1,750–1,780 | Sandstone and coal; coarse-grained, dark greyish buff and light-coloured, pepper and salt, calcareous sandstones; coal |
| 1,780–1,790 | Sandstone, medium-grained, pepper and salt, slightly calcareous |
| 1,790–1,800 | Shale and sandstone; dark grey, silty shale and fine-grained, dark grey, non-limy sandstone |
| 1,800–1,810 | Sandstone, dark grey, fine-grained, non-limy |
| 1,810–1,820 | Shale, dark grey, silty |
| 1,820–1,830 | Sandstone, dark grey, fine-grained, non-limy |
| 1,830–1,850 | Shale, dark grey; in part silty |
| 1,850–1,860 | Coal, shale and sandstone; coal and shale as above with medium-grained, non-limy, pepper and salt sandstone |
| 1,860–1,870 | Coal |
| 1,870–1,910 | Coal and dark grey, silty shale |
| 1,910–1,930 | Coal and shale as above with medium-grained, pepper and salt, non-limy sandstone |
| 1,930–1,940 | Sandstone and coal; fine- to medium-grained, grey, non-limy sandstone and coal |
| 1,940–1,950 | Sandstone, fine- and medium-grained, grey, non-limy |
| 1,950–1,960 | Shale and sandstone; dark grey shale and fine-grained, grey non-limy sandstone with some medium-grained, pepper and salt sandstone |
| 1,960–1,970 | Sandstone and shale; medium-grained, light grey, non-limy sandstone and dark grey shale |
| 1,970–1,980 | Shale and sandstone as above with some medium-grained, pepper and salt, limy sandstone |
| 1,980–1,990 | Shale and sandstone as above with some coal |
| 1,990–2,000 | Coal and medium-grained, pepper and salt sandstone |
| 2,000–2,020 | Sandstone and coal; fine-grained, dark greyish buff, non-limy sandstone and coal |
| 2,020–2,030 | Shale and sandstone; dark grey shale and medium-grained, grey, non-limy sandstone |
| 2,030–2,050 | Shale and sandstone as above with coal |
| 2,050–2,070 | Sandstone, shale and coal; fine- to medium-grained, grey, non-limy sandstone; some dark grey shale and coal |
| 2,070–2,080 | Shale and sandstone, dark grey, silty shale and fine-grained, dark grey sandstone |
| 2,080–2,090 | Sandstone and shale; coarse-grained (conglomeratic?) dark greyish buff and light-coloured, pepper and salt, limy sandstones, and dark grey shale |
| 2,090–2,100 | Sandstone and shale as above with coal |
| 2,100–2,110 | Sandstone and shale; dark grey and brownish grey shale and fine-grained, dark greyish buff sandstone |
| 2,110–2,120 | Sandstone and shale; fine-grained, dark greyish buff sandstone and dark grey shale; some coal |
| 2,120–2,140 | Sandstone and shale; sandstone as above and grey, silty shale |
| 2,140–2,160 | Sandstone and coal; medium-grained, pepper and salt, non-limy sandstone and greyish buff, limy sandstone with coal |
| 2,160–2,170 | Sandstone, shale and medium-grained, pepper and salt, non-limy sandstone; some grey shale and coal |
| 2,170–2,180 | Shale, coal and sandstone as above |
| 2,180–2,190 | Shale and coal, dark grey shale and coal |
| 2,190–2,200 | Sandstone, shale and coal; fine- to medium-grained sandstone; some shale and coal as above |
| 2,200–2,210 | Missing sample |
| 2,210–2,220 | Shale and coal as above |
| 2,220–2,230 | Shale and coal as above with some fine-grained, dark grey sandstone |
| 2,230–2,240 | Sandstone and coal; medium-grained, pepper and salt sandstone; some coal |
| 2,240–2,250 | Sandstone and coal; as above with medium-grained, light buff, very limy sandstone |

| Depth (feet) | |
|---|---|
| 2,250–2,260 | Sandstone and shale; medium-grained, pepper and salt, non-limy sandstone and dark grey shale |
| 2,260–2,270 | Sandstone and shale as above; some coal |
| 2,270–2,280 | Shale and coal; dark grey shale and coal |
| 2,280–2,310 | Sandstone, medium-grained, pepper and salt; in part slightly limy |
| 2,310–2,350 | Sandstone as above with coal |
| 2,350–2,360 | Coal and sandstone as above |
| 2,360–2,380 | Sandstone as above with some coal and dark grey shale |
| 2,380–2,390 | Sandstone as above |
| 2,390–2,410 | Sandstone and shale; sandstone as above with some dark grey shale |
| 2,410–2,420 | Shale and sandstone; dark grey shale and fine-grained, grey sandstone |
| 2,420–2,430 | Sandstone, fine-grained, grey |
| 2,430–2,440 | Sandstone and shale as above |
| 2,440–2,470 | Shale and sandstone; dark grey, silty shale, and some fine-grained, dark grey sandstone |
| 2,470–2,500 | Sandstone and shale; medium-grained, greyish buff, very limy sandstone; dark grey, shale (some dark brown crystalline limestone?) |
| 2,500–2,510 | Sandstone and shale; medium-grained, pepper and salt, slightly limy sandstone; some dark grey shale |
| 2,510–2,520 | Sandstone and shale; medium-grained (coarser than above), non-limy, pepper and salt sandstone; some dark grey shale |
| 2,520–2,540 | Shale and sandstone; dark grey shale, slickensided in part, medium-grained, slightly limy in part, pepper and salt sandstone |
| 2,540–2,580 | Shale as above |
| 2,580–2,620 | Shale as above and coal |
| 2,620–2,690 | Shale and sandstone; dark grey shale and fine-grained grey sandstone; some coal |

### LUSCAR-CADOMIN

| | |
|---|---|
| 2,690–2,710 | Shale, dark grey |
| 2,710–2,720 | Shale and coal; shale as above with coal |
| 2,720–2,790 | Shale and coal; carbonaceous shale and coal in part slickensided |
| 2,790–2,800 | Shale, dark grey with some coal |
| 2,800–2,810 | Shale, dark grey, some soft greyish white bentonitic shale and hard, fine-grained, greyish white sandstone |
| 2,810–2,820 | Shale and sandstone; soft, grey shale and fine-grained, light grey sandstone |
| 2,820–2,830 | Shale, dark grey, some coaly material |
| 2,830–2,840 | Shale and coal; dark grey shale and coal |
| 2,840–2,860 | Shale and coal; carbonaceous shale and coal with soft greyish shale |
| 2,860–2,880 | Shale, dark grey; some carbonaceous |
| 2,880–2,910 | Shale, dark grey, some coal and soft light grey shale |
| 2,910–2,920 | Shale and coal |
| 2,920–2,950 | Shale, dark grey |
| 2,950–2,960 | Sandstone and shale; fine-grained, light grey sandstone with dark grey shale |
| 2,960–2,970 | Sandstone, shale and coal; sandstone and shale as above with coal |
| 2,970–3,000 | Sandstone, fine- to medium-grained, light grey, speckled |
| 3,000–3,010 | Shale, dark grey, some sandstone as above |
| 3,010–3,040 | Sandstone, fine-grained, grey |
| 3,040–3,050 | Sandstone, as above with some soft, greyish white sandstone |
| 3,050–3,060 | Sandstone, soft, fine-grained, greyish white |
| 3,060–3,100 | Shale and sandstone; dark grey shale with some sandstone as above and hard, fine-grained, grey sandstone |
| 3,100–3,130 | Shale, black, carbonaceous, in part slickensided |
| 3,130–3,150 | Shale and coal; shale as above with coal |
| 3,150–3,170 | Shale, black, carbonaceous |
| 3,170–3,190 | Coal and shale; coal with shale as above |
| 3,190–3,230 | Shale, dark grey; some carbonaceous shale |
| 3,230–3,300 | Shale, carbonaceous or coaly |
| 3,300–3,310 | Sandstone and shale; coarse-grained, greyish buff, non-limy, in part cherty, with black, carbonaceous shale, slickensided |

| Depth (feet) | |
|---|---|
| 3,310–3,340 | Sandstone, mostly medium-grained sandstone but some conglomeratic, more grey than above; some cherty phases |
| 3,340–3,350 | Sandstone and shale; medium-grained grey sandstone with dark grey shale |
| 3,350–3,360 | Shale and sandstone as above |
| 3,360–3,370 | Shale, dark grey, carbonaceous, slickensided, some sandstone as above |
| 3,370–3,490 | Shale, dark grey, some carbonaceous and slickensided |
| 3,490–3,510 | Shale and sandstone; shale as above with fine-grained, greyish buff sandstone |
| 3,510–3,520 | Shale as above; traces of sandstone as above |
| 3,520–3,540 | Shale as above |
| 3,540–3,560 | Shale and sandstone; shale as above with fine-grained, grey sandstone |
| 3,560–3,570 | Sandstone, fine-grained, grey, very limy |
| 3,570–3,580 | Sandstone, medium-grained, grey, limy |
| 3,580–3,610 | Shale, dark grey and carbonaceous; some sandstone as above |
| 3,610–3,620 | Sandstone, medium-grained, greyish, slightly limy |
| 3,620–3,630 | Sandstone, as above with some fine-grained, grey sandstone |
| 3,630–3,640 | Sandstone and shale; sandstone as above with dark grey shale |
| 3,640–3,650 | Shale, dark grey, in part slickensided |
| 3,650–3,660 | Sandstone, fine-grained, grey, limy |
| 3,660–3,680 | Sandstone and shale; fine-grained, grey, slightly limy to non-limy sandstone with dark grey shale |
| 3,680–3,690 | Shale, dark grey, in part slickensided, some sandstone as above |
| 3,690–3,700 | Sandstone, fine-grained, grey, non-limy |
| 3,700–3,710 | Sandstone and shale; sandstone as above with slickensided dark grey shale |
| 3,710–3,720 | Sandstone, fine-grained, light grey, very limy. |
| 3,720–3,730 | Sandstone, fine-grained, grey, limy |
| 3,730–3,750 | Sandstone and shale; sandstone as above with slickensided dark grey shale |
| 3,750–3,760 | Sandstone, fine-grained, grey, slightly limy |
| 3,760–3,780 | Sandstone and shale; sandstone as above with dark grey shale |
| 3,780–3,790 | Sandstone and shale; fine-grained, greyish sandstone with dark grey slickensided shale |
| 3,790–3,820 | Sandstone, fine-grained, grey, limy |
| 3,820–3,840 | Sandstone and shale; fine-grained, grey, speckled, non-limy sandstone with dark grey, slickensided shale |
| 3,840–3,860 | Shale and sandstone; dark grey, slickensided shale with some sandstone as above |
| 3,860–3,870 | Sandstone, fine-grained, grey, slightly limy |
| 3,870–3,900 | Sandstone and shale; sandstone as above with dark grey shale |
| 3,900–3,910 | Shale, dark grey, some sandstone as above |
| 3,910–3,970 | Shale, dark grey, in part slickensided, some grey sandstone |
| 3,970–3,980 | Shale and sandstone; dark grey shale with fine-grained, grey, slightly limy sandstone |
| 3,980–4,120 | Shale, dark grey |
| 4,120–4,150 | Shale and sandstone; dark grey shale and fine-grained, speckled, slightly limy sandstone |
| 4,150–4,270 | Shale, dark grey, some fine-grained, grey sandstone |
| 4,270–4,290 | Sandstone and shale; fine-grained, greyish limy sandstone and dark grey shale |
| 4,290–4,310 | Shale, dark grey; some sandstone as above |
| 4,310–4,340 | Shale and sandstone; dark grey shale with fine-grained, grey sandstone, slightly limy |
| 4,340–4,400 | Shale, dark grey; with some fine-grained, grey, slightly limy sandstone |

### LUSCAR-CADOMIN CONGLOMERATE

| | |
|---|---|
| 4,400–4,410 | Sandstone, coarse-grained, speckled, non-limy |
| 4,410–4,430 | Sandstone, conglomeratic, speckled, non-limy, with black chert |
| 4,430–4,450 | Shale and sandstone; dark grey shale and conglomeratic cherty sandstone, non-limy |
| 4,450–4,460 | Sandstone as above with dark grey shale |
| 4,460–4,480 | Shale and sandstone as above |
| 4,480–4,490 | Shale, dark grey, with some sandstone as above |
| 4,490–4,500 | Shale, grey, sandy, with some sandstone as above |

| Depth (feet) | |
|---|---|
| 4,500–4,510 | Shale, dark grey and sandy |
| 4,510–4,520 | Shale and sandstone; dark grey shale and grey sandstone |
| 4,520–4,530 | Shale, dark grey, some conglomeratic sandstone |
| 4,530–4,550 | Shale, dark grey, some fine-grained, grey sandstone |
| 4,550–4,580 | Shale, dark grey, with fine-grained, greyish, limy sandstone |
| 4,580–4,590 | Sandstone, fine-grained, greyish limy |
| 4,590–4,600 | Shale and sandstone; dark grey shale and some limy sandstone |
| 4,600–4,630 | Shale and sandstone; dark grey shale and grey sandstone |
| 4,630–4,640 | Shale, dark grey, some fine-grained, grey sandstone, some conglomeratic sandstone |
| 4,640–4,650 | Shale and sandstone; dark grey shale and conglomeratic sandstone |
| 4,650–4,660 | Sandstone and shale as above |
| 4,660 | *Luscar-Cadomin Conglomerate Contact* |
| 4,660–4,670 | Sandstone and shale; as above with some grey chert pebble fragments |
| 4,670–4,700 | Shale, dark grey with grey chert pebble fragments; some fragments show grey sandstone matrix |
| 4,700–4,710 | Sandstone, medium-grained, grey, non-limy |
| 4,710–4,720 | Shale, dark grey, some grey sandstone |
| 4,720–4,730 | Sandstone, medium-grained, grey, non-limy; some grey shale |
| 4,730–4,740 | Sandstone and shale as above |

## *Superior et al. Solomon Creek No. 1*

| | |
|---|---|
| 5,100–5,120 | Siltstone, brownish grey, argillaceous; some shale |
| 5,120–5,150 | Siltstone as above; fine-grained quartz sandstone; siltstone and shale as above with calcite partings |
| 5,150–5,180 | Shale and siltstone as above; coal partings |
| 5,180–5,240 | Sandstone, fine-grained; clean quartz sand |
| 5,240–5,500 | Sandstone and very fine siltstone |
| 5,500–5,570 | Sandstone, yellowish brown, fine-grained; some shale and coal |

### FERNIE GROUP ? (R-LOG)

| | |
|---|---|
| 5,570–5,600 | Sandstone, yellowish brown, slightly calcareous, trace of glauconite; shale, brownish grey |
| 5,600–5,640 | Sandstone as above with pyrite; shale as above |
| 6,050–6,080 | Shale, dark brownish grey, silty; siltstone, brownish grey, quartzose, argillaceous |
| 6,080–6,120 | Sandstone, interbedded with dark brownish grey to coaly shale or shale partings |
| 6,120–6,160 | As above but with an increased amount of shale; probably shale with sandstone partings, slickensided shale abundant at 6,130′ |
| 6,160–6,210 | Shale, dark brownish grey, pyritic; trace of sandstone |
| | *Nordegg Member* |
| 6,210–6,280 | Shale, dark brownish grey to black; calcite partings |
| 6,287–6,296 | Core No. 20 |
| 6,290–6,390 | Shale, brownish grey; calcite along fractures, in part silty; some pyrite, slickensided |
| 6,356–6,358 | Core No. 21 |

### TRIASSIC

| | |
|---|---|
| 6,390–6,400 | Dolomite, light grey, finely crystalline, slightly silty |
| 6,400–6,409 | Cores Nos. 22 and 23 (siltstone) |
| 6,831–6,833 | Core No. 27 (siltstone) |
| 6,830–6,880 | Siltstone, brownish grey, argillaceous cement; some brownish grey shale |
| 6,880–6,900 | Dolomite, light grey, pyritic |
| 6,900–6,910 | Sandstone |

| Depth (feet) | |
|---|---|
| | RUNDLE GROUP |
| 6,910–6,920 | Siltstone, light grey, calcareous, highly pyritic |
| 6,930–6,940 | Sandstone |
| | *All above samples mostly shale with traces of other rock* |
| 6,940–6,950 | Core No. 28 (Rundle dolomite) |
| 7,615 | (Core) |
| 8,372–8,381 | Core No. 67 |
| 8,380–8,440 | Limestone, yellowish grey, finely crystalline |
| | BANFF FORMATION |
| 8,440–8,470 | Limestone as above; sandstone, fine-grained, brown, argillaceous cement |
| 8,471–8,510 | Core No. 68 (dolomite and siltstone interbedded) |
| 8,966–8,993 | Core No. 73 |
| 8,990–9,000 | Shale, dark brownish grey; dolomite, light grey, dense |
| 9,000–9,010 | Sandstone, fine-grained, argillaceous cement |
| 9,010–9,030 | Siltstone, dark brown, argillaceous |
| 9,030–9,050 | Limestone, yellowish grey, dense; sandstone |
| 9,050–9,060 | Sandstone, fine-grained, argillaceous cement to highly argillaceous; interbedded with shale |
| 9,060 | Limestone, yellowish brown, dense |
| 9,070–9,080 | As above, siltstone, greenish grey (breaks like shale) |
| 9,080–9,090 | Sandstone, yellowish brown as above; limestone partings |
| 9,090 | Sandstone as above; siltstone, argillaceous; trace of grey coarsely crystalline limestone; inclusion of white chert and pyrite |
| 9,100 | EXSHAW FORMATION (R-LOG) |
| 9,110 | PALLISER FORMATION (R-LOG) |
| 9,100–9,180 | Limestone, olive grey, dense calcite along fractures |
| 9,140–9,150 | Samples missing |
| 9,172–9,222 | Core No. 74, limestone, anhydrite, dolomite |
| 9,517–9,558 | Cores Nos. 75 and 76 (Alexo reported 9,545) |
| 9,900–9,940 | Limestone, olive grey, dense; in part argillaceous |
| 9,940 | ALEXO FORMATION |
| 9,940–9,950 | Limestone as above; trace of silty limestone |
| 9,950–9,960 | Limestone as above; dolomite, light grey, finely crystalline |
| 9,960–9,970 | Limestone and dolomite as above, trace of siltstone, quartzose with argillaceous cement |
| 9,970–10,030 | Dolomite, yellowish brown, fine- to medium-crystalline, interbedded argillaceous material colouring dolomite; limestone as above, trace of fine silt in dolomite |
| 10,030–10,080 | Dolomite, yellowish brown, finely crystalline, saccharoidal, trace of silt and crystalline calcite |
| 10,080–10,120 | Dolomite as above, white, medium-crystalline |
| 10,120–10,130 | Siltstone, trace of dolomite, greenish grey, calcareous |
| 10,130–10,140 | Dolomite, white, finely crystalline; some white anhydrite |
| 10,140–10,180 | Dolomite, yellowish brown, finely crystalline; some limestone, olive grey, dense |
| 10,185 | MOUNT HAWK FORMATION |
| 10,180–10,200 | Siltstone, light green, pyritic (looks like waxy shale), trace of dolomite |
| 10,200–10,220 | Limestone, olive grey; dolomite as above; few fragments of green siltstone |
| 10,230–10,300 | Dolomite as above; yellowish brown, white, crystalline dolomite; dark shale partings; scattered trace of green silt, pyritic. 10,260–10,270 pyrite associated with dolomite |
| 10,300–10,340 | Dolomite as above, large amount of white, crystalline dolomite |
| 10,340–10,400 | Dolomite as above, some limestone, olive grey, dense; scattered trace of green silt. 10,370–10,390 anhydrite and dolomite, greenish |
| 10,599–10,639 | Core No. 77, dolomite |
| 10,639–10,684 | Core No. 78, limestone, fossiliferous |
| 10,684–10,729 | Core not received by Conservation Board |
| 10,690–10,720 | Limestone, dark grey, finely crystalline, some dense and argillaceous |

| Depth (feet) | |
|---|---|
| 10,720–10,730 | Samples missing |
| 10,710 | PERDRIX FORMATION |
| 10,730–10,760 | Shale, dark grey, calcareous; limestone as above |
| 10,760–10,800 | Shale and limestone as above; sandstone, fine-grained rounded grains. 10,770 sandstone, dark brown, argillaceous |
| 10,800–10,830 | Shale, dark grey, calcareous, in part non-calcareous; trace of sandstone |
| 11,000–11,160 | Shale, dark grey, calcareous, pyritic, partings of fine-grained sandstone |
| 11,160–11,200 | Shale as above; limestone, dark grey, argillaceous, calcite partings |
| 11,200–11,230 | Shale, dark grey to brownish grey, pyritic, calcareous; calcite partings |
| 11,230–11,260 | Shale as above; limestone as above |
| 11,266–11,287 | Cores Nos. 80 and 81 |
| 11,282 | GHOST RIVER FORMATION |

## Muskeg No. 1 Well, Northern Foothills Agreement

### *Well Log*

The following log was prepared by Miss M. J. Quantz and the writer.

| | |
|---|---|
| | WAPIABI FORMATION |
| 0–20 | Missing |
| 20–30 | Shale, dark grey, silty, poorly laminated, finely micaceous |
| 30–40 | Shale, dark grey, silty to sandy, finely micaceous, poorly laminated, very slightly calcareous |
| 40–80 | Shale as above; pyrite, very finely crystalline, widely scattered |
| 80–90 | Shale as above; *Inoceramus* prisms; ironstone, greyish brown |
| 90–120 | Shale as above |
| | BIGHORN (CARDIUM) FORMATION |
| 120–130 | Sandstone, light grey, medium- to fine-grained, slightly calcareous and oil-stained, pepper and salt, micaceous; chert, white, yellow, blue, buff, brown, green; ironstone; small amount of pyrite associated with sandstone |
| 130–140 | Sandstone, light to faintly brownish grey, medium- to fine-grained, finely pepper and salt, micaceous, slightly calcareous |
| 140–150 | Sandstone, grey, medium- to fine-grained, shaly, slightly calcareous; pyrite associated with sandstone; ironstone; shale, grey, micaceous, very silty to sandy, poorly laminated |
| 150–160 | Sandstone, grey to pale brownish grey, pepper and salt, medium- to fine-grained, very slightly calcareous; ironstone |
| 160–170 | Sandstone as above; shale, dark grey, very silty to sandy, micaceous, poorly laminated; ironstone |
| 170–180 | Sandstone, shale, and ironstone as above; pyrite, *Inoceramus* prisms |
| 180–190 | Sandstone, shale and ironstone as above; chert, yellowish brown, grey |
| 190–200 | Sandstone, shale, and ironstone as above; pyrite |
| 200–210 | Shale, dark grey, very silty to sandy, micaceous, poorly laminated; sandstone, grey, pepper and salt, medium- to fine-grained, slightly calcareous; a few scattered ironstone fragments; traces of bitumen in shale |
| 210–220 | Sandstone and shale as above |
| 220–240 | Sandstone and shale as above; scattered large black chert fragments; ironstone |
| 240–250 | Sandstone and shale as above; traces of coal |
| 250–270 | Shale, grey to brownish grey, sandy, carbonaceous, poorly laminated; sandstone as above with interbedded shale; coal fragments |
| 270–300 | Shale, grey to brownish grey, silty to sandy, micaceous, poorly laminated; sandstone as above |
| 300–310 | Shale, bentonitic, and sandstone, coarser, as above; chert, white, widely scattered |
| 310–330 | Sandstone, grey, pepper and salt, medium- to fine-grained; shale, dark grey, finely micaceous, silty to sandy, poorly laminated; ironstone, greyish brown, brown |
| 330–340 | Sandstone, slightly calcareous, shale and ironstone as above; widely scattered yellow chert and pyrite |

| Depth (feet) | |
|---|---|
| 340–370 | Sandstone, slightly calcareous, and lesser amounts of shale as above; ironstone; scattered finely crystalline pyrite associated with sandstone; a few widely scattered coal fragments |
| 370–380 | Sandstone, grey to brownish grey, pepper and salt, coarse to fine-grained, in part slightly oil-stained; shale, dark grey, sandy, poorly laminated, in part carbonaceous, finely micaceous; ironstone; minor amounts of finely crystalline pyrite associated with sandstone; scattered coal fragments |
| 380–410 | Sandstone as above with scattered coal bands; shale; ironstone, pyrite and coal as above |
| 410–420 | Sandstone, grey and brownish grey, medium- to fine-grained, calcareous, slightly pepper and salt; shale, grey, silty to sandy, poorly laminated, finely micaceous, in part carbonaceous; ironstone; pyrite and coal as above; chert, white, yellowish brown, grey |
| 420–430 | Sandstone, shale, ironstone, as above |
| 430–440 | Sandstone, shale, ironstone, as above; minor amounts of pyrite associated with sandstone |
| 440–460 | Sandstone as above, calcareous to slightly so; shale as above; also brownish grey, soft, bentonitic; chert, scattered white and yellow fragments; bentonite with round black grains as inclusions |
| 460–480 | Sandstone as above; shale, dark grey, silty, micaceous, to brownish grey, soft, bentonitic |
| 480–490 | Sandstone as above; shale, dark grey, silty, micaceous, poorly laminated, in part carbonaceous; a few scattered chert fragments, white, almost translucent; ironstone |
| 490–510 | Sandstone, shale, and ironstone as above |
| 510–540 | Shale, dark grey, slickensided, very sandy, micaceous, poorly laminated; sandstone, grey, medium- to fine-grained, slightly calcareous, pepper and salt; scattered ironstone fragments |
| 540–550 | Sandstone and shale as above; scattered carbonaceous bands throughout sandstone |
| 550–560 | Sandstone and shale as above |
| 560–580 | Sandstone and shale as above; ironstone in minor amounts |
| 580–600 | Sandstone and shale as above |
| 600–620 | Sandstone and shale, with little evidence of slickensiding, as above |
| 620–630 | Sandstone and shale as above; minor amounts of ironstone; *Inoceramus* prisms |
| 630–670 | Sandstone, shale, and ironstone as above; pyrite in sandstone |
| 670–690 | Sandstone as above; in part brownish grey, coarse-grained; shale, dark grey, silty to sandy, finely micaceous; ironstone; widely scattered, finely crystalline pyrite |
| 690–700 | Shale, sandstone, ironstone, pyrite, as above |
| 700–710 | Sandstone, shale, ironstone, as above |
| 710–730 | Sandstone, shale, ironstone, as above; *Inoceramus* prisms |
| 730–750 | Sandstone, medium grey, quartzose, medium- to fine-grained, vuggy; lesser amounts of shale as above; ironstone |
| 750–770 | Sandstone and minor amounts of shale as above |
| 770–780 | Sandstone as above with shale partings, grading into dark grey, very sandy to sandy shale; shale as above; ironstone |

BLACKSTONE FORMATION

| | |
|---|---|
| 780–840 | Shale, dark grey, silty to very sandy; finely micaceous; ironstone |
| 840–850 | Shale, and ironstone as above; *Inoceramus* prisms |
| 850–880 | Shale, as above; ironstone in increasing amounts, in part associated with crystalline quartz |
| 880–890 | Shale and a large amount of ironstone as above; sandstone, light grey, medium- to fine-grained, banded through shale and ironstone; quartz crystals clustered on some ironstone fragments; a few white crystalline calcite veinlets in shale and ironstone |
| 890–920 | Shale and ironstone as above; scattered sandstone laminae and calcite veins associated with shale and ironstone |
| 920–930 | Shale as above with scattered light grey, medium-grained sandstone bands or partings |
| 930–940 | Shale and sandstone as above; ironstone |

| Depth (feet) | |
|---|---|
| 940–970 | Shale as above; ironstone, in part associated with white calcite veins; sandstone, grey, medium- to fine-grained, in part occurring as small leness or laminae in ironstone and shale; crystalline quartz on surface of some ironstone fragments |
| 970–990 | Shale, in part slickensided, as above; ironstone, sandstone bands as above scattered through shale and ironstone; *Inoceramus* prisms |
| 990–1,040 | Shale, with scattered sandy partings, as above; in part slickensided; ironstone; veins of white, calcite throughout ironstone; *Inoceramus* prisms |
| 1,040–1,050 | Shale, ironstone, and sandstone as above; ironstone in part associated with sandstone laminae; *Inoceramus* prisms |
| 1,050–1,070 | Shale, sandstone and ironstone, widely scattered, as above; *Inoceramus* prisms |
| 1,070–1,120 | Shale as above; ironstone, in part associated with crystalline quartz or sandstone bands; white calcite veins widely scattered through ironstone |
| 1,120–1,130 | Shale, sandstone and ironstone in part veined with calcite, as above |
| 1,130–1,140 | Shale, sandstone, and ironstone veined with calcite as above; *Inoceramus* prisms |
| 1,140–1,180 | Shale and sandstone as above; ironstone, yellowish to brown, in part associated with calcite |
| 1,180–1,190 | Shale and sandstone as above; ironstone, brown, in part associated with calcite; pyrite, finely crystalline, widely scattered |
| 1,190–1,220 | Shale, sandstone and ironstone, associated with calcite and crystalline quartz, as above |
| 1,220–1,230 | Shale, in part slickensided, sandstone and ironstone in lesser amounts, as above; *Inoceramus* prisms |
| 1,230–1,240 | Shale, sandstone, and ironstone, associated with calcite and crystalline quartz, as above |
| 1,240–1,280 | Shale as above; sandstone, grey, medium- to fine-grained, partly in bands and lenses through shale and ironstone; scattered crystalline quartz encrusting some surfaces of sandstone and ironstone; ironstone |
| 1,280–1,290 | Shale, with evidence of slickensiding and sandstone, as above; pyrite, widely scattered |
| 1,290–1,310 | Shale and sandstone as above; minor amounts of calcite |
| 1,310–1,340 | Shale and sandstone as above; ironstone; calcite associated with shale and ironstone |
| 1,340–1,350 | Shale, in part slickensided, sandstone, and ironstone, as above, minor amount of pyrite |
| 1,350–1,370 | Shale, sandstone, ironstone, as above; *Inoceramus* prisms |
| 1,370–1,380 | Shale, in part slickensided, as above; sandstone, grey, medium- to fine-grained, in increasing amounts; minor amounts of ironstone |
| 1,380–1,390 | Shale, in part slickensided, sandstone, minor amounts of pyrite and ironstone, as above; *Inoceramus* prisms |
| 1,390–1,400 | Shale, sandstone, a little ironstone, as above; *Inoceramus* prisms |
| 1,400–1,410 | Shale, sandstone and ironstone, as above |
| 1,410–1,430 | Shale, sandstone and a large amount of ironstone, as above |
| 1,430–1,440 | Shale, in part slickensided, sandstone, and ironstone, as above; pyrite, finely crystalline, widely scattered; calcite veins through ironstone; crystalline quartz encrusting some shale surfaces, vuggy |
| 1,440–1,460 | Shale, slickensided, sandstone, ironstone, and pyrite, as above |
| 1,460–1,470 | Shale, dark grey, silty to sandy, slickensided; sandstone, lighter grey, quartzose, medium- to fine-grained, in part banded through shale; ironstone; *Inoceramus* prisms |
| 1,470–1,490 | Shale, sandstone and ironstone as above; minor amounts of calcite associated mainly with ironstone; *Inoceramus* prisms |
| 1,490–1,550 | Shale, sandstone and lesser amounts of ironstone, as above; scattered calcite veins throughout ironstone |
| 1,550–1,570 | Shale, sandstone as above |
| 1,570–1,590 | Shale and sandstone as above; a few ironstone fragments |
| 1,590–2,120 | Missing |
| 2,120–2,140 | Shale, dark grey, silty to sandy, finely micaceous, slickensided, in part banded with lighter grey sandstone; sandstone, grey, medium- to fine-grained |
| 2,140–2,160 | Shale and a little sandstone as above; minor amounts of calcite in fine veins through shale |
| 2,160–2,170 | Shale and sandstone as above; widely scattered ironstone |

| Depth (feet) | |
|---|---|
| 2,170–2,200 | Shale and sandstone, slightly calcareous, as above; minor amounts of calcite |
| 2,200–2,210 | Shale as above; limestone, light grey, dolomitic, very shaly, silty to sandy |
| 2,210–2,220 | Shale and lesser amounts of dolomitic shaly limestone as above; scattered sandstone, grey, medium- to fine-grained, slightly calcareous |
| 2,220–2,250 | Shale, dark grey, micaceous, slightly silty; minor amounts of crystalline calcite, buff to white and grey, fine-grained sandstone; widely scattered pyrite |
| 2,250–2,280 | Shale as above; sandstone mainly in fine bands in shale; widely scattered ironstone fragments |
| 2,280–2,300 | Shale, silty to sandy, and minor amounts of sandstone, as above; scattered pyrite; calcite |
| 2,300–2,340 | Shale, silty to sandy, a little sandstone, calcareous, and calcite as above; widely scattered ironstone and/or pyrite in some samples |
| 2,340–2,360 | Shale, silty to sandy, increasing amount of calcareous sandstone, calcite, as above |
| 2,360–2,380 | Shale, silty to sandy, sandstone, calcareous, as above; calcite in part veined through shale |
| 2,380–2,390 | Shale, silty to sandy, a little sandstone, calcite, as above |
| 2,390–2,400 | Shale, silty to sandy, increasing amount of sandstone and calcite, as above |
| 2,400–2,410 | Shale, silty to sandy; sandstone, calcite, as above; pyrite, finely crystalline |
| 2,410–2,430 | Shale, silty to sandy; sandstone, as above |
| 2,430–2,480 | Shale, and very little sandstone, slightly calcareous, as above |
| 2,480–2,490 | Missing |
| 2,490–2,500 | Shale, dark grey, silty to very sandy, finely micaceous, in part slickensided; some sandstone fragments, grey, fine-grained, shaly partings, slightly calcareous; calcite in minor amounts veined through shale; a few ironstone fragments, brown to dark grey; *Inoceramus* prisms |
| 2,500–2,510 | Shale, and ironstone as above; *Inoceramus* prisms; very little sandstone |
| 2,510–2,530 | Shale as above, very little sandstone, in part banded through shale |
| 2,530–2,550 | Shale, very sandy, as above; sandstone as above in slightly greater quantity, in part banded through shale |
| 2,550–2,560 | Shale, a little sandstone, and calcite in minor amounts as above; pyrite, finely crystalline, widely scattered, associated with sandstone |
| 2,560–2,590 | Shale, a little sandstone, as above; a few ironstone fragments |
| 2,590–2,600 | Shale as above; a few sandstone fragments, in part banded through shale |
| 2,600–2,620 | Shale and minor amount of sandstone as above; a few ironstone fragments |
| 2,620–2,630 | Shale and lesser amounts of sandstone as above; in part banded through shale |
| 2,630–2,650 | Shale as above, in part banded with sandstone, dolomitic limestone, medium crystalline, brown, shaly |
| 2,650–2,690 | Shale as above; lesser amounts of fine-grained grey to brownish grey, shaly, calcareous sandstone |
| 2,690–2,700 | Shale as above; a little sandstone; pyrite |
| 2,700–2,740 | Shale as above, in part banded with sandstone; pyrite, finely crystalline, widely scattered through some samples. |
| 2,740–2,750 | Shale as above in part banded with sandstone; a little sandstone, grey, fine-grained; widely scattered pyrite |
| 2,750–2,770 | Shale as above, sandstone bands; a few scattered fragments of ironstone |
| 2,770–2,790 | Shale as above, in part very sandy and with scattered sandstone bands; a little sandstone as above |
| 2,790–2,800 | Shale and a little sandstone as above; *Inoceramus* prisms |
| 2,800–2,840 | Shale as above, sandstone banding in some fragments a few widely scattered ironstone and fine-grained sandstone fragments |
| 2,840–2,850 | Shale as above and slightly more sandstone |
| 2,850–2,890 | Shale as above |
| 2,890–2,900 | Shale as above, sandstone banding; pyrite; a few ironstone fragments |
| 2,900–2,930 | Shale as above |
| 2,930–2,960 | Shale as above; sandstone banding, a little sandstone; widely scattered pyrite |
| 2,960–2,980 | Shale and a little sandstone as above |
| 2,980–3,000 | Shale as above with sandstone bands scattered throughout |
| 3,000–3,010 | Shale as above, with sandstone banding; a little fine-grained brownish grey to grey sandstone |
| 3,100–3,040 | Shale as above |

| Depth (feet) | |
|---|---|
| 3,040–3,050 | Shale as above; a little pyrite, finely crystalline, very widely scattered |
| 3,050–3,080 | Shale as above with sandstone bands |
| 3,080–3,090 | Shale as above; a little sandstone, grey, medium- to fine-grained; in part banded through shale |
| 3,090–3,100 | Shale as above; a little fine-grained, grey sandstone, in part as bands through shale |
| 3,100–3,110 | Shale as above; much slickensided; a little white calcite coating shear planes; a little dark grey silt |
| 3,110–3,115 | Missing |
| 3,115–3,120 | Shale, dark grey, silty, slickensided; a little white calcite as coatings and veinlets; scattered grey, fine–grained sandstone laminae |
| 3,120–3,130 | Shale as above with calcite veinlets |
| 3,130–3,150 | Shale as above |
| 3,150–3,160 | Shale as above with considerable calcite |
| 3,160–3,190 | Shale as above |
| 3,190–3,200 | Shale as above with considerable calcite and scattered crystals of pyrite |
| 3,200–3,210 | Shale with calcite and pyrite as above |
| 3,210–3,220 | Shale as above with less calcite and no pyrite |
| 3,220–3,250 | Shale as above |
| 3,250–3,260 | Shale as above with considerable scattered small crystals of pyrite |
| 3,260–3,270 | Shale as above; no pyrite |
| 3,270–3,280 | Shale as above with calcite stringers and a little scattered pyrite |
| 3,280–3,290 | Shale as above with fragments of prismatic calcite |
| 3,290–3,300 | Shale as above, greatly slickensided |
| 3,300–3,320 | Shale as above |
| 3,320–3,330 | Shale as above, slickensided, finely micaceous |
| 3,330–3,340 | Shale as above |
| 3,340–3,350 | Shale as above, slickensided, scattered fine crystalline pyrite |
| 3,350–3,360 | Shale as above, calcareous; a little fine pyrite; a very little dark grey siltstone |
| 3,360–3,370 | Shale and siltstone as above; a little white calcite as coatings |
| 3,370–3,380 | Shale as above; considerable white calcite as veinlets |
| 3,380–3,420 | Shale as above |
| 3,420–3,430 | Shale as above; scattered fine pyrite crystals |
| 3,430–3,440 | Shale as above; white calcite as coatings; a very little dark grey, fine-grained sandstone |
| 3,440–3,450 | Shale as above but less calcite; a little pyrite |
| 3,450–3,460 | Shale as above; slickensided |
| 3,460–3,490 | Shale as above |
| 3,490–3,500 | Shale as above; greatly slickensided |
| 3,500–3,520 | Shale as above |
| 3,520–3,530 | Shale as above with silty bands; much white calcite along partings and as stringers; considerable pyrite as nodules |
| 3,530–3,560 | Shale as above |
| 3,560–3,570 | Shale as above with a little calcite |
| 3,570–3,580 | Shale as above |
| 3,580–3,590 | Shale as above, somewhat silty; considerable white calcite as coatings |
| 3,590–3,600 | Shale as above, less silt; widely scattered pyrite |
| 3,600–3,630 | Shale as above, slickensided |
| 3,630–3,640 | Shale as above; fine crystalline pyrite |
| 3,640–3,660 | Shale as above |
| 3,660–3,670 | Shale as above; considerable calcite as stringers |
| 3,670–3,680 | Shale and calcite as above; shale slickensided |
| 3,680–3,690 | Shale and calcite as above; shale slickensided |
| 3,690–3,700 | Shale as above |
| 3,700–3,710 | Shale and calcite as above; small nodules of finely crystalline pyrite |
| 3,710–3,720 | Shale as above; some calcite |
| 3,720–3,730 | Shale as above; no calcite |
| 3,730–3,740 | Shale as above with calcite stringers and coatings; minor amounts of silty shale |
| 3,740–3,760 | Shale and silty shale as above |
| 3,760–3,770 | Shale as above |

| Depth (feet) | |
|---|---|
| 3,770–3,780 | Shale as above; finely micaceous |
| 3,780–3,790 | Shale as above; much calcite |
| 3,790–3,800 | Shale as above with a few small pyrite crystals |
| 3,800–3,810 | Shale as above |
| 3,810–3,820 | Shale as above; some calcite |
| 3,820–3,830 | Shale as above |
| 3,830–3,840 | Shale as above; numerous calcite stringers and some scattered pyrite |
| 3,840–3,860 | Shale as above, slickensided |
| 3,860–3,870 | Shale as above; a little scattered pyrite as small crystals |
| 3,870–3,880 | Shale as above; some slickensiding |
| 3,880–3,890 | Shale as above |
| 3,890–3,900 | Shale as above, in part sandy |
| 3,900–3,910 | Shale as above, slickensided |
| 3,910–3,920 | Missing |
| 3,920–3,930 | Shale as above, slickensided with white calcite coatings and veinlets |
| 3,930–3,940 | Shale as above, with a little calcite |
| 3,940–3,950 | Shale as above, some slickensides |
| 3,950–3,960 | Shale as above, somewhat silty |
| 3,960–3,970 | Siltstone, dark grey; a little dark grey shale |
| | **Dunvegan Formation** |
| 3,970–3,980 | Sandstone, grey to dark grey, fine-grained quartzitic; a little glauconitic in sandstone; a few shale sandstones |
| 3,980–3,985 | Sandstone as above with dark grey silty shale in about equal amounts |
| 3,985–3,990 | Sandstone, dark grey, somewhat argillaceous; some dark grey, silty shale |
| 3,990–3,995 | Shale, dark grey, silty; minor amounts of fine, dark grey sandstone |
| 3,995–4,000 | Shale as above; very little sandstone |
| 4,000–4,010 | Shale as above, with silty laminae |
| 4,010–4,020 | Shale as above; a few greenish-grey chert fragments |
| 4,020–4,030 | Shale as above with a few thin white calcite stringers |
| 4,030–4,040 | Shale as above |
| 4,040–4,050 | Shale as above; some shale fragments are silty and considerable calcite is present as veinlets and coatings |
| 4,050–4,060 | Shale as above |
| 4,060–4,070 | Shale as above, somewhat silty |
| 4,070–4,080 | Shale as above |
| 4,080–4,090 | Shale as above; some silt as fine laminae throughout the shale |
| 4,090–4,110 | Shale as above |
| 4,110–4,120 | Sandstone, grey, fine-grained, somewhat argillaceous; shale, dark grey, silty |
| 4,120–4,130 | Shale as above, much less sandstone, a little white calcite as coatings |
| 4,130–4,140 | Shale and sandstone as above |
| 4,140–4,150 | Shale as above with considerable calcite |
| 4,150–4,160 | Sandstone, dark grey, very fine-grained with minor amount of dark grey shale |
| 4,160–4,170 | Sandstone and shale as above |
| 4,170–4,180 | Sandstone and shale as above in nearly equal amounts; a few fragments of ironstone |
| 4,180–4,190 | Sandstone and shale as above |
| 4,190–4,200 | Sandstone, brown to dark grey; fine-grained with minor amount of dark grey shale; a few fragments of prismatic calcite |
| 4,200–4,210 | Shale as above; lesser amounts of sandstone |
| 4,210–4,220 | Shale and sandstone as above; a little calcite as coatings on both shale and sandstone |
| 4,220–4,230 | Sandstone, dark grey, fine-grained; some shale as above |
| 4,230–4,240 | Shale, dark grey, silty |
| 4,240–4,250 | Shale as above with a little dark-grey, fine-grained sandstone |
| 4,250–4,260 | Shale as above, somewhat slickensided |
| 4,260–4,270 | Shale as above |
| 4,270–4,280 | Shale as above, very little slickensiding |
| 4,280–4,290 | Shale as above with a little white calcite as coatings |
| 4,290–4,300 | Shale as above |
| 4,300–4,305 | Missing |

| Depth (feet) | |
|---|---|
| 4,305–4,310 | Sandstone, grey, fine-grained, quartzitic; shale, dark grey, silty |
| 4,310–4,315 | Sandstone and shale as above; scattered fine pyrite crystals |
| 4,315–4,320 | Shale as above; lesser amounts of sandstone |
| 4,320–4,325 | Shale as above with dark grey siltstone laminae |
| 4,325–4,330 | Shale and siltstone as above |
| 4,330–4,335 | Missing |
| 4,335–4,340 | Shale, silty to sandy, a little fine-grained sandstone |
| 4,340–4,345 | Missing |
| 4,345–4,350 | Sandstone, dark grey with a little dark grey shale |
| 4,350–4,355 | Missing |
| 4,355–4,360 | Sandstone, light grey, fine-grained, quartzitic, slightly calcareous; numerous calcite stringers through sandstone; some dark grey silty shale |
| 4,360–4,365 | Sandstone and shale as above |
| 4,365–4,370 | Sandstone and shale as above with scattered pyrite crystals |
| 4,370–4,375 | Sandstone and shale as above |
| 4,375–4,380 | Shale, dark grey, silty; a little coarse, grey sandstone |
| 4,380–4,385 | Shale and sandstone as above |
| 4,385–4,390 | Sandstone, light grey, fine- to medium-grained, quartzitic sandstone with a minor amount of dark grey micaceous shale |
| 4,390–4,395 | Sandstone, light and dark grey, fine- to medium-grained; some dark grey shale containing silty lenses |
| 4,395–4,400 | Shale, dark grey with calcite stringers; a small amount of fine, grey sandstone |
| 4,400–4,410 | Shale and sandstone as above |
| 4,410–4,415 | Sandstone, light grey, quartzitic, fine-grained; a little dark grey shale |
| 4,415–4,420 | Sandstone, light grey, medium-grained, calcareous; minor dark grey shale |
| 4,420–4,425 | Sandstone, dark grey to brown, fine-grained, micaceous and slightly calcareous; minor amounts of light grey sandstone and dark grey shale |
| 4,425–4,430 | Siltstone and fine sandstone, dark brownish-grey, micaceous; a little grey shale; both sandstone and shale are calcareous |
| 4,430–4,435 | Sandstone, dark grey and brown, calcareous; some dark grey shale and silty shale |
| 4,435–4,440 | Siltstone and fine-grained sandstone, dark grey and brownish grey; shale, dark grey, micaceous, slickensided |
| 4,440–4,445 | Sandstone, light grey, medium-grained; some dark grey, micaceous shale with calcite stringers and coatings |
| 4,445–4,450 | Shale, dark grey, micaceous, some slickensided, a little calcite as coatings; minor sandstone, grey, medium-grained, calcareous |
| 4,450–4,455 | Sandstone, light and dark grey, fine-grained; a little dark grey shale and a few fragments of ironstone |
| 4,455–4,460 | Sandstone, fine-grained, brownish grey, calcareous; siltstone, dark grey, slightly calcareous; minor dark grey shale |
| 4,460–4,465 | Shale, dark grey, silty; a little fine brownish sandstone; scattered pyrite crystals |
| 4,465–4,470 | Shale, dark grey, silty, slickensided; some fine dark greyish-brown sandstone and a little light grey, medium-grained sandstone; scattered fragments of ironstone |
| 4,470–4,475 | Sandstone, light and dark grey, fine- to medium-grained; a little dark grey shale |
| 4,475–4,480 | Shale, dark grey, silty, minor dark grey siltstone |
| 4,480–4,485 | Shale, dark grey, somewhat silty, slightly calcareous; some fine, dark grey calcareous sandstone; scattered small pyrite crystals |
| 4,485–4,490 | Shale, dark grey, silty; some ironstone associated with the shale; a little brownish-grey, fine sandstone |
| 4,490–4,495 | Sandstone, dark grey, fine-grained; considerable dark grey, silty, shale and shale; much ironstone with the shale |
| 4,495–4,500 | Sandstone, light and dark grey, fine-grained; minor dark grey, silty shale; a little ironstone |
| 4,500–4,505 | Sandstone and shale as above with considerable calcite as veinlets |
| 4,505–4,510 | Shale, dark grey, micaceous; with calcite veinlets and coatings; a little pyrite as clusters of small crystals |
| 4,510–4,515 | Shale, dark grey with silty laminae; a small amount of dark grey, fine-grained sandstone |
| 4,515–4,520 | Shale and siltstone as above |

| Depth (feet) | |
|---|---|
| 4,520–4,525 | Shale and siltstone as above; a very little dark grey, fine-grained, slightly calcareous sandstone |
| 4,525–4,530 | Shale as above; a little grey, fine-grained sandstone; a little pyrite |
| 4,530–4,535 | Sandstone, grey, medium-grained, calcareous, sideritic, few calcite-filled fractures, carbonaceous partings; minor dark grey shale |
| 4,535–4,540 | Shale and sandstone as above |
| 4,540–4,545 | Same as above; much slickensiding of shale |
| 4,545–4,550 | Same as above with considerable white calcite |
| 4,550–4,555 | Sandstone, light grey, fine-grained; shale, dark grey and slightly calcareous |
| 4,555–4,560 | Shale and silty shale interbedded; dark-grey calcareous; trace of light grey, fine-grained sandstone |
| 4,560–4,565 | Sandstone, light grey, fine-grained, calcareous; interbedded with dark grey shale |
| 4,565–4,570 | Sandstone, light and dark grey, very fine grained, calcareous; a little dark grey calcareous shale; numerous ironstone fragments |
| 4,570–4,575 | Siltstone, grey to brown, fine; some dark grey shale with associated ironstone |
| 4,575–4,580 | Sandstone, light grey to brown, fine-grained; shale, dark grey, silty, slickensided; calcite stringers through shale |
| 4,580–4,585 | Sandstone and silty shale interbedded, light grey, fine- to medium-grained sandstone; shale, dark grey, calcareous |
| 4,585–4,590 | Sandstone and shale as above |
| 4,590–4,595 | Sandstone and shale as above with considerable calcite |

## 'Fort St. John' Group

| | |
|---|---|
| 4,595–4,600 | Shale, dark grey, slickensided, with calcite stringers; some fine, grey siltstone; scattered crystals of pyrite |
| 4,600–4,605 | Shale as above with silty bands; a little grey, fine-grained sandstone; considerable white calcite |
| 4,605–4,610 | Shale, dark grey interbedded with dark grey, silty bands; considerable white calcite; a small amount of fine-grained grey sandstone |
| 4,610–4,620 | Shale and siltstone as above |
| 4,620–4,625 | Shale and siltstone as above |
| 4,625–4,630 | Shale and siltstone as above; one or two small marcasite nodules |
| 4,630–4,635 | Shale and siltstone as above; a little sandstone, dark grey, fine-grained; scattered, small pyrite crystals |
| 4,635–4,640 | Sandstone, dark grey, very fine; shale, silty, dark grey; slickensided, slightly calcareous, calcite veinlets; a little marcasite |
| 4,640–4,645 | Sandstone and shale as above |
| 4,645–4,650 | Shale as above; decreased amount of siltstone and sandstone; small marcasite nodules; scattered ironstone fragments; considerable white calcite coatings |
| 4,650–4,660 | Shale as above, silty; some fragments of prismatic calcite |
| 4,660–4,670 | Shale as above; much ironstone and calcite |
| 4,670–4,680 | Shale as above; some ironstone fragments; a few small marcasite fragments |
| 4,680–4,690 | Shale, dark grey, silty; sandstone, dark grey, fine-grained, much white calcite as veinlets and coatings |
| 4,690–4,700 | Shale, dark grey, slickensided |
| 4,700–4,710 | Shale as above; ironstone fragments |
| 4,710–4,720 | Shale as above; slickensided; scattered, fine pyrite crystals |
| 4,720–4,730 | Shale as above; ironstone fragments |
| 4,730–4,740 | Shale as above; much calcite; small marcasite nodules; siltstone, dark grey |
| 4,740–4,750 | Shale and siltstone as above |
| 4,750–4,760 | Shale, dark grey to black, slickensided; much white calcite as stringers and coatings; sandstone, grey, medium-grained, slightly calcareous |
| 4,760–4,820 | Shale as above |
| 4,820–4,840 | Shale as above; small amount of grey, fine to medium sandstone |
| 4,840–4,870 | Shale as above |
| 4,870–4,890 | Shale as above, greatly slickensided; sandstone, dark grey, fine-grained |
| 4,890–4,900 | Shale as above, slickensided; much calcite as veinlets and coatings; a little green-grey chert |

| Depth (feet) | |
|---|---|
| 4,900–4,960 | Shale as above; minor amounts of fine sandstone and siltstone; some sandstone and shale interbedded as thin laminae |
| 4,960–4,970 | Sandstone, grey to dark grey, fine-grained, slightly calcareous; shale, silty; with scattered small pyrite crystals |
| 4,970–5,000 | Sandstone, grey and brown, fine- to medium-grained, quartzitic; some dark grey, silty shale |
| 5,000–5,020 | Shale, silty, black slickensided, calcite veinlets; siltstone, dark grey as thin lenses and laminae throughout shale |
| 5,020–5,030 | Shale as above; sandstone in minor amounts, dark grey, fine-grained |
| 5,030–5,040 | Sandstone, coarse to gritty, dark grey to mottled; composed largely of dark chert grains and quartz; very little dark grey to black shale |
| 5,040–5,050 | Shale, black, somewhat silty; some grit, dark grey; minor light grey, medium-grained sandstone |

LUSCAR (MOUNTAIN PARK ?) FORMATION

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|---|---|
| 5,050–5,070 | Sandstone, light and dark grey, fine- to medium-grained, quartzitic; small quantity of dark grey silty shale |
| 5,070–5,090 | Same as above; a little fine-grained, brown sandstone |
| 5,090–5,110 | Sandstone, light grey, pepper and salt, medium-grained; sandstone, grey to grey-green and light brown, fine-grained; shale, light grey; some ironstone fragments |
| 5,110–5,120 | Sandstone, mostly light grey to greenish, medium-grained; some sandstone, dark grey and fine-grained; shale, dark grey; calcite stringers and ironstone fragments associated with the shale |
| 5,120–5,130 | Sandstone, light grey, pepper and salt, coarse, slightly calcareous; carbonaceous grains in sandstone; minor amounts of fine-grained, brown sandstone and dark grey shale |
| 5,130–5,140 | Sandstone and shale as above; shale, light greenish grey; calcite stringers; a few small pyrite crystals |
| 5,140–5,150 | Shale, dark grey; shale, light green; sandstone, brown to grey, very fine grained; trace of light grey coarse sandstone |
| 5,150–5,160 | Same as above; increased amount of sandstone |
| 5,160–5,170 | Shale, silty, dark grey, calcite stringers; sandstone, dark brownish grey, fine-grained |
| 5,170–5,180 | Sandstone, dark grey, fine-grained; light greenish grey, medium-grained; shale, medium grey to green; scattered ironstone fragments |
| 5,180–5,190 | Sandstone and shale; sandstone, light grey, coarse, pepper and salt; sandstone, brownish, fine-grained; shale, dark grey, silty; coaly streaks through shale |
| 5,190–5,200 | Sandstone and shale as above; more coal |
| 5,200–5,210 | Sandstone, light grey, coarse; sandstone, grey to brown, fine-grained; shale, dark grey, carbonaceous; shale, light grey |
| 5,210–5,220 | Sandstone as above; increased amount of coarse, light grey, slightly calcareous sandstone; some calcite stringers |
| 5,220–5,230 | Sandstone, light grey, pepper and salt; a little dark grey fine-grained sandstone; some light grey to green shale |
| 5,230–5,240 | Shale, silty, grey to dark green; sandstone, grey, medium-grained; coal |
| 5,240–5,250 | Sandstone, light grey, coarse; shale, silty, dark grey, with coaly streaks; scattered pyrite crystals; numerous calcite stringers |
| 5,250–5,260 | Sandstone, light grey, pepper and salt, coarse; sandstone, brown, fine-grained; shale, dark grey, micaceous; shale, light greenish grey; some pyrite |
| 5,260–5,270 | Sandstone as above, calcareous; shale as above |
| 5,270–5,280 | Sandstone and shale as above in equal amounts |
| 5,280–5,290 | Sandstone, grey to light grey, fine- to medium-grained; shale, dark grey and light green |
| 5,290–5,300 | Sandstone, light grey, medium to coarse; sandstone, brown; shales light greenish-grey to grey; much calcite |
| 5,300–5,330 | Sandstone and shale as above |
| 5,330–5,340 | Sandstone and shale as above. Shale and silty shale; mostly dark grey, some light grey; a little light grey, coarse sandstone; much coal; scattered pyrite in sandstone |
| 5,340–5,350 | Sandstone, light grey, coarse, pepper and salt; very little dark grey, silty shale |

| Depth (feet) | |
|---|---|
| 5,350–5,370 | Sandstone as above; shale light grey green |
| 5,370–5,400 | Sandstone as above; shale dark grey carbonaceous; considerable coal associated with shale |
| 5,400–5,410 | Sandstone as above grading into grit; some chert grains of grit size; shale, silty, grey and light brown; much pyrite |
| 5,410–5,420 | Siltstone, grey, fine-grained, thinly bedded; sandstone, light grey, coarse; shale, silty, grey to brown, slickensided in part; much calcite associated with shale |
| 5,420–5,430 | Sandstone, grey to dark grey, very fine grained, shale, grey and carbonaceous; a few fragments of grey chert; much coal |
| 5,430–5,440 | Missing |
| 5,440–5,450 | Sandstone and siltstone: fine- to medium-grained sandstone, grey with interbedded dark grey siltstone; some silty shale, dark grey, with calcite stringers; much coal |
| 5,450–5,460 | Shale, silty, grey; minor amount of light grey sandstone; some coal |
| 5,460–5,490 | Siltstone, grey, and fine-grained sandstone, grey; traces of grey shale; small pyrite crystals throughout shale and siltstone; trace of coal |
| 5,490–5,510 | Sandstone, grey to dark grey, fine- to medium-grained; shale, grey to brown; coal; white calcite along slickensided surfaces of shale |
| 5,510–5,520 | Shale, silty, dark brownish grey; sandstone, grey, medium-grained; shale, grey, slickensided; some calcite coatings |
| 5,520–5,570 | Sandstone, light grey to grey, coarse, calcareous pepper and salt with carbonaceous grains; shale, dark grey, silty, carbonaceous; shale, light greenish grey; much calcite as stringers in sandstone; much coal |
| 5,570–5,580 | Sandstone as above; some coarse, brown, sandstone |
| 5,580–5,590 | Sandstone as above; increased amount of brown sandstone; decreasing amount of coal; some dark grey shale |
| 5,590–5,610 | Sandstone and shale as above; a few fragments of ironstone |
| 5,610–5,620 | Sandstone and shale as above; no coal |
| 5,620–5,630 | Sandstone, light grey, coarse; sandstone, brown, medium-grained; shale, some dark grey and some light grey to green |
| 5,630–5,640 | Sandstone, light grey, coarse-grained; sandstone, dark grey, fine-grained; minor amounts of buff-coloured, fine-grained sandstone; shale, dark grey |
| 5,640–5,650 | Shale, grey, dark grey and black with coal stringers; much coal; some sandstone |
| 5,650–5,660 | Sandstone, light grey, medium to coarse; scattered pyrite crystals in the sandstone; shale, dark grey, carbonaceous, some coal |
| 5,660–5,670 | Sandstone and shale; sandstone, coarse- to medium-grained, light to dark grey and brown; shale mostly dark grey, some light grey; much coal |
| 5,670–5,680 | Sandstone, mostly fine-grained, grey and brownish; a little coarse, light grey sandstone. Shales grey to buff, silty. Some coal |
| 5,680–5,690 | Siltstone, dark grey to brownish, fine-grained; carbonaceous shale and coal |
| 5,690–5,710 | Siltstone, shale and coal as above |
| 5,710–5,740 | Siltstone, shale and coal as above; some light grey, medium-grained sandstone |
| 5,740–5,750 | Sandstone, light grey, very coarse to grit; grit composed mainly of dark chert; sandstone, dark grey, fine-grained; shale, silty; dark grey, slickensided; some coal |
| 5,750–5,760 | Missing |
| 5,760–5,770 | Sandstone, grey, medium-grained; some sandstone, light grey, very coarse grained; shale, dark grey with coaly streaks; calcite stringers |
| 5,770–5,780 | Sandstone, light grey, pepper and salt, very coarse; siltstone, dark brownish grey siltstone; shale, dark grey |
| 5,780–5,800 | Sandstone and siltstone as above; increased amount of dark grey shale |
| 5,800–5,810 | Missing |
| 5,810–5,820 | Sandstone as above; carbonaceous; shale, light grey and grey; coal |
| 5,820–5,830 | Sandstone, light grey, coarse-grained, calcareous; sandstone, grey to brown, fine-grained; shale, grey and greenish grey; coal |
| 5,830–5,850 | Shale, grey and greenish grey, with thin coal stringers; minor amounts of grey-brown siltstone; pyrite; calcite |
| 5,850–5,880 | Shale as above; sandstone, grey, fine-grained; calcareous; scattered pyrite crystals; a little coal |
| 5,880–5,890 | Sandstone, brownish grey, medium- to coarse-grained, slightly calcareous; shale, dark grey with carbonized plant stems; shale, light greenish grey |

| Depth (feet) | |
|---|---|
| 5,890–5,900 | Siltstone, dark grey; sandstone, grey to brown, medium-grained; shale, dark grey, grey and green; pyrite |
| 5,900–5,910 | Sandstone, grey, fine- to medium-grained; calcareous; shale, grey to dark grey |
| 5,910–5,940 | Sandstone as above, very calcareous; less shale |
| 5,940–5,960 | Sandstone, buff to grey, fine- to medium-grained; shales, mostly dark grey to black, some green; coal associated with black shale |
| 5,960–5,970 | Sandstone and shale as above; some light grey, coarse-grained, calcareous sandstone |
| 5,970–5,990 | Shale, grey and greenish grey, calcareous; some ironstone |
| 5,990–6,000 | Sandstone, grey to dark grey, fine- to medium-grained; shale, grey to dark grey; a few coal fragments |
| 6,000–6,010 | Shale, grey, somewhat silty; siltstone and fine sandstone, grey to buff, some calcite |
| 6,010–6,020 | Shale as above; sandstone, grey, fine- to medium-grained, calcareous; some ironstone, pyrite and coal |
| 6,020–6,040 | Siltstone and silty shale; grey to brown; a little green-grey shale; some coal and ironstone |
| 6,040–6,050 | Sandstone, light grey, medium- to coarse-grained; sandstone, dark grey to buff, fine-grained; a few fragments of ironstone |
| 6,050–6,070 | Sandstone as above; some green grey shale; calcite stringers throughout the shale |
| 6,070–6,110 | Sandstone, light grey, pepper and salt, coarse-grained; shale, grey and brown; some coal |
| 6,110–6,120 | Sandstone as above; no coal |
| 6,120–6,130 | Sandstone, dark grey and greyish brown calcareous, fine- to medium-grained; shale, dark grey and grey brown with coaly streaks |
| 6,130–6,150 | Siltstone, grey to brown; shale, grey and buff |
| 6,150–6,170 | Sandstone, light grey to buff, calcareous, coarse-grained; shale, silty, grey to black, carbonaceous, a little coal |
| 6,170–6,180 | Sandstone and shale in equal amounts: sandstone, grey, medium-grained, calcareous; shale, grey, silty; some scattered pyrite; a few ironstone fragments |
| 6,180–6,190 | Shale, greenish to grey; some black and carbonaceous; a little grey siltstone and sandstone |
| 6,190–6,220 | Sandstone, fine to medium, grey to buff; shale, silty, grey; some sandstone contains carbonized plant material; a little pyrite |
| 6,220–6,240 | Missing |
| 6,240–6,250 | Shale, grey to dark grey; silty; ironstone fragments |
| 6,250–6,280 | Shale as above; a little green shale; a few fragments of prismatic calcite |
| 6,280–6,290 | Missing |
| 6,290–6,300 | Shale as above |
| 6,300–6,330 | Sandstone, grey, fine- to medium-grained, very calcareous; shale, silty, grey; pyrite fragments |
| 6,330–6,350 | Sandstone, grey, pepper and salt, coarse-grained, calcareous; shale, grey, slightly calcareous, calcite stringers |
| 6,350–6,360 | Siltstone, silty shale and shale; grey to dark grey with calcite veinlets |
| 6,360–6,370 | Siltstone, brown-grey; a little grey and buff shale |
| 6,370–6,380 | Sandstone, grey and brown, medium- to coarse-grained; shale, grey to greenish grey with calcite veinlets |
| 6,380–6,390 | Shale, silty, grey to brown; some is silty |
| 6,390–6,400 | Shale, grey and dark grey with coal streaks; minor grey siltstone; a little calcite |
| 6,400–6,410 | Shale, grey; a very little dark grey, coarse sandstone; some pyrite fragments and calcite stringers |
| 6,410–6,420 | Shale as above with some coarse grey sandstone |
| 6,420–6,440 | Missing |
| 6,440–6,450 | Shale as above; increased amount of sandstone |
| 6,450–6,460 | Sandstone, grey and brown; fine- to medium-grained; shale, grey, silty; coal |
| 6,460–6,490 | Shale, light and dark grey, minor amounts of grey siltstone and fine sandstone; coal |
| 6,490–6,500 | Sandstone, grey and brown, medium- to coarse-grained; shale, dark grey to black carbonaceous; much calcite as stringers; a little coal |
| 6,500–6,510 | Sandstone and shale as above; no coal |

| Depth (feet) | |
|---|---|
| 6,510–6,580 | Sandstone, light grey, pepper and salt, very coarse, calcareous; shale, light grey; some coaly streaks in some of the shale |
| 6,580–6,590 | Sandstone, light grey, very coarse to gritty; large amount of large chert and quartzite fragments; chert, light grey, green-grey and dark grey; shale, dark grey |
| 6,590–6,600 | Sandstone, grey, fine- to medium-grained; shale, light and dark grey |
| 6,600–6,610 | Sandstone, light grey, pepper and salt, very coarse; shale, dark brown-grey and some light grey; coaly streaks in some shale |
| 6,610–6,620 | Grit and very coarse sandstone; considerable chert and quartzite fragments; shale, silty, dark grey |
| 6,620–6,630 | Sandstone and grit, very coarse (chert); chert, green grey and pink quartzite; shale, silty, dark grey, a little coal |
| 6,630–6,640 | Shale, silty, dark grey; some carbonaceous with coaly streaks; few fragments of grey chert and pinkish white quartzite; some small fragments of grey sandstone |
| 6,640–6,650 | Siltstone and fine-grained sandstone; grey to brown, slightly calcareous; shale and silty shale, mostly grey to dark grey |
| 6,650–6,660 | Siltstone, sandstone and shale as above; a few coal fragments |
| 6,660–6,670 | Sandstone, dark grey and brown, medium- to fine-grained; shale, dark grey to black with coaly streaks; some coal fragments |
| 6,670–6,680 | Sandstone and shale as above; a few fragments of white calcite |
| 6,680–6,690 | Sandstone, shale, calcite as above; a few pyrite fragments |
| 6,690–6,700 | Sandstone, dark grey, fine-grained; silty shale and shale, dark grey to black with coaly streaks; some carbonaceous shale |
| 6,700–6,710 | Sandstone and shale as above; some light greenish grey shale |
| 6,710–6,720 | Sandstone and shale as above; much coal |
| 6,720–6,730 | Shale and silty shale, dark grey to black, coal streaks in some shale; a little dark grey to brown, fine-grained sandstone; a little light grey, very coarse grained pepper and salt sandstone |
| 6,730–6,740 | Siltstone and shale, grey to dark grey; some carbonaceous shale and coal |
| 6,740–6,750 | Sandstone, grey to brown, fine- to medium-grained; shale, and silty shale, grey to black, some carbonaceous |
| 6,750–6,760 | Siltstone and silty shale, grey to brown; some light grey to green shale with calcite stringers; sandstone, light grey, coarse and slightly calcareous; a little coal |
| 6,760–6,770 | Siltstone, shale and sandstone as above |

## Cadomin Formation

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|---|---|
| 6,770–6,780 | Sandstone, light grey, coarse-grained; much grey and green chert fragments; shale, grey and green-grey; some coaly debris |
| 6,780–6,790 | Chert and quartzite; chert is green, dark grey, light grey; quartzite, white to pink; shale, mostly dark grey and silty |
| 6,790–6,800 | Chert and quartzite as above; a little coal |
| 6,800–6,810 | Chert and quartzite as above; some coarse, grey grit; shale, green-grey, very little |
| 6,810–6,830 | Chert, quartzite, and grit as above; a little brownish grey, medium-grained, quartzitic sandstone |
| 6,830–6,840 | Sandstone, dark grey to brown, fine- to medium-grained; shale, grey, very little |

## Nikanassin Formation—Fernie Group

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|---|---|
| 6,840–6,850 | Sandstone, dark grey and brownish grey, fine- to medium-grained; shale, grey, very little |
| 6,850–6,860 | Shale, silty shale and fine-grained sandstone; shale, grey; sandstone, brownish, fine-grained, quartzitic, slightly calcareous |
| 6,860–6,870 | Siltstone, mostly brownish; shale, mostly dark grey, some light greenish grey; some coal fragments |
| 6,870–6,890 | Shale, dark grey to black; coaly streaks in some shale; little very fine-grained, dark brown sandstone |
| 6,890–6,910 | Sandstone, gritty, medium- to fine-grained, dark grey and dark brown; very calcareous; carbonaceous; a little dark grey shale |
| 6,910–6,930 | Sandstone and shale as above; coal fragments; a little light grey shale |

| Depth (feet) | |
|---|---|
| 6,930–6,940 | Sandstone and shale as above; increased amount of shale |
| 6,940–6,960 | Siltstone and silty shale; dark grey, coaly streaks; some fragments are calcareous |
| 6,960–6,970 | Siltstone, very fine sandstone and shale, all dark grey |
| 6,970–6,990 | Sandstone, dark brown to dark grey, fine- to medium-grained; sandstone contains black carbonaceous grains; a little dark grey shale |
| 6,990–7,020 | Siltstone and silty shale, dark grey to black, carbonaceous; some coal stringers; a little greenish-grey shale |
| 7,020–7,050 | Sandstone, grey and dark grey, fine- to medium-grained; shale, dark grey to black with coal stringers |
| 7,050–7,070 | Sandstone, grey and green grey, fine- to medium-grained, dolomitic; siltstone, dark grey; shale, dark grey to black, carbonaceous |
| 7,070–7,080 | Sandstone and shale as above; some coal |
| 7,080–7,100 | Sandstone and shale as above; much coal |
| 7,100–7,120 | Sandstone, buff to dark grey, fine- to medium-grained, quartzitic with carbonaceous grains; shale, dark grey and carbonaceous |
| 7,120–7,140 | Sandstone as above; sandstone; grey, pepper and salt, coarse; many fragments of calcite |
| 7,140–7,160 | Sandstone, grey to dark grey, medium-grained, dolomitic; shale, grey to dark grey |
| 7,160–7,170 | Missing |
| 7,170–7,180 | Sandstone and shale as above; numerous calcite fragments |
| 7,180–7,200 | Sandstone, grey to brown, quartzitic, fine-grained; sandstone, shale, grey to dark grey; some coal |
| 7,200–7,210 | Missing |
| 7,210–7,250 | Sandstone and shale as above |
| 7,250–7,260 | Shale and sandstone in equal amounts; shale, grey and green-grey; sandstone, grey brown and dark grey, fine- to medium-grained |
| 7,260–7,270 | Shale and sandstone as above; sandstone extremely calcareous |
| 7,270–7,290 | Shale and sandstone as above; some coal fragments |
| 7,290–7,300 | Sandstone, grey to dark grey, fine- to medium-grained, slightly calcareous, slightly porous; shale, dark grey |
| 7,300–7,310 | Sandstone and shale as above; pyrite fragments |
| 7,310–7,320 | Sandstone and shale as above; non-calcareous |
| 7,320–7,330 | Sandstone and shale; sandstone, brownish, fine-grained, slightly calcareous; shale, grey to dark grey; some coal |
| 7,330–7,350 | Sandstone, brown, medium-grained; shale, grey |
| 7,350–7,360 | Sandstone as above; some grey, medium-grained sandstone; shale, grey, silty |
| 7,360–7,380 | Sandstone, grey, buff and brown, fine- to medium-grained, some of it vuggy; shale, grey to black and carbonaceous; a little coal |
| 7,380–7,390 | Sandstone, grey, medium- to coarse-grained, calcareous; some brownish, fine-grained sandstone; shale, dark grey; some coal and pyrite fragments |
| 7,390–7,430 | Sandstone, brown and dark grey, fine- to medium-grained; shale, dark grey, carbonaceous |
| 7,430–7,440 | Sandstone and shale as above; some light grey shale; some coal fragments |
| 7,440–7,500 | Sandstone, grey and brown, fine- to medium-grained, carbonaceous; shale, grey to dark grey, somewhat silty; some black coaly shale |
| 7,500–7,530 | Sandstone, brown to dark grey, mostly fine-grained, dolomitic; a little light grey, medium-grained, glauconitic sandstone; siltstone, dark grey to brownish; shale, grey, dark grey to black |
| 7,530–7,540 | Sandstone, grey and greenish grey, fine- to medium-grained; shale, dark grey to black, carbonaceous; some coal |
| 7,540–7,560 | Sandstone, brown to black, quartzitic with black carbonaceous material, fine-grained, porous; shale, dark grey to black and carbonaceous; some coal fragments; a few ironstone fragments |
| 7,560–7,570 | Shale, silty, dark grey, micaceous; a little dark grey, fine-grained sandstone; a little coal |
| 7,570–7,600 | Sandstone, grey to buff, dolomitic, fine-grained; shale, dark grey, micaceous, some coal |
| 7,600–7,610 | Sandstone, grey to brown, fine-grained, slightly calcareous; shale, dark grey, pyrite; some coaly material |

| Depth (feet) | |
|---|---|
| 7,610–7,620 | Sandstone, brownish grey, fine-grained, quartzitic; some light grey, fine-grained, quartzitic sandstone; shale, mostly dark grey, micaceous, well-laminated; a little greenish shale; a few white calcite fragments |
| 7,620–7,630 | Sandstone, shale and calcite as above; some iron stain as patches on the sandstone |
| 7,630–7,640 | Sandstone as above; mostly brownish grey to brown; fine-grained; shale, dark grey to black, carbonaceous with coaly streaks; coatings of white iron sulphate on some shale and sandstone; some yellow iron stain; fragments of white and pink calcite |
| 7,640–7,650 | Sandstone, grey, dark grey and green, fine-grained, quartzitic; shale as above |
| 7,650–7,660 | Sandstone, grey to buff, fine- to medium-grained, quartzitic; shale grey to black, some carbonaceous with coaly streaks |
| 7,660–7,670 | Sandstone and shale as above, about half and half |
| 7,670–7,680 | Sandstone and shale as above; many fragments of pink calcite |
| 7,680–7,690 | Sandstone as above; shale, grey; no carbonaceous shale; numerous calcite fragments |
| 7,690–7,700 | Sandstone and shale as above; much calcite; a few pyrite fragments |
| 7,700–7,710 | Sandstone, grey to dark grey, fine- to medium-grained, quartzitic; shale, mostly grey to black; a little light grey pyrite |
| 7,710–7,720 | Sandstone, shale and pyrite as above; numerous calcite fragments |
| 7,720–7,730 | Missing |
| 7,730–7,740 | Sandstone and shale as above; grey sandstone predominates, much calcite as above |
| 7,740–7,750 | Sandstone and shale as above; some sandstone, very micaceous; large quantity of calcite |
| 7,750–7,760 | Shale, grey to dark grey and carbonaceous with coaly streaks; sandstone dark grey and brown, fine-grained; some very dark sandstone; some iron stain on sandstone |
| 7,760–7,770 | Sandstone, brown and very dark grey, fine- to medium-grained, quartzitic; some black due to carbonaceous or bituminous matter; shale, light and dark grey, micaceous, numerous fragments of white calcite |
| 7,770–7,780 | Sandstone and shale as above in equal amounts; some pyrite fragments |
| 7,780–7,790 | Sandstone and shale as above |
| 7,790–7,800 | Sandstone, shale and pyrite as above; much white calcite |
| 7,800–7,810 | Sandstone, light grey to buff, fine-grained, quartzitic, shale, green and dark grey |
| 7,810–7,820 | Sandstone, and shale as above with minor amount of coaly shale; a few coal fragments |
| 7,820–7,830 | Shale as above with a lesser amount of sandstone as above |
| 7,830–7,840 | Sandstone and shale as above |
| 7,840–7,850 | Sandstone, buff and brown, medium-grained, quartzitic; shale, grey to dark grey; considerable calcite |
| 7,850–7,860 | Sandstone, shale and calcite as above |
| 7,860–7,870 | Sandstone, shale and calcite as above |
| 7,870–7,880 | Sandstone, grey and brown, glauconitic, fine- to medium-grained, quartzitic; shale, grey to micaceous dark grey, some carbonaceous |
| 7,880–7,890 | Sandstone and shale as above |
| 7,890–7,900 | Shale, grey to dark grey, some carbonaceous; sandstone, mostly buff to brown, fine-grained, quartzitic |
| 7,900–7,910 | Shale, grey, silty, micaceous with some thin laminae of fine sandstone; sandstone, buff, very fine grained |
| 7,910–7,920 | Shale as above; minor amount of dark grey, medium-grained, quartzitic sandstone; a few calcite fragments |
| 7,920–7,930 | Shale as above; small quantity of fine, dark grey sandstone and siltstone |
| 7,930–7,940 | Shale as above; a little dark grey, fine-grained quartzitic sandstone; a little light grey, medium-grained quartzitic sandstone |
| 7,940–7,950 | Shale, grey, silty, micaceous; some brownish grey, fine-grained quartzitic sandstone |
| 7,950–7,960 | Shale, grey, silty; very little, dark grey, fine-grained, sandstone; much pyrite associated with shale |
| 7,960–7,970 | Shale, grey to dark grey, finely micaceous; some silty shale; a little brown, very fine grained quartzitic sandstone or siltstone |
| 7,970–7,980 | Shale as above |
| 7,980–7,990 | Shale as above; some slickensided |
| 7,990–8,000 | Shale as above, micaceous; some fine-grained, quartzitic sandstone laminae |

| Depth (feet) | |
|---|---|
| 8,000–8,010 | Shale with fine sandstone laminae as above; much pyrite |
| 8,010–8,020 | Shale, grey, micaceous; shale, light green grey; sandstone, very fine grained, dark grey and brownish grey |
| 8,020–8,030 | Shale and sandstone as above; much pyrite |
| 8,030–8,040 | Shale, dark grey, finely micaceous; shale, grey, silty |
| 8,040–8,050 | Shale, grey to dark grey; some silty shale, a little very fine grained, dark grey quartzitic sandstone |
| 8,050–8,060 | Shale and sandstone as above |
| 8,060–8,070 | Shale, grey to dark grey, micaceous; much pyrite |
| 8,070–8,080 | Shale as above |
| 8,080–8,090 | Shale as above; some silty shale |
| 8,090–8,100 | Shale and silty shale as above; much pyrite, a few fragments of brown ironstone |
| 8,100–8,110 | Shale, dark grey to black, some silty; much pyrite |
| 8,110–8,120 | Shale as above |
| 8,120–8,130 | Shale as above; some light grey shale, much pyrite; a few fragments of prismatic calcite |
| 8,130–8,140 | Shale, dark grey as above; great deal of pyrite |
| 8,140–8,150 | Shale, dark grey to black as above; pyrite; a few fragments of grey, fine-grained sandstone |
| 8,150–8,160 | Shale as above with some calcite veinlets; some pyrite |
| 8,160–8,170 | Shale as above; pyrite nodules |
| 8,170–8,180 | Shale as above; some pyrite; some calcite veinlets |
| 8,180–8,190 | Shale as above; some pyrite and calcite |
| 8,190–8,200 | Shale as above; pyrite |
| 8,200–8,210 | Shale as above; pyrite; very small amount of greenish glauconitic sandstone |
| 8,210–8,230 | Shale, sandstone and pyrite as above |
| 8,230–8,240 | Shale, sandstone and pyrite as above; much calcite |
| 8,240–8,250 | Shale, dark grey to black; considerable calcite as veinlets; some pyrite; small pelecypods resembling *Astarte* |
| 8,250–8,260 | Shale and calcite as above |
| 8,260–8,270 | Shale as above; much pyrite |
| 8,270–8,280 | Shale as above |
| 8,280–8,290 | Shale as above, some calcareous; much calcite as veinlets and coatings; sandstone, fine-grained, green, glauconitic; some pyrite |
| 8,290–8,300 | Shale, black, slickensided; some shale very calcareous; much pyrite |
| 8,300–8,310 | Shale, mostly grey-black, calcareous; some black, non-calcareous; much pyrite |
| 8,310–8,320 | Shale, black, non-calcareous; a little calcareous shale; a few ironstone fragments; some nodular pyrite |
| 8,320–8,330 | Shale as above; pyrite |
| 8,330–8,340 | Shale, black, calcareous; pyrite |
| 8,340–8,350 | Shale as above; grey, medium-grained, calcareous sandstone; much pyrite |
| | TRIASSIC (WHITEHORSE FORMATION) |
| 8,350–8,360 | Limestone, dolomitic, grey, fine-grained, compact; shale, black, pyritic; large pyrite fragments |
| 8,360–8,370 | Limestone, dolomitic, grey, fine-grained, compact, a little arenaceous limestone; a few fragments of black, calcareous shale; a few fragments of white gypsum; scattered pyrite |
| 8,370–8,380 | Dolomite, siliceous, grey, somewhat mottled, pin-point porosity; some pyrite fragments |
| 8,380–8,390 | Limestone, dolomitic grey to slightly mottled, dense; much pyrite as large fragments |
| 8,390–8,400 | Limestone, as above; shale, black, soft |
| 8,400–8,410 | Limestone, grey, arenaceous, non-porous, calcite fragments; some pyrite |
| 8,410–8,420 | Limestone, dolomitic, light grey, compact, pyritic; some mottled dark and light grey |
| 8,420–8,430 | Dolomitic limestone as above, some porosity; some pores filled with black pyrobitumen |
| 8,430–8,440 | Limestone, dolomitic; most mottled light and dark grey; some light grey to white; shale, black, pyritic |

| Depth (feet) | |
|---|---|
| 8,440–8,450 | Limestone, dolomitic, mostly very little grey to white; some mottled light and dark grey; shale black, very little |
| 8,450–8,460 | Limestone, light grey to grey, fine-grained to compact; some pyrite no porosity |
| 8,460–8,470 | Limestone as above; a little black shale |
| 8,470–8,480 | Limestone, siliceous, light grey; some grey limestone; a little black shale; much pyrite |
| 8,480–8,490 | Limestone and shale as above; a little dark grey dolomite |
| 8,490–8,500 | Limestone, dolomitic, somewhat mottled light and dark grey |
| 8,500–8,510 | Limestone as above, soft and sugary; some light grey calcareous siltstone, much pyrite |

### Main Part of Triassic

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|---|---|
| 8,510–8,520 | Shale, dark grey to black; limestone dolomitic, light grey, fine-grained |
| 8,520–8,530 | Shale, dark grey to black; some silty shale; much pyrite |
| 8,530–8,540 | Shale as above; some calcareous siltstone; grey; much pyrite; numerous limestone fragments |
| 8,540–8,550 | Siltstone, dolomitic, dark grey, hard |
| 8,550–8,560 | Siltstone as above, dolomitic, some black shale; a little grey limestone |
| 8,560–8,570 | Same as above |
| 8,570–8,580 | Same as above; much pyrite |
| 8,580–8,590 | Shale and siltstone, dark grey, dolomitic; limestone, dolomitic, grey; much pyrite with limestone |
| 8,590–8,600 | Shale, siltstone and limestone as above |
| 8,600–8,610 | Siltstone, grey, calcareous; shale, dark grey, pyritic |
| 8,610–8,620 | Siltstone, grey to dark grey |
| 8,620–8,630 | Siltstone as above; some slightly calcareous |
| 8,630–8,640 | Siltstone, grey to dark grey, calcareous |
| 8,640–8,650 | Siltstone, dark grey, argillaceous and calcareous |
| 8,650–8,660 | Siltstone, dark grey, argillaceous and dolomitic |
| 8,660–8,670 | Siltstone as above; some dark grey shale |
| 8,670–8,710 | Siltstone as above |
| 8,710–8,720 | Siltstone as above; pyritic |
| 8,720–8,730 | Siltstone as above |
| 8,730–8,740 | Siltstone, grey to dark grey, dolomitic; some thin black shaly planes |
| 8,740–8,750 | Siltstone as above; some pyrite |
| 8,750–8,760 | Siltstone and pyrite as above |
| 8,760–8,770 | Siltstone as above |
| 8,770–8,780 | Siltstone as above; some iron stain |
| 8,780–8,790 | Siltstone as above |
| 8,790–8,800 | Siltstone as above; some pyrite |
| 8,800–8,810 | Siltstone as above |
| 8,810–8,820 | Siltstone as above |
| 8,820–8,830 | Siltstone as above; much pyrite and iron stain |
| 8,830–8,870 | Siltstone as above |
| 8,870–8,880 | Siltstone as above; much pyrite |
| 8,880–8,900 | Siltstone as above |
| 8,900–8,910 | Siltstone as above; mostly dark grey here |
| 8,910–8,920 | Siltstone, very fine, dolomitic, light and dark grey in about equal amounts; a little black shale |
| 8,920–8,930 | Siltstone as above |
| 8,930–8,940 | Siltstone, grey as above; some argillaceous and softer; much pyrite |
| 8,940–8,950 | Siltstone as above |
| 8,950–8,960 | Siltstone, grey to dark grey and argillaceous; very slightly dolomitic |
| 8,960–8,970 | Siltstone as above |
| 8,970–8,980 | Siltstone as above; a little pyrite |
| 8,980–8,990 | Siltstone and pyrite as above |
| 8,990–9,010 | Siltstone as above |
| 9,010–9,020 | Siltstone and fine-grained sandstone, grey to dark grey, slightly dolomitic; pyrite |
| 9,020–9,030 | Siltstone and sandstone as above |

| Depth (feet) | |
|---|---|
| 9,030–9,040 | Siltstone and sandstone as above |
| 9,040–9,050 | Siltstone as above |
| 9,050–9,060 | Siltstone, dark grey, argillaceous and slightly dolomitic |
| 9,060–9,080 | Siltstone as above |
| 9,080–9,090 | Siltstone as above; some pyrite |
| 9,090–9,150 | Siltstone as above |
| 9,150–9,160 | Siltstone as above; some pyrite |
| 9,160–9,180 | Siltstone as above |
| 9,180–9,190 | Siltstone as above; some pyrite |
| 9,190–9,220 | Siltstone as above |
| 9,220–9,230 | Siltstone, hard, dark grey, argillaceous, slightly calcareous |
| 9,230–9,240 | Siltstone as above |
| 9,240–9,250 | Siltstone as above; very little black shale |
| 9,250–9,350 | Siltstone as above |
| 9,350–9,360 | Siltstone as above; a little black shale containing scattered minute pyrite crystals |
| 9,360–9,370 | Siltstone as above; more calcareous than usual |
| 9,370–9,380 | Siltstone as above |
| 9,380–9,390 | Siltstone, dark grey, calcareous; sandstone, very fine, grey, calcareous; siltstone and sandstone interlaminated |
| 9,390–9,400 | Siltstone as above |
| 9,400–9,410 | Siltstone as above; a little shale here |
| 9,410–9,440 | Siltstone as above |
| 9,440–9,450 | Siltstone as above; a little black shale |
| 9,450–9,460 | Siltstone and shale as above |
| 9,460–9,510 | Siltstone as above |
| 9,510–9,520 | Siltstone, dark grey to black, slightly calcareous; sandstone, very fine grained, light grey, slightly calcareous |
| 9,520–9,530 | Siltstone and sandstone as above; a little pyrite |
| 9,530–9,540 | Siltstone and sandstone as above |
| 9,540–9,560 | Siltstone as above |
| 9,560–9,570 | Siltstone as above; some pyrite |
| 9,570–9,600 | Siltstone as above |
| 9,600–9,610 | Missing |
| 9,610–9,640 | Siltstone as above |
| | RUNDLE FORMATION |
| 9,640–9,650 | Missing |
| 9,650–9,660 | Dolomite, calcareous, grey to light grey, dense; some dark grey siltstone |
| *9,664–9,770 | Cored interval, mainly dolomite |
| 9,760–9,770 | Dolomite, greyish brown, finely crystalline, compact |
| 9,770–9,900 | Cored interval, mainly dolomite |
| 9,880–9,900 | Dolomite, dark greyish brown, finely crystalline, dense; thin veinlets of anhydrite |
| 9,900–9,905 | Dolomite, dark brownish grey, dense, argillaceous, a few calcite stringers |
| 9,905–9,910 | Dolomite, dark brownish grey, dense to finely crystalline, slightly argillaceous; small amount of dark brownish grey dolomite containing small vugs. Some white calcite |
| 9,910–9,915 | Dolomite, brownish grey to dark brownish grey, finely crystalline, considerable finely crystalline quartz as vug linings; small amount of black shale, small amount of anhydrite |
| 9,915–9,920 | Dolomite, compact to finely crystalline, brownish grey; slightly calcareous; contains many small vugs, small amount of black shale; very small amount of anhydrite |
| 9,920–9,930 | Dolomite, brown, finely crystalline, slightly argillaceous, fairly porous, some pores filled with calcite; small amount of grey chert, small amount of anhydrite |
| 9,930–9,950 | Cored interval, mainly dolomite |
| 9,950–9,955 | Dolomite, brown, finely crystalline; some fragments contain small vugs; some greenish brown, compact dolomite; some thin calcite stringers |
| 9,955–9,960 | Dolomite, grey brown to very dark grey, crystalline and compact somewhat argillaceous; small amount of grey chert; some very thin calcite stringers |

*For a more detailed description of these cores *see* Core Report following this log.

| Depth (feet) | |
|---|---|
| 9,960–9,966 | Dolomite as above, argillaceous |
| 9,966–9,990 | Cored interval, mainly dolomite |
| 9,990–9,995 | Dolomite, dark grey, dense, shaly; pyritic; small amount dark grey shale |
| 9,995–10,000 | Dolomite and shale as above; a little brown, finely crystalline dolomite and some calcite |
| 10,000–10,140 | Cored interval, dolomite and limestone |
| 10,140–10,145 | Limestone, dark brown, silty; some dolomite calcite stringers |
| 10,145–10,150 | Limestone, dolomitic, dark grey and grey brown, finely crystalline; some grey and greenish coloured chert |
| 10,150–10,165 | Limestone, dolomitic, dark grey and grey brown as above |
| 10,165–10,170 | Limestone, grey, fine to medium, crystalline, argillaceous; a little dark grey calcareous shale |
| 10,170–10,175 | Limestone, grey, medium-grained, sugary; some grey chert |
| 10,175–10,180 | Limestone as above, sugary; inclusions of white calcite |
| 10,180–10,195 | Limestone as above |
| 10,195–10,205 | Cored interval, limestone |
| 10,205–10,210 | Limestone, grey to greyish brown, crystalline; a few small vugs |
| 10,210–10,215 | Limestone as above |
| 10,215–10,225 | Limestone, grey brown crystalline; some calcite stringers |
| 10,225–10,230 | Limestone, grey to grey brown, finely crystalline to compact; some dolomitic; considerable white calcite |
| 10,230–10,280 | Cored interval, mainly dolomite |
| 10,280–10,285 | Limestone, grey, compact; a little dark grey crystalline limestone speckled with white calcite |
| 10,285–10,290 | Limestone as above |
| 10,290–10,295 | Limestone as above; much white calcite |
| 10,295–10,300 | Limestone as above |
| 10,300–10,305 | Limestone, dark grey, compact; a few calcite-filled vugs, pyritic in places |
| 10,305–10,325 | Limestone as above |
| 10,325–10,330 | Limestone, grey, compact, slightly pyritic; some dense, grey brown limestone |
| 10,330–10,335 | Limestone, grey and dark grey, compact, dense |
| 10,335–10,345 | Limestone as above, slightly pyritic |
| 10,345–10,348 | Limestone as above |
| 10,348–10,351 | Limestone, grey to dark grey, dense, slightly argillaceous; small white, calcite inclusions; small amount of pyrite; limestone is platy |
| 10,351–10,354 | Limestone as above; much of it mottled due to numerous white calcite inclusions |
| 10,354–10,360 | Limestone as above; a little anhydrite |
| 10,360–10,365 | Limestone as above; stringers of calcite |
| 10,365–10,370 | Limestone as above; calcite inclusions not numerous |
| 10,370–10,375 | Limestone as above; some dark grey limestone mottled with calcite inclusions |
| 10,375–10,380 | Limestone as above |
| 10,380–10,385 | Limestone, grey, very finely crystalline |
| 10,385–10,390 | Missing |
| 10,390–10,395 | Limestone, grey, finely crystalline, slightly pyritic; small amount of calcite as stringers |
| 10,395–10,425 | Limestone as above |
| 10,425–10,430 | Limestone, dark grey, finely crystalline |
| 10,430–10,445 | Limestone as above |
| 10,445–10,450 | Limestone as above; small amount of light grey dense limestone |
| 10,450–10,455 | Limestone, grey, finely crystalline; some grey dense limestone; a little calcite in stringers |
| 10,455–10,460 | Limestone as above |
| 10,460–10,465 | Dolomite, dark grey, finely crystalline; some small calcite-filled cavities |
| 10,465–10,470 | Dolomite, limy, dark grey, dense |
| 10,470–10,475 | Limestone, grey, dense; many inclusions of white calcite |
| 10,475–10,480 | Limestone, grey; mottled with inclusions of white calcite |
| 10,480–10,485 | Limestone as above |

| Depth (feet) | |
|---|---|
| 10,485–10,490 | Limestone as above; decreased amount of white calcite |
| 10,490–10,495 | Limestone as above; more calcite |
| 10,495–10,505 | Limestone as above |
| 10,505–10,510 | Limestone as above; dolomite, dark grey, argillaceous, dense; shale, dolomitic, black |
| 10,510–10,515 | Limestone, grey-brown, dense; considerable white calcite as cavity fillings |
| 10,515–10,530 | Limestone as above |
| 10,530–10,535 | Limestone as above; decreased amount of white calcite |
| 10,535–10,540 | Limestone as above |
| 10,540–10,545 | Limestone as above, much white calcite; some dark grey, finely crystalline |
| 10,545–10,550 | Limestone as above |
| 10,550–10,555 | Limestone, grey, dense, mottled with white calcite inclusions |
| 10,555–10,560 | Limestone as above |
| 10,560–10,565 | Limestone, grey, dense; slightly mottled with white calcite |
| 10,565–10,580 | Limestone as above |
| 10,580–10,585 | Limestone as above; small amount of dark grey, finely crystalline, argillaceous limestone |
| 10,585–10,590 | Limestone as above; increased amount of argillaceous limestone |
| 10,590–10,595 | Limestone, grey, dense; much white calcite as stringers |
| 10,595–10,600 | Limestone, light grey to grey, dense; stringers of white calcite |
| 10,600–10,605 | Limestone as above; some finely crystalline |
| 10,605–10,610 | Limestone, grey to grey brown, dense; a few white calcite inclusions |
| 10,610–10,615 | Limestone as above |
| 10,615–10,620 | Limestone, brownish grey, dense; mottled appearance due to inclusion of white calcite |
| 10,620–10,635 | Limestone as above |
| 10,635–10,640 | Limestone as above; dense to finely crystalline; very little white calcite |
| 10,640–10,645 | Limestone, grey and grey-brown, dense; a little dark grey, calcareous shale; a few white inclusions in limestone |
| | **Banff Formation (?)** |
| 10,645–10,650 | Limestone, grey, pyritic, dense; limestone, argillaceous, dark grey, dense; shale, black, slightly calcareous. Equal amounts of shale and limestone |
| 10,650–10,655 | Limestone and shale as above |
| 10,655–10,660 | Limestone, grey to grey brown, compact to finely crystalline, pyritic; a few calcite inclusions |
| 10,660–10,665 | Limestone as above |
| 10,665–10,685 | Missing |
| 10,685–10,690 | Limestone as above; a little dark grey, argillaceous limestone |
| 10,690–10,700 | Limestone, dark grey, finely crystalline to dense, argillaceous; limestone grey brown, dense; small amount of black grey shale |
| 10,700–10,705 | Limestone, grey to greyish brown, dense; small amount of white calcite as cavity fillings |
| 10,705–10,709 | Missing |

## *Core Report*

The following description of the cores from the Muskeg No. 1 Well is included in this report by kind permission of the Petroleum and Natural Gas Conservation Board of Alberta.

| *Core* | *Depth (feet)* | *Recovery* | *Unit* | *Description* |
|---|---|---|---|---|
| 1 | 4,019–4,031 | 4′ | 4′ | Shale, dark grey, scattered grains of pyrite near top; scattered fine specks of mica; compaction slickensiding near top |
| 2 | 4,368–4,378 | 9′ | 4′ | Shale and sandstone; finely micaceous, dark grey, in part silty shale, interbedded with grey fine-grained sandstone, sandstone becomes calcareous near base. Limestone band near top |
| | | | 3′ | Sandstone, grey, medium-grained, calcareous, salt and pepper; some shaly partings; scattered specks of mica |
| | | | 1′6″ | Shale, dark grey, silty; interbedded with grey, fine-grained sandstone |
| 3 | 4,475–4,487 | 12′6″ | 12′6″ | Shale, dark grey, finely micaceous; traces of slickensiding; fossil remains 3′ from base |
| 4 | 5,229–5,235 | 5′ | 5′ | Sandstone, medium grey, medium-grained, calcareous, sideritic, salt and pepper; scattered carbonaceous material; few calcite-filled fractures, carbonaceous partings near base; one large coal-filled fracture near base |
| 6 | 7,181–7,186 | 5′ | 5′ | Sandstone and shale; medium to dark grey, very fine to fine-grained quartz sand with two 3″ dark grey shale breaks showing bedding plane; slickensiding (dip 30°) |
| 17 | 9,664–9,671 | 5′9″ | 5′9″ | Dolomite, grey, dense, argillaceous; some fine fracturing |
| 18 | 9,671–9,679 | 6′8″ | 6′8″ | Dolomite, as above; fracturing more apparent |
| 19 | 9,679–9,686 | 5′ | 9″ | Dolomite, as above |
| | | | 2′ | Dolomite, buff, dense, fractured |
| | | | 3′3″ | Dolomite, grey, dense, slightly argillaceous, brecciated appearance |
| 20 | 9,686–9,694 | 7′ | 7′ | Dolomite, as above, fractured; brecciated appearance; few inclusions of grey chert |
| 21 | 9,694–9,702 | 7′ | 7′ | Dolomite, as above; few irregular bands of dark grey shale; considerably fractured in top part with calcite and dark grey shale along fracture plane; in one place dark grey shale is slickensided; inclusions of white crystalline siliceous material and some anhydrite to give brecciated appearance; dolomite in part is slightly limy, probably due to calcite distribution |
| 22 | 9,702–9,702′6″ | 6″ | 6″ | Dolomite, as above, with white, crystalline, siliceous inclusions and some anhydrite as above; brecciated |
| 23 | 9,702′6″–9,711 | 7′ | 7′ | Dolomite, as above; dark grey shale band at top; in part core has vertical and horizontal fractures with dark grey shale and small amount of calcite |
| 24 | 9,711–9,718 | 7′ | 7′ | Dolomite and shale: dolomite as above, interbedded with dark grey shale near top; considerably fractured with anhydrite and calcite along fracture planes and in inclusions to give brecciated appearance |

| Core | Depth (feet) | Recovery | Unit | Description |
|---|---|---|---|---|
| 25 | 9,718–9,726 | 8′ | 8′ | Dolomite, argillaceous, dark grey and grey-brown; bands of dark grey shale (dip 45°); small amount of pyrite |
| 26 | 9,726–9,734 | 8′ | 8′ | Dolomite, medium to dark brownish grey, in part shaly, pyritic |
| 27 | 9,734–9,748 | 12′ | 12′ | Dolomite, dark brownish grey, argillaceous dolomite band at top and at 9,760′ with calcite-filled vugs; considerable fracturing; few dark grey shale bands; top part is pyritic |
| 28 | 9,748–9,761 | 11′ | 11′ | Dolomite, dark brownish grey, crystalline; some argillaceous dolomite; a few dark grey shale breaks are slickensided; top part is fractured; in part anhydrite along fractures; some slickensided, dark grey shale breaks |
| 29 | 9,761–9,778 | 14′ | 7′ | Dolomite, dark greyish brown, finely crystalline, argillaceous; scattered small to coarse vugs lined with calcite; few vertical and horizontal fractures, pyritic |
| | | | 6′ | Dolomite, grey-brown, crystalline, silty; becomes dark grey brown and argillaceous at the base; scattered small to coarse vugs lined with calcite; few narrow dark grey shale-filled fractures; scattered pyrite; large white anhydrite inclusions at base. Few coarse vugs are filled with calcite |
| 30 | 9,778–9,797 | 18′6″ | 8′6″ | Dolomite, dark brown, crystalline, silty; considerable calcite in inclusions and along fracture planes; one area has scattered small vugs lined with calcite; few narrow dark grey shale bands and partings |
| | | | 10′ | Dolomite, dark grey brown, crystalline, argillaceous; intermittent bands of small to medium vugs in part lined with calcite and in part filled with calcite; a few dark grey shale breaks |
| 31 | 9,797–9,820 | 19′6″ | 19′6″ | Dolomite, dark brown and greyish brown, crystalline; in part silty dolomite; intermittent bands with fine to medium vugs lined with calcite; irregular calcite inclusions and stringers; few large vugs not completely filled with calcite; few fractures; few dark grey shale partings |
| 32 | 9,824–9,844 | 15′(?) | 15′(?) | Dolomite as above; greater number of calcite-filled vugs, inclusions and stringers; more vertical and horizontal fractures |
| 33 | 9,844–9,867 | 15′ | 15′ | Dolomite, dark brown, silty; appears shaly at top; a few large irregular calcite inclusions; some smaller calcite-filled vugs; few stringers; few slickensided, dark grey shale breaks |
| 34 | 9,869–9,894 | 4′3″ | 4′3″ | Dolomite, dark brownish grey, dense; in part appears shaly; a few narrow, dark grey shale bands and streaks |
| 35 | 9,903–9,925 | 11′6″ | 11′6″ | Dolomite, dark brownish grey, dense, shaly; grades into dark brown, silty dolomite |

| Core | Depth (feet) | Recovery | Unit | Description |
|---|---|---|---|---|
| 36 | 9,928–9,939 | 11′6″ | 3″ | Dolomite as above |
| | | | 6″ | Calcite, white, coarsely crystalline |
| | | | 10′9″ | Dark grey shale break at the base; dolomite, dark brown, finely crystalline, silty; some dark brownish grey, argillaceous dolomite; scattered small areas of fine vugs; a few calcite stringers; a few large, irregular, calcite inclusions; stylolite at top and near base |
| 37 | 9,939–9,955 | 13′ | 13′ | Dolomite as above, calcitic; a few irregular horizontal fractures with dark shale filling |
| 38 | 9,955–9,977 | 22′ | 22′ | Dolomite, dark brownish grey, argillaceous to shaly; calcitic; one band toward the base is irregularly interbedded with argillaceous material; a few vertical and horizontal fractures |
| 39 | 9,977–9,985 | 12′ | 12′ | Dolomite, dark grey, dense, shaly; calcite along fracture planes near top; a few dark grey shale-filled fractures |
| 40 | 9,985–9,989 | 3′3″ | 3′3″ | Dolomite, dark grey, dense, shaly; some fine fracturing |
| 41 | 9,991–10,018 | 26′ | 8′6″ | Dolomite, dark brown, argillaceous; a 2-inch band of shaly dolomite 3′ from top; a few calcite-filled vertical fractures |
| | | | 13′3″ | Dolomite, dark grey, dense, shaly dolomite with a few narrow, dark grey shale bands with a dip of 40°; a 1-inch band with tube structure (coral ?) filled with white material (celestite ?) at 10,003′; some fracturing |
| | | | 4′3″ | Dolomite and anhydrite; dark brownish grey, finely crystalline, silty dolomite; anhydrite-filled fracture and inclusion at top; a few white inclusions toward base, in part anhydrite, in part calcite; a 2-foot band of white crystalline anhydrite in middle of core |
| 42 | 10,018–10,046 | 25′ | 6′ | Dolomite, dark brownish grey, silty to argillaceous; a few fractures filled in part with calcite, in part with anhydrite; some fine vertical and horizontal fracturing |
| | | | 15′ | Dolomite, dark grey, dense, shaly; a few large anhydrite inclusions |
| | | | 4′ | Shale, dark grey, dolomitic, silty |
| 43 | 10,046–10,053 | 6′ | 4′ | Dolomite, dark brown, finely crystalline, silty |
| | | | 2′ | Siltstone, dark grey, argillaceous, dolomitic |
| 45 | 10,080–10,089 | 2′3″ | 2′3″ | Dolomite, dark brown, argillaceous; considerable small calcite inclusions due in part to fossil replacement; trace of sulphur at top |
| 46 | 10,097–10,100 | 1′ | 1′ | Dolomite as above; numerous calcite inclusions and stringers; one large white anhydrite inclusion near base |
| 47 | 10,100–10,110 | 1′9″ | 1′9″ | Anhydrite, white, opaque; contains scattered fragments of dark grey, shaly limestone |
| 48 | 10,120–10,123 | 1′6″ | 1′6″ | Limestone, dark brown, silty to argillaceous; dolomitic at top; one 3-inch band of anhydrite with sulphur along bedding plane; a few vertical fractures; some calcite as above |



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| Core | Depth (feet) | Recovery | Unit | Description |
|---|---|---|---|---|
| 49 | 10,127–10,140 | 13′ | 13′ | Limestone, dark brown, argillaceous to silty; some dolomitic limestone near base; a few vertical fractures, some with sulphur along the fracture planes; some horizontal fracturing; calcite inclusions and stringers throughout |
| 52 | 10,195–10,214 | 16′3″ | 16′3″ | Limestone as above; considerable calcite-replaced fossil fragments; calcite-filled vertical fractures |
| 53 | 10,214–10,220 | 5′6″ | 5′6″ | Limestone as above; dolomitic in part |
| 54 | 10,220–10,227 | 5′ | 5′ | Limestone as above at top; grades downward into medium brown, crystalline limestone; considerable calcite-replaced fossils (corals, brachiopods); a few calcite-filled fractures |
| 55 | 10,230–10,252 | 20′ | 20′ | Dolomite, dark brown, argillaceous to shaly; a few dark shale breaks; considerable fossil replacement, partly by calcite, and partly by anhydrite; a few large anhydrite inclusions; a few calcite-filled fractures |
| 56 | 10,252–10,273 | 20′ | 6′6″ | Dolomite as above; a few narrow, dark grey shale bands |
| | | | 13′6″ | Limestone, medium brown, argillaceous to silty; in part dolomitic; at 3′ from top occur 2- to 3-inch bands of dark grey, shaly limestone with slickensiding; a few vertical fractures in part with calcite and sulphur along fracture planes |
| 57 | 10,273–10,281 | 2′6″ | 2′6″ | Dolomite, medium to dark brown, silty to argillaceous; somewhat limy due to calcite replacements of fossils at base; very hard; may be siliceous |
| 58 | 10,281–10,292 | 9″ | 9″ | Limestone, dark grey, shaly |

## Jasper No. 1 Well

The following log of the Jasper No. 1 Well at Folding Mountain, prepared by Mr. D. G. Penner, is included in this report by kind permission of the Petroleum and Natural Gas Conservation Board, Anglo-Canadian Oil Company, Limited, and Imperial Oil, Limited.

| Depth (feet) | |
|---|---|
| 0–100 | Mostly drift |
| | FERNIE GROUP |
| 100–110 | Limestone, grey to dark grey, argillaceous |
| 110–200 | Shale, dark grey to black, firm; few fragments of grey, crystalline limestone |
| 200–230 | Shale and limestone; black, slightly calcareous shale as above; grey, argillaceous, finely crystalline limestone |
| 230–240 | Shale, black, hard, calcareous |
| 240–250 | Shale, as above, with trace of bluish white coating (phosphate) |
| 250–260 | Shale, as above, with much phosphatic coating |
| 260–300 | Limestone, black, argillaceous and phosphatic<br>NOTE: Chemical analysis of cutting from 280–300 feet showed 0.54 per cent $P_2O_5$ |
| 300–310 | Limestone, as above, with few calcite veinlets |

NOTE: Several of the formational names used in this log by the Petroleum and Natural Gas Conservation Board differ from the terms used by the writer.

| Depth (feet) | |
|---|---|
| | SPRAY RIVER FORMATION |
| 310–340 | Missing |
| 340–350 | Limestone, buff, pinkish buff, and light grey; dense; trace of light grey, calcareous sandstone |
| 350–360 | Siltstone, light grey with faint greenish tinge, slightly calcareous, argillaceous; buff, ferruginous stained, calcareous sandstone; trace of buff, dense limestone |
| 360–370 | Limestone, light grey, somewhat sandy, dense |
| 370–390 | Limestone, as above, and pinkish buff, dense limestone |
| 390–410 | Dolomite, light grey, granular, and dense, grading into siltstone |
| 410–420 | Siltstone, light greenish grey, argillaceous, pyritic |
| 420–430 | Siltstone, light greenish grey, medium grey, pyritic |
| 430–440 | Siltstone and dolomite: siltstone as above, lighter in colour; light grey, argillaceous, and dense dolomite |
| 440–460 | Siltstone and sandstone: siltstone as above, buff, ferruginous stained, very fine-grained, slightly to non-calcareous sandstone |
| 460–520 | Siltstone, light grey, argillaceous, finely pyritic, micro-micaceous, very slightly calcareous |
| 520–530 | Siltstone, light greenish grey, argillaceous, slightly calcareous; trace of grey-green shale |
| 530–540 | Siltstone, grey, argillaceous, very slightly calcareous; trace of green micro-micaceous shale |
| 540–550 | Missing |
| 550–570 | Siltstone, light to medium grey, argillaceous, and very slightly calcareous; trace of green, silty shale |
| 570–650 | Missing |
| 650–660 | Siltstone, grey, argillaceous, slightly calcareous, micro-micaceous, trace of dark grey, argillaceous limestone |
| 660–680 | Siltstone, as above, medium grey |
| 680–710 | Siltstone, shale, and limestone: siltstone as above; grey to dark grey; very dense limestone |
| 710–730 | Siltstone and shale: siltstone as above, darker in colour; shale as above |
| 730–850 | Siltstone and shale: siltstone as above and trace of white to light buff siltstone; shale as above, silty; scattered traces of black, argillaceous limestone |
| 850–860 | Shale, siltstone, and limestone: dark grey, finely micaceous, platy shale; siltstone as above; trace of black, argillaceous limestone |
| 860–880 | Siltstone and shale, as above: siltstone predominating; small traces of limestone |
| 880–900 | Siltstone and shale, as above; more shale than above |
| 900–920 | Shale and siltstone: for most part dark grey, silty shale grading into grey, argillaceous siltstone |
| 920–930 | Shale, as above, coated with cement<br>NOTE: Much cement in samples from 920 to 1,100 feet |
| 930–940 | Dolomite, medium grey, crystalline, in part with streaks of dark grey shale; trace of porosity; traces of black bitumen in cavities |
| 940–950 | Dolomite, as above; no porosity |
| 950–960 | Dolomite, as above, light grey; trace of porosity |
| 960–970 | Siltstone, shale, and limestone: light grey to grey, argillaceous siltstone; dark grey shale; dark grey, argillaceous limestone |
| 970–980 | Siltstone, grey, argillaceous, slightly calcareous |
| 980–1,010 | Siltstone, medium to light grey, argillaceous, slightly calcareous |
| 1,010–1,040 | Siltstone, as above, medium grey to grey, with traces of calcite veining |
| 1,040–1,070 | Siltstone, as above, medium grey |
| 1,070–1,100 | Siltstone and limestone: siltstone as above; black, argillaceous, and dense limestone; trace of dark grey, micro-micaceous, slightly calcareous shale |
| 1,100–1,110 | Siltstone, as above, and traces of limestone and shale as above |
| 1,110–1,140 | Siltstone and shale: medium grey to grey, argillaceous, slightly calcareous siltstone; minor amount of dark grey, silty shale and trace of black limestone |
| 1,140–1,170 | Siltstone, as above |
| 1,170–1,190 | Siltstone and shale: siltstone as above; dark grey, silty, slightly calcareous shale; trace of black, argillaceous limestone; few fragments of medium grey, porous dolomite |
| 1,190–1,200 | Missing |



95036—15½

| Depth (feet) | |
|---|---|
| | RUNDLE FORMATION |
| 1,200–1,220 | Dolomite, medium grey, slightly pyritic, granular, and dense |
| 1,220–1,230 | Dolomite and calcite, buff, granular to dense, numerous calcite crystals |
| 1,230–1,260 | Dolomite, as above, and light buff, finely crystalline to granular dolomite |
| 1,260–1,270 | Dolomite, medium grey, finely crystalline; small trace of porosity |
| 1,270–1,300 | Dolomite, buff, granular to dense |
| 1,300–1,310 | Dolomite, as above, and grey-buff, finely crystalline |
| 1,310–1,320 | Dolomite, buff to grey-buff, dense |
| 1,320–1,330 | Dolomite, medium grey, granular to dense |
| 1,330–1,340 | Dolomite, grey, finely pyritic, argillaceous, and dense |
| 1,340–1,350 | Dolomite, buff to greyish buff, dense |
| 1,350–1,370 | Dolomite, greyish buff, dense |
| 1,370–1,390 | Dolomite, as above, and buff, finely crystalline |
| 1,390–1,410 | Dolomite, buff to grey-buff, dense |
| 1,410–1,420 | Dolomite, greyish buff, dense |
| 1,420–1,470 | Dolomite, grey, argillaceous, and dense |
| 1,470–1,490 | Dolomite, as above, and grey-buff, dense |
| 1,490–1,500 | Dolomite, buff, dense |
| 1,500–1,510 | Dolomite, buff to greyish buff, finely crystalline |
| 1,510–1,520 | Dolomite and chert: dolomite as above; trace of bluish white chert |
| 1,520–1,540 | Dolomite, buff, finely crystalline |
| 1,540–1,550 | Dolomite, grey-buff to grey-brown, dense |
| 1,550–1,570 | Dolomite, grey-brown, dense |
| 1,570–1,600 | Dolomite, grey-brown, finely crystalline; numerous quartz crystals |
| 1,600–1,620 | Limestone, grey-brown, finely crystalline |
| 1,620–1,630 | Dolomite, grey-brown, finely crystalline; trace of porosity |
| 1,630–1,640 | Dolomite, as above; trace of porosity: few pieces have pores filled with white and cream-coloured, kaolinitic material |
| 1,640–1,650 | Dolomite, grey, argillaceous, and dense |
| 1,650–1,660 | Dolomite and shale: dolomite as above; dark grey and dark grey to black, non-calcareous shale |
| 1,660–1,690 | Limestone, dark brownish grey, argillaceous and dense; some dolomite as above; one piece of oolitic limestone at 1,680 feet |
| 1,690–1,700 | Limestone, greyish buff, dense |
| 1,700–1,720 | Limestone, grey, finely crystalline |
| 1,720–1,730 | Limestone, buff, coarsely crystalline |
| 1,730–1,740 | Limestone, greyish buff, fine and coarsely crystalline |
| 1,740–1,760 | Limestone, dark brownish grey, argillaceous, and dense |
| 1,760–1,770 | Limestone, grey, granular, argillaceous, and dense |
| 1,770–1,780 | Dolomite and shale: dark brownish grey, argillaceous, and dense dolomite; dark grey, non-calcareous shale |
| 1,780–1,790 | Anhydrite and dolomite: white, finely crystalline anhydrite; dark brownish grey, argillaceous, and dense dolomite |
| 1,790–1,800 | Anhydrite and dolomite: white anhydrite with intermixed grey-buff, dense dolomite |
| 1,800–1,810 | Anhydrite and dolomite: anhydrite as above; grey-brown, dense dolomite |
| 1,810–1,830 | Dolomite, dark brownish grey, argillaceous, and dense; trace of anhydrite at 1,820 feet |
| 1,830–1,850 | Dolomite and anhydrite: dolomite as above, and grey-buff, dense dolomite; white, finely crystalline anhydrite |
| 1,850–1,880 | Dolomite, as above, and trace of anhydrite |
| 1,880–1,910 | Dolomite, shale, and anhydrite: dark grey, argillaceous and dense dolomite; dark grey to black, non-calcareous shale; white, finely crystalline anhydrite |
| 1,910–1,930 | Dolomite, as above, and medium grey, granular dolomitic limestone; traces of anhydrite |
| 1,930–1,940 | Dolomite and shale: dolomite as above; black, non-calcareous shale |
| 1,940–1,950 | Dolomite and anhydrite: brownish grey, argillaceous dolomite; white, finely crystalline anhydrite |
| 1,950–1,960 | Anhydrite, as above, some dolomite as above and trace of black shale |
| 1,960–1,970 | Limestone and anhydrite: dark grey, argillaceous, and dense limestone; anhydrite as above |

| Depth (feet) | |
|---|---|
| 1,970–1,980 | Limestone, grey-brown, argillaceous, and dense, fossiliferous; trace of black, calcareous shale |
| 1,980–2,030 | Limestone, brownish grey, argillaceous, and dense; trace of shale |
| 2,030–2,040 | Limestone, shale, and anhydrite: limestone as above, and grey, buff, dense limestone; black, non-calcareous shale; anhydrite intermixed with grey-buff limestone |
| 2,040–2,050 | Dolomite and shale: grey, argillaceous, and dense dolomite; dark grey to black, non-calcareous shale |
| 2,050–2,070 | Dolomite, shale, and anhydrite: dolomite and shale as above; white, finely crystalline anhydrite |
| 2,070–2,100 | Limestone and anhydrite: brownish grey, argillaceous and dense limestone; anhydrite as above |
| 2,110–2,140 | Limestone, grey-brown, argillaceous, and dense; anhydrite as above |
| 2,140–2,320 | Limestone, grey-buff, dense with numerous calcite veinlets; trace of black, non-calcareous shale at 2,250 feet; anhydrite at 2,260 feet |
| 2,320–2,360 | Limestone, grey-buff, and dark brownish grey; argillaceous and dense limestone; trace of dark grey, very slightly calcareous shale |

BANFF FORMATION

| | |
|---|---|
| 2,360–2,370 | Dolomite, grey with slight greenish cast, pyritic, argillaceous, and dense |
| 2,370–2,380 | Limestone, grey-buff, finely crystalline to dense; grey-brown, argillaceous, and dense limestone |
| 2,380–2,410 | Limestone and shale: dark brownish grey, argillaceous, and dense limestone; trace of dark grey, calcareous shale; amount of shale increasing at 2,400 feet |
| 2,410–2,420 | Shale, dark grey, slightly calcareous |
| 2,420–2,430 | Shale, as above, calcareous and grading into argillaceous limestone |
| 2,430–2,460 | Limestone and shale: dark brownish grey, argillaceous, and dense limestone; dark grey, calcareous shale |
| 2,560–2,570 | Limestone, as above, and grey-buff, coarsely crystalline |
| 2,570–2,580 | Missing |
| 2,580–2,610 | Limestone, as above |
| 2,610–2,620 | Limestone, as above, grey-buff predominating over dark grey limestone |
| 2,620–2,630 | Limestone and shale: dark brownish grey, argillaceous, and dense, and light to medium grey, granular limestone; dark grey to black, calcareous shale |
| 2,630–2,660 | Limestone and shale: dark brownish grey, argillaceous, and dense limestone, grey-buff, coarsely crystalline limestone; shale as above |
| 2,660–2,680 | Limestone and shale: as above, and buff to grey-buff, granular limestone |
| 2,680–2,770 | Shale and limestone: dark grey to black, calcareous shale grading into argillaceous limestone; buff to grey-buff, granular, dense, and soft limestone near top; traces of buff, dense limestone at 2,700 feet (caving?) |
| 2,770–2,780 | Limestone and shale: buff to grey-buff, crystalline limestone; dark grey to black, calcareous shale |
| 2,780–2,820 | Limestone, grey-buff, coarsely crystalline |
| 2,820–2,830 | Limestone, brownish grey, argillaceous, and dense |
| 2,830–2,890 | Limestone and shale: limestone as above, and grey-buff, granular, and dense limestone; dark grey, calcareous shale; much calcite at 2,880 feet |
| 2,890–2,930 | Limestone and shale: grey-buff to dark grey, argillaceous, dense limestone; dark grey, calcareous shale |
| 2,930–2,955 | Limestone, mainly dark grey, argillaceous, and dense, grading into dark grey, calcareous shale |

EXSHAW FORMATION[1]

| | |
|---|---|
| 2,955–2,970 | Shale, dark grey to black, very slightly calcareous |
| 2,970–2,975 | Shale, black, slightly calcareous to non-calcareous |

[1] The equivalent of these beds in Brûlé map-area is included with the Banff formation.

| Depth (feet) | |
|---|---|
| | MINNEWANKA FORMATION |
| 2,975–2,980 | Shale and limestone: shale as above; trace of grey-buff, crystalline limestone |
| 2,980–2,985 | Limestone, grey-buff to brown, crystalline, in part dolomitic, few fragments of slight porosity |
| 2,985–3,010 | Limestone, grey and grey-brown, dense |
| 3,010–3,025 | Limestone, medium grey and grey-brown, crystalline |
| 3,025–3,070 | Limestone, as above, crystalline to dense |
| 3,070–3,075 | Limestone, buff, dense |
| 3,075–3,085 | Limestone, grey-buff to light brown, finely crystalline to dense |
| 3,085–3,090 | Limestone, greyish buff, crystalline |
| 3,090–3,105 | Limestone, grey-buff, crystalline; brown, dense limestone |
| 3,105–3,125 | Limestone, brownish grey, dense |
| 3,125–3,130 | Limestone, grey, crystalline |
| 3,130–3,140 | Limestone, as above, oolitic |
| 3,140–3,195 | Limestone, brownish grey, dense |
| 3,195–3,205 | Limestone, as above; grey, finely crystalline limestone |
| 3,205–3,250 | Limestone, brownish grey, dense |
| 3,250–3,260 | Limestone, shale, and chert: limestone as above; dark brownish grey, calcareous, pyritic shale with chocolate-brown streak; trace of grey-buff chert fragments |
| 3,260–3,330 | Limestone, as above; trace of shale as above |
| 3,330–3,365 | Limestone, medium grey, fairly soft, crystalline to granular |
| 3,365–3,390 | Limestone, as above; few fragments of crystalline limestone with small show of porosity and black bitumen in pores |
| 3,390–3,435 | Limestone, as above |
| 3,435–3,495 | Limestone, brownish grey, hard, dense |
| 3,495–3,505 | Limestone, dark brownish grey, dense, softer than above |
| 3,505–3,655 | Limestone, as above, in part crystalline and oolitic (?) fragment of fossil brachiopod at 3,550 and 3,555 feet |
| 3,655–3,770 | Limestone, brownish grey, dense |
| 3,770–3,775 | Limestone, grey-buff, finely crystalline, fairly soft |
| 3,775–3,780 | Limestone, buff, dense |
| 3,780–3,790 | Limestone, buff, crystalline, and white; soft limestone containing much black bitumen |
| 3,790–3,795 | Limestone, buff, crystalline; white, finely crystalline to granular limestone |
| 3,795–3,825 | Limestone, buff and greyish buff, finely crystalline, soft |
| 3,825–3,835 | Dolomite, greyish buff, finely crystalline, fairly soft |
| 3,835–3,840 | Limestone and anhydrite: grey-buff to light brown, dense limestone; white, finely crystalline anhydrite |
| 3,840–3,845 | Dolomite and limestone, grey-buff, finely crystalline, faintly oil-stained, of slight porosity; limestone and anhydrite as above |
| 3,845–3,850 | Dolomite, as above, faintly oil-stained and trace of porosity |
| 3,855–3,860 | Limestone, brownish grey, finely crystalline, with numerous calcite veinlets |
| 3,860–3,865 | Dolomite, light buff or grey-white, finely crystalline; small trace of porosity; strong sulphur odour when heated |
| 3,865–3,875 | Limestone and anhydrite: grey, finely crystalline; fragments of dense limestone and white anhydrite |
| 3,875–3,880 | Dolomite, oil-stained, finely crystalline; small trace of porosity; trace of anhydrite |
| 3,880–3,885 | Limestone, brownish grey, finely crystalline |
| 3,885–3,890 | Limestone, as above; trace of dense limestone |
| 3,890–3,895 | Dolomite, whitish grey, finely crystalline |
| 3,895–3,905 | Limestone, light grey, finely crystalline |
| 3,905–3,910 | Limestone, dark brownish grey, finely crystalline |
| 3,910–3,920 | Dolomite, light grey, finely crystalline |
| 3,920–3,940 | Limestone, brownish grey, finely crystalline, dolomitic |

| Depth (feet) | |
|---|---|
| 3,940–3,950 | Limestone and shale: limestone as above: black calcareous, finely pyritic shale with chocolate-brown streak |
| 3,950–3,960 | Limestone, grey and brownish grey, finely crystalline to dense; trace of above shale |
| 3,960–3,990 | Limestone, as above; light grey, crystalline limestone |
| 3,990–4,005 | Dolomite, dark brownish grey, argillaceous and dense |
| 4,005–4,010 | Shale and limestone: green, finely pyritic, slightly calcareous, firm shale; limestone as above |
| 4,010–4,015 | Limestone, grey-buff, dense |
| 4,015–4,020 | Limestone, grey-brown, argillaceous, and dense |
| 4,020–4,025 | Limestone, dark brownish grey, argillaceous, and dense, with calcite veinlets |
| 4,025–4,030 | Limestone, light grey, crystalline, with black bitumen specks |
| 4,030–4,035 | Limestone, as above; dark brownish grey, argillaceous, and dense, limestone with calcite veinlets |
| 4,035–4,045 | Limestone, medium grey to brownish grey, argillaceous and dense |
| 4,045–4,055 | Limestone, buff to light grey, crystalline |
| 4,055–4,075 | Limestone, buff to grey-buff, dense; some crystalline limestone |
| 4,075–4,085 | Limestone, buff, dense |
| 4,085–4,110 | Limestone, grey-buff, dense, with calcite veinlets |
| 4,110–4,115 | Limestone, buff, dense |
| 4,115–4,130 | Limestone, light buff; numerous calcite crystals |
| 4,130–4,140 | Limestone and shale: buff, dense limestone; green, firm, pyritic, slightly calcareous shale |
| 4,140–4,170 | Limestone, light buff to white, dense; trace of dark brownish grey, argillaceous and dense, dolomitic limestone; much calcite |
| 4,170–4,180 | Limestone, grey-buff, dense |
| 4,180–4,190 | Limestone, buff, in part crystalline and dolomitic |
| 4,190–4,195 | Limestone and shale: buff and grey-buff, dense limestone; green pyritic, firm, slightly calcareous shale |
| 4,195–4,205 | Limestone, grey-white, crystalline, somewhat dolomitic |
| 4,205–4,215 | Limestone, light buff, dense; grey-buff, dense limestone |
| 4,215–4,225 | Dolomite, light grey to bluish grey, coarsely crystalline; trace of porosity |
| 4,225–4,230 | Limestone, grey, coarsely crystalline, dolomitic; trace of porosity |
| 4,230–4,235 | Limestone, as above and dark brownish grey, argillaceous and dense limestone |
| 4,235–4,240 | Dolomite, light grey, grey to brown, crystalline; trace of porosity |
| 4,240–4,245 | Limestone, grey-buff, dense |
| 4,245–4,250 | Dolomite, grey-buff and dark brown, crystalline |
| 4,250–4,255 | Dolomite, as above; trace of porosity in light dolomite |
| 4,255–4,260 | Dolomite, faintly oil-stained, coarsely crystalline; trace of porosity |
| 4,260–4,265 | Dolomite, bluish grey to light brown, fine and coarsely crystalline; trace to fair porosity with black bitumen in pores |
| 4,265–4,270 | Dolomite, grey-buff, of medium crystallinity; trace of porosity |
| 4,270–4,280 | Dolomite and anhydrite or gypsum; dark grey-brown, finely crystalline dolomite; white, crystalline anhydrite or gypsum, which appears to be largely in veins |
| 4,280–4,290 | Dolomite, grey-buff to light brown, finely crystalline, pyrite; trace of porosity with black bitumen in pores; gypsum or anhydrite as above |
| 4,290–4,295 | Dolomite, as above, and dark grey-brown, finely crystalline; white, crystalline gypsum or anhydrite |
| 4,295–4,300 | Dolomite, dark and light brown, of medium crystallinity; small trace of porosity |
| 4,300–4,310 | Dolomite, brown, coarsely crystalline; trace of porosity; trace of cream-coloured, kaolinitic material in pores |
| 4,310–4,330 | Dolomite, light brown, coarsely crystalline; small trace of porosity |
| 4,330–4,345 | Dolomite, grey-buff to bluish grey, coarsely crystalline; small trace of porosity with black bitumen in pores |
| 4,345–4,355 | Dolomite and gypsum: dolomite as above; small trace of porosity; white, crystalline gypsum |
| 4,355–4,360 | Dolomite, brown, crystalline, medium-grained; small trace of porosity, trace of black, calcareous shale with chocolate-brown streak |
| 4,360–4,365 | Dolomite, light brown, crystalline, medium-grained; trace of porosity; white, crystalline gypsum |

| Depth (feet) | |
|---|---|
| 4,365–4,375 | Dolomite, buff to grey-buff, coarsely crystalline; small trace of porosity; white, crystalline gypsum |
| 4,375–4,385 | Dolomite, buff, coarsely crystalline; trace of porosity with bitumen; trace of gypsum |
| 4,385–4,390 | Dolomite, grey-brown, finely crystalline and brownish black; argillaceous dolomite grading into black, dolomitic shale |
| 4,390–4,395 | Dolomite, brown, coarsely crystalline |
| 4,395–4,400 | Dolomite, as above, crystalline, medium-grained |
| 4,400–4,405 | Dolomite, buff to grey-buff, coarsely crystalline; trace of porosity with black bitumen in pores |
| 4,405–4,410 | Dolomite, as above, and light brown, finely crystalline dolomite |
| 4,410–4,415 | Dolomite, grey-white, coarsely crystalline; small trace of porosity |
| 4,415–4,420 | Dolomite, as above, trace to fair porosity; black bitumen in pores; numerous fragments of white, crystalline gypsum?; trace of sulphur |
| 4,420–4,425 | Dolomite, buff, coarsely crystalline; small trace of porosity |
| 4,425–4,430 | Dolomite, grey-buff, coarsely crystalline |
| 4,430–4,440 | Dolomite, brownish grey, finely crystalline, with numerous veinlets of white calcite |
| 4,440–4,450 | Dolomite, light brown, crystalline, medium-grained; small trace of porosity |
| 4,450–4,570 | Dolomite, brown, finely crystalline, with numerous calcite and gypsum? veinlets and fragments |
| 4,570–4,595 | Dolomite and limestone: dolomite as above; trace of buff, dense limestone |
| 4,595–4,605 | Dolomite, brown, finely crystalline, with calcite veinlets and fragments; trace of pyrite |

### Blackface Mountain Shale

| | |
|---|---|
| 4,605–4,615 | Dolomite and shale: brown, finely crystalline dolomite grading into brownish grey. argillaceous, and dense dolomite; black, fissile, calcareous shale |
| 4,615–4,625 | Shale and limestone: black, fissile, calcareous shale; dark brownish grey, argillaceous, and dense limestone and grey-buff, crystalline limestone |
| 4,625–4,650 | Shale, black, highly calcareous, firm, grading into black, argillaceous limestone; fossiliferous at 4,630 feet |
| 4,650–4,665 | Limestone, dark brownish grey, argillaceous, and dense, with white calcite inclusions |
| 4,665–4,670 | Shale, dark grey, silty, firm, calcareous |
| 4,670–4,675 | Shale, as above, dark grey to black |
| 4,675–4,690 | Shale and limestone: shale as above; dark brownish grey, argillaceous, and dense limestone |
| 4,690–4,700 | Shale, black, firm, calcareous, finely pyritic |
| 4,700–4,715 | Limestone, dark brownish black, argillaceous, and dense, grading into black, calcareous shale |
| 4,715–4,720 | Shale and limestone: black, slightly calcareous shale; limestone as above |
| 4,720–4,735 | Shale, black, slightly calcareous to non-calcareous |
| 4,735–4,740 | Dolomite and shale: black, argillaceous, and dense dolomite; shale as above |
| 4,740–4,755 | Dolomite, brownish black, finely crystalline, with numerous calcite veinlets |
| 4,755–4,765 | Dolomite and shale: brown, finely crystalline dolomite; few fragments of green shale |
| 4,765–4,770 | Dolomite, brownish black, crystalline |
| 4,770–4,780 | Dolomite, dark brownish grey, crystalline |
| 4,780–4,805 | Dolomite, brown, crystalline, medium-grained, with numerous calcite veinlets |
| 4,805–4,810 | Dolomite, as above; buff, crystalline dolomite |
| 4,810–4,835 | Dolomite, dark brownish grey, finely crystalline; trace of black shale; few fragments of green, finely pyritic shale |
| 4,835–4,840 | Dolomite, as above; trace of buff, coarsely crystalline dolomite |
| 4,840–4,845 | Dolomite, buff, coarsely crystalline, cherty |
| 4,845–4,850 | Dolomite, dark brownish grey, crystalline; trace of black shale, in part slickensided |
| 4,850–4,860 | Dolomite, dark brownish grey, finely crystalline, containing rounded quartz and calcite inclusions and veinlets |
| 4,860–4,900 | Dolomite, as above, greyish brown to brownish grey, with numerous calcite veinlets |

| Depth (feet) | |
|---|---|
| | BLAIRMORE GROUP (FAULT CONTACT) |
| 4,900–4,910 | Shale, black, highly slickensided |
| 4,910–4,915 | Shale, dark grey; black, slickensided shale |
| 4,915–4,935 | Shale and sandstone: shale as above; light grey, fine-grained, salt and pepper sandstone; traces of grey limestone fragments |
| 4,935–4,945 | Sandstone and shale; grey-buff, medium-grained sandstone; non-calcareous, salt and pepper sandstone; shale as above; few limestone fragments |
| 4,945–4,955 | Sandstone and shale, as above, and brownish, very fine grained, non-calcareous sandstone grading into brownish grey, silty shale; dark grey shale; one fragment of green shale at 4,950 feet |
| 4,955–4,965 | Shale, grey-brown, silty to sandy; dark grey shale; some black, slickensided shale |
| 4,965–4,970 | Shale, dark grey and black, slickensided; trace of salt and pepper sandstone |
| 4,970–4,975 | Shale and sandstone: shale as above; grey-buff, fine- to medium-grained, salt and pepper sandstone |
| 4,975–4,980 | Sandstone, as above, in part calcareous |
| 4,980–4,985 | Sandstone, buff, fine-grained, calcareous, salt and pepper |
| 4,985–4,990 | Sandstone, limestone, and shale: sandstone as above; grey-buff, dense limestone; dark grey shale |
| 4,990–4,995 | Sandstone and shale; grey-buff, very fine grained sandstone; grey and dark grey, slickensided shale and one fragment of green shale |
| 4,995–5,015 | Sandstone, grey-buff, fine-grained, slightly calcareous, salt and pepper |
| 5,015–5,020 | Shale and sandstone: dark grey, in part slickensided, shale; sandstone as above, very fine grained |
| 5,020–5,040 | Sandstone and shale, as above; trace of green shale |
| 5,040–5,050 | Shale and sandstone, as above, shale predominating; traces of medium-grained, salt and pepper sandstone |
| 5,050–5,055 | Sandstone and shale: grey-buff, fine-grained, slightly calcareous, salt and pepper sandstone; dark grey, in part slickensided, shale |
| 5,055–5,065 | Sandstone and shale, as above, sandstone darker in colour |
| 5,065–5,085 | Sandstone and shale: buff, fine-grained, slightly calcareous, salt and pepper sandstone; shale as above |
| 5,085–5,096 | Shale and sandstone, as above, shale predominating; sandstone coarser grained |

# APPENDIX E

## Data on Coal Seams

| | Thickness Feet | Inches |
|---|---|---|

## Sheep Creek—Smoky River Region

### *Section 1. On the southeast side of Sheep Creek about ⅛ mile west of the Luscar-Kaskapau fault contact*

*Formation: Luscar*

| | Feet | Inches |
|---|---|---|
| Shale, sandy | 14 | 00 |
| Shale, carbonaceous; numerous coaly streaks | — | 04 |
| Coal, broken | 4 | 02 |
| Coal and shale, interbedded | 3 | 00 |
| Siltstone and shale | 3 | 00 |
| Coal | | 03 |
| Shale, black, carbonaceous | 4 | 06 |
| Coal, hard, banded bright and dull | | 09 |
| Siltstone | 3 | 00 |
| Shale, black, carbonaceous | 5 | 00 |
| Sandstone, grey, hard | 1 | 00 |

### *Section 2. On the southeast side of Sheep Creek about ¼ mile west of the Luscar-Kaskapau fault contact*

*Formation: Luscar*

| | Feet | Inches |
|---|---|---|
| Sandstone, grey, massive | 50 | 00 |
| Siltstone, dark grey, thinly bedded; a few hard sandstone bands; carbonized plant remains | 60 | 00 |
| Shale, grey | 5 | 00 |
| Shale, dark grey to black, carbonaceous | 3 | 00 |
| Coal; contains two 3-inch shale partings at 10 feet and 15 feet from the base | 22 | 06 |
| Shale, carbonaceous, black | 2 | 06 |
| Sandstone, grey, hard | | 10 |

### *Section 3. On Sheep Creek near water level upstream from sections 1 and 2, about latitude 54°02′, longitude 119°09′*

*Formation: Luscar*

| | Feet | Inches |
|---|---|---|
| Sandstone, grey, hard; some interbedded grey siltstone | 15 | 00 |
| Coal, very shaly | | 10 |
| Shale, black, carbonaceous | 2 | 00 |
| Coal | 3 | 00 |
| Shale, grey | 1 | 00 |
| Coal | 2 | 11 |
| Shale, grey | 1 | 00 |
| Sandstone, grey, fine-grained | 6+ | |

| | Thickness Feet | Inches |
|---|---|---|

*Section 4. On Sheep Creek about ½ mile upstream from the Luscar-Kaskapau fault contact*

*Formation: Luscar*

| | Feet | Inches |
|---|---|---|
| Shale, black, carbonaceous | 5 | 00 |
| Siltstone, grey | 3 | 00 |
| Coal, hard, banded | 0 | 08 |
| Shale, black, carbonaceous | 4 | 06 |
| Coal | 0 | 04 |
| Shale, grey, silty | 3 | 00 |
| Shale, grey; with several thin coal stringers | 3 | 00 |
| Coal, bright, sheared | 4 | 06 |
| Coal, silty | 0 | 02 |
| Coal, sheared, bright | 2 | 00 |

## Wildhay River—Thoreau Creek Region

*Section 5. On the east side of Carson Creek about 1 mile above its mouth*

*Formation: Luscar*

| | Feet | Inches |
|---|---|---|
| Shale, grey | 3 | 00 |
| Coal, weathered, powdery | 7 | 00 |
| Shale, coaly | 1 | 03 |
| Coal, weathered, friable, containing small lenses of clay | 22 | 00 |
| Shale, coaly | 2+ | |

*Section 6. In the west bank of Thoreau Creek about ¾ mile above its mouth*

*Formation: Luscar*

| | Feet | Inches |
|---|---|---|
| Shale, grey | 1+ | |
| Coal | 4 | 00 |
| Shale, grey; contains fragments of stems and leaves | 1 | 00 |
| Coal | 8 | 00 |
| Shale, coaly, dark grey | 6 | 00 |
| Coal | 25 | 00 |
| Sandstone, grey, medium-grained | 2+ | |

## Muskeg River—Sterne Creek Region

*Section 7. On Sterne Creek about 2½ miles above its mouth*

*Formation: Luscar*

| | Feet | Inches |
|---|---|---|
| Sandstone, shaly, grey; zones of concretionary ironstone | 20 | 00 |
| Sandstone, silty, fine-grained, grey | 6 | 00 |
| Coal | 6 | 00 |
| Shale, dark grey; coal stringers and lenses | 6 | 06 |
| Siltstone, with interbedded ribbons of ironstone | 1 | 03 |
| Shale, grey | 2 | 00 |
| Coal | 1 | 00 |
| Sandstone, shaly, grey, fine-grained | 7 | 00 |

| | Thickness Feet | Inches |
|---|---|---|

***Section 8. On the east bank of Muskeg River about ½ mile above its mouth***

***Formation: Luscar***

| | Feet | Inches |
|---|---|---|
| Sandstone, grey, sheared | 10 | 00 |
| Shale, and shaly sandstone | 4 | 04 |
| Coal, sheared, friable | 1 | 06 |
| Shale, dark grey to black | 2 | 00 |
| Shale, and silty shale, grey | 12 | 02 |
| Sandstone, hard, grey, medium-grained, massive; contains wood fragments | 16 | 00 |
| Shale, grey and dark grey; contains two 6-inch coal seams near the middle | 70 | 00 |
| Shale, black; with coaly stringers | 6 | 00 |
| Coal | 13 | 06 |
| Sandstone, silty, grey, soft | 1 | 00 |
| Sandstone, grey, medium-grained, massive | 9 | 00 |
| Sandstone, fine-grained, grey, silty | 45 | 00 |
| Shale, grey | 2 | 03 |
| Sandstone, hard, grey, medium-grained | 1 | 06 |
| Siltstone, grey | 2 | 00 |
| Shale and silty shale, grey | 12 | 00 |
| Coal | 0 | 04 |
| Shale, grey | 0 | 05 |
| Coal | 0 | 06 |
| Shale, grey | 0 | 06 |
| Coal | 1 | 00 |
| Shale, grey and black; some thin, concretionary bands | 7 | 00 |
| Sandstone, fine-grained, grey, concretionary | 1 | 06 |
| Shale, carbonaceous, black; some thin sandstone bands | 6 | 06 |
| Coal | 4 | 00 |
| Siltstone, grey; with some black shale partings | 15 | 00 |

## Nickerson Creek—Caw Creek Region

***Section 9. On a branch of Nickerson Creek at approximately latitude 54°03′, longitude 119°28′***

***Formation: Luscar***

| | Feet | Inches |
|---|---|---|
| Sandstone, medium-grained, grey, buff weathering | 20 | 00 |
| Sandstone, fine-grained, grey, buff weathering; weathers platy and contains plant remains | 4 | 00 |
| Shale, grey; interbedded with black, carbonaceous shale and thin coal stringers | 2 | 06 |
| Coal, sheared and weathered; apparently no shale partings | 15 | 11 |
| Sandstone, fine-grained, grey; interbedded with grey shale; plant remains in shale and sandstone; large wood fragments in sandstone | 5 | 04 |
| Sandstone, fine- to medium-grained, grey to brown weathering; some plant remains | 6 | 00 |
| Shale, dark grey to black, carbonaceous | 5 | 00 |
| Sandstone, fine- to medium-grained, grey, brown weathering | 17 | 01 |
| Shale, grey; some black carbonaceous shale | 3 | 00 |
| Coal, broken and weathered | 2 | 00 |
| Shale, grey | 0 | 08 |
| Coal, weathered | 1 | 00 |
| Sandstone, fine-grained, grey-brown, buff weathering | 5 | 00 |

### *Section 10: At the headwaters of Caw Creek at approximately latitude 54°03′, longitude 119°22′*

### *Formation: Luscar*

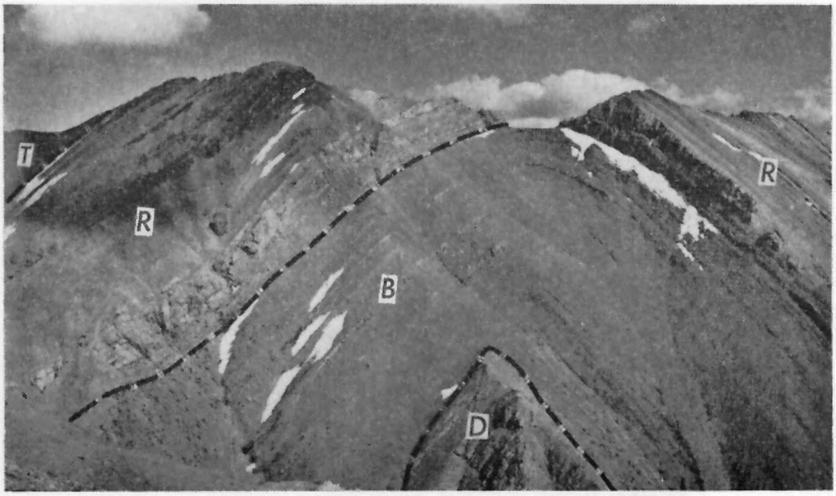
| | Thickness Feet | Inches |
|---|---|---|
| Sandstone, grey, buff weathering, fine-grained | 20 | 00 |
| Coal | 12 | 00 |
| Sandstone, grey, buff weathering; contains ironstone concretions | 2 | 00 |
| Shale, grey | 5 | 00 |
| Coal | 5 | 05 |
| Shale, grey; numerous grey sandstone bands up to 1 foot thick | 20 | 00 |
| Sandstone, grey-brown, buff weathering | 100 | 00 |
| Coal | 23 | 00 |
| Sandstone, grey, fine-grained; contains plant remains | 4 | 00 |

PLATES II-VII


100933

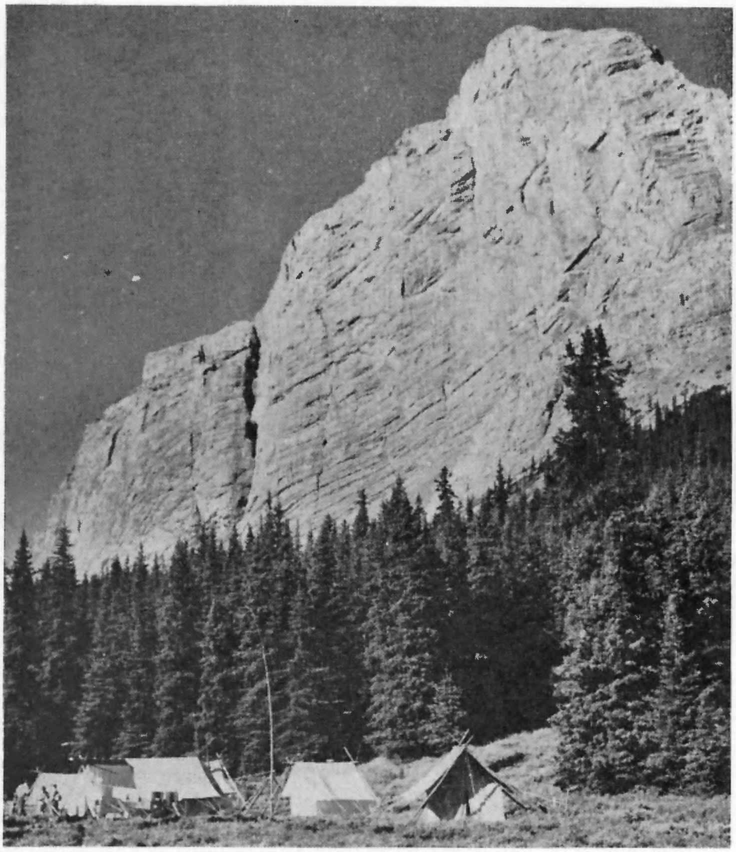
*A. View south showing overturned Cretaceous formations in front of (northeast of) Berland Range in the Tip Top thrust sheet, near the head of Mumm Creek, Alberta. Mississippian is indicated by M, Triassic by T, and Cretaceous by C.*

PLATE




100917

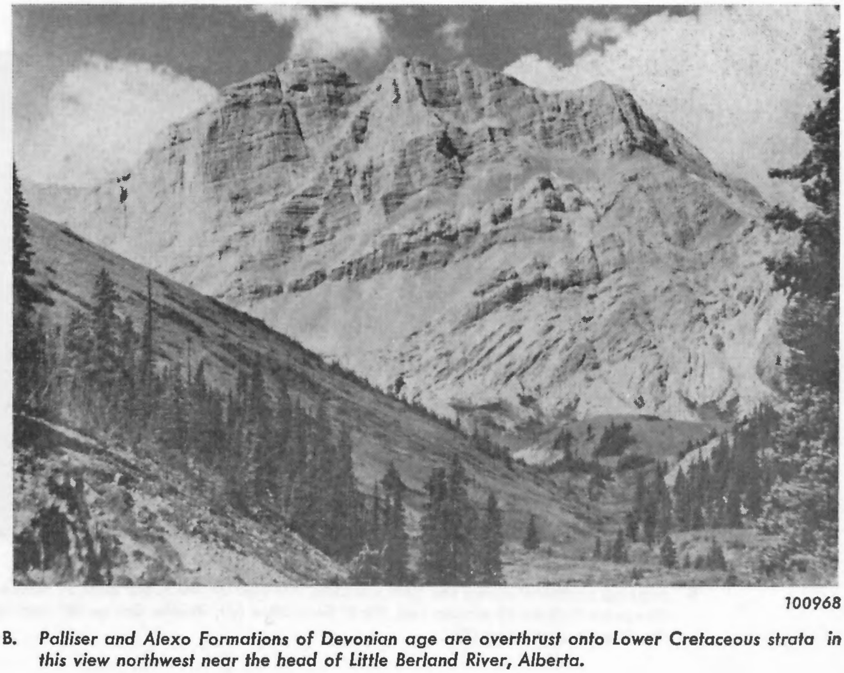
*B. Looking southeast along the Hoff anticline just west of the lower part of Mumm Creek showing Devonian Palliser Formation (D), Banff Formation (B), Rundle Group (R), and the lower part of the Triassic succession (T).*



A. *View west showing the Palliser and Alexo Formations of Devonian age overthrust onto Lower Cretaceous strata near the head of Moon Creek, Alberta.*

**PLATE III**

3-7-47 E.J.W.I.



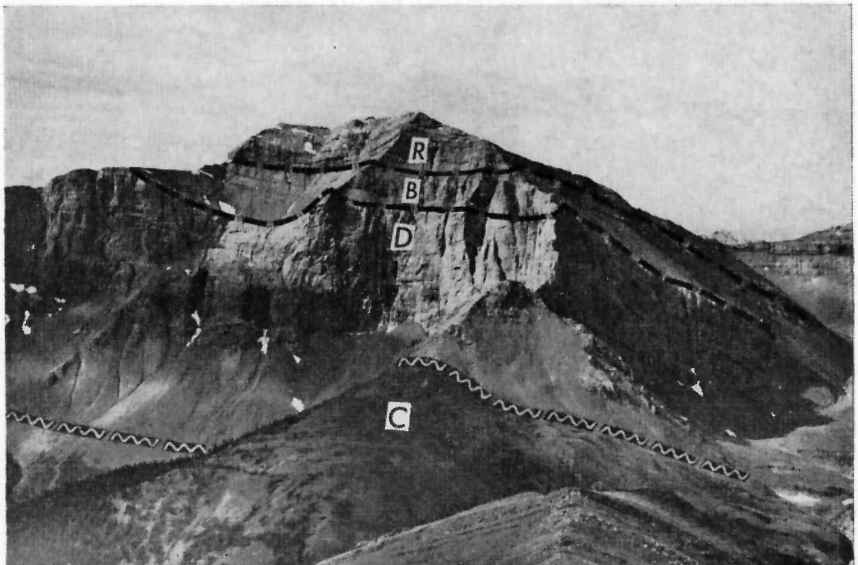
100968

B. *Palliser and Alexo Formations of Devonian age are overthrust onto Lower Cretaceous strata in this view northwest near the head of Little Berland River, Alberta.*


1-7-47 E.J.W.I.

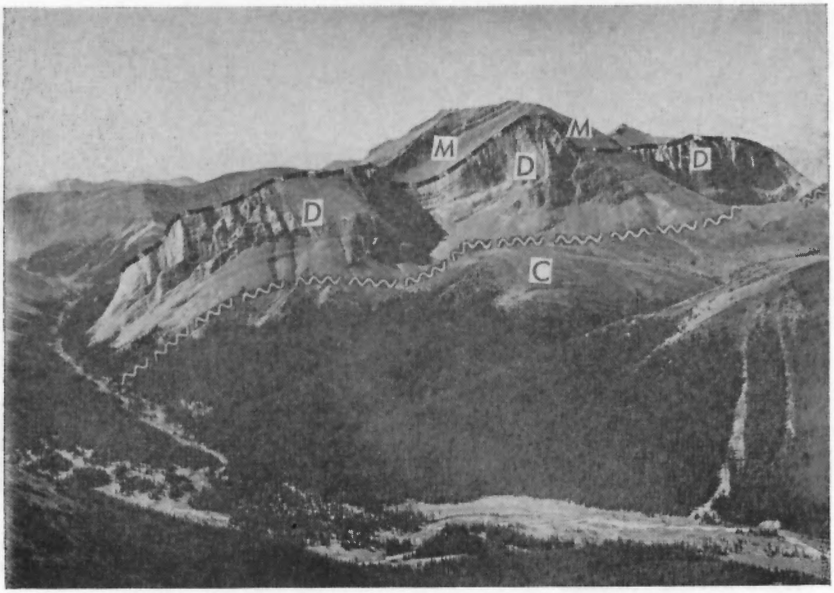
A. *View north showing steeply dipping back-limb thrust faults and repetitions of strata on the southwest side of the Berland Range, Alberta. R indicates the Rundle Group, and T the Triassic Sulphur Mountain Formation.*

**PLATE IV**




100970

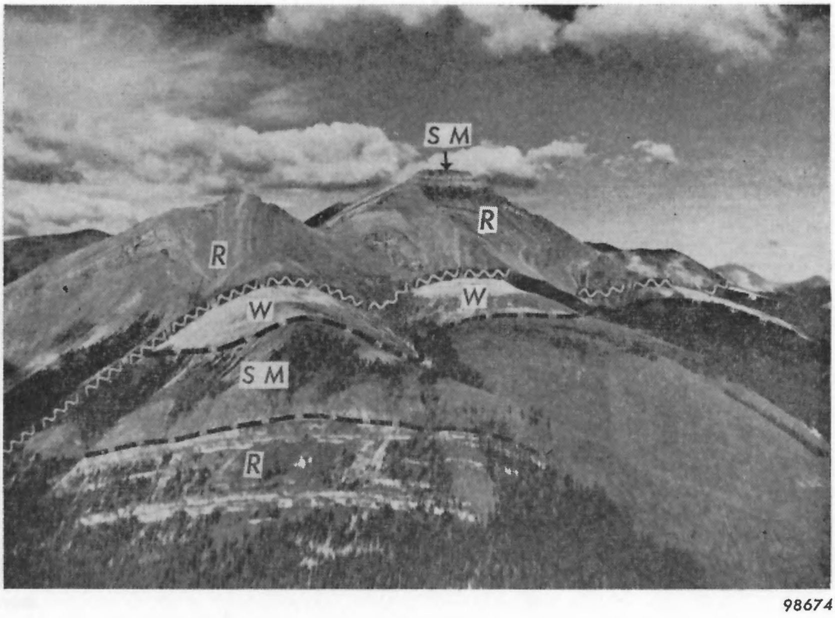
B. *On Tip Top Mountain near the head of Little Berland River, Alberta, the Rundle Group (R), Banff Formation (B), Devonian (D) and Cretaceous (C) are exposed on the northeast-facing scarp above the Tip Top thrust fault, seen here from the west.*




100101

A. *The Devonian Palliser, Alexo and Mount Hawk Formations (D) and Mississippian strata (M) are thrust to the northeast on the Tip Top fault over Lower Cretaceous formations (C) as seen here in the scarp front of the Berland Range on the north side of Moon Creek.*

PLATE V



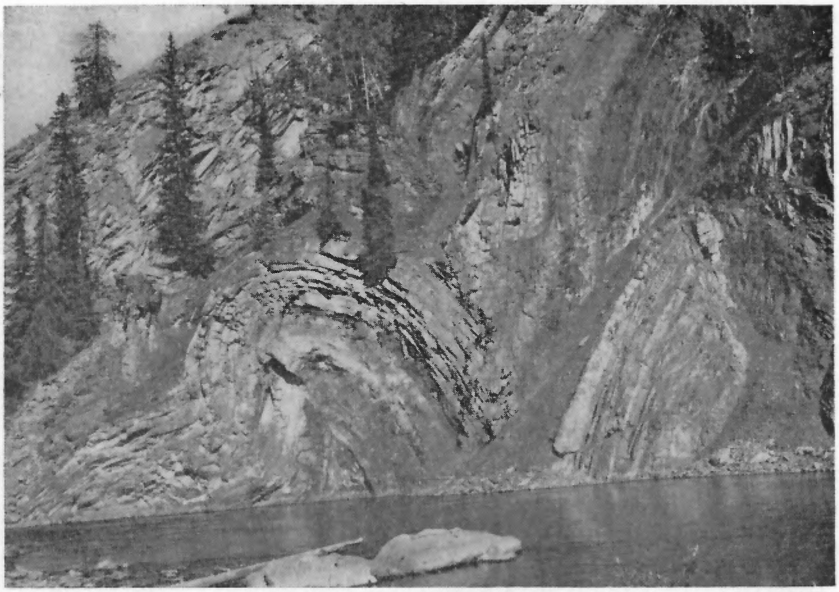

98674

B. *Northwest view of the Berland Range, northwest of Moon Creek, showing a drag anticline on a back-limb thrust above the Hoff anticline, Hoff Range, Alberta. SM indicates the Sulphur Mountain Formation, R the Rundle Group, and W the Whitehorse Formation.*

2-7-47 E.J.W.I.

A. *Contorted beds of the Lower Cretaceous Nikanassin Formation near the mouth of Carson Creek in the Thoreau Creek Basin between the Berland and Persimmon Ranges.*

PLATE VI



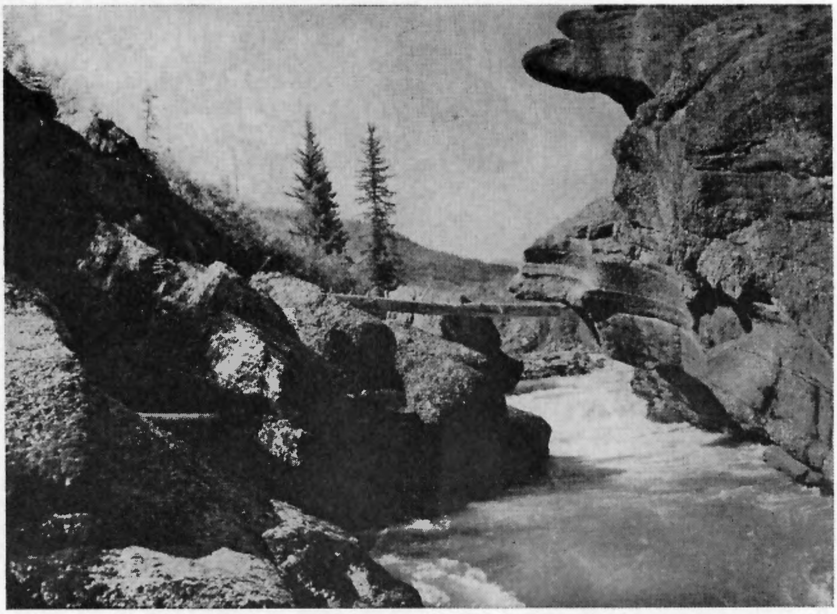
2-10-49 E.J.W.I.

B. *Faulted and folded Luscar strata 4 miles above the mouth of Sheep Creek lie just above a southwest-dipping thrust fault whose surface is about 200 yards to the right of the picture.*

2-10-52 E.J.W.I.

A. *Typical Cadomin conglomerate showing the size of pebbles and cobbles.*

PLATE VII



3-6-49 E.J.W.I.

B. *Typical gorge formed where streams cut across bands of the Cadomin Formation on Sheep Creek about 6 miles above its mouth.*

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