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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

MEMOIR 258

PIERRE GREYS LAKES MAP-AREA, ALBERTA

BY

E. J. W. Irish

OTTAWA
EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
KING'S PRINTER AND CONTROLLER OF STATIONERY
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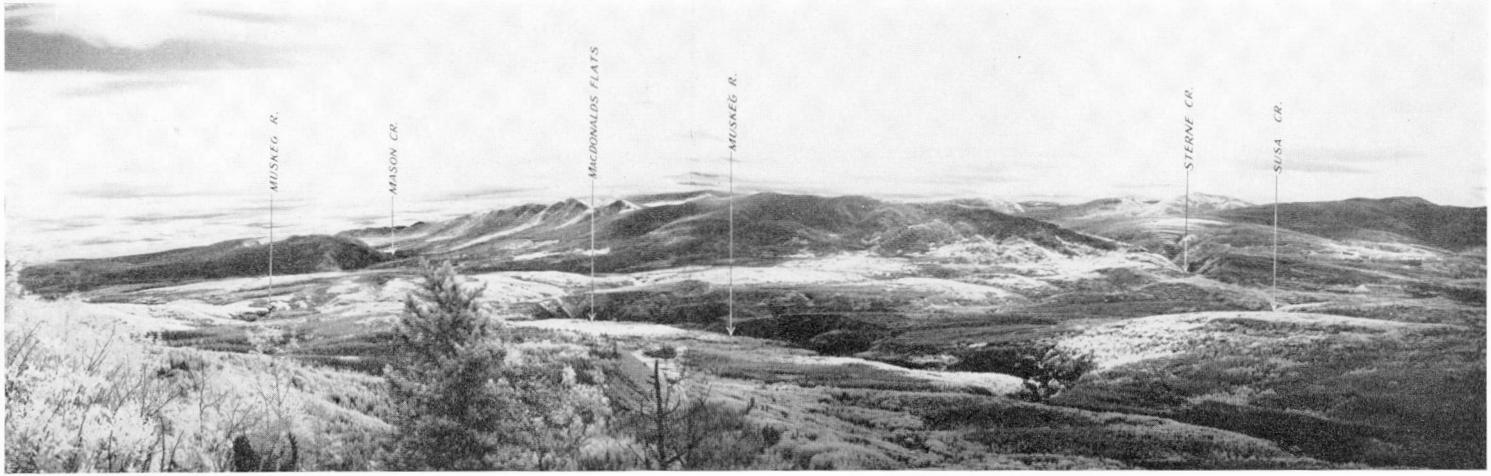

Typical topography of the western part of Pierre Greys Lakes map-area. View looking south across the valley of Muskeg River.

(Photograph by M. E. Nidd, Topographical Survey, 1946.)

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PREFACE

Pierre Greys Lakes map-area represents a cross-section of most of the Foothills belt in that part of northwestern Alberta traversed by Muskeg River. Interest has centred recently on a deep test well, sunk as a joint venture of several oil companies, on a structure known as the Muskeg anticline. The test proved unsuccessful, but provided data that should prove useful in any further exploration. The area is known to contain significant coal deposits of late Lower Cretaceous and perhaps later ages, but its relative inaccessibility may prove a handicap to their development for some time to come.

The present report deals with the physical features, stratigraphy, structure, and economic possibilities of the area. Particular attention is given to difficulties in formational nomenclature and correlation that rose as a result of a transition in the geological succession from that of areas south of Athabasca River to that of the Peace River district to the north. The report includes a detailed log of Muskeg No. 1 well, and is illustrated by a geological map, with several structure-sections, and by a figure illustrative of the main structural features of the area.

GEORGE HANSON,
Chief Geologist, Geological Survey of Canada

OTTAWA, January 31, 1950

Pierre Greys Lakes Map-Area, Alberta

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

Pierre Greys Lakes map-area, comprising about 370 square miles, is in the Foothills belt of west-central Alberta, north of Athabasca River, between latitudes 53°45′ and 54°00′, and longitudes 118°30′ and 119°00′. The nearest railway is the transcontinental line of the Canadian National, which follows the valley of the Athabasca about 60 miles south of the area. Entrance, a village on the railway about 190 miles west of Edmonton, provides the nearest store, post office, and telegraph service for an extensive region to the north and northwest.

The oil possibilities of Pierre Greys Lakes map-area have been investigated by oil companies during the past few years, because the stratigraphy and structural features are in many respects similar to those of the Foothills of southern Alberta where oil is produced. A test well, Muskeg No. 1, was drilled by arrangement among several oil companies, under the Northern Foothills Agreement, on the most promising structure in the area. Drilling was stopped in the Banff formation at a depth of 10,709 feet, and no commercial flows of oil or gas were obtained. It has since been abandoned, but the failure of this well does not entirely condemn the region for further testing.

The area may be of importance in the future because of its coal reserves. No mining has been done, but for a few years after 1916 a part of the Foothills belt north of Athabasca River, including Pierre Greys Lakes area, was intensively prospected, and many coal seams were discovered. Most of these outcrop west of this map-area, but good seams also occur within its western part.

No extensive stands of good timber occur in the Foothills between Athabasca River and the map-area, but several companies are logging both for lumber and railroad ties for some miles north of the river. Pierre Greys Lakes area contains a few, small, isolated stands of good spruce trees, but most of the area has been burned at various times and is now covered by second-growth jack pine.

ACCESSIBILITY

The nearest railway is the transcontinental line of the Canadian National, which follows the valley of Athabasca River about 60 miles south of the map-area. Although Jasper is the nearest town to the area, it is not in direct communication because of high intervening mountain

ranges. Entrance, a village on the railway about 50 miles east of Jasper, has been the outfitting point for coal prospectors, forest rangers, hunting parties, and, more recently, for exploratory geological parties representing oil companies. It may be reached by Canadian National railway or by a branch road 3 miles long that connects with the Edmonton-Jasper highway to the south. No roads existed until recently throughout the extensive territory north of Entrance and Athabasca River, but travel is facilitated by pack-trails, which are maintained by rangers of the Alberta Forest Service.

Until the summer of 1947, Pierre Greys Lakes map-area was accessible only by two main forestry trails. The more easterly route, known as the Lower trail, extended northwest from Entrance, followed the eastern edge of the Foothills and crossed the area from the east to west boundary, trending northwesterly and then westerly. In 1946 and 1947, under the Northern Foothills Agreement, a road that followed approximately the route of the lower trail was built to the site of Muskeg No. 1 well, a distance of 74 miles. This road was suitable for trucks during 1947 and 1948, but, with the abandonment of the well, may not be kept in repair, and may soon become impassable for trucks.

The more westerly route, or Mountain trail, branches from the Lower trail about a mile north of Wildhay River (about 20 miles northwest of Entrance), follows the river westward to Rock Lake, and then follows up Rock Creek to its source. Leaving Rock Creek, the trail crosses the divide and follows down Sulphur River to join the Lower trail near Smoky River a few miles west of the western border of the map-area.

The area is serviced by several branch Forestry trails and old Indian trails. Horses can be used on most of these, but boggy places are numerous where muskegs occur. All parts of the area are accessible on foot, but there are few places where horses can be taken without trails. Horses, in fact, will be the only means of transportation of both men and supplies if the Muskeg well road is abandoned.

GENERAL CHARACTER OF THE MAP-AREA

The region has a fairly moderate climate, with winter temperatures and snowfall that are not excessive. Most of the precipitation occurs as rain in the spring and early summer, the later part of the summer being generally warm and dry.

Much of Pierre Greys Lakes area was swept by forest fires years ago and is now covered by poplar and jack pine. Small stands of virgin spruce remain in some places, with here and there a few balsam fir and white birch. Where poplar predominates, the country is usually open and grassy. The ample rainfall in the spring and early summer promotes a luxuriant growth of grass and pea-vine and an abundant and varied assortment of wild flowers. Stock graze all winter in the valleys of the major streams.

HISTORY OF THE GENERAL REGION

The first recorded activities of white men in the region of which Pierre Greys Lakes area is a part are relatively recent.

Jasper National Park was established in 1907, and the Indians then residing in that district were given a choice of certain other areas outside

of the park boundary in which to re-establish themselves. Their choice of a location was at Grande Cache near a lake that now bears that name, and just east of the confluence of Sulphur and Smoky Rivers.

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

Probably very few white men had travelled through the territory north of Athabasca River prior to the cutting of pack-trails by Forestry rangers, but subsequently many white trappers entered the region. The completion of the rival Grand Trunk and Canadian Northern railways, in 1911 and 1914 respectively, and their amalgamation in 1916 as the Government-sponsored Canadian National Railways, caused fresh interest in the relatively unknown district to the north. Many of the men who entered the foothills and mountains with the construction of the railways remained to trap fur and prospect for coal in the vast territory north of Athabasca River Valley. Some of these men are still living at Entrance and other points west to Jasper. For some years after 1916 the Foothills were actively prospected for coal as far north as the Smoky River district.

More recently, there has been a renewal of interest in the region north of Athabasca River, and especially in Pierre Greys Lakes area, because of its oil and gas possibilities. The construction of 74 miles of gravel road from Entrance to Muskeg No. 1 well and the drilling of the well itself provided an incentive in opening up this northern region. Unfortunately, Muskeg No. 1 well was unproductive, and operations in the region have been suspended indefinitely.

PREVIOUS GEOLOGICAL WORK

In 1910 and 1911, D. B. Dowling (10)[1] studied the coal deposits of Jasper Park and published brief descriptions of the formations near Brûlé Lake and Moosehorn Creek. In 1916, J. M. MacVicar (29–31) examined the coal occurrences between Brûlé Lake and Smoky River. In 1925, a summary, by J. McEvoy (34), of MacVicar's work in the Smoky River coal district was published by the Dominion Fuel Board in co-operation with the Geological Survey. B. R. MacKay of the Geological Survey made a detailed study of the Brûlé coal deposits in 1927 (26), and in 1930 published the results of other coal examinations in the same district (27).

In recent years, areas in the Foothills belt north of Athabasca River have been mapped by A. H. Lang (20–23), and by E. J. W. Irish (15–17, 23).

FIELD WORK AND ACKNOWLEDGMENTS

The field work on which this report is based was done during the seasons of 1947 and 1948. In 1947, A. H. Lang mapped the northern three-quarters of the area between longitudes 118°30′ and 118°45′, and also an area in the vicinity of Muskeg No. 1 oil well. In the same year the writer mapped the southern quarter of the area between longitudes 118°30′ and 118°45′ and, in 1948, completed the mapping of the area between longitudes 118°45′ and 119°00′.

[1] Numbers in parentheses are those of references in the bibliography.

During the field season of 1947 the writer was ably assisted by E. Hall, H. G. Gammell, and G. C. Wells, and in 1948 by T. G. Perry, R. D. Hughes, and A. R. Nielsen. Dr. Lang was assisted in 1947 by T. G. Perry, R. E. Laurence, and J. E. Reid.

Both Dr. Lang and the writer are greatly indebted to many residents of the district for assistance and many courtesies, particularly to the staff of the Alberta Forestry Branch, and to Messrs. S. H. Clark, R. Neighbor, A. E. Davey, M. F. Truxler, and G. Munro. Sincere thanks are also extended to personnel of Imperial Oil Limited and the New West Construction Company.

The Mesozoic invertebrate fossils collected were identified by F. H. McLearn, and the fossil plants by W. A. Bell, both of the Geological Survey of Canada. The upper 3,090 feet of the Muskeg well were logged by Miss M. J. Quantz of the Geological Survey, and the remainder of the well by the writer.

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CHAPTER II

PHYSICAL FEATURES

TOPOGRAPHY

Pierre Greys Lakes map-area lies within the Foothills belt of west-central Alberta, and nearly two-thirds of it is characterized by northwesterly trending ridges and valleys. This northwesterly alinement becomes less noticeable toward the northeast where the high, elongated ridges give way to low, irregularly shaped hills separated by wide swampy valleys. The progressive increase in elevation and the greater regularity of the ridges toward the southwest is thought to be due partly to greater uplift nearer the Rocky Mountains and partly to the more intense folding and faulting nearer these mountains. Ridges in the northeast half of the map-area are relatively flat topped and rather poorly defined; those in the southwest half are well defined and steep sided, with narrow, rounded crests.

Timber-line is about 6,000 feet above sea-level, and the few points in the area that exceed this elevation are bare on top. Most of the ridges, however, are completely forested where not burned. The highest summit, reaching an elevation of more than 6,600 feet, is at the south boundary of the map-area on the Cabin Creek anticline (Figure 1), and parts of several other ridges rise to elevations in excess of 6,000 feet. The lowest point in the area, about 3,200 feet, is on Muskeg River in the northwest corner of the area. The maximum relief is, therefore, about 3,400 feet.

Stream valleys in the southwestern half of the area, with one or two exceptions, are roughly parallel with the ridges, but toward the northeast, where the hills are more irregular, the intervening valleys trend in various directions. Most valleys are wide and have gentle slopes, but some streams have cut deep canyons in parts of their courses.

A valley 2 or 3 miles wide extends from west to east across the map-area slightly north of its centre. In the west it is occupied by Muskeg River, and in the east by Pierre Greys Lakes and the lower reaches of Lone Teepee Creek. Another large east-west valley, in the southwest part of the area, is now occupied by the upper part of Cowlick Creek, by À La Pêche Lake, and by À La Pêche Creek. This valley joins that of Muskeg River about 2 miles west of longitude 118°45′.

A large area of swamp and muskeg lies east and south of Pierre Greys Lakes, and smaller areas occupy most of the stream valleys in the south and southeastern parts of the map-area. Small patches of floating bog were observed within some of the larger swamps, but these are relatively scarce.

DRAINAGE

All of the drainage of Pierre Greys Lakes map-area is tributary to Smoky River except for Cabin Creek in the southeast corner, which empties into Berland River, a part of the Athabasca system. The principal

streams in the area are Muskeg River and its larger tributaries, such as Susa, Sterne, Mason, Findley, Chapman, Lone Teepee, and Mahon Creeks. Other important streams include Simonette River, Cabin Creek, and Cowlick Creek. Most of the area is drained by Muskeg River and its tributaries.

Muskeg River has its source in the mountains to the south. It enters the map-area at the south boundary and flows northeast just southeast of the centre of the area to a point about 1 mile south of the fifteenth base line. From this point it flows north and northwest toward the Muskeg ranger station, and then swings west across the northern part of the area to its confluence with Susa Creek. At this point, the river makes an abrupt turn to the northwest, leaving the area near its northwest corner.

From the point where Muskeg River enters the map-area to the point in tp. 56, rge. 5, where it turns abruptly to the north, its valley is relatively wide and floored with gravel. For about 5 miles northeast of its confluence with À La Pêche Creek, large grassy flats are almost continuous at 10 to 15 feet above river level. Low terraces flank the stream. From the end of these flats to where the river enters the wide, flat, east-west valley near Muskeg ranger station, its valley is much narrower and is flanked with jack-pine terraces. From a point 7 miles west of the Muskeg ranger station to where it leaves the map-area, the river has cut a deep canyon in Upper Cretaceous strata.

Most of the major streams in the Foothills flow northeasterly normal to the trend of the structures, 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 Muskeg River the latter turns agains and flows northwesterly parallel with the formational trend.

It is probable that during some part of Tertiary time Smoky River flowed eastward through the map-area and carved the wide valley now occupied by Pierre Greys Lakes and the part of Muskeg River within the map-area, by Little Smoky River to the east of the area, and by Grande Cache and Peavine Lakes to the west of the area. At that time the ancestral Muskeg River joined the Smoky near the present site of Muskeg ranger station. During Pleistocene time this valley was filled with ice, the disappearance of which left the valley 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, thus causing the sharp bend in tp. 57, rge. 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 canyon.

In the southwestern half of the map-area the creeks form a roughly rectangular pattern; the major streams follow the structural trend, and

smaller tributaries enter nearly at right angles. Small canyons are typical of many of these latter streams.

In the northeastern half of the area the drainage pattern is much less regular, and the creeks are swampy along most of their courses.

À La Pêche, Pierre Greys, and Peavine Lakes all occupy pre-Glacial stream valleys, and probably owe their origin to damming by morainal material. These lakes are quite shallow, and lie within extensive areas of swamp and muskeg. In most places they are difficult to approach because of the bordering swamp.

Swamps and muskegs are most numerous in the eastern and southeastern parts of the map-area; some even occur on the sides of hills. Where the ridges are higher, swampy areas are usually found only on low divides between the heads of creeks.

GLACIATION

Large valley glaciers at one time undoubtedly occupied parts of the map-area, and morainal material high on the sides of the lower hills to the southeast suggests that these may have been completely covered with ice. It is not known, however, whether or not this 'ice-sheet' completely covered the higher ridges to the west and southwest, as recent erosion has obliterated any evidence of glaciation that may have existed there.

Deposits of till occur in the eastern part of Pierre Greys Lakes area, and others of poorly stratified sands and gravels, which probably represent reworked morainal material, were observed in the valleys of Muskeg River and many of the larger creeks. Limestone erratics are found on top of some of the lower hills, and a small patch of moraine was seen near the head of Cabin Creek.

No cirques, cols, or arrêtes were observed in Pierre Greys Lakes map-area.

CHAPTER III

STRATIGRAPHY

GENERAL STATEMENT

The map-area is underlain by a succession of marine and non-marine sedimentary strata ranging in age from Mississippian to, probably, Paleocene. The strata have been deformed by folding along northwesterly trending axes and by thrust faults that parallel the axes of the folds. As a result, the formations are, in general, exposed as long, relatively narrow, northwest-trending bands and tongues.

The older formations are exposed just to the north, and near the middle, of the south boundary of the area, and are faulted and complexly folded. The younger formations outcrop in the northeastern part of the area, where the folds are more gentle and faults appear to be less common.

The formations underlying the map-area are, on the whole, poorly exposed. Outcrops are sufficient in most places, however, to permit reasonably accurate location of geological boundaries, but in parts of the area these positions have had to be inferred from relatively little outcrop data, and it is probable that in such places more minor folds and faults are present than are indicated on the map. Bedrock is best exposed in the stream beds, especially where canyons have formed, but good exposures are also found on the higher ridges to the southwest. They are scarce on the lower, timbered ridges and in the large areas of muskeg and swamp.

The formations have been traced from other map-areas to the southeast, and most of them are the approximate counterparts of formations that were first studied and named in southwestern Alberta, 200 to 300 miles away. Some of the formations show remarkable similarity to those of the type localities, but others have changed lithologically to the extent that it is difficult to decide whether or not to continue to use the original names. Some formations of southern Alberta do not extend as far north as this area, and still others occur here that are not present farther south. The most noteworthy differences between the stratigraphic succession in this area and that of southern Alberta are: the absence of the Rocky Mountain quartzite; 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 Bearpaw formation, which makes it difficult to distinguish strata that in the south are mapped as Belly River and Edmonton formations.

The stratigraphic succession in the map-area shows analogies to that of the Peace River district 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.

TABLE OF FORMATIONS

Period or epoch	Formation or group and approximate thickness (feet)	Lithological subdivisions and faunal zones	Lithology
Pleistocene and Recent			Till; fluvioglacial gravel, sand, and silt; alluvium and talus
Paleocene (?)			Sandstone, shale, conglomerate, coal? (non-marine)
Upper Cretaceous	Brazeau 6,000 ±		Sandstone, shale, conglomerate (non-marine)
		Solomon member 80-100	Sandstone (marine)
	Wapiabi 1,500 –	*Baculites ovatus* zone	Shale, shaly sandstone (marine)
		Scaphites ventricosus zone	
	Bighorn 600 ±		Quartzitic sandstone, shale, sandy shale (marine and non-marine)
	Blackstone 1,800 ±	*Prionotropis* zone	Shale and minor siltstone (marine)
	Dunvegan 500 ±		Sandstone, shale, and sandy shale (marine and non-marine)
Lower Cretaceous	'Fort St. John' 400 +		Shale and sandy shale (marine)
	Blairmore group: Luscar and ? Mountain Park 2,000		Sandstone, shale, conglomerate, coal (non-marine)
	Blairmore group: Cadomin 30-100		Conglomerate
	Nikanassin 1,000 ±		Quartzitic sandstone and shale (marine and non-marine)
Jurassic	Fernie 900 ±		Shale and quartzitic sandstone (marine)
Triassic	Whitehorse 130		Limestone and dolomite; some arenaceous (marine)
	Main part of Triassic 1,000		Quartzitic sandstone and siltstone (marine)
	Disconformity		
Mississippian	Rundle (only upper part exposed) 90 +		Limestone and dolomite (marine)

MISSISSIPPIAN

RUNDLE FORMATION

Distribution and Lithology. The oldest strata exposed in Pierre Greys Lakes area are those of the upper 90 feet of the Rundle formation, which outcrops in a small area at the centre of the Cabin Creek structure (*See* Figure 1) just within the south border of the map-area. The Rundle there plunges to the northwest, and disappears beneath Triassic strata.

The exposed Rundle strata consists of thick-bedded, grey-brown to ash-grey weathering, grey to brown dolomites, containing numerous thin bands and nodular lenses of chert, small masses of white calcite, and, in some beds, numerous corals. The chert bands and calcite masses are typical of the upper strata of the Rundle formation north of Athabasca River. These strata form steep, precipitous cliffs and craggy outcrops.

The following partial section of the Rundle formation was measured on the Cabin Creek anticline:

	Thickness Feet
Overlying beds: Triassic strata	
Dolomite, dark grey, light grey weathering, thick-bedded; beds up to 3 feet thick; much white calcite in small cavities and as stringers; thin chert bands and nodules....	40
Dolomite, very fine-grained, grey, buff weathering, compact	14
Dolomite, fine-grained, light grey, light grey weathering...	5
Dolomite, fine-grained, compact, grey, grey weathering; numerous lenses and nodules of dark grey chert; a few, thin shaly weathering beds; corals.....	16
Limestone, dolomitic, fine-grained, dark grey, light grey weathering; contains large and small nodules of white calcite; corals and brachiopods present.....	11
Dolomite, fine-grained, very hard, dark grey, buff to brown weathering; small calcite-filled vugs very numerous; weathered rock presents a 'honeycomb' appearance....	6
Total thickness exposed.....	92
Underlying beds: covered	

Palæontology. Few fossils except corals occur in the upper part of the Rundle formation in Pierre Greys Lakes map-area, but these are prolific in some beds. Scattered brachiopods and some crinoid plates were seen on weathered surfaces, but these, now altered entirely to white calcite, are difficult to break out of the fresh rock. The following forms were collected:

Corals
- *Triplophyllum minnewankensis* Shimer
- *Syringopora aculeata* Girty

Crinoids
- Fragmentary plates not identified

These forms indicate a Mississippian age for the Rundle formation, but are not diagnostic.

TRIASSIC

GENERAL STATEMENT

In 1924, Kindle (18) proposed the name 'Spray River formation' for the Triassic strata in Bow River Valley previously called the 'Upper Banff shale'. This name was adopted by Shimer (43) and Warren (44), and its use was extended to Jasper Park by Allan, Warren, and Rutherford (5). Warren 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 laminated shale and limestone containing Lower Triassic fossils. The Whitehorse member, named from Whitehorse River near Cadomin, Alberta, consists of sandy limestone and dolomite, and contains Middle Triassic fossils.

In those Foothills areas that have been mapped north of Athabasca River, 80 to 150 feet of limestone and sandy limestone at the top of the Triassic section contains a Middle Triassic fauna. These limy beds are correlative with Warren's Whitehorse member of the Spray River formation, and have previously been mapped as that member. However, in map-areas north of Athabasca Valley, the Triassic strata lying below the Whitehorse 'member' and above the Mississippian Rundle formation consist of hard, quartzitic siltstone and fine-grained sandstone, which have yielded no diagnostic fossils by which their age might be determined. It is evident that these beds do not resemble the Sulphur Mountain member of Warren lithologically, and that they resemble that member only in their analogous stratigraphic position. It is possible that future work may prove a lateral variation in lithology of this part of the Triassic section and, also, may provide evidence by which the age of these strata can be determined. For the present, however, it has seemed best to leave them unnamed until more information has been obtained. They are referred to in this report and on the accompanying map as 'the main part of the Triassic section'. Nor, as these quartzitic beds comprise about nine-tenths of the Triassic assemblage in the Foothills north of Athabasca River, and as they cannot be correlated with the Sulphur Mountain shale and limestone member of the Spray River formation south of the river, does it seem appropriate to continue to use this formational name. It has, therefore, been omitted from the accompanying map, and is not used for the Triassic assemblage in the Pierre Greys Lakes map-area.

On the other hand, the limestone lying above the 'main part of the Triassic section' is a persistent map-unit, in part at least of Middle Triassic age, and with only slight variations in lithological characteristics, that extends from its type locality near Cadomin, Alberta, northwestward at least as far as Smoky 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 in this report and on the accompanying map.

In Pierre Greys Lakes map-area, the Triassic assemblage lies disconformably on the eroded surface of the Rundle formation, and in nearby map-areas to the southeast a limestone conglomerate 2 inches to 2 feet thick forms the base of the series. In the present map-area, this lower

contact is not exposed, and the conglomerate was not observed. Enough information was obtained, however, to establish definitely the presence in the map-area of the two distinct lithologic units, the Whitehorse formation and the underlying sandstone and siltstone.

MAIN PART OF THE TRIASSIC SECTION

Distribution and Lithology. Strata of Triassic age outcrop only in the south-central part of the map-area, where four small areas are underlain by these rocks. Three of the four areas occur in the Cabin Creek structure (*See* Figure 1) where erosion of the northwest-plunging, complex fold has exposed the beds as small isolated patches. The fourth area is on the northwest-plunging anticline that is adjacent on the west to the Cabin Creek structure. The beds are poorly exposed in all four areas.

The main part of the Triassic section consists of very fine-grained, hard, grey, red-brown weathering sandstone and siltstone, a few beds of which are somewhat argillaceous and some calcareous. The whole assemblage becomes calcareous toward the top. Most of these strata are thin bedded and platy weathering, but in places beds are up to 2 feet thick. Where weathered, the red-brown colour and thin, slabby nature of the rocks are distinctive.

About 40 feet only of these beds are exposed in Pierre Greys Lakes map-area, but in Moon Creek map-area to the southeast a thickness of about 1,000 feet was obtained for this part of the Triassic assemblage.

Age and Correlation. No diagnostic fossils have been obtained from these beds and, consequently, no definite age has been assigned to them. For this reason, and because of their different lithological characteristics, they are not correlated here with the Sulphur Mountain member of the Spray River formation although they occupy a similar stratigraphic position.

It should be noted, however, that Warren (44) has described beds of the Sulphur Mountain member of the Spray River formation in the Rocky Mountains along Athabasca Valley whose lithological characteristics are similar to those at the type locality for that member. It may be, therefore, that a change in lithology occurs from west to east, at least in that area between Athabasca and Smoky Rivers.

WHITEHORSE FORMATION

Distribution and Lithology. The siltstone and fine-grained sandstone of the main part of the Triassic section are overlain conformably by the Whitehorse formation, the distribution of which is identical with that of the underlying arenaceous beds. The Whitehorse consists of 80 to 150 feet of grey to white, buff, cream, and light grey weathering limestone and dolomite, some of which is sandy. Some beds are hard, compact, and brittle; others are soft and porous; and beds of hard, grey, light grey weathering limestone and dolomite resembling parts of the Rundle formation were seen in several places. Small cavity fillings of white calcite are very common, and these when weathered give to the beds a 'honeycomb' appearance.

The Whitehorse formation is 110 feet thick in Pierre Greys Lakes map-area. It is an excellent horizon marker, not only because of its

lithology, but also because its cream-white colour when weathered is conspicuous between the underlying red-brown arenaceous beds and the overlying black shales of the Fernie group.

Age and Correlation. No fossils were found in the Whitehorse formation in Pierre Greys Lakes map-area. In Moon Creek map-area (17) to the southeast, poorly preserved ammonites collected from the lower part of the formation were assigned a Middle Triassic age by F. H. McLearn. Therefore, the formation can be identified, at least in part, with the Whitehorse member of the Spray River formation.

THICKNESS OF TRIASSIC SECTION

No complete section of the Triassic assemblage could be measured in this map-area, but a composite section farther to the southeast (17) measured about 1,100 feet thick, of which the Whitehorse formation accounted for 100 feet and the underlying arenaceous strata for the remaining 1,000 feet.

The following partial section was measured on the Cabin Creek anticline at the south border of the Pierre Greys Lakes map-area.

	Thickness Feet
Overlying beds: Fernie group	
Limestone and dolomite, hard and soft, grey to white, white to cream weathering; some sandy beds porous and some compact	110
Siltstone, fine-grained, grey, buff weathering; very calcareous	10
Siltstone, fine-grained, very hard, dark grey, red-brown weathering, thin-bedded, platy; a few beds of silty limestone	30
Total thickness exposed	150
Underlying beds: covered	

JURASSIC

FERNIE GROUP

Distribution and Lithology. The Whitehorse formation is overlain, apparently conformably, by strata of the Fernie group.

Rocks of the Fernie group underlie a large area in the Cabin Creek structure (*See* Figure 1) and two smaller areas to the west on the noses of two, northwest-plunging anticlines. They also underlie two other small areas farther to the northwest, where erosion has exposed Fernie strata in the Susa Creek anticline (*See* Figure 1), one where Susa Creek cuts through the fold, and the other where the same fold is cut through by the west fork of Mason Creek. In all of these areas exposures are poor.

The lower part of the Fernie group consists mainly of black, fissile shale and silty shale, but near the base of these strata are several beds of extremely hard, brittle, cherty rocks, and some that are calcareous. Numerous concretionary, yellow weathering, ironstone bands were observed in the lower 300 feet of shale. Upward in the group, dark grey, silty shale predominates over the black fissile type, and quartzitic sandstone beds become more numerous. Toward the top of the formation, hard, grey, quartzitic sandstone becomes the predominant rock type, though some grey shale is interbedded with it.

The Fernie group is gradational upward into the overlying Nikanassin formation of Lower Cretaceous age, the uppermost beds of the Fernie being similar lithologically to the lower strata of the Nikanassin. For this reason and to facilitate field mapping, the contact between the two has been placed, arbitrarily, at the base of the first bed of massive, quartzitic sandstone having a thickness of 20 feet or more.

Thickness and Measured Sections. No complete section of the Fernie group is exposed in Pierre Greys Lakes map-area, but the following partial sections were measured on the Cabin Creek anticlinal structure at the south border of the area:

	Thickness Feet
Overlying beds: Nikanassin formation	
Sandstone, grey, hard, siliceous; one or two black shale partings up to 2 inches thick	26
Sandstone, hard, siliceous, grey, buff weathering; minor amounts of silty shale in beds up to 5 inches	10
Shale, silty, dark grey; with many ribbons of grey sandstone about 4 inches thick	25
Total thickness exposed	61
Underlying beds: covered	
Overlying beds: covered	
Shale, black, fissile; contains two nodular ironstone bands about 1 foot thick	21
Shale, black, fissile; several beds up to 1 foot thick of black, hard, fine-grained, siliceous rock; some calcareous shale	15
Total thickness exposed	36
Underlying beds: Whitehorse formation	

In Moon Creek map-area (17) to the southeast, a thickness of approximately 900 feet was obtained for the Fernie group.

Age and Correlation. A few poorly preserved specimens of *Aucella* of undetermined species and two fragments of belemnite guards were collected from the lower shale beds. These forms indicated no more than a general Jurassic age, but Fernie strata southeast of this area (21) have yielded fossils that have been identified as of early Middle Jurassic age. Many belemnite guards were also obtained from these beds in Moon Creek map-area (17) to the southeast.

The name 'Fernie shale' was first applied by Leach (24) to Jurassic shales in the Crowsnest Pass region that had formerly been grouped with the Kootenay, but he did not strictly define their limits. Warren (45) pointed out that the Fernie appears to pass upward into the Kootenay or Kootenay equivalent by the intercalation of sandstone beds, but that a hiatus is probably present because the highest fauna so far obtained in the Fernie was of middle Upper Jurassic age. The term has been extended by several workers to designate Jurassic strata as far north as Athabasca Valley, and has included strata of different lithological characters and of different Jurassic epochs. It is used, therefore, in this report, according to the present practice of the Geological Survey of Canada, as designating a group rather than a formation.

LOWER CRETACEOUS

GENERAL STATEMENT

The thick succession of Lower Cretaceous sediments overlying the Jurassic strata represents the northern continuation of the Kootenay and Blairmore strata of southwestern Alberta.

In southwestern Alberta the Lower Cretaceous strata have been divided into the Kootenay formation and the overlying Blairmore group, the base of the latter being placed at the base of a prominent conglomerate bed referred to as the Blairmore conglomerate. A summary of the development of this nomenclature is given by Lang (21, p. 23).

In the central Foothills it was found that the commercial coal seams lay above a conglomerate bed equivalent in age to the Blairmore conglomerate, that is, they occur in beds of Blairmore rather than Kootenay age. This has been found to hold true for the central and northern Foothills as far north as surface geological mapping has progressed. In the Mountain Park area, MacKay (28) named the strata lying between the Fernie and Blairmore conglomerate the 'Nikanassin formation' and the coal-bearing beds above it the 'Luscar formation'. Despite its relative thinness, he named the conglomerate at the base of the Luscar the 'Cadomin conglomerate', and on later maps he used the term 'Cadomin formation' because it outcrops prominently and is an important horizon marker in coal prospecting. 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.

In 1927, MacKay (26) mapped a small area at Brûlé and extended the use of the names Nikanassin, Cadomin, and Luscar to the Lower Cretaceous rocks of that area, but was unable definitely to recognize the Mountain Park formation.

The formational names given to the Lower Cretaceous strata by MacKay have been extended northward 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 containing no coal seams do overlie the typical coal-bearing part of the Blairmore group, and these strata may correspond in age to the Mountain Park. For this reason, and following the present practice in reports on Foothills areas north of Athabasca River, strata lying between the Cadomin formation and 'Fort St. John' group have been mapped as Luscar and (?) Mountain Park formations.

NIKANASSIN FORMATION

Distribution and Lithology. The Nikanassin formation overlies the Fernie group conformably. It occurs only in the southwestern half of the map-area, as long, narrow, irregular bands and patches that have been exposed by erosion of anticlinal ridges. The most northerly exposures of these beds are on the ridge formed by the Susa Creek anticline (*See* Figure 1). Southwest and south of this anticline, Nikanassin strata underlie a large area on the ridges formed by the composite Cabin Creek

structure, and on the three anticlinal noses that form the northwest continuation of this structure. Still farther southwest, Nikanassin beds are exposed in several less persistent and less regular anticlinal folds.

In Pierre Greys Lakes map-area, an arbitrary boundary between the Fernie group and Nikanassin formation has been adopted to facilitate field mapping. This boundary has been placed, as in nearby areas to the southeast (17, 21), at the base of the lowest sandstone bed having a thickness of at least 20 feet. It should be understood that this is a purely arbitrary division, and that the lack of fossils in the lower, marine beds of the section included with the Nikanassin allows the possibility of these beds being of Jurassic age.

The strata, with the exception of some beds at the base of the formation, consist of non-marine, hard, grey, quartzitic sandstones that weather buff, brown, and grey. Interbedded with them are minor amounts of grey and black shale. Grey and brown, buff weathering sandstone, grey, silty shale, and thin coaly beds predominate in the upper part of the formation.

In some places in this map-area, where the Nikanassin formation was seen in contact with the overlying Cadomin formation, the uppermost stratum of the Nikanassin is a 6-inch to 1-foot bed of black, carbonaceous, silty shale. Elsewhere this shale is missing, indicating a possible erosional disconformity at the top of the Nikanassin.

Thickness and Section. No complete section of the Nikanassin was observed in Pierre Greys Lakes map-area, but a graphical measurement of the stratigraphic interval between the arbitrary base of the formation and the overlying Cadomin formation provides an estimate of 1,000 feet for the Nikanassin formation in this area. In Moon Creek map-area about 5 miles to the southeast (17), the Nikanassin measured 904 feet where it is exposed on Berland River.

The following partial section of the Nikanassin formation was measured where Mason Creek cuts through the Susa Creek anticline:

	Thickness Feet
Overlying beds: covered	
Shale, silty, grey	6
Sandstone, fine-grained, hard, brown, yellow weathering	3
Shale, black, fissile	10
Sandstone, hard, fine-grained, quartzitic, grey, grey weathering	30
Shale, silty, dark grey; interbedded with hard sandstone bands up to 1 inch thick	10
Sandstone, hard, fine-grained, banded, thin-bedded, dark grey to brown weathering	50
Sandstone, hard, quartzitic, massive, light grey, grey weathering	16
Total thickness exposed	125
Underlying beds: Fernie group	

Age. The strata mapped as Nikanassin correspond with those so mapped by the writer in the Moon Creek map-area (17); by Lang (21) in the

Entrance and Brûlé areas; and by MacKay (26) at Brûlé. No recognizable fossils were found in the formation in Pierre Greys Lakes area. In areas south of Athabasca River, fossil plants found in the upper part of the Nikanassin are considered to be equivalent to the Kootenay flora. In Moberly Creek area (22) the lower part of the formation contains marine fossils that may be of Jurassic age.

CADOMIN FORMATION

The Cadomin formation lies stratigraphically above the Nikanassin. In Pierre Greys Lakes area it forms a long, narrow, sinuous band on either flank of most of the larger anticlinal folds, and may extend around one or both ends of these structures depending on their angle of plunge. The formation usually outcrops boldly, and for this reason is an excellent horizon marker. It is exceptionally useful in this area because of the way it outlines minor structures on the major folds.

The Cadomin is a hard, closely packed, and well-cemented conglomerate. The pebbles are well rounded, commonly ovoid, consisting chiefly of black, green, and grey chert, and pink, light grey, and white quartzite. They range from $\frac{1}{4}$ inch to 5 inches in size, but most of them are 1 inch to 2 inches in diameter. The matrix is siliceous, and so consolidated that the rock generally fractures across the pebbles rather than around them.

The thickness of the formation ranges between 30 and 100 feet, but in most places is between 50 and 75 feet. In most exposures in the map-area the conglomerate includes lenses and beds of hard, grey, quartzitic sandstone; and carbonized wood may be seen here and there in small fragments and lenses. An exposure where Sterne Creek crosses the Susa Creek anticline (*See* Figure 1) shows two distinct conglomerate bands, each about 35 feet thick, separated by 30 to 50 feet of sandstone and sandy shale. This division into two bands of conglomerate was also noticed where the formation crosses the headwaters of Sterne Creek, but a single band is more common in this area. Considerably more sandstone is present in the formation than in map-areas farther southeast. The variations in thickness of the conglomerate may be due partly to irregularities in the underlying floor, but there is not sufficient evidence in this map-area to prove a large erosional disconformity between the Nikanassin and Cadomin formations. MacKay (26) reports a disconformity at the base of the Cadomin near Brûlé.

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

LUSCAR AND (?) MOUNTAIN PARK FORMATIONS[1]

Distribution and Lithology. Luscar strata overlie the Cadomin conformably, and occupy the greater part of the southwestern half of the map-area south of the Susa Creek anticline. Directly northwest of the

[1] A query is used in this heading because of the uncertainty of the continuation of the Mountain Park formation or its equivalents into Pierre Greys Lakes map-area. In the following account the term 'Luscar formation' will, unless otherwise noted, be used to include any possible overlying Mountain Park strata or their equivalents.

Cabin Creek structure is an extensive area that has been mapped as underlain by Luscar, but, because much of this region is drift covered, it may be that structures there, more complex than those indicated, have brought other formations to the surface. Excellent exposures of Luscar beds occur on Sterne Creek and on the west fork of Mason Creek, but it is difficult to ascertain the true thickness of the formations because of considerable repetition due to close folds and numerous faults. Other good exposures were observed on the first south-flowing tributary of Cowlick Creek, east of the west boundary of the map-area, and on the north-flowing tributary of Cowlick Creek just east of the Mountain trail.

Rocks of the Luscar formation are considered to be of non-marine and brackish-water origin. The upper part of the section, which may represent the Mountain Park formation, consists mainly of 300 to 350 feet of fine-, medium-, and coarse-grained, grey and greenish grey, buff weathering, thick-bedded sandstones. Interbedded with these are minor amounts of grey shale and siltstone. Carbonized plant fragments are common in many of the sandstone beds.

Below the strata just described are typical Luscar beds, which consist of fine- to medium-grained, grey and brown, buff, brown, and grey weathering sandstone; grey, greenish grey, and black shale; coal seams, ranging in thickness from 6 inches to 10 feet; and thin, yellow weathering ironstone bands generally associated with shale. Conglomerate is scarce except toward the base of the section, but some of the coarse sandstone beds contain scattered pebbles.

On both Sterne and Mason Creeks the lower 200 feet of the Luscar formation includes a discontinuous, 20-foot zone of conglomerate and pebbly sandstone. The pebbles are 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 Luscar formation shows lateral variations in lithology within relatively short distances, but the general character of the sediments is maintained over large areas.

Thickness and Sections. No complete section of the Luscar formation is exposed within the map-area, but the total thickness was estimated graphically on structure-sections to be about 2,000 feet.

The following section was measured on the first north-flowing tributary of Cowlick Creek east of the Mountain trail.

	Thickness Feet
Overlying beds: covered	
Sandstone, fine-grained, hard, dark grey; weathers light grey to buff, thin-bedded, calcareous	8·3
Shale, silty, grey, grey weathering; carbonaceous in places; 2-foot coal seam near top	28·5
Coal	5·0
Shale, silty, grey-brown, grey weathering; 8-inch ironstone bed near top	25·1
Sandstone, hard, medium- to coarse-grained, grey-buff to brown weathering; thin-bedded to platy; some finely laminated	10·0

	Thickness Feet
Shale, siltstone, and sandstone; interbedded, mostly grey weathering; some bands brown weathering; plant remains	73·6
Sandstone, fine and coarse bands interbedded; grey, grey and buff weathering	74·7
Covered; mainly silty sandstone with some yellow weathering ironstone bands	94·1
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
Sandstone, hard, fine-grained, dark grey, yellow weathering, very calcareous	13·9
Sandstone, hard, fine-grained, greyish brown, buff weathering, calcareous	4·6
Sandstone, hard, fine-grained, grey, buff weathering, finely laminated and crossbedded, very calcareous; no plant remains	13·1
Sandstone, fine-grained, brownish grey; buff weathering	12·1
Conglomerate; pebbles of chert and quartzite up to ½ inch	0·5
Sandstone, fine-grained, brownish grey, buff weathering	6·0
Sandstone, medium- to coarse-grained, brownish grey, buff weathering; thin-bedded, hard	16·6
Shale, silty, dark grey to black	9·2
Sandstone and shale, in beds up to 3 feet thick; brown weathering	31·1
Sandstone, medium-grained, grey, buff weathering, thin-bedded to platy	27·4
Shale, dark grey; some silty bands; brackish-water pelecypods	17·7
Sandstone, fine-grained, grey; a few thin shale bands	11·6
Sandstone, fine-grained, grey, hard, laminated	11·9
Shale, silty, brownish grey to chocolate-brown; a few, thin, grey sandstone bands	17·9
Sandstone, fine-grained, platy, brownish grey, buff weathering; some interbedded dark grey shales; plant stems common	11·4
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
Sandstone, fine-grained, hard, grey, grey weathering	12·1
Shale, silty, grey to black; some carbonaceous	12·6
Sandstone, fine-grained, very hard, grey, grey weathering, slightly calcareous	23·1
Covered	19·6
Siltstone, fine-grained, brownish grey and brown weathering; contains plant remains	21·8
Shale, silty, brownish grey; interbedded carbonaceous shale	3·7
Siltstone, fine-grained, brownish grey, brown weathering, finely laminated and platy weathering, slightly calcareous	3·9

	Thickness Feet
Sandstone, silty, fine-grained, grey and grey weathering; carbonized plant remains throughout and 2 feet of dark grey carbonaceous shale with ½-inch coal lenses near the base	15·4
Sandstone, grey, grey to buff weathering, fine-grained; small conglomerate lenses with pebbles up to ¾ inch in diameter; scattered wood fragments; slightly calcareous	31·0
Total thickness exposed	764·2

Underlying beds: Cadomin formation

The following section was measured on the first south-flowing tributary of Cowlick Creek east of the west boundary of the map-area.

Overlying beds: 'Fort St. John' group	Thickness Feet
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
Sandstone, hard, massive, siliceous, crossbedded, medium- to coarse-grained, grey, grey weathering; some carbonized plant stems and a few scattered pebbles	83·3
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
Sandstone, coarse-grained, thick-bedded, grey, grey weathering; carbonized plant stems; scattered pebbles	30·0
Shale, silty, greenish grey, greenish grey weathering; minor, interbedded, black, carbonaceous shale	36·2
Covered	30·0
Sandstone, fine-grained, grey, grey weathering	10·2
Shale, silty, greenish, grey-green weathering; 1 foot of coaly shale at top; poorly preserved plant remains	10·0
Sandstone, fine-grained, grey, buff weathering; with interbedded silty sandstone and shale; plant remains common	63·4
Shale, grey-green; somewhat concretionary	27·8
Shale, coaly	3·8
Coal	2·4
Shale, silty, dark grey; minor grey sandstone beds up to 1 foot thick	26·4
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
Siltstone, fine-grained, grey; interbedded with grey-green, silty shale	11·0
Coal	1·8
Sandstone and interbedded shale; sandstone, fine-grained, grey; shale, greenish	56·5
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

	Thickness Feet
Shale, silty, dark grey to black, containing three coal seams about 1 foot thick	7·0
Sandstone, medium- to coarse-grained, hard, grey, buff weathering; very calcareous; poorly preserved plant remains	30·0
Covered; probably silty shale	18·9
Sandstone, fine-grained, hard, dark grey, grey to buff weathering, very calcareous	36·8
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
Covered	67·2
Shale, grey; some thin, grey siltstone bands	12·0
Covered	104·3
Sandstone, fine-grained, dark grey, grey weathering, carbonaceous in places	10·3
Covered	49·5
Sandstone, coarse-grained, hard, massive, grey, grey weathering	24·6
Sandstone, silty, fine-grained, grey to dark grey; interbedded with grey shale; all very poorly exposed	260·7
Total thickness exposed	1,813·7

Underlying beds: covered

Palæontology and Age. Plant remains are common in the Luscar strata, but well-preserved material is difficult to obtain. Fauna is scarce.

The following fossil plants were collected from the most westerly, south-flowing tributary of Cowlick Creek:

Ferns
- *Coniopteris brevifolia* (Fontaine)

Conifers
- *Athrotaxites ungeri* Halle
- *Elatides dicksoniana* Heer

These species are considered by W. A. Bell to indicate an Aptian (early upper Lower Cretaceous) age, and are typical of the Luscar formation.

Besides the flora listed above, numerous very small and fragile pelecypods were collected from dark grey shale on both creeks where the preceding sections were measured. These fossils were identified by F. H. McLearn as unionids and probably indicate brackish-water conditions.

'FORT ST. JOHN' GROUP

Distribution and Lithology. Lying conformably above the Luscar formation is about 400 feet of dark grey to black shale, much of which is silty. No fossils were found in this shale, but its stratigraphic position below the Dunvegan formation suggests that it is equivalent in age to

part of the Fort St. John group of the Peace River district. It is also probable that the 'Fort St. John' of this area is equivalent in age to the lower part of the Blackstone formation as mapped in areas south of Athabasca River where the Dunvegan is missing. This point is taken up more fully in the description of the early Upper Cretaceous series.

The 'Fort St. John' shale is brought to the surface mainly in the southwestern half of Pierre Greys Lakes map-area. In nearly all places it occurs as long, narrow bands or tongues on the flanks or on the noses of plunging anticlines, or in synclines. The most northerly occurrence of this shale occupies the centre of an anticlinal structure just north of the Susa Creek anticline (*See* Figure 1) at the western border of the map-area. Probably the largest area underlain by this shale is on the complex anticlinal structure that is cut by both Muskeg River and Mahon Creek and that lies just northeast of the Mason fault. Smaller areas lie southeast of this fault.

The section consists mainly of about 400 feet of dark grey to black, silty shale. Between 15 and 35 feet above the base is a zone of dark grey, medium-grained, hard sandstone beds ranging in thickness between 1 foot and 6 feet. These are interbedded with thin shale bands.

The most complete exposure of the 'Fort St. John' group occurs on the south-flowing tributary of Cowlick Creek close to the western boundary of the map-area.

Age and Correlation. No fossils were found in these beds except fish scales, but the stratigraphic position of the beds below the Dunvegan formation suggests that they represent some part of the Fort St. John group of the Peace River district. The shales would, therefore, be of Lower Cretaceous age.

EARLY UPPER CRETACEOUS

GENERAL STATEMENT

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 (14), and was divided into Upper and Lower Alberta formations separated by the relatively thin 'Cardium sandstone'. Malloch (32), when mapping the Bighorn coal basin, gave the name 'Bighorn' to a sandstone unit that is of the same age, although thicker, than the typical 'Cardium' beds. He named the shales below the Bighorn the 'Blackstone' and those above it the 'Wapiabi'. These formational names are now in general use throughout the Foothills belt of Alberta, and have, from the beginning, been regarded as representing strata of Upper Cretaceous and, in general, early Upper Cretaceous age. The upper part of the Blackstone is of Colorado age, according to American nomenclature, and contains abundant *Inoceramus labiatus* as well as other fossils of the '*Inoceramus labiatus* zone'. The lower part of the formation contains few fossils; it has generally been considered to be of early Upper Cretaceous (Colorado) age, though this consideration has been based rather on lithological continuity with the upper part than on its sparse fossil content. Above the Blackstone, the relatively sandy Bighorn formation contains, in its upper

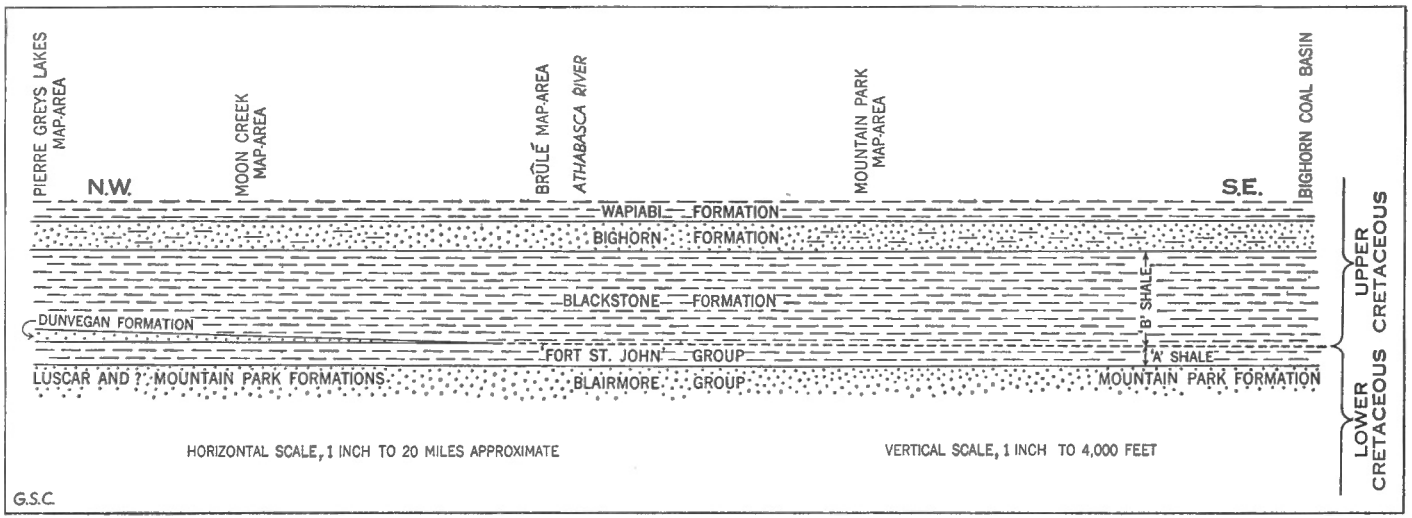

Figure 2. Diagrammatic sketch illustrating the relationship between the Bighorn formation, Blackstone formation, Dunvegan formation, and 'Fort St. John' group.

part, the diagnostic fossil *Cardium pauperculum*, also indicative of Colorado time. The succeeding Wapiabi formation is divisible into a lower, *Scaphites ventricosus* zone and an upper, *Baculites ovatus* zone, the former of Colorado age, the latter indicating a transition from Colorado to Montana time (48).

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 strata comprise the Dunvegan formation, which attains a thickness of 1,100 feet and overlies the Lower Cretaceous Fort St. John group. It is overlain, in turn, by the Smoky group, which is thought to have roughly the same stratigraphic range as the Alberta group of the southern Foothills and corresponding with the Blackstone, Bighorn, and Wapiabi formations of Athabasca Valley. At its base a series of dark marine shale forms the Kaskapau formation. This is overlain by the relatively thin Bad Heart sandstone formation, which is succeeded in turn by an unnamed series of marine shales.

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 this report the writer has continued to use the southern nomenclature as far as possible rather than that of Peace River district, until further stratigraphic and palæontological evidence is obtained and definite correlations can be established.

In the foothills region south of Athabasca Valley, the stratigraphic interval above the Blairmore group and below the Bighorn formation is occupied by a succession of mainly dark marine shales to which the name Blackstone formation has been applied, and which has been 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* Figure 2). There, a basal section, about 400 feet thick, overlying the Luscar and (?) Mountain Park beds of the Blairmore group, is composed of black, marine shales from which fossils recently collected by R. Thorsteinsen for the Geological Survey appear to indicate a Lower Cretaceous age, equivalent to that of some part of the Fort St. John group of the Peace River district. Northwest from Brûlé map-area (21), this marine shale is overlain by a gradually thickening wedge of sandstone, partly at least of marine origin, about 300 feet thick where it reaches Pierre Greys Lakes map-area. From this sandstone, fossils characteristic of the basal Upper Cretaceous Dunvegan formation have been collected, and the similarity in lithology to that formation, which is widespread in the Peace River country, leaves no alternative but to identify the sandstone of the Brûlé-Pierre Greys Lakes region as Dunvegan. 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 (*See* 'B' shale, Figure 2). The shales are succeeded by the Bighorn formation, which in the adjacent Moon Creek map-area carries specimens of the diagnostic fossil species *Cardium pauperculum*.

The 'Fort St. John' shales of Pierre Greys Lakes map-area appear to maintain a generally uniform thickness southeast to Athabasca Valley, and on the assumption that they 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 (*See* Figure 2) would be difficult or impossible. For this reason, therefore, it seems probable that for some unknown distance south of the Athabasca, including, perhaps, the original type area of the Blackstone formation of the Bighorn coal basin (32), this formation, as mapped, included some undifferentiated Lower Cretaceous marine shales of the Fort St. John group (*See* 'A' shales, Figure 2), shales that can only be separated from the overlying, dominant Upper Cretaceous beds of the Blackstone formation on fossil evidence. No information is yet available as to how far south of Athabasca Valley the northern marine seas of Fort St. John time may have extended, nor, for that matter, that they did reach any appreciable distance south of that valley. For the present, therefore, and except where fossil evidence indicates otherwise, it seems best to regard the Blackstone as an Upper Cretaceous marine formation, which, in the Pierre Greys Lakes-Brûlé region, overlies the Dunvegan and underlies the Bighorn formation, and which, in areas beyond the southeasterly extension of the Dunvegan, overlies the Blairmore group but may include some undifferentiated, Lower Cretaceous, Fort St. John shales.

In the Peace River district, the stratigraphic position of the Bad Heart formation relative to the Bighorn formation of Athabasca Valley is uncertain, and until further investigations are made and more diagnostic fossils collected it appears unsafe to identify either this sandstone or the underlying Kaskapau shale with the Athabasca succession.

DUNVEGAN FORMATION

Distribution and Lithology. The Dunvegan formation overlies the 'Fort St. John' group. Its distribution is similar to that of the 'Fort St. John', and is entirely confined to the southwest half of the map-area where it is brought to the surface as long, narrow bands and tongues on anticlinal and synclinal folds.

The formation consists of hard, fine- to medium-grained, grey sandstone, and dark grey to black, silty shale. In Pierre Greys Lakes area the Dunvegan contains nearly as much shale as sandstone, but in Moon Creek map-area, to the southeast, sandstone predominates. Crossbedding and carbonized wood fragments are common in some sandstone beds. A 6-inch bed composed almost entirely of crushed oyster shells was seen in one exposure; a similar coquina was noticed on Little Berland River to the southeast of this map-area.

The following section was measured on the first south-flowing tributary of Cowlick Creek east of the western border of the map-area:

	Thickness Feet
Overlying beds: Blackstone formation	
Sandstone, medium-grained, quartzitic, light grey, buff weathering, crossbedded; beds up to 1 foot thick.....	15
Covered.....	230
Shale, silty, dark grey; a few bands of hard, grey sandstone up to 4 feet thick.....	125
Sandstone, very hard, fine-grained, grey, grey weathering, platy; beds up to 2 feet thick; a little interbedded shale; carbonized wood.....	40

	Thickness Feet
Shale, silty, dark grey to black; a few thin, grey, sandstone beds	45
Sandstone, hard, fine- to medium-grained, grey, grey to buff weathering; in beds up to 3 feet thick; minor amounts of interbedded grey shale	75
Total thickness	530

Underlying beds: 'Fort St. John' group

On Mahon Creek, near the mouth of Isaac Creek, the Dunvegan formation seems to contain more sandstone than in the above section.

Palæontology. Specimens of *Inoceramus rutherfordi* Warren were collected from the Dunvegan where it was measured on the south-flowing tributary of Cowlick Creek just inside the west border of the area. This, according to F. H. McLearn, is a typical Dunvegan form. A collection of fossil shells from the exposure on Mahon Creek was reported by McLearn to contain *Lingula* sp. and *Corbula* sp., which he considers to represent a Dunvegan fauna.

BLACKSTONE FORMATION

Distribution and Lithology. The Dunvegan formation is overlain, apparently conformably, by the Blackstone shales, which, because they are soft, are generally poorly exposed.

The largest area underlain by the Blackstone lies between the Mason syncline and the Susa Creek anticline (*See* Map 996A and Figure 1). Toward the northwest this is a single band about 1½ miles wide, but toward the southeast two narrower bands are separated by older formations on either flank of an anticlinal structure.

Another narrow, northwesterly trending band is exposed in the southwest part of the map-area. It has a normal contact with the Dunvegan formation on the northeast and a fault contact against the Luscar formation of the southwest. Smaller areas underlain by Blackstone shale occur in both the southeast and northwest corners of the map-area.

The Blackstone formation consists almost entirely of black, fissile to thin-bedded, somewhat silty, marine shale, with numerous, interbedded, hard, grey, yellow weathering, concretionary, discontinuous ironstone beds up to 1½ feet thick. Toward the top of the formation are a few, thin, hard, grey, fine-grained sandstone beds, and at least one bed of silty limestone. A 20-foot zone at the top consists of interbedded sandstone and silty shale in beds up to 4 inches thick. Sandstone increases in amount toward the top of this zone.

Blackstone strata are well exposed on Mahon Creek just south of the mouth of Isaac Creek, and in the northwest part of the area where Susa Creek and Muskeg River have cut deep canyons. The exposures on Mahon Creek and Muskeg River are too contorted for satisfactory measurements, but on Susa Creek the exposures of the shale, though not continuous, indicate relatively little repetition, so that the stratigraphic interval of 1,800 feet between the Dunvegan and Bighorn formations is believed to represent, approximately, the thickness of the formation.

Palæontology and Age. The following fossils from the Blackstone shale in the map-area were collected opposite the mouth of Susa Creek:

Pelecypods
Inoceramus corpulentus McLearn
Inoceramus labiatus Schlotheim

The presence of *Inoceramus labiatus* indicates a Colorado age for this part of the formation.

BIGHORN FORMATION

Distribution and Lithology. The Bighorn formation overlies the Blackstone conformably, and, because it includes thick, hard, sandstone beds, parts of the formation outcrop well. In Pierre Greys Lakes map-area, the largest area underlain by Bighorn strata is a narrow strip along the southwestern limb of the Mason syncline (*See* Map 996A and Figure 1). Good exposures of this band occur where Mahon Creek, Chapman Creek, and Muskeg River cross this band, and excellent exposures of the lower contact occur on an escarpment paralleling Muskeg River on the northeast side in the northwest corner of the map-area. This escarpment is formed of gently dipping beds of the Bighorn formation. A good, although incomplete, section of the formation is exposed where it has been cut by Muskeg River.

Beds of the Bighorn formation are also exposed on Susa Creek very close to the fault on the northeast side of the Susa Creek anticline. They probably do not persist far either north or south of Susa Creek, but are cut off by the Mason fault.

Farther southeast the Bighorn band outcrops again, and persists southeastward along the southwest flank and then around the southeast nose of the Mahon Creek anticlinal structure.

The formation consists of hard, slabby, light grey, quartzitic sandstone, softer grey sandstone and silty shale, and minor amounts of grey and black shale, conglomerate, and local, thin coal seams. Two, and probably three, hard, thick sandstone bands occur in the formation in this map-area. The lowest, hard sandstone band, where it is exposed by Muskeg River, is 55 feet thick, and contains 8 feet of pebble-conglomerate near the base. This sandstone is quartzitic, hard, medium grained, grey, and platy. The conglomerate is composed of white, black, grey, and green chert pebbles about the size of peas, in a sandy matrix.

The section of the Bighorn formation exposed on Muskeg River is as follows:

	Thickness Feet
Overlying beds: Wapiabi formation	
Sandstone, medium-grained, hard, very pebbly; conglomeratic in places	6
Covered	321
Conglomerate, with sandstone and pebbly sandstone	10
Sandstone, hard, platy, grey, grey to buff weathering	75
Sandstone, siltstone, and shale; poorly exposed	100
Sandstone, massive, platy, hard, grey, grey and buff weathering	60

	Thickness Feet
Conglomerate; pebbles of black, grey, and green chert.....	6
Sandstone, hard, medium-grained, slabby, grey, and grey weathering.....	3
Total thickness.....	581

Underlying beds: Blackstone formation

The thickness of the formation where it is crossed by Muskeg River is, therefore, 581 feet. At this locality it includes two thick, hard, sandstone units with a suggestion of a third unit at the top of the formation.

Palæontology and Correlation. Specimens of *Inoceramus leylandensis* McLearn were collected about 30 feet above the base of the lowermost sandstone band of the formation just east of MacDonald Flat. A few other pelecypods were collected, but were indeterminate. Some of the shaly beds contain plant remains.

The presence of *Inoceramus leylandensis* indicates that these beds can be correlated with the Bighorn formation of more southerly districts.

WAPIABI FORMATION

Distribution and Lithology. Wapiabi marine shales overlie the Bighorn formation conformably. It can be seen by reference to Map 996A and Figure 1 that they occupy the centre of the Muskeg anticline; a large area on both sides, and around the northwest nose, of the Mason syncline; a wide area around the southeast nose of the Mahon Creek anticline; and a narrow strip extending to about the middle of the map-area, between the Mahon Creek anticline and the Mason fault. A very narrow strip is underlain by Wapiabi shale just northeast of the Mason fault where it is crossed by Susa Creek. The Wapiabi beds are generally poorly exposed, and no complete section was obtained. The best exposures are along the lower part of Veronique Creek and along Muskeg River about half a mile above the mouth of Veronique Creek. At both of these localities the strata lie on the northeast flank of the Muskeg anticline. The only other good exposure was observed along the lower part of the first south-flowing tributary of Muskeg River east of MacDonald Flat.

The thickness of the Wapiabi formation is assumed to be approximately 1,500 feet, which is the stratigraphic interval between the Bighorn formation and the Solomon member of the Brazeau formation as scaled from structure-sections A-B or C-D.

Palæontology and Correlation. The following fauna was collected from the Wapiabi formation in the map-area:

Pelecypods
- *Oxytoma* cf. *nebrascensis*
- *Ostrea* sp.
- *Inoceramus pontoni*

Cephalopods
- *Scaphites ventricosus*

Inoceramus pontoni and *Scaphites ventricosus* are guide fossils to the *ventricosus* or lower Wapiabi zone of the Upper Cretaceous. This evidence,

together with that of the lithology and stratigraphic position of the Wapiabi between the Bighorn formation and the non-marine Upper Cretaceous strata, is sufficient grounds for identifying these beds with the Wapiabi of more southerly areas.

LATE UPPER CREATACEOUS AND TERTIARY

GENERAL STATEMENT

Overlying the Wapiabi shales conformably are 80 to 100 feet of marine sandstone, which is called the Solomon sandstone (21) north of Athabasca River and is known by various names in districts to the south. This marine member is overlain by several thousand feet of non-marine sediments of late Upper Cretaceous and earliest 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 marine Bearpaw formation separates the non-marine Belly River and Edmonton formations. This subdivision presents no difficulty in the south, but the Bearpaw disappears to the west and northwest, and where it is missing the Edmonton cannot be separated satisfactorily from the Belly River formation.

The Edmonton is overlain by the Paskapoo formation of Paleocene age, which is lithologically fairly similar to the Edmonton. South of Athabasca River a disconformity has been recognized at the base of the Paskapoo (4), but where neither this disconformity nor diagnostic fossils are found, it may be impossible to separate the Edmonton from the Paskapoo.

The non-marine strata above the Wapiabi formation were first mapped by Rutherford (40). More recently, MacKay (28) divided this post-Wapiabi assemblage into the Brazeau and Edmonton formations of Upper Cretaceous age and the Paskapoo formation of Paleocene age. In this subdivision the base of the Edmonton formation was drawn by MacKay at the base of a conspicuous conglomerate bed lying about 900 feet below the lowest commercial coal seam, and the base of the Paskapoo at the base of another thick bed or beds of conglomerate that lay about 3,000 feet above the assumed base of the Edmonton. The procedure adopted by MacKay was followed by Lang (21) 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 Paleocene formations. 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 (41), 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 (39) 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.

The term 'Brazeau' is used here 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, of late Upper Cretaceous age, lies conformably above the Wapiabi shales, and underlies the greater part of the northeastern half of the map-area.

Solomon Member

Distribution and Lithology. The Solomon sandstone, forming the lower 80 to 100 feet of the Brazeau formation, is a useful horizon marker, and, following the practice adopted in nearby areas, has been mapped separately. Due to repetition by folding it occurs as thin, northwesterly trending bands exposed intermittently on each limb of both the Muskeg anticline and the Mason syncline. Near the southeast corner of the map-area the member outcrops at several places on the Mahon Creek anticline where this structure plunges southeast. The only other band outcrops in a fault block at the south boundary of the map-area. In places the position of the Solomon member has been inferred.

The member consists of a distinctive, hard, grey to greenish grey, buff weathering, slabby sandstone. The rock resembles the typical Bighorn strata.

Palæontology. Marine fossils have been found in the Solomon sandstone in nearby areas, and although none was found in Pierre Greys Lakes area, there is no reason to doubt that it is marine here as elsewhere.

Main Part of the Brazeau Formation

Distribution and Lithology. Strata lying immediately above the Solomon member are best exposed on Veronique Creek. There they consist of dark greenish grey, medium-grained, soft sandstone with interbedded grey shale and silty shale, and resemble beds occupying a similar position in other areas. These strata are generally softer and more shaly than overlying beds of the lower main part of the Brazeau formation.

The remainder of the formation consists of roughly 6,000 feet of thick-bedded sandstone, conglomerate, and shale. The sandstone is generally medium to coarse grained, grey and greenish grey, green and brown weathering, commonly crossbedded, and fairly soft. The conglomerate consists mainly of pebbles from ½ to 1 inch in diameter composed of white quartzite and grey and black chert. In places the pebbles are closely packed, but elsewhere the rocks show gradations from conglomerate to sandstone containing scattered pebbles. The conglomerate and pebble beds are more abundant in the lower part of the formation, and are commonly cross-bedded like the sandstone. The shales are dark grey and greenish grey, and are commonly silty. The formation contains some beds that appear to be water-lain ash.

Some of the lower beds of the Brazeau formation are well exposed in the canyon on Muskeg River, where they occur on the southwest flank of the Mason syncline. No complete section could be measured, but the total thickness of the formation is assumed to be about the same as in the Gregg Lake and Moon Creek map-areas to the southeast where the Brazeau formation consists of about 6,000 feet of strata.

Palæontology and Correlation. Plant remains were seen at many places in sandstone and shale, but identifiable fossil plants were collected at only two localities. W. A. Bell of the Geological Survey identified these as follows:

Lot L. 6 (Geol. Surv. Cat. No. 3724), Muskeg River at the 15th base line:

Conifers

Sequoia ? sp.

Ginkgophytes

Ginkgoites laramiensis (Ward)

The *Sequoia* listed above is probably of Edmonton age.

Lot L. 15 (Geol. Surv. Cat. No. 3725), Muskeg River ½ mile north of the 15th base line:

Conifers

Sequoia sp.

Angiosperms

Grewiopsis nebrascensis (Newberry) forma *grandidentata* Lesquereux

Bell reports that the angiosperm "is the only identifiable leaf among the many fragments of angiosperms. It ranges from high in the Upper Cretaceous to the Paleocene, but is most abundant in the Upper Cretaceous and, tentatively, I consider the age of the florule to be equivalent to that of some of the Edmonton formation and of the upper part of the Brazeau formation".

PALEOCENE ?

Strata in the northeast corner 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. They consist of sandstone, shale, and conglomerate resembling those of the Brazeau formation, but are, on the whole, more thickly bedded, softer, and fresher in appearance. The lithological difference between these strata and those of the Brazeau formation is not sufficient to permit the drawing of a geological boundary. The strata outcrop poorly, and because no identifiable fossils were found in them, they have not been mapped separately on the map accompanying this report.

PLEISTOCENE AND RECENT

Till and fluvioglacial gravel mantle large areas of the eastern part of the map-area, but toward the west these deposits are confined more to the larger stream valleys. Thick deposits of sand and gravel underlie the wide, westerly trending valley north of the fifteenth base line. The pebbles and boulders of this material consist of quartzite, chert, conglomerate, sandstone, and limestone, all of which, except the quartzite, are characteristic of the rock formations of the area. The terraces that flank Muskeg River are composed mainly of reworked glacial debris that was probably transported and deposited by the stream since the close of Glacial time. Most of this material is coarse gravel, but there are also deposits of finer gravel and sand.

Accumulations of talus occur in the higher regions, and Recent gravel, sand, and silt form flood-plain deposits in the valleys of Muskeg River and the larger creeks.

Small deposits of calcareous sinter occur in gravel and on rock surfaces below deposits of boulder clay. They are being deposited by water that has leached calcium carbonate from the boulder clay. In some places Recent gravel has been cemented with calcium carbonate to form a conglomerate.

CHAPTER IV

STRUCTURE

GENERAL STATEMENT

Northwesterly trending strike thrust faults and complex folds are the dominant structural features of Pierre Greys Lakes map-area. With few exceptions, anticlines form the ridges and synclines the valleys. All anticlines are relatively narrow and compressed, whereas the synclines are relatively more open. The folds are irregular, and form a somewhat *en échelon* pattern. The faults themselves are rarely visible, and their positions are generally inferred. From the distribution of the strata and from general conditions known to prevail in other areas, at least most of these faults are believed to dip southwest.

The number of faults and the steepness of the folds increase from northeast to southwest across the map-area. The folds and faults shown on the accompanying geological map are the minimun number required to explain the distribution of the exposed rocks; more minor folds and faults may be present. For convenient reference, some of the more important folds and faults have been named (*See* Figure 1).

FOLDS

The Muskeg Anticline. The most northeasterly fold, the Muskeg anticline, can be traced northwesterly from a point near the fifteenth base line, 4 miles from the eastern border of the map-area, to and beyond the northern boundary. Because the fold plunges to the southeast in the southeastern part of the map-area, it probably does not continue far south of the base line. Scarcity of outcrops in this region prohibits an accurate determination of its southeastern limit.

The Muskeg anticline is not as compressed as folds farther southwest. At the north border of the area the fold is apparently nearly symmetrical, but toward the southeast the dip readings obtained suggest a slight asymmetry, the southwest limb being in general somewhat steeper than the northeast limb. Wapiabi strata are exposed at the centre except on the top of the ridge north of the well site, where a thin layer of the Solomon sandstone covers the shale, and just southeast of the Muskeg well site, where a small patch of Bighorn sandstone is exposed.

The log of Muskeg No. 1 well shows the presence of only 120 feet of Wapiabi shale above the Bighorn formation at that point. It is interesting to note that the well penetrated 3,200 feet of Blackstone shale between the Bighorn and Dunvegan formations and, even allowing for a moderate dip, this thickness is about 1,000 feet more than that obtained at other localities in the area from structure-sections. This increased thickness is considered to be due to squeezing of the incompetent shale into the anticline between the more competent Dunvegan and Bighorn sandstone

formations, an explanation that is supported by the fact that the chip samples examined show innumerable, small slickensided surfaces, indicating adjustment throughout the formation. No evidence could be found of any large fault northeast of this anticline such as might dip southwest and have displaced part of the fold.

Mason Syncline. Southwest of the Muskeg anticline, and separated from it by the Muskeg fault, is a relatively wide syncline known as the Mason syncline. This structure begins just north of the map-area and plunges gently to the southeast. It can be traced southeastward to where it crosses Muskeg River south of the fifteenth base line, but beyond this point the structure loses its identity. Brazeau strata occur at the centre of the syncline and Wapiabi shale on the flanks.

Susa Creek Anticline. The large anticline to the southwest of the Mason syncline is the Susa Creek anticline. This is a narrow, compressed fold that enters the map-area just northwest of Susa Creek and continues southeasterly to a point just north of Muskeg River where the river flows northeast. At this point the fold is cut off by the Mason fault. Fernie strata are the oldest exposed in this fold.

Other Folds. Between the Mason syncline and the Mason fault to the southwest, are two smaller fold structures. A narrow anticline enters the area near the northwest corner and more or less parallels the west side of Muskeg River. This fold exposes Dunvegan and 'Fort St. John' strata, and ends just south of Susa Creek. To the southeast of the fold is a complex structure consisting of two small anticlines and a syncline. This structure begins near the source of Chapman Creek and persists southeastward to near the south border of the map-area. The folds are poorly exposed except where they are cut by Mahon Creek. The oldest rocks exposed are of the Luscar formation.

At the south boundary of the map-area, near longitude 118°40′, is another complex structure. South of Pierre Greys Lakes area it consists of a large, single fold known as the Cabin Creek anticline, but as this fold crosses into the map-area it develops two subsidiary folds, one on either side of the main axis. As this structure is followed to the northwest, the main anticline plunges to the northwest and is cut off by the Sterne Creek fault about 2 miles north of Muskeg River. The subsidiary fold on the northeast side of the axis of this anticline continues northwesterly, with a small plunge to the northwest, for about 7 miles before losing its identity. On the other hand, the fold formed on the southwest side of the axis of the Cabin Creek anticline expands to the northwest into a major anticline that persists to and beyond the western border of the map-area. This is a narrow, compressed anticline exposing Nikanassin strata. Its strike is fairly regular, but it appears to plunge gently at one place to the northwest and at another to the southeast.

Southwest of the folds already described are numerous minor anticlines and synclines, most of which appear to plunge gently to the northwest and most of which are complex and irregular. The *en échelon* character of the folds is apparent but not conspicuous.

FAULTS

Muskeg Fault. The most northeasterly fault mapped, the Muskeg fault, lies between the Mason Creek syncline and the Muskeg anticline, and can be traced from the north boundary of the map-area southeast to a point just south of the fifteenth base line. Because the fault has brought Wapiabi and Bighorn strata up against Brazeau beds on the northeast, it is considered to be a thrust from the southwest.

Mason Fault. The Mason fault follows the northeast flank of the Susa Creek anticline, and persists both to the northwest and southeast of the map-area. The identity of the strata on either side suggests that this fault dips to the southwest and that strata have been thrust from the southwest. The position of the Mason fault toward the southeast in this map-area has been assumed.

Sterne Fault. The next large fault to the southwest, the Sterne fault, apparently begins about 1½ miles north of the southern border of the area and on the northeast side of the composite Cabin Creek structure. The fault continues northwesterly beyond the western border of the area. Here again, the position of the fault has had to be assumed in places.

Cowlick and Mahon Faults. To the southwest of the Sterne fault, the Cowlick and Mahon faults cross from the south to the west border of the map-area, and both are, apparently, thrust faults dipping southwest. Still farther southwest are three unnamed faults, which are probably also thrusts from the southwest.

Fox Fault. In contrast with the previously described faults, the Fox fault in the southeast corner of the map-area (*See* Figure 1) is thought to dip to the northeast. Although this fault apparently terminates to the northwest in this map-area, it is known to extend southeastward through the Gregg Lake (16), Moberly Creek (22), and Moon Creek (17) map-areas. In the Gregg Lake and Moberly Creek areas no positive evidence has been obtained regarding its direction of dip, but in Moon Creek area the fault occurs along the southwest flank of an asymmetrical anticline with its steeper limb to the southwest, a condition the reverse of that which generally obtains in the Foothills regions. This suggests that the fault represents an overthrust to the southwest, and, therefore, that the fault dips to the northeast, a suggestion borne out by the formational distribution on either side of the fault.

Other Structures. Many minor anticlines and synclines occur on the flanks of the major folds, but these structures are too small to map even where they can be determined. It is probable also that many small faults have not been recognized.

CHARACTERISTICS OF THE FAULTS

All faults in Pierre Greys Lakes map-area are strike-thrust faults, and their outstanding characteristic is the apparent regular trend of their surface traces, suggesting that the faults dip steeply, at least near the present surface.

In Moon-Creek map-area (17) many small thrust faults were observed to pass downward into bedding planes, and, although most of these faults were dipping at a high angle near ground level, the inclination of the

fault surface, though irregular, decreased with depth. No fault surfaces could be seen in Pierre Greys Lakes map-area and no definite information regarding the attitude of the faults was obtained, but it is probable that the dips of all faults decrease downward from their surface exposures.

Information regarding the displacement of strata in the map-area due to the faults can be obtained only from the structure-sections (*See* Map 996A) and then only roughly. The maximum dip-slip appears to have taken place on the Mason fault, where Nikanassin beds have been thrust up over Wapiabi, Bighorn, and Blackstone strata. Structure-section E-F shows the Nikanassin formation thrust northwestward over the Wapiabi formation, and a rough estimation along section E-F gives an apparent dip-slip of 9,500 feet, a vertical offset of 2,500 feet, and a horizontal offset of 4,000 feet. It is probable that a certain amount of strike slip movement has also taken place, but this cannot be ascertained.

Movement on the other faults in the map-area does not appear to have been as great as that on the Mason fault, but the total horizontal displacement on all faults present must represent appreciable shortening across the area from southwest to northeast.

CHAPTER V

ECONOMIC GEOLOGY

OIL AND GAS POSSIBILITIES

The oil and gas possibilities of Pierre Greys Lakes map-area have been investigated in recent years as part of a general exploratory campaign along the Foothills belt. Several oil companies made geological studies, and one well was drilled, with disappointing results. This test well, Muskeg No. 1, was financed jointly by the Gulf, Imperial, McColl-Frontenac, Shell, and Socony-Vacuum companies under a compact known as the Northern Foothills Agreement, and was drilled on the Muskeg anticline, the most promising structure in the area. The hole was spudded in near the axis of the anticline, in sec. 24, tp. 57, rge. 6, W. 6th mer., commencing in Wapiabi shale and ending 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 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. The detailed log of Muskeg No. 1 well is given in Appendix I of this report.

It is improbable that the more complex and faulted structures to the southwest of the Muskeg anticline will be considered in the near future, but the failure of this one well does not condemn the area as a whole for further testing.

COAL

In Pierre Greys Lakes map-area no coal seams more than 2 inches thick were observed in strata other than the Luscar formation. However, south of Athabasca River, coal seams of commercial size are known to occur in the Upper Cretaceous Brazeau formation and in the overlying Paleocene strata, and Lang (22) has reported a 7-foot seam about 2,000 feet above the assumed base of the Paleocene succession in Moberly Creek map-area. In Pierre Greys Lakes area it is possible that good seams are present but are not exposed, as scarcity of outcrops is typical of the areas underlain by these younger strata.

The general district contains bituminous coal seams in the Luscar formation. These measures occur in the northwestward continuation of the same zone as that which contains the seams formerly mined at Brûlé (21) and those now being mined at Cadomin and Luscar still farther southeast. Important seams have also been found in the Luscar formation along Smoky River, 10 miles west of the map-area (30, 31). Within the map-area, coal was found in the Luscar formation at three localities, to which the following comments apply.

On Sterne Creek, a 6-foot seam is exposed on both sides of the creek about 2½ miles above its mouth. The following section was measured on the east bank:

Top of section	Thickness Feet
Sandstone, shaly, grey; zones of concretionary ironstone....	20·0
Sandstone, silty, fine-grained, grey.....	6·0
Coal.....	6·0
Shale, dark grey; coal stringers and lenses.....	6·5
Siltstone, with interbedded ribbons of ironstone.....	1·4
Shale, grey.....	2·0
Coal.....	1·0
Sandstone, shaly, grey, fine-grained.....	7·0

Two seams are exposed on the south-flowing tributary of Cowlick Creek just east of the west border of the map-area. The upper is 2·4 feet thick and occurs about 506 feet below the top of the formation. It is overlain by greenish grey shale and coaly shale and underlain by grey, silty shale. The lower is 1·8 feet thick and occurs about 890 feet below the top of the formation. This seam is overlain by fine-grained, grey sandstone.

The only other coal outcrop observed is on the north-flowing tributary of Cowlick Creek just east of the Mountain trail. Here, a good exposure reveals a 5-foot seam about 725 feet above the base of the Luscar formation. It is overlain by grey, silty shale and underlain by greyish brown, silty shale.

It is probable that three different seams are represented by the above-mentioned exposures, and it is possible that others are present but not exposed.

No coal has yet been mined, and, even if transportation was made available, the high costs involved compared with those of more accessible areas might prohibit production at this time. The western part of Pierre Greys Lakes map-area, as a part of the general Foothills belt, may, however, contain large reserves of high-grade bituminous coal that can be made available when required.

APPENDIX I

LOG OF MUSKEG NO. 1 WELL

(NORTHERN FOOTHILLS AGREEMENT)

The following log of Muskeg No. 1 well, Northern Foothills Agreement, was prepared by M. Joan Quantz of the Geological Survey and by the writer.

LITHOLOGY

Depth Feet	
	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 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, calcite 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	Bighorn Formation—*Concluded*
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 to brownish grey, silty, micaceous, 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 as above; little evidence of slickensiding.
620–630	Sandstone and shale as above; minor amounts of ironstone; calcite 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; calcite 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; calcite 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 laminæ and calcite veins associated with shale and ironstone.

Depth Feet	Blackstone Formation—*Continued*
920–930	Shale as above, with scattered light grey, medium-grained sandstone bands or partings.
930–940	Shale and sandstone as above; ironstone.
940–970	Shale as above; ironstone, in part associated with white calcite veins; sandstone, grey, medium- to fine-grained, in part occurring as small lenses or laminæ 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; calcite prisms.
990–1,040	Shale, with scattered sandy partings, as above; in part slickensided; ironstone; veins of white calcite throughout ironstone; calcite prisms.
1,040–1,050	Shale, ironstone, and sandstone as above; ironstone in part associated with sandstone laminæ; calcite prisms.
1,050–1,070	Shale, sandstone, and ironstone, widely scattered, as above; calcite 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 as above; in part veined with calcite.
1,130–1,140	Shale, sandstone, and ironstone veined with calcite as above; calcite 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 as above; associated with calcite and crystalline quartz.
1,220–1,230	Shale, in part slickensided; sandstone and ironstone in lesser amounts, as above; calcite 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 as above, with evidence of slickensiding, and sandstone; 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, and ironstone, as above; calcite 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; calcite prisms.
1,390–1,400	Shale, sandstone, and a little ironstone, as above; calcite 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; calcite prisms.
1,470–1,490	Shale, sandstone, and ironstone as above; minor [illegible] of calcite associated mainly with ironstone; calcite prisms.
1,490–1,550	Shale, sandstone, and lesser amounts of ironstone, a[illegible] above; scattered calcite veins throughout ironstone.
1,550–1,570	Shale and sandstone, as above.
1,570–1,590	Shale and sandstone, as above; a few ironstone fragments.
1,590–2,120	Missing.

Depth Feet	Blackstone Formation—*Continued*
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.
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; calcite prisms.
2,500–2,510	Shale and ironstone as above; calcite prisms; very little sandstone.
2,510–2,530	Shale, as above; very little sandstone, in part banded through shale; some calcite.
2,530–2,550	Shale, very sandy; 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 minor 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; calcite prisms.

Depth Feet	Blackstone Formation—*Continued*
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 bands; pyrite; a few ironstone fragments.
2,900–2,930	Shale as above.
2,930–2,960	Shale as above, with sandstone bands; 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 bands; a litttle fine-grained, brownish grey to grey sandstone.
3,010–3,040	Shale as above.
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 laminæ.
3,120–3,130	Shale as above, with calcite veinlets.
3,130–3,140	Shale as above.
3,140–3,150	Shale as above.
3,150–3,160	Shale as above. with considerable calcite.
3,160–3,170	Shale as above.
3,170–3,180	Shale as above.
3,180–3,190	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.
3,220–3,230	Shale as above.
3,230–3,240	Shale as above.
3,240–3,250	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.
3,300–3,310	Shale as above.
3,310–3,320	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, finely 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.
3,380–3,390	Shale as above.
3,390–3,400	Shale as above.
3,400–3,410	Shale as above.
3,410–3,420	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.
3,460–3,470	Shale as above.
3,470–3,480	Shale as above.
3,480–3,490	Shale as above.

Depth Feet	Blackstone Formation—*Concluded*
3,490–3,500	Shale as above, greatly slickensided.
3,500–3,510	Shale as above.
3,510–3,520	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.
3,530–3,540	Shale as above.
3,540–3,550	Shale as above.
3,550–3,560	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.
3,600–3,610	Shale as above, slickensided.
3,610–3,620	Shale as above, slickensided.
3,620–3,630	Shale as above, slickensided.
3,630–3,640	Shale as above; finely crystalline pyrite.
3,640–3,650	Shale as above.
3,650–3,660	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.
3,740–3,750	Shale and silty shale as above.
3,750–3,760	Shale and silty shale as above.
3,760–3,770	Shale as above.
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.
3,840–3,850	Shale as above, slickensided.
3,850–3,860	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 slickensided.
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 shaly sandstone beds.
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 laminæ.
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.

Depth Feet	Dunvegan Formation—*Continued*
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 laminæ throughout the shale.
4,090–4,100	Shale as above.
4,100–4,110	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.
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 laminæ.
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, 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 little fine grey sandstone.
4,400–4,405	Shale and sandstone as above.
4,405–4,410	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.

Depth Feet	Dunvegan Formation—*Concluded*
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; 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 laminæ; a little dark grey, fine-grained sandstone.
4,515–4,520	Shale and siltstone as above.
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; a few calcite-filled fractures; carbonaceous partings; minor dark grey shale.
4,535–4,540	Shale and sandstone as above.
4,540–4,545	Shale and sandstone as above; much slickensiding of shale.
4,545–4,550	Shale and sandstone 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.

Depth Feet	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 little 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 as 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-grained 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.
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 laminæ 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 and (?) Mountain Park Formations
5,050–5,070	Sandstone, light and dark grey, fine- to medium-grained, quartzitic; a little 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.

Depth Feet	Luscar and (?) Mountain Park Formations—*Continued*
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, medium-grained; 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-grained; 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.
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; sandstone, fine- to medium-grained, 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.

Depth Feet	Luscar and (?) Mountain Park Formations—*Continued*
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; decreased 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-grained; 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; shale, 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 gritty; 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-grained; siltstone, dark brownish grey; 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.
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.

Depth Feet	Luscar and (?) Mountain Park Formations—*Continued*
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-grained, 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.
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 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.

Depth Feet	Luscar and (?) Mountain Park Formations—*Concluded*
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, and 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 grey-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-grained and slightly calcareous; a little coal.
6,760–6,770	Siltstone, shale, and sandstone as above.
	Cadomin Formation
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, 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
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; a 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.
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.

Depth Feet	Nikanassin Formation–Fernie Group—*Continued*
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; also 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 and 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, 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.
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 yellowish iron stain; fragments of white and pink calcite.

Depth Feet	Nikanassin Formation–Fernie Group—*Continued*
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, in about equal amounts.
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; abundant calcite fragments.
7,740–7,750	Sandstone and shale as above; some sandstone very micaceous; abundant calcite fragments.
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, in part 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.
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 laminæ of fine sandstone; sandstone, buff and 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; a little 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 laminæ.
8,000–8,010	Shale, with fine sandstone laminæ 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.

Depth Feet	Nikanasson Formation–Fernie Group—*Concluded*
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 calcite prisms.
8,130–8,140	Shale, dark grey, as above; much pyrite.
8,140–8,150	Shale, dark grey to black; 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; a very little greenish, glauconitic sandstone.
8,210–8,220	Shale, sandstone, and pyrite as above.
8,220–8,230	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 pelcypods 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 shale; 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.
	Whitehorse Formation
8,350–8,360	Limestone, dolomitic, grey, fine-grained, compact; shale, black, pyritic; large pyrite fragments.
8,360–8,370	Limestone, dolomitic, 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, mostly mottled light and dark grey, some light grey to white; shale, black, pyritic.
8,440–8,450	Limestone, dolomitic, mostly very little grey to white, some mottled light and dark grey; shale, black, very little.

Depth Feet	Whitehorse Formation—*Concluded*
8,450–8,460	Limestone, light grey to grey, fine-grained to compact, no porosity; some pyrite.
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 section
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	Siltstone, shale, and limestone as above.
8,570–8,580	Siltstone, shale, and limestone 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.
8,670–8,680	Siltstone as above.
8,680–8,690	Siltstone as above.
8,690–8,700	Siltstone as above.
8,700–8,710	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 partings.
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.
8,830–8,840	Siltstone as above.
8,840–8,850	Siltstone as above.
8,850–8,860	Siltstone as above.
8,860–8,870	Siltstone as above.
8,870–8,880	Siltstone as above; much pyrite.
8,880–8,890	Siltstone as above.
8,890–8,900	Siltstone as above.
8,900–8,910	Siltstone, mostly dark grey.
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.

Depth Feet	Main part of Triassic section—*Continued*
8,990–9,000	Siltstone as above.
9,000–9,010	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.
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.
9,060–9,070	Siltstone as above.
9,070–9,080	Siltstone as above.
9,080–9,090	Siltstone as above; some pyrite.
9,090–9,100	Siltstone as above.
9,100–9,110	Siltstone as above.
9,110–9,120	Siltstone as above.
9,120–9,130	Siltstone as above.
9,130–9,140	Siltstone as above.
9,140–9,150	Siltstone as above.
9,150–9,160	Siltstone as above; some pyrite.
9,160–9,170	Siltstone as above.
9,170–9,180	Siltstone as above.
9,180–9,190	Siltstone as above; some pyrite.
9,190–9,200	Siltstone as above.
9,200–9,210	Siltstone as above.
9,210–9,220	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.
9,250–9,260	Siltstone as above.
9,260–9,270	Siltstone as above.
9,270–9,280	Siltstone as above.
9,280–9,290	Siltstone as above.
9,290–9,300	Siltstone as above.
9,300–9,310	Siltstone as above.
9,310–9,320	Siltstone as above.
9,320–9,330	Siltstone as above.
9,330–9,340	Siltstone as above.
9,340–9,350	Siltstone as above.
9,350–9,360	Siltstone as above; a little black shale containing scattered, minute, pyrite crystals.
9,360–9,370	Siltstone, more calcareous than normally.
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
9,410–9,420	Siltstone as above.
9,420–9,430	Siltstone as above.
9,430–9,440	Siltstone as above.
9,440–9,450	Siltstone as above; a little black shale.
9,450–9,460	Siltstone and shale as above.
9,460–9,470	Siltstone as above.
9,470–9,480	Siltstone as above.
9,480–9,490	Siltstone as above.
9,490–9,500	Siltstone as above.
9,500–9,510	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.
9,540–9,550	Siltstone as above.
9,550–9,560	Siltstone as above.
9,560–9,570	Siltstone as above; some pyrite.
9,570–9,580	Siltstone as above.

Depth Feet	Main part of Triassic section—*Concluded*
9,580–9,590	Siltstone as above.
9,590–9,600	Siltstone as above.
9,600–9,610	Missing.
9,610–9,620	Siltstone as above.
9,620–9,630	Siltstone as above.
9,630–9,640	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* [1]; 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; a little 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; a little black shale; a very little anhydrite.
9,920–9,930	Dolomite, brown, finely crystalline, slightly argillaceous, fairly porous; some pores filled with calcite; a little grey chert; a little 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; a little grey chert; some very thin calcite stringers.
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; a little 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 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.
10,180–10,190	Limestone as above.
10,190–10,195	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 limsetone 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.

[1]For a more detailed description of these cores *See* Appendix II.

Depth Feet	Rundle Formation—*Continued*
10,300–10,305	Limestone, dark grey, compact; a few calcite-filled vugs; pyritic in places.
10,305–10,310	Limestone as above.
10,310–10,315	Limestone as above.
10,315–10,320	Limestone as above.
10,320–10,325	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, platy; small, white, calcite inclusions; a little pyrite.
10,351–10,354	Limestone as above; some 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 darker 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; a little calcite as stringers.
10,395–10,400	Limestone as above.
10,400–10,405	Limestone as above.
10,405–10,410	Limestone as above.
10,410–10 415	Limestone as above.
10,415–10,420	Limestone as above.
10,420–10,425	Limestone as above.
10,425–10,430	Limestone, dark grey, finely crystalline.
10,430–10,435	Limestone as above.
10.435–10,440	Limestone as above.
10,440–10,445	Limestone as above.
10,445–10,450	Limestone as above; a little 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.
10,485–10,490	Limestone as above; decreased amount of white calcite.
10,490–10,495	Limestone as above; more calcite.
10.495–10,500	Limestone as above.
10,500–10,505	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.
10,515–10,520	Limestone as above.
10,520–10,525	Limestone as above.
10.525–10,530	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.

Depth Feet	Rundle Formation—*Concluded*
10,565–10,570	Limestone as above.
10,570–10,575	Limestone as above.
10,575–10,580	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.
10,620–10,625	Limestone as above.
10,625–10,630	Limestone as above.
10,630–10,635	Limestone as above.
10,635–10,640	Limestone, 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; a little black-grey shale.
10,700–10,705	Limestone, grey to greyish brown, dense; a little white calcite as cavity fillings.
10,705–10,709	Missing.

APPENDIX II

CORE REPORT ON MUSKEG NO. 1 WELL

(NORTHERN FOOTHILLS AGREEMENT)

The following description of the cores from Muskeg No. 1 well is included in this report by kind permission of the Petroleum and Natural Gas Conservation Board of Alberta, Imperial Oil Limited, Canadian Gulf Oil Company, Socony Vacuum, Texaco Exploration Company, McColl-Frontenac Oil Company, and Shell Oil Company.

Core No. 1	4,019–4,031	Recovery: 4 feet
4 feet	Shale, dark grey, scattered grains of pyrite near top; scattered, fine specks of mica; compaction slickensiding near top.	
Core No. 2	4,368–4,378	Recovery: 8 feet 6 inches
4 feet	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 feet	Sandstone, grey, medium-grained, calcareous, salt and pepper; some shaly partings and some carbonaceous partings; scattered specks of mica.	
1 foot 6 inches	Shale, dark grey, silty; interbedded with grey, fine-grained sandstone.	
Core No. 3	4,475–4,487	Recovery: 12 feet 6 inches
12 feet 6 inches	Shale, dark grey, finely micaceous; trace of slickensiding; fossil remains 3 feet from the base.	
Core No. 4	5,229–5,235	Recovery: 5 feet
5 feet	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.	
Core No. 5	5,805–5,813	Recovery: 7 feet
7 feet	Sandstone, light grey, salt and pepper, fine- to medium-grained; quartz, feldspar, and coal; carbonaceous material on bedding planes; non-calcareous and non-porous; average dip 20 degrees.	
Core No. 6	7,181–7,186	Recovery: 5 feet
5 feet	Sandstone and shale; medium to dark grey, very fine to fine-grained, quartz sand with two 3 inch dark grey shale breaks showing bedding plane, slickensiding (dip 30 degrees).	
Core No. 7	8,202–8,205	Recovery: 2 feet 6 inches
2 feet 6 inches	Shale, dark grey, pyritic, glauconitic, slickensided; calcite in fractures.	
Core No. 8	8,380–8,386	Recovery: 1 foot 6 inches
1 foot 6 inches	Limestone, dolomitic, dense, mottled grey and light grey; minor pin-point porosity, fine gas bleeding, core had strong hydrogen sulphide odour; dip about 25 degrees.	
Core No. 9	8,427–8,437	Recovery: 4 feet 6 inches
4 feet 6 inches	Dolomite, dark grey, calcareous, finely granular; some lighter grey limestone; pyrobitumen.	
Core No. 10	8,960–8,963	Recovery: 1 foot 6 inches
1 foot 6 inches	Siltstone, dolomitic, contains finely disseminated pyrite and some mica; argillaceous in places; shows some banding.	
Core No. 11	9,085–9,085⅓	Recovery: 3 feet 6 inches
3 feet 6 inches	Siltstone, dolomitic, black, argillaceous bedding planes. Strong odour of H_2S.	
Core No. 12	9,088–9,091½	Recovery: 13 feet 6 inches
13 feet 6 inches	Siltstone, dolomitic, with black argillaceous bedding planes. Strong H_2S odour. Dip 35 degrees.	

Core No. 13	9,403–9,407	Recovery: 3 feet 6 inches
3 feet 6 inches	Siltstone, dolomitic, argillaceous, micaceous; some pyrite. Dip 40 degrees.	
Core No. 14	9,626–9,629	Recovery: 3 feet
3 feet	Siltstone, dolomitic, argillaceous, dark grey, thin-bedded, hard; calcite in fractures.	
Core No. 15	9,637–9,640	Recovery: 2 feet
2 feet	Dolomite, dense, dark grey; scattered pyrite and quartz grains.	
Core No. 16	9,644–9,651	Recovery: 5 feet
5 feet	Dolomite, medium dark grey, dense to lithographic in texture, hard, pyritic; traces of organic material.	
Core No. 17	9,664–9,671	Recovery: 5 feet 9 inches
5 feet 9 inches	Dolomite, grey, dense, argillaceous; some fine fractures.	
Core No. 18	9,671–9,679	Recovery: 6 feet 8 inches
6 feet 8 inches	Dolomite, as above; fracturing more apparent.	
Core No. 19	9,679–9,686	Recovery: 5 feet
9 inches	Dolomite, as above.	
2 feet	Dolomite, buff, dense, fractured.	
3 feet 3 inches	Dolomite, grey, dense, slightly argillaceous, brecciated appearance.	
Core No. 20	9,686–9,694	Recovery: 7 feet
7 feet	Dolomite as above, fractured; brecciated appearance; few inclusions of grey chert.	
Core No. 21	9,694–9,702	Recovery: 7 feet
7 feet	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.	
Core No. 22	9,702–9,702½	Recovery: 6 inches
6 inches	Dolomite as above, with white, crystalline, siliceous inclusions and some anhydrite as above; brecciated.	
Core No. 23	9,702½–9,711	Recovery: 7 feet
7 feet	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.	
Core No. 24	9,711–9,798	Recovery: 7 feet
7 feet	Dolomite and shale; dolomite as above interbedded with dark grey shale near top; considerably fractured with anhydrite and calcite along fractures planes and in inclusions to give brecciated appearance.	
Core No. 25	9,718–9,726	Recovery: 8 feet
8 feet	Dolomite, argillaceous, dark grey and grey-brown; bands of dark grey shale (dip 45 degrees); small amount of pyrite.	
Core No. 26		
	Dolomite, medium to dark brownish grey, in part shaly; pyritic.	
Core No. 27	9,734–9,748	Recovery: 12 feet
12 feet	Dolomite, dark brownish grey; argillaceous dolomite band at top and at 9,760 feet with calcite-filled vugs; considerable fracturing; few dark grey shale bands; top part is pyritic.	
Core No. 28	9,748–9,761	Recovery: 11 feet
11 feet	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.	
Core No. 29	9,761–9,778	Recovery: 14 feet
7 feet	Dolomite, dark greyish brown, finely crystalline, argillaceous; scattered, small to coarse vugs lined with calcite; few vertical and horizontal fractures, pyritic.	
6 feet	Dolomite, grey-brown, crystalline, silty; becomes dark grey-brown and argillaceous at the base; scattered small to coarse vugs lined with calcite; few irregular, dark grey, shale-filled fractures; scattered pyrite; large, white, anhydrite inclusions at base (few coarse vugs are filled with calcite).	

Core No. 30	9,778–9,797	Recovery: 18 feet 6 inches
8 feet 6 inches	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 feet	Dolomite, dark grey-brown, crystalline, argillaceous; intermittent bands of small to medium vugs in part lined with calcite and in part filled with calcite; few dark grey shale breaks.	
Core No. 31	9,797–9,820	Recovery: 19 feet 6 inches
19 feet 6 inches	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.	
Core No. 32	9,824–9,844	Recovery: 15 feet (?)
15 feet (?)	Dolomite as above; greater number of calcite-lined vugs, inclusions, and stringers; more vertical and horizontal fractures.	
Core No. 33	9,844–9,867	Recovery: 15 feet
15 feet	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.	
Core No. 34	9,869–9,894	Recovery: 4 feet 3 inches
4 feet 3 inches	Dolomite, dark brownish grey, dense; in part appears shaly; a few narrow, dark grey shale bands and streaks.	
Core No. 35	9,903–9,925	Recovery: 11 feet 6 inches
11 feet 6 inches	Dolomite, dark brownish grey, dense, shaly; grades into dark brown silty dolomite.	
Core No. 36	9,928–9,939	Recovery: 11 feet 6 inches
3 inches	Dolomite as above.	
6 inches	Calcite, white, coarsely crystalline.	
10 feet 9 inches	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.	
Core No. 37	9,939–9,955	Recovery: 13 feet
13 feet	Dolomite as above, calcitic; a few irregular, horizontal fractures with dark grey shale fillings.	
Core No. 38	9,955–9,977	Recovery: 22 feet
22 feet	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.	
Core No. 39	9,977–9,985	Recovery: 12 feet
12 feet	Dolomite, dark grey, dense, shaly; calcite along fracture planes near top; a few, dark grey, shale-filled fractures.	
Core No. 40	9,985–9,989	Recovery: 3 feet 3 inches
3 feet 3 inches	Dolomite, dark grey, dense, shaly; some fine fracturing.	
Core No. 41	9,991–10,018	Recovery: 26 feet
8 feet 6 inches	Dolomite, dark brown, argillaceous; a 2-inch band of shaly dolomite 3 feet from top; a few, calcite-filled, vertical fractures.	
13 feet 3 inches	Dolomite, dark grey, dense, shaly dolomite with a few, narrow, dark grey shale bands with a dip of 40 degrees; a 1-inch band with tube structure (coral ?) filled with white material (celestite ?) at 10,003 feet; some fracturing.	
4 feet 3 inches	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.	
Core No. 42	10,018–10,046	Recovery: 25 feet
6 feet	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 feet	Dolomite, dark grey, dense, shaly; a few large anhydrite inclusions.	
4 feet	Shale, dark grey, dolomitic, silty.	

Core No. 43	10,046–10,053	Recovery: 6 feet
4 feet	Dolomite, dark brown, finely crystalline, silty.	
2 feet	Siltstone, dark grey, argillaceous, dolomitic.	
Core No. 44	10,053–10,080	Recovery: 27 feet
5 feet	Shale, dolomitic, anhydrite inclusions.	
3 feet	Dolomite, silty, dark grey, dense, limy at top; anhydrite inclusions; brachiopod fragments.	
19 feet	Dolomite and limy dolomite, brown to greyish brown, coarsely crystalline to hard; contains calcite and anhydrite replacements of fossils. Trace of pin-point porosity in lower part.	
Core No. 45	10,080–10,089	Recovery: 2 feet 3 inches
2 feet 3 inches	Dolomite, dark brown, argillaceous; considerable small calcite inclusions due in part to fossil replacement; trace of sulphur at top.	
Core No. 46	10,097–10,100	Recovery: 1 foot
1 foot	Dolomite as above; numerous calcite inclusions and stringers; one large, white anhydrite inclusion near base.	
Core No. 47	10,100–10,110	Recovery: 1 foot 9 inches
1 foot 9 inches	Anhydrite, white, opaque; contains scattered fragments of dark grey, shaly limestone.	
Core No. 48	10,120–10,123	Recovery: 1 foot 6 inches
1 foot 6 inches	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.	
Core No. 49	10,127–10,140	Recovery: 13 feet
13 feet	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.	
Core No. 50	10,143–10,149	No recovery
	(Drill cuttings indicate hard, dolomitic shale.)	
Core No. 51	10,154–10,164	No recovery
	(Drill cuttings indicate dolomitic shale, becoming calcareous with depth; grey limestone at base.)	
Core No. 52	10,195–10,214	Recovery: 16 feet 3 inches
16 feet 3 inches	Limestone as above; considerable calcite-replaced fossil fragments; calcite-filled vertical fractures.	
Core No. 53	10,214–10,220	Recovery: 5 feet 6 inches
5 feet 6 inches	Limestone as above; dolomitic in part.	
Core No. 54	10,220–10,227	Recovery: 5 feet
5 feet	Limestone as above at top; grades downward into medium brown, crystalline limestone; considerable calcite-replaced fossils (corals, brachiopods); a few calcite-filled fractures.	
Core No. 55	10,230–10,252	Recovery: 20 feet
20 feet	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.	
Core No. 56	10,252–10,273	Recovery: 20 feet
6 feet 6 inches	Dolomite as above; a few, narrow, dark grey, shale bands.	
13 feet 6 inches	Limestone, medium brown, argillaceous to silty; in part dolomitic; at 3 feet from the top occur 2-inch to 3-inch bands of dark grey, shaly limestone with slickensiding; a few vertical fractures in part with calcite and sulphur along fracture planes.	
Core No. 57	10,273–10,281	Recovery: 2 feet 6 inches
2 feet 6 inches	Dolomite, medium to dark brown, silty to argillaceous; somewhat limy due to calcite replacements of fossils at base; very hard; may be siliceous.	
Core No. 58	10,281–10,292	Recovery: 9 inches
9 inches	Limestone, dark grey, shaly.	

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