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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 61-31

MOUNT ROBSON (SOUTHEAST) MAP-AREA, ROCKY MOUNTAINS OF ALBERTA AND BRITISH COLUMBIA

83 E/SE

(Report, 7 figures, Map 41-1961, and Appendix)

E. W. Mountjoy

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By

E.W. Mountjoy

DEPARTMENT OF

MINES AND TECHNICAL SURVEYS

CANADA

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MOUNT ROBSON (SOUTHEAST) MAP-AREA, ROCKY MOUNTAINS OF ALBERTA AND BRITISH COLUMBIA

INTRODUCTION

This preliminary account of the geology of the northern and eastern parts of the Mount Robson (southeast) map-area includes new structural data concerning parts of the western Foothills, Front Ranges and eastern Main Ranges of northern Jasper National Park. The principal structures are southwest-dipping thrust sheets which contain a number of folds. New stratigraphic information is presented concerning Cambrian, Devonian, Mississippian and Jurassic sediments. Several Lower Palaeozoic formation names are extended into this area from other parts of the Rocky Mountains. A Devonian reef complex occurs in the Colin and Chetamon thrust sheets west of the De Smet Range.

Location and Access

The map-area (53°00' to 53°30'N lat. and 118°00' to 119°00'W long.) lies largely within the northern half of Jasper National Park, Alberta. It includes parts of the Foothills, Front and Main Ranges of the Rocky Mountains; the Foothills are restricted to the northeast corner. The surface trace of the Snaring thrust is selected as the boundary between the Front and Main Ranges. The continental divide, which follows the general northwest-southeast trend of the mountains, crosses the southwest corner of the area.

The southeastern and eastern parts of the map-area may be reached by Highway 16 or the park road to Snake Indian River. The northeastern part can be reached by the road to Rock Lake which leaves Highway 16 west of Hinton[1].

The remainder of the area is accessible on horseback. Good trails follow the valleys of Snake Indian River and Blue, Mowitch, Rock, and Moosehorn Creeks, in the northern and northeastern parts of

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[1] Due to lack of space, some geographic names could not be shown on the accompanying geological map. For more detail see topographic map of Jasper National Park, 3 miles to 1 inch (Surv. and Mapping Br., Dept. Mines, Tech. Surv.).

the area. Snake Indian trail is the main access route. During the summer of 1960 a rough trail was extended northward from west of Mount Cumnock, entering Snake Indian Valley about a mile downstream from the junction of Blue Creek. Trails were also cut along the southern tributaries of Snake Indian River to reach areas east and west of The Rajah.

Previous Work

One-inch-to-one-mile maps have been published by the Geological Survey for adjoining areas to the north (Irish, 1949*, 1954; Eccles, 1957a; and Lang, 1949), to the east (Lang, 1947a), and to the southeast (Mountjoy, 1960a). Brown (1952) mapped a small area between the Snaring and Snake Indian Rivers. Reconnaissance mapping of the Athabasca Valley has been done by McEvoy (1900), Collet and Paréjas (1932), Allan, Warren and Rutherford (1932), and the Alberta Society of Petroleum Geologists (1955). Recently a small area near the junction of Blue Creek and Snake Indian River has been reported on by Ziegler (1960), and parts of the Bosche and Boule Ranges and the Moosehorn Valley have been mapped on a 1:50,000 scale by O'Brien (1960).

Field Work and Acknowledgments

The Mount Robson map-area was studied by the writer during the summers of 1959 and 1960, ably assisted in 1959 by H.P. Nicholson, R. Bugry and L.M. Parsons, and in 1960 by W.S. MacKenzie, L.S. Nikkel and J.T. Walasko. Investigations were continued during the summer of 1961 and results of that work will be published at a later date. Additional study of some of the Devonian and Mississippian carbonate rocks has been done by Bugry, MacKenzie and Parsons, and their work helped considerably in determining the petrographic character of these rocks. The writer is also grateful to P. Smyth, W. MacKinnon, J. Williams, T. Hoszouski, J. Hargreaves and T. McCready for assistance with horses, cutting trails, and various camp duties; and to the wardens and other officials of the National Parks service for their friendly cooperation. Fossils were identified by the palaeontological staff of the Geological Survey.

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* Names and dates in parentheses refer to publications listed in the References.

STRATIGRAPHY

Rocks of different ages occur in each of the main topographic divisions. Thus, Upper Cretaceous strata occur in the eastern Foothills and Lower Cretaceous strata in the western Foothills; both Mesozoic and Palaeozoic strata are present in the Front Ranges, with Palaeozoic rocks predominant in the western part; and Cambrian and Precambrian rocks outcrop in the Main Ranges. Generalizing and taking into account the layered nature of the thrust sheets (oldest rocks occur at the base), there is a progressive increase in the age of exposed rocks across the area in the southwesterly direction.

PROTEROZOIC

Miette Group (Map-unit 1)

The oldest rocks in the area are well exposed above the Snake Indian thrust to the west of Blue Creek and above the Snaring thrust near the heads of both forks of Snake Indian River. Similar rocks occur south of the area and have been variously referred to as 'Miette sandstones', 'Jasper series' and 'Hector Formation' (Figure 1). 'Miette Formation' was named by Walcott (1913) for a series of massive grey sandstones with interbedded shales which occur, beneath Lower Cambrian quartz sandstones, in the vicinity of Yellowhead Pass. 'Jasper series' was later proposed by Allan, Warren and Rutherford (1932) for similar quartz, sandstones, argillites, sedimentary breccias and slates with numerous conglomerate beds beneath Lower Cambrian sandstones near Jasper at the base of Pyramid Mountain. Walcott's Miette Formation includes similar rocks, though they are not mentioned in his descriptions. In the writer's opinion there are more similarities than differences between the strata of Pyramid Mountain and those near Yellowhead Pass. Consequently the term 'Miette' has priority and is used here with group status. Mappable units within the Miette Group, such as those which occur near the head of Snake Indian River and near Jasper townsite (Charlesworth and Remington, 1960), may be referred to as formations.

Miette Group is redefined to include all the strata beneath Lower Cambrian Gog quartz sandstones in the Mount Robson district and the northern and western parts of Jasper National Park. This is considered to be the type region. No type section is designated, as most exposures of the Miette Group are structurally disturbed and there are few continuous sections. Good sections are present west of Blue Creek and at the head of Snake Indian River.

Rocks of the Miette Group underlie the resistant and massive quartz sandstones of the Lower Cambrian Gog Group. The

PERIOD	MOUNT ROBSON Walcott (1913, 1928) Barling (1923, 1955) Mountjoy (this report)	NORTH JASPER PARK Mountjoy (this report)	SUNWAPTA PASS Hughes (1955)	GLACIER LAKE Walcott (1928)	UPPER BOW VALLEY Walcott (1928) Deiss (1939, 1940) Rasetti (1951) Okulitch (1956)	BANFF AREA de Wit (1956) Usher (1959)
DEVONIAN mostly upper	Not present	Cairn or Flume Fm.	Flume Fm.	Cairn (?) Fm.	Not present	Cairn Fm.
U. ORDOVICIAN OR EARLIER	Regional unconformity		Mount Wilson Fm.	Mount Wilson Fm.	Regional unconformity	
LOWER ORDOVICIAN	Chushina Fm.	Chushina Fm.	Formation A	Sarbach Fm.	Sarbach Fm.	Sarbach Fm.
UPPER CAMBRIAN	Lynx Fm.	Lynx Fm.	Tangle Ridge Fm.	Mons Fm. Lyell Fm. Sullivan Fm.	Mons Fm. Lyell Fm. ? Bosworth Fm.	Mons Fm. Formations A to E
?	Arctomys Fm.	Arctomys Fm.	Arctomys Fm.	Arctomys Fm.	Arctomys Fm.	Arctomys Fm.
MIDDLE CAMBRIAN	Pika Fm. Titkana Fm. Tatei Fm. Chetang Fm. Hota-Adolphus Fm.	Pika Fm. Titkana Fm. Map unit 3	Sunwapta Peak Fm. Mount Whyte Fm.	Murchison Fm. Not exposed	Pika Fm. Eldon Fm. Stephen Fm. Cathedral Fm. Mount Whyte Fm.	Pika Fm. Eldon Fm. Not exposed
? LOWER CAMBRIAN AND OLDER	Gog Group: Mahto Fm. Tah Fm. McNaughton Fm.	Gog Group	Jonas Creek Fm.		Gog Fm.: St. Piran Member Lake Louise Mbr. Fort Mountain Member	
PROTEROZOIC	Miette Group	Miette Group	Hector Fm.		Hector Fm. Corral Creek Fm.	

Base not exposed

GSC

Figure 1. Correlation of Cambrian and Precambrian formations, Jasper and Banff National Parks, Alberta

contact appears to be conformable, but was not studied in detail. Near Mount Robson this contact has been reported as an unconformity by Walcott (1928). Approximately 1,500 feet of these strata occur south of Topaz Lake and 3,000 feet is present near the head of the south fork of Snake Indian River. Measurements were scaled from structure cross-sections. In both areas the base of the Miette Group is the underlying thrust surface.

Miette strata consist of alternating recessive and resistant units between 300 and 1,000 feet thick. The recessive units comprise a series of grey, dark grey and greenish grey shales and phyllites, with thin interbeds of siltstone, coarse-grained sandstone and minor, poorly sorted conglomerate, with pebbles 1/4 inch to 2 inches in diameter. The resistant units consist of sandstone, calcareous sandstones and silty carbonates. The sandstones are generally fine to medium grained, quartzose, and light grey, with thin siltstone and silty shale interbeds. The carbonates comprise reddish-brown-weathering silty dolomites and dolomitic sandstones, with pisolite layers and fine markings and laminations suggestive of algal structures. West of Blue Creek the carbonate unit occurs directly beneath the Gog sandstones and is between 300 and 1,000 feet thick, in places terminating abruptly against greenish grey shales. Near Idamalene Lakes (118°44'W, 53°12'N) a similar carbonate between 500 and 800 feet thick occurs about 1,000 feet beneath the base of the Gog Group.

Strata equivalent to the Miette Group can be readily traced beneath the Gog Group south from Jasper to Lake Louise, east of the Banff-Jasper Highway. In the Sunwapta Pass area, strata of similar lithology and stratigraphic position to the Miette Group were referred to the Hector Formation by Hughes (1955). As redefined in this paper the Miette Group would include the type Hector and Corral Creek Formations of Walcott (1913) near Lake Louise (Figure 1).

Reesor (1957, p. 160) has correlated the Horsethief Creek Series with the Hector and Corral Creek Formations of the Bow Valley area, and with the Miette sandstones, on a basis of stratigraphic position, and content of similar quartz-pebble sandstones and conglomerates. However it seems unwise at present to refer these strata to the Horsethief Creek Series until they have been studied in more detail and more positive correlations can be made. The Miette Group could well represent an entirely different sequence of strata.

CAMBRIAN

Cambrian strata can be divided into six mappable units: Lower Cambrian and earlier Gog Group, Middle Cambrian map-unit 3,

Titkana and Pika Formations, Middle and Upper Cambrian Arctomys Formation, and Upper Cambrian Lynx Formation. In an eastward direction Middle Cambrian formations appear to thin and the lower part becomes more argillaceous. Upper Cambrian strata are progressively truncated in an eastward direction by the unconformity beneath Devonian strata. This unconformity has been used as a datum for Figure 2.

Pertinent Cambrian stratigraphic data are summarized diagrammatically in the figure. These formations are correlated with the Cambrian formations of the Mount Robson district to the west and the Miette area to the southeast (Mountjoy, 1960a). In the composite Mount Robson section (Figure 2), field data of the writer has been combined with published data of Walcott and Burling and unpublished data of Burling. Units used in Miette map-area extend into the eastern part of this map-area along the Bosche Range. Stratigraphic positions of the more important fossil collections are indicated on Figure 2 and listed in the text.

LOWER CAMBRIAN AND EARLIER

Gog Group (Map-unit 2)

Quartz sandstones of Lower Cambrian age and older are widespread in the Rocky Mountains of western Alberta and have been variously assigned in different areas to a number of formations as follows: Lake Louise - Assiniboine region—St. Piran and Fort Mountain Formations (Walcott, 1908 and 1912), Gog Formation (Deiss, 1940) and St. Piran Formation redefined (North and Henderson, 1954); Jasper region—Cavell Formation (Raymond, 1930, p. 293), Jonas Creek Formation (Hughes, 1955); and Mount Robson region—Mahto, Tah and McNaughton Formations (Walcott, 1913), Mahto and Mural Formations and unnamed unit (Burling, 1923). Since all of these formations occupy the same stratigraphic position and are essentially part of the same thick sandstone sequence that can be traced from area to area, these units should be grouped together under one formation or group name. The Gog Formation has been used in this way in the Lake Louise - Assiniboine region (Deiss, 1940; Okulitch, 1956). The type section occurs at Wonder Pass on the northeastern spur of Mount Towers near Mount Assiniboine (Deiss, 1940, p. 772), and consists of pure, quartzose, crossbedded quartzites with minor pebble-conglomerates. These sandstones occur stratigraphically above Hector shales and below Middle Cambrian shales, sandstones and carbonates.

The Gog Group is used here to designate all the sandstone strata above the Miette Group and beneath the carbonate and argillaceous strata of map-unit 3. It occurs in three narrow belts across the area mapped—in the hanging-walls of the Colin, Snake Indian

and Snaring thrusts. It comprises a series of thick-bedded, resistant and massive sandstones which are fine to coarse grained, clean, quartzose, and very light grey. Towards the base the Gog Group is generally coarser grained and contains chert and quartz pebbles and abundant feldspar grains. The pebbles average between 1/2 and 1 inch in diameter. A basal conglomerate was not observed. Current bedding is also abundant in the lower part of the group, and the persistent southwest dips of these structures in the area studied are suggestive of a southwesterly direction of transport. From a distance, rocks of the Gog Group appear to weather dark grey with shades of red and purple, due to lichen covering and iron-oxide stain. Graphic measurements indicate that this unit is about 4,500 feet thick in the hanging-wall of the Snake Indian thrust.

A distinct carbonate and argillaceous interval occurs towards the top of the Gog Group. It consists of argillaceous and calcareous fine-grained sandstones, siltstones and silty shales with interbeds of limestone and dolomite. This interval weathers moderately recessive; it is about 100 feet thick in the Chetamon thrust sheet and 300 feet thick in the Snake Indian thrust sheet, occurring 200 and 400 feet, respectively, below carbonates of map-unit 3. The amount of carbonate and the thickness of this unit increase to the southwest. The unit appears to be equivalent to the Tah (Mural) Formation of the Mount Robson district. Many of the carbonates contain abundant Archaeocyathids, except in the Chetamon thrust sheet.

Palaeontology—As well as the Archaeocyathids noted above, *Scolithus* tubes were observed in about the upper 1,000 feet of the Gog Group at several localities. *Olenellus* occurs in the Mahto Formation (upper part of Gog Group) near Mumm Peak in the Mount Robson area (Burling, 1955).

MIDDLE CAMBRIAN

The Middle Cambrian succession is divisible into three gross lithic units: a lower and unnamed, thick, recessive-weathering sequence of greenish grey shales with a few thin but prominent limestone units; a middle Titkana Formation of thick cliff-forming limestones; and an upper thin Pika Formation of argillaceous and thin-bedded limestones. The Titkana Formation has been modified and extended eastward from Mount Robson, and the Pika Formation extended from the upper Bow Valley area. This sequence differs from the better-known Bow Valley and Mount Robson Middle Cambrian Formations, in that the lower half consists largely of recessive argillaceous rocks instead of massive carbonate strata.

Map-unit 3[1]

Map-unit 3 conformably overlies the Gog Group and has a similar distribution in the area studied. The upper part of the unit is also present in the Bosche and Miette Ranges where it comprises a series of recessive-weathering greenish grey shales and several resistant limestone interbeds between 25 and 200 feet thick. Limestones are generally dark grey, micro- to cryptocrystalline, weather light grey, and contain thin partings of argillaceous dolomite and limestone. The partings weather pale yellow to orange. Thin pisolite layers, 1 inch to 12 inches thick, occur scattered through the upper half. Map-unit 3 weathers recessive compared to underlying and overlying units.

A typical section occurs in a saddle on the ridge-crest 1/2 mile northeast of Chetamon Mountain summit. A summary description of this section is included in the appendix at the end of this report. Other good sections occur on the northeast side of the mountain range that continues northwest of Chetamon Mountain. All dominantly argillaceous strata above the Gog sandstones and beneath the Titkana limestones are included in map-unit 3. Both contacts are conformable and distinct in the Front Ranges. The contact with the overlying Titkana Formation may be more difficult to determine in the Main Ranges, as shales of map-unit 3 appear to intertongue and grade laterally into Titkana limestones east of Mount Robson.

The stratigraphy of map-unit 3 has been studied in some detail along the Chetamon and Snake Indian thrust sheets. Three carbonate units occur in these shales in the Chetamon thrust sheet forming a number of distinct sub-units. The following were recognized, from bottom to top; red silty shales, interbedded green and red shales, followed by three limestone units each separated by greenish grey shales. The uppermost green shales contain several layers of pisolites. These three limestone units can be traced within the Chetamon thrust sheet from the Athabasca Valley to The Rajah. The basal red-shale unit appears to continue westward into the Mount Robson sections. Total thickness varies from 1,400 to 1,800 feet.

In a section measured west of Mount Simla, additional thin carbonate units appear in the shale units, and near the continental divide carbonate strata are predominant. Near Mount Robson, corresponding strata consist of resistant carbonates, except for some argillaceous carbonates in the Hota-Adolphus and Tatei Formations

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[1] The lowest beds of this unit contain Olenellus at one locality. Elsewhere the basal strata may also be of early Cambrian age, though fossil data are lacking.

(Figures 1 and 2). Consequently, in a southwest direction across the area, map-unit 3 changes from a dominantly shale facies to a dominantly carbonate facies.

Palaeontology—Several thin argillaceous limestones in the middle part of this unit are fossiliferous, and the following trilobites were identified by B.S. Norford of the Geological Survey. (See Figure 2 for position of F1, F2, etc.)

F1—GSC loc. 42591; ridge 2 miles southwest of Mount Simla (118°41'W, 53°16'N), about 30 feet above base.
olenellid species aff. *Bristolia* and aff. *Olenellus logani* Walcott

F2—GSC loc. 42583; all same location as F1, 975 to 1,060 feet above base.
Glossopleura cf. *G. boccar* (Walcott)

" " 42584; talus, 915 to 975 feet above base.
Glossopleura sp.
Iphidella cf. *I. grata* Resser

" " 42578; *Glossopleura* sp.

F3—GSC loc. 42049; ridge 1 mile north of Whitecap Mountain, about 250 to 300 feet above base.
Ptarmigania gordonensis Resser
Albertella cf. *A. bosworthi* Walcott

F4—GSC loc. 42070; ridge 1 mile south of Mount Rowand, 1,365 to 1,700 feet above base.
cf. *Glossopleura* spp.

" " 42593; Appendix, section 3, unit 10, Mount Chetamon northeast side.
?*Glossopleura* sp.
Iphidella cf. *I. grata* Resser

F5—GSC loc. 42062; same location as 42070, 100 to 200 feet below top.
Iphidella sp.
?*Glyphaspis* sp.

Olenellus has only been found in one section in the area mapped, about 2 miles southwest of Mount Simla. In that section it occurs in limestones 25 feet above the base of map-unit 3. The highest *Olenellus* occurs in a similar stratigraphic position in the Hota-Adolphus Formation (Figure 2) near Mount Robson (Burling, 1955, p. 17), and in the Mount Whyte Formation (Peyto member) of the Sunwapta Pass area (Hughes, 1955, p. 80), and the Bow Valley (Rasetti, 1951).

Olenellus is normally regarded as restricted to the Lower Cambrian. However, early Cambrian rocks are commonly barren of fossils and the Lower-Middle Cambrian boundary is difficult to define in the field. In this report this epoch boundary is arbitrarily placed at the distinct lithological boundary between the Gog Group and map-unit 3, though in actual fact it probably occurs somewhat higher in the basal carbonates of map-unit 3. Representatives of the Albertella zone occur in the lowest third of map-unit 3 (Figure 2) in the Chetamon thrust sheet and in the Chetang Formation of the Robson district (Burling, 1923; Walcott, 1928), and representatives of the Glossopleura zone are present in the middle part of map-unit 3.

Correlation—Map-unit 3 occupies the same stratigraphic interval as Cambrian Formation A of the Miette area (Mountjoy, 1960a) and the Hota-Adolphus, Chetang and Tatei Formations of the Mount Robson district. It appears to be the stratigraphic equivalent of the lower half of the Sunwapta Peak Formation (Hughes, 1955), and the approximate stratigraphic equivalent of the Mount Whyte, Cathedral and Stephen Formations of the upper Bow Valley (Figure 1).

Titkana and Pika Formations (Map-unit 4)

On the enclosed geological map, the Titkana and Pika Formations have been grouped together, though they form distinct mappable units.

The Titkana Formation was designated by Walcott (1913, 1928) for massive-bedded grey limestones and dolomitic limestones in the upper half of the Middle Cambrian succession. The type section is on the southwest slopes of Titkana Peak, 5 miles northeast of Mount Robson. From unpublished work of Burling (Geological Survey of Canada files) it appears that strata equivalent to the Pika Formation were included in the upper part of the Titkana Formation. The Titkana Formation in this paper is modified so that between 200 and 700 feet of recessive-weathering, thin-bedded argillaceous limestones are excluded from the top.

Strata of the Titkana Formation form a thick massive limestone which in most places outcrops as prominent cliffs 500 to 800 feet high. These limestones are uniformly crypto- to microcrystalline, dark grey, and contain prominent fine bands or laminations of dolomitic and/or argillaceous carbonate on the weathered surface. In places, secondary coarsely crystalline dolomite occurs in irregular layers and large lenses which transect the bedding. These carbonates appear to occur conformably above map-unit 3.

Typical sections were examined on the southeast side of Chetamon Mountain (see Appendix, section 3), in the valley of Snake Indian River about 5 miles southeast of Snake Indian Mountain, and on the northeastern ridges of Roche Miette. No fossils were collected from this formation.

The revised Titkana Formation occupies the same stratigraphic position as Formation B of the Miette area (Mountjoy, 1960 a) and the upper half of the Sunwapta Peak Formation near Sunwapta Pass (Hughes, 1955). It is approximately equivalent to the Eldon Formation of the upper Bow Valley (Figure 2).

The Pika Formation was first named and described by Deiss (1939, pp. 965-966 and 1008-1009) for grey, thin-bedded, in part argillaceous limestones and dolomites which contained some edgewise and intraformational conglomerates. The type section 550 feet thick, is on the west side of Helena Ridge north of Mount Eisenhower (formerly called 'Castle Mountain'). These carbonates weather more recessively than underlying cliff-forming Eldon dolomites and occur beneath the distinctive green and red shales of the Arctomys Formation.

The Pika Formation consists of a series of recessive-weathering limestone and shale interbeds, each 10 to 40 feet thick. The limestones are generally dark grey, cryptocrystalline, and weather with a banded appearance similar to that of the Titkana limestones. Thin layers of intraformational conglomerates with limestone fragments are present in the limestone beds and vary from a few inches to a foot thick. Many of the upper layers of the limestone units contain abundant trilobites. Fossils are also abundant in the argillaceous units. The top is marked by the highest beds of argillaceous thin-bedded limestones and in some sections a limestone conglomerate with abundant trilobite fragments is present. The overlying green and maroon shales of the Arctomys Formation provide a distinct and sharp upper contact. The base appears to be transitional and was chosen where limestones changed from the cliff-forming character of the Titkana Formation to a recessive-weathering, thin-bedded and argillaceous character. A calcareous shale or covered interval marks the base in most places.

A typical section of the Pika Formation occurs on the east side of Chetamon Mountain (see Appendix, section 3), and others occur along strike to the northwest (see section 2). It is between 500 and 700 feet thick. These strata appear to be more argillaceous than beds in the type section. They occur beneath the Arctomys Formation, as in the type Pika Formation.

Palaeontology—Several fossil lots have been grouped together for the purposes of this report. The following trilobites from

the Pika Formation were identified by B.S. Norford:

F6 (Figure 2)—
?Parehmania spp.
?Glyphaspis spp.
?Ehmaniella sp.
"Kochaspis" sp.
?Kootenia sp.

Norford states that they seem to represent an undescribed fauna, related to the Thompsonaspis fauna and later pre-Cedaria faunas (Denson, 1942).

The Pika Formation is stratigraphically equivalent to the lower half of map-unit 3 (beneath the maroon shale) of the Miette area (Mountjoy, 1960a), and to the upper part of the original Titkana Formation, as discussed above. The Pika Formation of Bow Valley contains similar fossils (Denson, 1942).

MIDDLE AND/OR UPPER CAMBRIAN

Arctomys Formation (Map-unit 5)

Walcott (1923, p. 461) proposed the name 'Arctomys Formation' for silty and calcareous shales and finely laminated limestones which occur above Middle Cambrian limestone and below Upper Cambrian carbonates. The type locality is on the south slopes of Sullivan and Survey Peaks north of Glacier Lake. Farther south, Walcott (1928) noted that equivalent strata contained ripple-marks, mud-cracks and casts of salt crystals. Deiss' more recent and detailed work (1939, 1940) has added considerable refinement to Walcott's observations. In particular, Deiss noted the recessive, bright tan and maroon weathering-character, and the unusual natural and sharp boundary-demarcations of the Arctomys Formation.

Strata of map-unit 5 have been referred to the Arctomys Formation because they are lithologically very similar and occupy the same stratigraphic position as the type Arctomys. The Arctomys Formation is the only thin, widespread, varicoloured siltstone and shale unit known in the Cambrian succession with salt-crystal pseudomorphs, ripple-marks, and other sedimentary features suggesting shallow-water deposition. In the northern half of Jasper Park it has proven to be a most useful stratigraphic marker.

In the area mapped, the Arctomys Formation forms a distinct, mappable, light-orange-weathering unit and has a similar distribution to that of the underlying units. It consists of a series of

red and green silty shales. Silt content increases upwards until the upper 200 feet consists of light yellow to orange-weathering siltstone and very fine grained sandstone, with thin, pale green mudstone interbeds. Moulds and casts of salt crystals are characteristic in the middle part of the formation. Fine crossbedding and ripple-marks are common throughout but are more abundant in the upper half. The thickness of the Arctomys Formation varies between 600 and 800 feet in the Chetamon and Snake Indian thrust sheets. No fossils were found in this unit.

Equivalent strata are present at the base of the Lynx Formation (Burling, 1923, pp. 729 and 738; and Walcott, 1928, p. 360); along the Miette Range in the upper half of map-unit 3 (Mountjoy, 1960a); near Sunwapta Pass (Hughes, 1955, p. 92); and in several sections in Banff National Park (Walcott, 1928 and Deiss, 1939 and 1940).

Walcott (1928) and Deiss (1939, 1940) considered the Arctomys Formation to be Upper Cambrian, and Usher (1959) considered it to be both Middle and Upper Cambrian. Its age remains problematical, as no diagnostic fossils have been found in it. In this report a late Middle Cambrian and/or early Upper Cambrian age has been arbitrarily designated.

UPPER CAMBRIAN

Lynx Formation (Map-unit 6)

The Lynx Formation was named by Walcott (1913, p. 334) for thin-bedded, grey and bluish grey limestone with bands of shale, with type section on Chushina Ridge between Snowbird Pass and Billings Butte, directly east of Mount Robson. The section is difficult to reach and is obscured by several tributary glaciers of the main Robson Glacier (Walcott, 1928, Plate 105, facing p. 356). The only systematic description of the Lynx Formation is Burling's description (in Walcott, 1928, pp. 366 and 367) of the much better exposed and accessible Rearguard (Iyatunga) Mountain section, about 2 1/2 miles along strike to the northwest. There the Lynx Formation is about 3,500 feet thick and consists of alternating units of cliff-forming carbonates and recessive-weathering argillaceous carbonates. This section will be considered as a supplemental type section. According to Burling (1923), shales at the base of the Lynx Formation exhibit shallow-water phenomena. Walcott (1928, pp. 245, 360) noted that these strata were probably representative of the Arctomys Formation. In this paper the Lynx Formation is emended to exclude thin-bedded and silty shales and carbonates of Arctomys lithologies from the base. The contact with the overlying Lower Ordovician Chushina Formation is placed following Burling's (1955, p. 26) suggestion: "... where massive cliff-forming limestones gave way to thin-bedded limestones, shales, and interformational conglomerates ..."

The Lynx Formation comprises a variable sequence of thin-bedded, light grey to brown, fine-grained, silty carbonates with varying shale and sand content. Finely laminated and crossbedded, silty dolomites form the bulk of the stratigraphic sequence. Zones of varve-like carbonates consisting of thin beds of alternating carbonate and argillaceous carbonate and intraformational conglomerates are characteristic of parts of the formation. They are particularly common near the top and bottom. The intraformational conglomerates contain carbonate fragments between 1/2 inch and 2 inches in long diameter.

A section 2,400 feet thick was measured in the Chetamon thrust sheet in a cirque basin 3 miles southeast of The Rajah and a comparable thickness was computed for the Snake Indian thrust sheet. The contact with the underlying Arctomys Formation is transitional over an interval of 10 to 30 feet. The upper contact was placed where resistant carbonates change to recessive-weathering greenish grey shales with thin interbeds of intraformational conglomerates.

The Lynx Formation commonly forms the crest of a mountain range, as for example in the range between Mount Chetamon and The Rajah, and the range continuing northwest and southeast form Snake Indian Mountain. In some places the formation is deformed into a series of very narrow folds. Good examples of this type of folding are present in the mountain range east of Snaring River between Mount Rutherford and Chetamon Mountain.

The age of unfossiliferous sub-Devonian strata in the western Front Ranges of Jasper Park has long been in doubt. Between 500 and 1,000 feet of these thin-bedded silty carbonates occur in the Colin thrust sheet. Near Morro Peak the upper 400 feet of these strata, well exposed along Highway 16, have been described by de Wit and McLaren (1950, pp. 30, 31). Mostly they consist of thin- to medium-bedded, finely crystalline, silty dolomites. Similar dolomites occur in the upper part of the Lynx Formation southeast of The Rajah. Up to 40 feet of silty thin-bedded dolomites also occur locally beneath the Flume Formation in the Greenock thrust sheet. The only carbonates in the entire Lower Palaeozoic succession which have similar characteristics occur in the Lynx Formation. These silty carbonates beneath the Devonian in the Greenock and Colin thrust sheets are correlated with the Lynx Formation and are consequently of Upper Cambrian age.

Palaeontology—The Lynx Formation contains few fossils. Preliminary identifications of two collections by B.S. Norford are as follows: F7—GSC No. 42060; Mount Strange section, 730 feet above base.
asaphiscid trilobite
cf. *Coosia* sp.
GSC No. 42052; Whitecap Mountain southeast side, lowest third of formation.
?coosellid trilobite

Fragments collected from the lower and middle parts of the Lynx Formation at three different localities were identified by Norford as crepicephalid trilobites. These coosellid and crepicephalid trilobite fragments are suggestive of the Dresbachian stage of the late Cambrian. Upper Cambrian fossils have been collected by Burling (1955, p. 26) near the top of the Lynx Formation on Rearguard Mountain.

F8—GSC Nos. 36743 and 36744; from the base of this unit in the Miette area, identified by A.W. Norris.

Kormagnostus sp.
cf. Modocia sp.
cf. Camaraspis sp.
cf. Taenicephalus sp.
cf. Wilbernia sp.

The Lynx Formation is equivalent to map-unit 4 of the Miette area (Mountjoy, 1960a), to the Tangle Ridge Formation near Sunwapta Pass (Hughes, 1955), and to the Sullivan, Lyell, and lower part of the Mons Formations of Glacier Lake and more southern areas (Figure 1).

LOWER ORDOVICIAN

Chushina Formation (Map-unit 7)

The Chushina Formation was named by Walcott (1923, p. 458) for thin-bedded limestones and shales in the lower part of the Robson limestones, which occur on Extinguisher Tower (type section) and Lynx Mountain east of Mount Robson. This section has not been described. It was defined so as to include all Lower Ordovician faunas, and the top was arbitrarily drawn 1,500 feet above the Extinguisher horizon with the Kainella (Hungia, 61q) fauna. Later, Burling (1955, p. 26) modified the definition so that the Lynx-Chushina contact was located according to lithology (see Lynx Formation above). Burling's suggested definition of the base of the Chushina Formation has proven to be very useful, and on this basis the Chushina Formation has been distinguished from underlying Lynx Formation in the area mapped.

In the Chetamon thrust sheet and in the Snake Indian thrust sheet south of Snake Indian River, the Chushina Formation forms a recessive-weathering unit beneath the Devonian Flume or Cairn Formations and above massive Upper Cambrian carbonates. The Chushina Formation consists of interbedded greenish grey argillaceous limestone and calcareous shale in thin beds. Thin beds of intraformational limestone are very common, with the limestone fragments reaching a maximum length of about 2 inches. Silty dolomite and limestones are present at the top in some sections. It has the same lithology,

contains similar fossils, and occupies the same stratigraphic position as the type Chushina. Between 20 and 40 feet of fine-grained light grey quartz sandstones occur above the Chushina Formation in a section on the north end of the Palisades, immediately south of the map-area.

The Chushina Formation increases in thickness from 75 feet, northwest of The Rajah, to between 600 and 800 feet on the Palisades. It has a computed thickness of about 700 feet in the Snake Indian thrust sheet at the head of the south fork of Snake Indian River. It was not studied at this latter locality by the writer, but Collet and Paréjas (1932, note 8, p. 66) reported that resistant limestones with Devonian fossils occur above it.

Palaeontology—Two collections were obtained from the Chushina Formation.

GSC No. 42047; on a ridge, 2 miles north of The Rajah, about 60 feet below the base of the Cairn Formation.
Symphysurina sp.
orthid and lingulellid brachiopods

GSC Nos. 42594 to 42604; creek west of Swift's ranch near south end of the Palisades, about 3 miles south of the map-area.

from upper half: Symphysurina sp.
cf. Nanorthis sp.

middle part: Eoorthis sp.
symphysurinid trilobite

at base: cf. Bellefontia sp.
Syntrophina convexa (Kindle)
? Huenella sp.

Norford reported that the fossils of both collections are of early Ordovician (Canadian) age. As well as the above, C.H. Kindle (1929) reported a number of other fossils from the Swift's ranch locality, among them being Symphysurina walcotti Kindle.

Southeast of the area these strata occur beneath the Devonian along much of the Chetamon thrust sheet. At Medicine Lake, Harker, Hutchinson and McLaren (1954, p. 57) reported the occurrence of Bellefontia cf. nonius (Walcott) 90 feet below Devonian dolomites. Similar greenish grey argillaceous limestone and shales with intra-formational conglomerates (Formation A of Hughes, 1955, p. 92) occur near Sunwapta Pass and also contain Bellefontia nonius (Walcott) (Harker, Hutchinson and McLaren, 1954, p. 57).

Quartz sandstones occurring between Lower Ordovician and Devonian strata in some sections may represent a basal Devonian unit. Alternately, some of these sandstones may also represent part of the Mount Wilson quartzite or may represent sandstones in the Ordovician succession recorded by Harker, Hutchinson and McLaren (1954, pp. 61-62) at Cecilia and Kakwa Lakes, some 50 miles northwest of the map-area.

Of considerable interest in this region is the sub-Devonian unconformity. Along the present tectonic strike in most of the map-area this unconformity remains at about the same stratigraphic horizon. However, across the strike in a northeast direction it gradually truncates Lower Ordovician and Upper Cambrian units until Devonian strata rest on strata of the Arctomys Formation in the Bosche and Miette Ranges. Similarly, in the Bow Valley this unconformity truncates older strata in an eastward direction across the mountains (de Wit, 1956).

UPPER DEVONIAN

A carbonate complex or biostromal reef, here referred to as 'the Ancient Wall' carbonate complex, occurs northwest of Mount Haultain in the Colin and Chetamon thrust sheets to Glacier Pass in the Ancient Wall (see map, and distribution of Cairn and Southesk Formations, map-units 9 and 10). Important stratigraphic variations occur in these sediments which differ somewhat from other Devonian reef complexes (Figures 3, 4, and 5). A study of the stratigraphic relationships between units of this reef complex is important and fundamental to a proper evaluation of the geological history of the Devonian in this region, and may provide valuable data concerning the development of Devonian reefs in adjacent areas.

The Ancient Wall reef complex consists of two major units: a lower, dark, well-bedded, stromatoporoidal dolomite (Cairn Formation); and an upper, light-coloured, dense limestone (Southesk Formation). Terminologies employed are those proposed by de Wit and McLaren (1950) and McLaren (1955) and modified by the writer (Mountjoy, 1960a, 1960b). Also used are new formation and member names designated by McLaren and Mountjoy (1962) for strata subjacent to the Palliser Formation.

Another development of Southesk and Cairn carbonates was observed a few miles northwest of Eagles Nest Pass, immediately north of the map-area. Excellent sections can be studied in the valleys at the head of Berland River in the Adams Lookout area. It is not known whether these two carbonate bodies may merge, as there are no exposures of this part of the Devonian sequence between the two areas. The presence of Mount Hawk and Perdrix Formations in

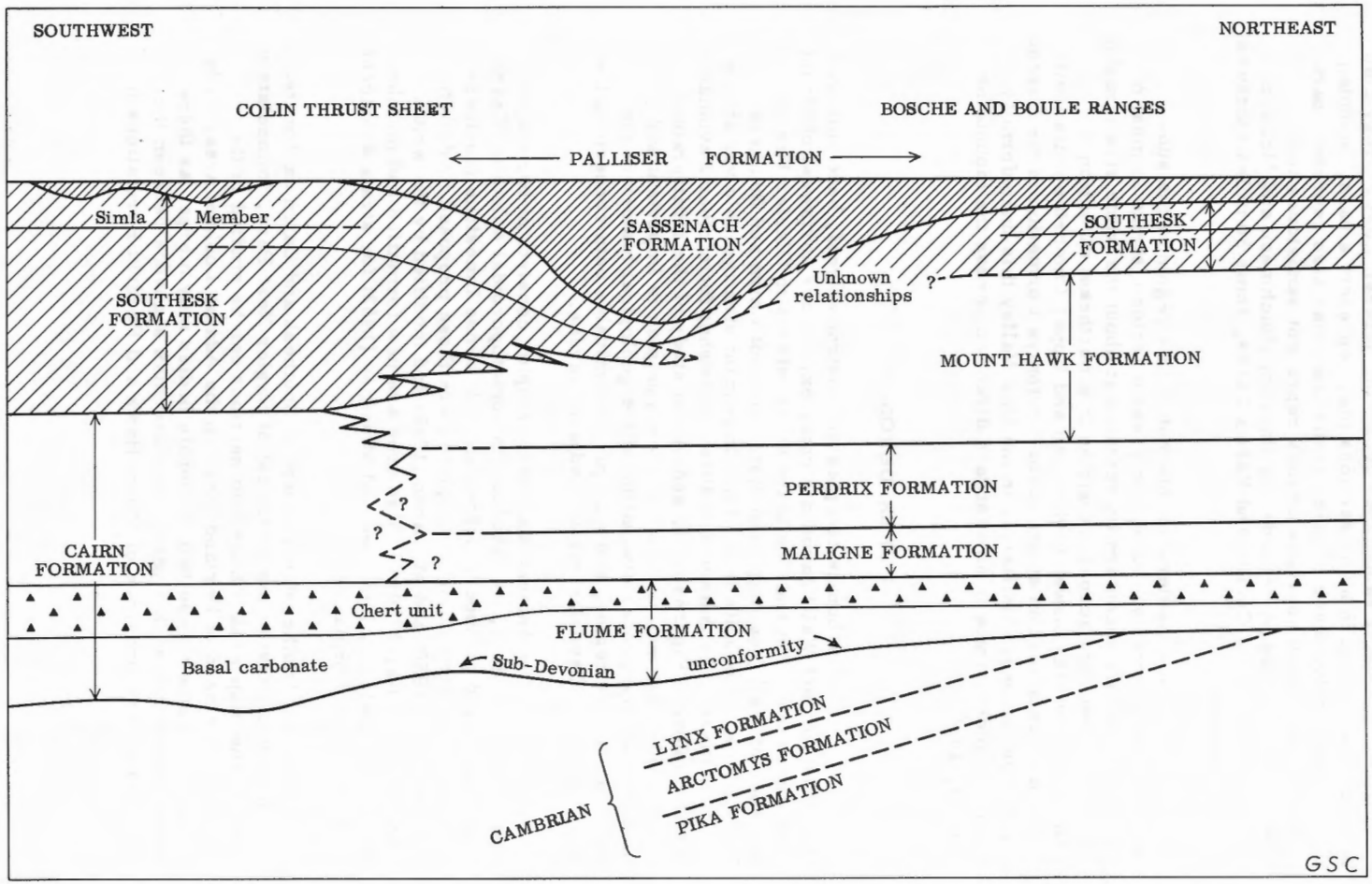

Figure 3. Schematic diagram showing probable relationships of Devonian formations across thrust sheets of northern Jasper National Park

the De Smet Range and at Eagles Nest Pass suggests that the eastern limit of the Ancient Wall carbonate complex occurs between the traces of the Greenock and Colin thrust faults.

Near the east boundary of the map-area in the Bosche and Boule Ranges, thick coralliferous limestones occur in the upper part of the Mount Hawk Formation and suggest a near-reef facies. This facies may indicate the proximity of the reefs observed in the Miette area in the Miette Range and beneath Folding Mountain (Mountjoy, 1960 a).

Devonian fossils were identified by D.J. McLaren, who provided a description of section 4 (Figure 4), used in modified form by the writer. Additional data collected by the writer and McLaren in 1961 have been included in Figures 4 and 5, and have helped immeasurably to better understand the stratigraphy of the Sassenach Formation and Simla Member. The upper parts of sections 4 to 10, and 12 (Figure 4) were revisited and described in more detail, and sections 2 and 11 were added.

The main stratigraphic variations of the Ancient Wall carbonate complex are illustrated in exaggerated form in Figure 4. This figure greatly distorts the observed variations, particularly in the vicinity of Mount Haultain. The information has been plotted without exaggeration in Figure 5.

Carbonate Facies

Cairn Formation (Map-unit 9)

The Cairn Formation occurs in the Colin and Chetamon thrust sheets as the basal unit of the Ancient Wall carbonate complex in the map-area. As at the type section (McLaren, 1955, p. 17), it consists of well-bedded, dark brown, fine- to medium-grained, organic carbonates, mostly dolomite. Near the southeastern edge of the reef in the vicinity of Mount Tory and Mount Haultain (Figure 4), limestone becomes predominant. Total thickness varies from 750 to 900 feet. The Cairn Formation can be divided into three units or members; a lower organic carbonate about 150 feet thick, a middle chert unit between 100 and 150 feet thick, and an upper unit of interbedded stromatoporoid carbonate and nonorganic carbonates about 550 feet thick. The carbonates with stromatoporoids also contain numerous *Amphipora*. The lower two units are grouped together as the Flume Member, since they correspond to the Flume Formation beyond the carbonate complex.

The lower contact is a regional unconformity. The variation in thickness of the lower half of the Flume Member may reflect irregularities in the surface upon which Devonian strata were

deposited. Thus at Blue Creek the Ladogioides kakwaensis fauna (McLaren, 1954) is probably older than faunas of the lower part of the Cairn and Flume Formations elsewhere in the area. The basal unit is only 20 feet thick in the Miette area to the southeast. The middle chert unit differs very little in lithology from the upper and lower units, except that it contains abundant small nodules and some thin beds of dark grey chert. The upper unit in general has a more intercrystalline and vuggy porosity than the Flume Member and stromatoporoids are less abundant.

Most of the abrupt changes from carbonate to argillaceous carbonate take place over distances of less than 1/2 mile (see map). Unfortunately these transitions occur in drift-filled valleys, and some of the important stratigraphic relationships could not be observed. The principal transitions occur: (1) on the east ridges of Mount Haultain, Figures 4 and 5; (2) in the valley north of Mount Rowand; (3) in the valley southeast of The Rajah; and (4) northwest of Noonday Peak near Glacier Pass (Figure 4). In most instances the upper part of the Cairn Formation occupies the same stratigraphic interval as the Perdrix and lower part of the Mount Hawk Formations.

Palaeontology and Correlation—Fossils are not abundant. In places the Flume Member carries the following:

Atrypa multicostellata Kottlowski
Allanaria sp.
Athyris sp.

The Cairn Formation is very similar in lithology and thickness to the type Cairn Formation which is 558 feet thick (McLaren, 1955) and to the Cairn of the Miette carbonate complex which is 680 feet thick (Mountjoy, 1960a).

Southesk Formation (Map-unit 10)

The Southesk Formation has a distribution similar to that of the Cairn Formation, but generally extends a few miles beyond the main edge of the carbonate complex, forming a distinct light grey carbonate above argillaceous carbonates of the Mount Hawk Formation (Figure 4). A thin unit of Southesk Formation also occurs above Mount Hawk strata in the Bosche Range.

The type Southesk Formation (McLaren, 1955, p. 19) is divisible into three members: a lower, coarse-grained, structureless dolomite; a middle, thin dolomite coral bed with Amphipora, stromatoporoids and corals; and an upper, granular, thick-bedded limestone. A different sequence occurs in the Southesk Formation of the Ancient Wall carbonate complex. A coral-bed member could not be distinguished,

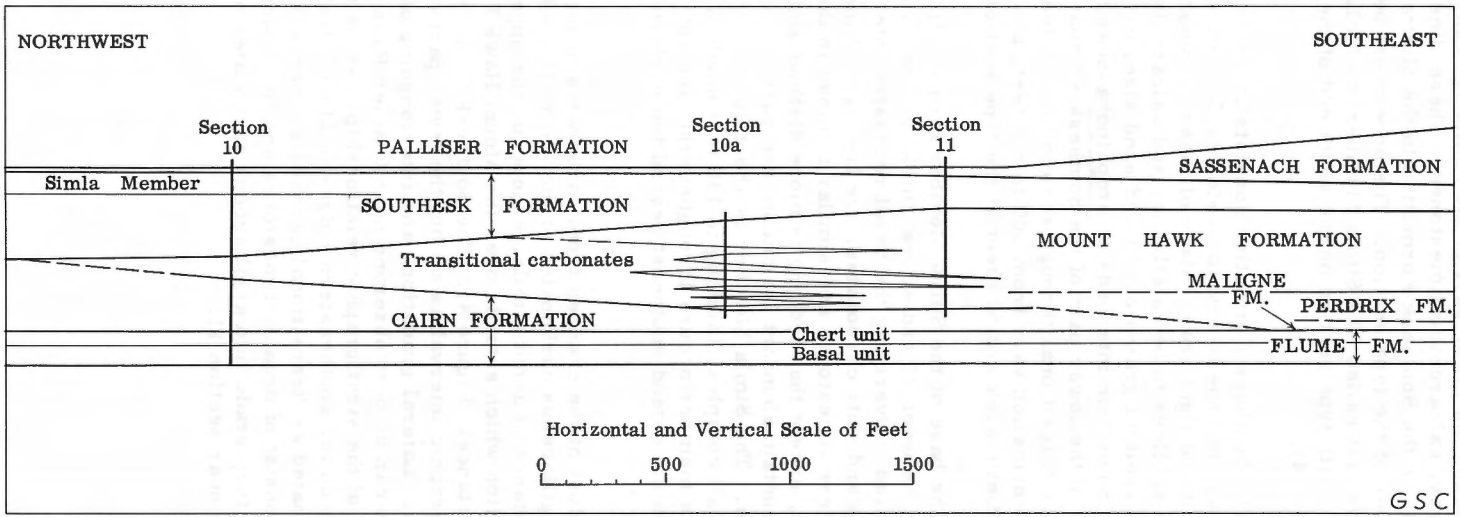

Figure 5. Southeast edge of Ancient Wall reef complex, Mount Haultain and vicinity

and in most sections the lower part of the formation consists of well-bedded, light grey, calcarenitic limestones. These limestones are identical to those in the Southesk Formation in the Miette area and to the upper member of the type section. The uppermost beds form a distinct mappable unit called 'the Simla Member' by McLaren and Mountjoy (1962), with type section on the south end of the Ancient Wall (section 4, Figure 4).

The Southesk Formation consists of a thick series of well-bedded, grey, micro- to cryptocrystalline limestones, which weather resistant and light grey. Many of these carbonates were observed in thin sections to be calcilutites and calcarenites consisting of rounded, non-skeletal grains of silt and sand size, cemented by sparry calcite. Some thin interbeds of Amphipora-bearing dolomite and limestone occur in the lower part of the Southesk Formation, and the lower boundary is transitional through some 50 to 110 feet. Thicknesses of the Southesk Formation vary from 600 to 800 feet, as compared with 530 feet in the Miette area and 528 feet at the type section.

The base of the Simla Member forms a distinct mappable recessive notch, between 20 and 40 feet thick, whose strata are commonly obscured. Overlying the basal recessive interval of red and green mudstones and silty carbonates, are light grey limestones in 1- to 5-foot beds. These limestones are similar to those in the lower part of the formation, except that bedding is more distinct and regular and the limestones contain abundant fragments and partings of greenish grey calcareous shale. The Simla Member is about 200 feet thick over most of the Ancient Wall complex, thinning to 130 feet north of Glacier Pass (Figure 4). This member occurs throughout the Ancient Wall carbonate complex but does not extend southeast beyond the eastern spur of Mount Haultain (Figure 5).

Most of the changes from carbonates of the Southesk Formation to argillaceous carbonates of the Mount Hawk Formation occur over a distance of about a mile, except for the upper part of the Southesk Formation which extends over the Mount Hawk Formation for much greater distances (Figure 4). The Southesk Formation occupies the same stratigraphic interval as all but the lower part of the Mount Hawk Formation. Lateral gradations and intertonguing of the strata of these formations can be best observed near Glacier Pass on Mount Haultain. Some of the stratigraphic relationships can be traced along the mountainside on the southeastern ridges of Mount Haultain (Figure 5). The rocks designated as 'transitional carbonates' between sections 10 and 11 largely consist of organic limestones and form biostromes and bioherms where they grade into argillaceous carbonates of the Mount Hawk Formation near section 11.

Stratigraphic relationships near Mount Haultain indicate that the upper contact is disconformable. The Palliser Formation consists of similar carbonates, and where it directly overlies the Simla Member it is difficult to recognize this important boundary. The Palliser limestones generally can be distinguished on the basis of darker colour, poorer bedding with a tendency to weather more recessive and rubbly, and dolomitic tracery.

Stromatoporoids including Amphipora, solitary and colonial corals, and some brachiopods occur in the Southesk Formation. The Simla Member is more fossiliferous, with Atrypa, Alveolites, Phacellophyllum, Pachyphyllum as well as stromatoporoids occurring in several sections. Similar corals were collected from limestones in the upper part of the Southesk Formation in the Bosche Range and in the Mount Hawk Formation near Eagles Nest Pass.

Argillaceous Facies

The Flume and Maligne Formations (map-unit 8) and the Perdrix and Mount Hawk Formations (map-unit 11), the normal stratigraphic sequence around the carbonate complexes, are grouped together for purposes of discussion. The Perdrix and Mount Hawk Formations are dominantly argillaceous whereas carbonate strata predominate in the Flume and Maligne Formations and the upper part of the Mount Hawk Formation. A description of these formations at Morro Peak in the Colin thrust sheet near the southeast corner of the area (section 15, Figure 4) has been given by de Wit and McLaren (1950, pp. 26-30).

Flume and Maligne Formations (Map-unit 8)

The Flume Formation occurs in most of the main thrust sheets of the area. It is a thin equivalent of the Flume Member of the Cairn Formation. Like this member it can be split into an upper, thin cherty carbonate and a lower non-cherty carbonate, consisting of fine- to medium-grained and crystalline, dark brown dolomite and limestone, with relatively abundant Amphipora and spherical stromatoporoids.

Thickness varies from 100 feet to more than 200 feet near the edge of the Ancient Wall complex. The Flume Formation is sparingly fossiliferous, with Allanaria and Atrypa multicostellata being most abundant.

The Maligne Formation is a thin transitional argillaceous limestone unit between the Perdrix shales and the Flume carbonates. It has a thickness that averages about 50 feet, generally increasing to twice this figure close to the Ancient Wall reef. The Maligne Formation

is restricted to the area west and south of the Ancient Wall reef, the southern parts of the De Smet Range and the Bosche Range. Upper and lower contacts are generally gradational through intervals of 2 to 10 feet.

The uppermost few feet is in many places very fossiliferous and commonly contains the following fossils.

Eleutherokomma reidfordi Crickmay
Calvinaria variabilis athabascensis (Kindle)
Atrypa sp. I

Perdrix and Mount Hawk Formations (Map-unit 11)

The Perdrix and Mount Hawk formations are widely distributed in the map-area, occurring in the Boule, Bosche and De Smet Ranges, near Eagles Nest Pass, northwest of Glacier Pass, southeast of The Rajah, and between Mount Haultain and Mount Hawk. In several of these localities the lower part of the Perdrix Formation is missing through faulting.

The Perdrix Formation consists of recessive-weathering, thin-bedded black shales, in part calcareous. A few thin, dark grey, argillaceous limestone interbeds are commonly present at the base and top of the formation. The upper part of the formation is transitional to the argillaceous limestone of the Mount Hawk Formation. In this transition zone, which is about 100 feet thick, the colour changes from black to yellowish grey and the carbonate content increases. The change from Cairn to Perdrix is commonly concealed in the vicinity of the Ancient Wall reef. Perdrix shales appear to interfinger with Cairn carbonates northwest of Glacier Pass, southeast of The Rajah and near Mount Haultain. Thickness of the Perdrix Formation varies between 250 and 350 feet in the Colin thrust sheet and is about 450 feet in the Bosche Range. The Perdrix Formation contains few fossils. Fragments of Tentaculites commonly occur near the base.

The Mount Hawk Formation consists of a series of fine-grained, dark grey, medium-bedded limestones. In many sections the carbonate content increases upwards, and argillaceous nodular limestones are common in the lower third. The upper third generally contains corals. Corals are very abundant in the upper Mount Hawk, in parts of the Boule and Moosehorn Ranges. The Mount Hawk Formation varies in thickness from 550 to 650 feet in the eastern half of the area, to 300 feet in the Colin thrust sheet beneath the thick part of the Sassenach Formation.

Fossils are abundant and a brachiopod fauna is well developed in the middle and upper parts. Collections from the Boule

and Moosehorn Ranges, Eagles Nest Pass, the Ancient Wall and the Colin thrust sheet (Fa, Figure 4) commonly contain:

Atrypa sp.
Calvinaria albertensis (Warren)
Grunewaldtia cf. G. americana Stainbrook
Indospirifer cf. I. orestes (H&W)
Productella sp.
Pugnoides cf. P. solon Thomas & Stainbrook
Schizophoria sp.
Schuchertella sp.
Thomasaria rockymontana (Warren)

Corals are locally abundant near the top of the Mount Hawk Formation in the Boule and Moosehorn Ranges. Some of these corals also occur in silty carbonates at Eagles Nest Pass and near the base of the Simla Member (Fb, Figure 4). The following occur in these collections and McLaren states that they are characteristic of the fauna that is present in the scarp-forming Kakisa Formation between Middle Kakisa and Trout Rivers, Northwest Territories.

Pachyphyllum exiguum (Lambe)
P. cf. P. fenense McLaren
P. nevadense (Stumm)
Ptychophyllum? kindlei Smith
Acinophyllum camselli (Smith)
Mictophyllum nobile Lang and Smith
Hexagonaria sp. L.

Silt and Sand Facies

Sassenach Formation (Map-unit 12)

The Sassenach Formation was designated by McLaren and Mountjoy (1962) for about 600 feet of calcareous shales, silty mudstones and argillaceous limestones which grade upward into calcareous siltstones and sandstones. The type section is on a mountain ridge 2 miles south of Mount Haultain (section 12, Figure 4), where the formation occurs above the Southesk Formation and beneath the Palliser Formation. The lower contact is sharp and probably unconformable as it is marked by a conglomerate and the basal strata onlap the Southesk Formation on the southern ridges of Mount Haultain (Figures 4 and 5). The upper contact is also sharp.

In general two members can be distinguished in the Sassenach Formation: the lower and thicker part consists of fossiliferous, dark grey, calcareous, silty mudstones and argillaceous limestones; and

the upper and more resistant part, about 100 feet thick, consists of silty and sandy limestone with some calcareous quartz sandstones.

The Sassenach Formation thins northwest, from 100 feet on Mount Haultain to 2 feet on Mount Tory; it appears to be absent between Mount Tory and Mount Stornoway and northwest of Glacier Pass.

In the De Smet, Bosche and Boule Ranges, thin-bedded, in part silty, carbonates occur between Palliser and Mount Hawk or Southesk carbonates. These silty carbonates are between 100 and 200 feet thick, commonly exhibit fine laminations and crossbedding, and occasionally contain intraformational carbonate conglomerates or breccias. The lower contact is very difficult to position as these silty carbonates appear to grade into underlying strata. Their relationships with the Sassenach Formation are not known but these strata are probably homotaxial with the upper member, and have been assigned to the Sassenach Formation. However, they may also represent part of the Mount Hawk or Southesk Formations as silty carbonates are also known to occur in these units.

A brachiopod fauna occurs in about all but the upper 100 feet of the Sassenach Formation at several localities (Fc, Figure 4). The following are representative:

Cyrtospirifer cf. *C. mimetes* (Crickmay)
Cyrtiopsis sp.
Athyris angelicoides (Merriam)
productellids
rhynchanellids

Reef Geometry and Depositional History

The Ancient Wall reef complex has a length of 26 miles along the Colin thrust sheet. Present minimum width in the Colin and Chetamon thrust sheets is 4 miles, but originally it was probably in the order of 8 to 10 miles across, possibly more. Thus the area of this reef would be approximately 250 square miles. Organic buildups and reef detritus appear to be thickest and most prolific on the north and south edges of the biostrome, where more than 1,500 feet of Cairn and Southesk carbonates occur.

An east-southeast trend of the southern edge of the reef complex is apparent from the geological map. The original trend of this edge was roughly east-west, if the thrust faults are restored to their relative positions prior to displacement. Since reef carbonates are absent in the De Smet Range it appears that the eastern edge of the reef complex had a general north-south trend.

A preliminary interpretation of the data available suggests these important deductions concerning depositional history: The overall lithologies and petrographic characteristics of these sediments are indicative of shallow-water shelf conditions. Initial sediments consist of a uniform development of stromatoporoidal biostromal carbonates, Flume Formation and Member, which were deposited over the entire area. Conditions favourable for organic growth were restricted during Maligne sedimentation to the area between Glacier Pass and Mount Haultain, probably as a result of increased regional subsidence, though local tectonic movements may have also occurred (see below). The thicker Flume Member in sections 3 and 6 to 9 (Figure 4) may indicate the loci of shoals in this unit on and around which organic growth flourished. Greater subsidence which restricted lateral growth but increased vertical growth is suggested by the presence of black Perdrix shales surrounding the upper stromatoporoidal carbonates of the Cairn Formation. Stratigraphic relationships between the Perdrix and Cairn Formations are not well known because of poor exposures.

The intertonguing of organic Cairn and Southesk carbonates with upper Perdrix and Mount Hawk argillaceous carbonates is indicative of gradual shallowing and filling of the depositional basin (Figures 4 and 5). Shallowing continued until the uppermost Southesk carbonates extended well beyond the main carbonate complex over the argillaceous Mount Hawk Formation. This shallowing is also reflected in the reef carbonates, as the Southesk Formation contains few organic carbonates, except near the edges of the carbonate complex, but abundant bedded granular limestones are suggestive of very shallow water bank conditions. The Ancient Wall reef was then subjected to some erosion, especially on the southeastern edge. This erosion was followed by deposition of argillaceous Sassenach sediments on the south and west sides, with the main part of the reef remaining emergent during this period. Finally, silts and sands of the uppermost Sassenach Formation filled the depositional basin overlapping the Southesk Formation near Mount Haultain, on the south end of the Ancient Wall, and near The Rajah (Figure 4).

The abrupt stratigraphic variations in the vicinity of sections 9 to 13 (Figures 4 and 5) suggest that subsidence of the area south of the Ancient Wall reef may have been controlled tectonically by local vertical adjustments in underlying rocks. The greater thickness of the Southesk Formation between Mount Tory and Mount Haultain (sections 8 to 11) suggests relatively greater subsidence of this area and areas to the southeast during upper Southesk time. Similarly, the abrupt increase in thickness of the Sassenach Formation south of Mount Haultain also suggests further subsidence of this latter area. The restriction of organic growth in Maligne times in the same area might also be explained in this way.

The depositional history of the Ancient Wall reef complex is similar in several respects to that of the Miette reef complex (Mountjoy, 1960b) and Devonian reefs of central Alberta (Belyea, 1955, 1958; Andrichuk, 1960).

A new cycle of subsidence was initiated with deposition of Palliser granular carbonates. The characteristics of these rocks are suggestive of a widespread bank deposit comparable to the present Bahama Banks (Beales, 1956).

Palliser Formation (Map-unit 13)

The Palliser Formation occurs throughout the northeastern half of the area. It forms the crests of many of the mountain ranges and is also cliff-forming. The Palliser Formation is between 700 and 900 feet thick and consists of dark grey, fine- to cryptocrystalline, massive limestones with varying amounts of dolomitic tracery and banding. Calcarenite and fossil-fragment limestones occur locally and are common at the top of the formation.

Fossils from the base of the Palliser Formation at Brewsters Wall were identified by McLaren as follows.

GSC No. 40208; *Cyrtiopsis* cf. *C. mimetes* Crickmay (Fd, section 1, Figure 4)
GSC No. 40205; *Camarotoechia nordeggi* Kindle

The uppermost beds are generally fossiliferous. Included in collections from these beds are the following.

Cyrtiopsis cf. *C. monticola* (Haynes)
C. cf. *C. kindlei* (Stainbrook)
Camarotoechia banffensis Warren
C. nordeggi Kindle

MISSISSIPPIAN

The succession of Mississippian strata in the map-area is similar to that of the Miette area (Mountjoy, 1960a) and the central Foothills (Brady, 1958). Mississippian strata are separated into Banff Formation (map-unit 15) and Rundle Group (map-unit 16). The Rundle Group is divisible into four formations, on a basis of petrographic and weathering character. These are informally designated Rundle Formations A, B, C, and D respectively, oldest to youngest. The same formations were mapped in the Miette area.

Brown (1952) has described the stratigraphy and palaeontology of several sections along the Athabasca Valley in the southeast corner of the map-area. In order to conform with regional development, Brown's stratigraphic units are recast. The upper and middle members of Brown's Greenock Formation are assigned to the Rocky Mountain Formation. The lower member of the Greenock Formation is equivalent to Rundle Formation D of this report.

The well-exposed Mount Greenock section is a good reference section for the Mississippian of the Jasper region. This section (see description in Appendix, section 5) is located along the Trans-Mountain pipeline right-of-way and is readily accessible from the Celestine Lake road, 6 miles from its junction with Highway 16.

Banff Formation (Map-unit 14)

The Banff Formation disconformably overlies the Palliser Formation. A few inches of sandstone occurs between these two units. This sandstone appears to be the basal unit of the Exshaw Formation. Harker and McLaren (1958, p. 258) reported less than 1 inch of sandstone with bone fragments, phosphate and pyrite nodules at Mount Greenock and on the Deer Creek anticline at Mowitch Creek. A 1-foot, brown, fine-grained sandstone was observed at the top of the Palliser Formation in the Bosche Range, but no black shales typical of the Exshaw Formation are present.

The Banff Formation can be divided into three parts. The lower unit is dark brown shale, calcareous and thin bedded, with thin 1- to 3-inch interbeds of argillaceous limestone occurring in the upper half and increasing in frequency upwards. It is between 300 and 450 feet thick. The middle unit is crinoidal limestone, 30 to 50 feet thick, resistant to weathering and coarse grained. The upper unit, 100 to 200 feet thick, comprises interbedded argillaceous limestone and fossiliferous, crinoidal limestone. Abundant silt occurs in the uppermost 10 to 30 feet, forming a distinct marker unit.

In general the Banff Formation weathers a yellow-brown and is recessive relative to overlying and underlying carbonate units. In the Ancient Wall outcrops, it weathers to a pale green. Total thickness varies from 650 feet in the Boule and Bosche Ranges to 750 feet near Mount Simla. Thicknesses of only 500 feet were measured on the Deer Creek anticline and on the Ancient Wall. Fossils similar to those described and listed by Brown (1952) were collected but many of these collections have not yet been studied. Of interest is the occurrence of *Lithostrotionella microstyla* (White) (=*L. jasperensis* Kelly of Nelson) at the top of the Banff Formation on the northwest side of The Rajah.

Table 1

Thickness of Carboniferous Units

Unit	Mount Simla (118°37W, 53°17N)	Brewsters Wall (118°54W, 53°28N)	Thornton Creek (118°17W, 53°09 1/2N)	Mowitch Creek (118°43W, 53°10N)	Mount Bistre (118°13W, 53°12N)	Whitecap Creek (118°08W, 53°09N)	Mount Greenock (118°04W, 53°05 1/2N)	Eagles Nest Pass (118°35 1/2W, 53°29 1/2N)	Moosehorn Lakes (118°11W, 53°23 1/2N)	Soloman Creek (118°05 1/2W, 53°23 1/2N)	Solomon + Bore-hole (117°57W, 53°24N)
Rocky Mountain Formation	152	110	216	64	---	121		36	0	0	0
Rundle Group Formation D	918	383	353	259	284	281	335	303	251	378	230
" C		310	367	354	307	400	378	202	141	164	
" B	234	347	280	332	211	443*	235	338	303	145	640
" A	270	306	210	116	122	119	244	116	199	155	220
Total Rundle Group	1,685	1,346	1,210	1,200	924	1,243*	1,192	959	894	869	1,090
upper Formation A	182	154	126	46	24	22	71	85	87	123	---
lower " A	88	152	84	70	98	97	173	31	112	32	---
Banff Formation	760	498	743	500	---	---	600	---	654	698	420

* Possible faulting.

\+ Interval 7,590 to 9,100.

Rundle Group (Map-unit 15)

Formation A consists of massive crinoidal limestone. Formation B comprises thin-bedded, dark grey, argillaceous limestone. Formation C consists of porous massive dolomite. The youngest, Formation D, consists of microcrystalline cherty dolomites. All contacts are gradational. Total thickness of the Rundle Group varies from about 850 feet in the Boule Range to 1,400 feet on the Ancient Wall and 1,600 feet on Mount Simla (Table 1).

Formation A

Strata of Formation A form a distinct, light-grey-weathering, resistant, massive-bedded limestone, averaging about 125 feet in thickness and locally thickening to 200 feet; in the more westerly sections it is more than 300 feet thick. It can be divided into two units: a lower, cliff-forming, coarse-grained encrinite; and an upper, thin-bedded, fine-grained limestone with fewer crinoid fragments. The encrinite limestones consist predominantly of disarticulated, rounded, echinoderm ossicles and plates with some bryozoan fragments cemented with clear calcite. A few chert nodules are present in some places in the upper part, and some thin beds of dolomite also occur. The contact with the underlying Banff Formation is distinct. The resistant encrinite limestones generally overlie thin-bedded, finely laminated, silty limestones and calcareous siltstones. The contact is apparently conformable in the area studied. Fossils are generally comminuted, but small broken solitary corals are common.

Formation B

Formation B consists of thin- to medium-bedded, finely crystalline to cryptocrystalline (lithographic), dark grey to dark brown limestones. The limestones are also argillaceous in part and contain grains, pellets and occasional superficial ooliths. Much of the rock is speckled with clear calcite due to abundant sparry calcite cement. Thin interbeds of lithographic dolomite are also present, some of which may be primary. Formation B varies in thickness from 200 feet to about 400 feet in the more westerly and northerly sections. In the eastern part of the area some thin beds of intraformational breccias and silty carbonates are present. Corresponding cored intervals in the Superior et al. Solomon Creek well (6-17-51-27-W5) immediately east of the area contain abundant anhydrite. This suggests that these breccias have originated through the solution of anhydrite and gypsum. Both upper and lower contacts are gradational and apparently conformable. Formation B generally weathers more recessive and thin-bedded than Formations A and C. The thickness of Formation B varies from 200 feet in the De Smet Range to more than 300 feet in the eastern and northeastern parts of the map-area (Table 1). These thicknesses do not appear to follow

any consistent pattern in the map-area. Fossils are generally rare, though a fauna with Camarotoechia cobblestonensis is widespread in the lower half of Formation B in much of this and surrounding areas. Fossils collected from higher strata on Mount Greenock at about the middle of the formation were identified by P. Harker of the Geological Survey as Spirifer cf. keokuk Hall and Spirifer cf. forbesi Norwood and Pratten. Corals are common in some sections in the upper part of Formation B. The following collections, identified by E.W. Bamber of the Geological Survey, appear to be representative.

GSC loc. 40252; at top of Formation B, Brewsters Wall section.
Lithostrotion (Siphonodendron) sp. cf. L. (S.) warreni Nelson

GSC loc. 40255; same location, 80 feet below top of Formation B.
Ekvasophyllum proteus Sutherland
Syringopora spp.

GSC loc. 36756; Mount Greenock section, 90 feet below top.
Ekvasophyllum proteus Sutherland
Vesiculophyllum sp.

Formation C

Formation C comprises a series of carbonates, mostly dolomite, which are fine to coarse grained, massive bedded, in part porous, and contain relicts of crinoid, coral and other fossil fragments. Lesser amounts of fine-grained, light grey, argillaceous limestones and dolomites with minor chert are interbedded. The coarse-grained parts are commonly finely laminated and crossbedded. Porous zones are associated with the fossil-fragment dolomite horizons. In the Mount Greenock section (see Appendix), Formation C can be divided into two parts: a lower 205 feet of recessive-weathering porous dolomites, and an upper 173 feet of resistant-weathering, very slightly porous dolomites. Thicknesses vary from about 150 feet in the Front Ranges to more than 300 feet, west of the Snake Indian River. Contacts are gradational. The upper contact is difficult to distinguish and has been placed where finely crystalline, cherty dolomites of Formation D lithology become predominant and the weathering colour changes from a light grey-brown to a light yellow-grey. Some interbeds of Formation C type dolomites occur at the base of Formation D in several sections. A distinct but poorly preserved coral fauna occurs in the porous carbonates, particularly near the base. According to E.W. Bamber of the Geological Survey, they include species of Vesiculophyllum, Lithostrotion and Syringapora. Lithostrotion (Siphonodendron) sp. cf. L. (S.) warreni Nelson was collected from the middle and lower parts of Formation C in several sections. The following collections were obtained from the upper part of Formation C.

GSC loc. 40257; collected northwest of Brewsters Wall.
Lithostrotion (Siphonodendron) sp. cf. L. (S.) whitneyi (Meek)
Vesiculophyllum sp.

GSC loc. 40249; 65 feet below top of Formation C in Eagles Nest Pass section.
Lithostrotion (Siphonodendron) n. sp.
Vesiculophyllum sp.
Linoproductus ovatus ? (Hall).

Strata of Formation C in the western part of the area may have been deposited at the same time as strata of the lower part of Formation D in the eastern part. Palaeontological control is insufficient to verify this relationship.

Formation D

Formation D consists of fine- to cryptocrystalline, brownish grey, cherty dolomites, which weather thin- to medium-bedded with a distinct pale-yellow colour. Some thin beds of silty dolomite and breccia occur locally. Generally the chert is dark grey, weathers orange, and occurs in lenticular nodules and beds 1 inch to 2 inches thick. Some thin zones of argillaceous dolomite occur in the Foothills and adjacent Front Ranges. The association of anhydrite with dolomites in cores from this unit in the Solomon Creek bore-hole suggests that many of these dolomites may have a primary origin. The thickness of Formation D varies from 250 feet to nearly 400 feet. Most of the thicker sections occur in the southwestern Front Ranges. Formation D is overlain by the Rocky Mountain Formation in much of the area. Triassic Sulphur Mountain strata occur above it east of Rock Creek and Moosehorn Creek, along the northwestern part of the Bosche Range. This contact is very sharp and distinct. At several localities a thin chert conglomerate, 1/2 foot to 2 feet thick, separates Formation D from the overlying Rocky Mountain Formation or the Sulphur Mountain Formation. The pebbles consist of chert and quartzite and average about 1/2 inch in diameter, though some angular fragments up to 16 inches were observed at one locality. In a few places the Rocky Mountain chert and sandstone occur in channels, up to 7 feet deep, cut into Formation D. Some of the eastward thinning of Formation D may be due to erosion prior to deposition of the Rocky Mountain Formation. Consequently this contact is very probably unconformable.

A zone of silicified brachiopods including Spirifer n. sp. A of Brown occurs between 50 and 70 feet above the base of Formation D in the Mount Greenock section. Similar silicified brachiopods were also observed at about the same stratigraphic position in other sections.

Correlation

These Rundle formations appear to extend as far south as Nordegg along the Foothills and Front Ranges. Correlation farther south is more difficult as there are no published accounts of the Mississippian stratigraphy between Nordegg and the Bow Valley. The Mississippian sequence at Moose Mountain has recently been described by Illing (1959) and the stratigraphic sequence there is very similar to that of the Athabasca Valley area.

The following tentative correlations are suggested. Formations A and B are probably equivalent lithologically to the Pekisko and Shunda Formations near Nordegg and areas farther south. Formations C and D are probably equivalent to the Turner Valley Formation and the lower part of the Mount Head Formation in the same region. Formations A and B may be the rock equivalents of the middle and upper parts of the type Banff Formation (Moore, 1958), or of the upper part alone (Nelson and Rudy, 1959, p. 258; Nelson, 1960, pp. 107,112).

PERMIAN AND (?) PENNSYLVANIAN

Rocky Mountain Formation (Map-unit 16)

Strata of the Rocky Mountain Formation are massive white-to-grey cherts, brown cherty sandstones, and fine- to medium-grained orthoquartzitic sandstones and siltstones. In the area between Snake Indian and Athabasca Rivers, the Rocky Mountain Formation is divisible into an upper thin sandstone, about 25 feet thick, with chert nodules, and a lower chert with some thin lenses of sandstone, which is between 100 and 200 feet thick. Chert with minor sandstone is predominant in the sections observed north of Snake Indian River.

The upper sandstone and lower chert at Mount Greenock were originally defined as the upper and middle members of the Greenock Formation (Brown, 1952). Lithologically these sandstones and cherts closely resemble the upper 50 to 100 feet of the massive chert and cherty sandstones of the Ishbel Formation of the Rocky Mountain Group of the Banff area (McGugan and Rapson, 1961).

TRIASSIC

Triassic strata are widely distributed in the northeast half of the area. Contacts with the underlying Rocky Mountain Formation and the overlying Fernie Group are disconformable. A thin, 1- to 2-inch chert-pebble conglomerate commonly occurs at the base above Formation D carbonates, and locally above Rocky Mountain strata. It

appears to be indicative of Triassic transgression and the disconformity between Sulphur Mountain and Rocky Mountain strata.

Triassic strata can be divided into two mappable units: an upper Whitehorse Formation of light-coloured silty carbonate with solution breccias, multicoloured silty mudstones and some gypsum; and a lower Sulphur Mountain Formation of brown siltstones and fine-grained sandstones with some black shales. These formations grade into each other. The contact is placed at the change from brown sandstones to yellow silty carbonates, calcareous sandstones and breccias. These formations are lithologically similar to, and occupy the same stratigraphic position as, the type Whitehorse and Sulphur Mountain Members of Warren (1945). Triassic rocks thicken markedly in a southwesterly direction across the map-area. Triassic data from the northern part of Jasper Park have recently been summarized by Manko (1960) and that from the region south of the Athabasca River by Best (1958). Manko's stratigraphic units can be distinguished in most of the area.

Sulphur Mountain Formation (Map-unit 17)

Siltstones are predominant throughout the Sulphur Mountain Formation and can be divided into three sub-units: a lower, brown siltstone and fine-grained sandstone, about 600 feet thick, dominantly argillaceous at the base; a middle, thin shale, about 100 feet thick, which in places contains ammonites; and an upper, siltstone and sandstone, about 200 feet thick, which changes in colour from medium brown to light yellowish brown. Total thickness varies from 600 feet in the Foothills to about 1,000 feet, west of Mowitch Creek.

Palaeontology and Correlation—In 1952, Harker collected the following fossils from near the base of the middle shale unit near The Natural Arch.

GSC loc. 21399; 14 feet above base.
Longobardites cf. *nevadanus* Hyatt and Smith
Gymnotoceras ? sp.

GSC loc. 21400; 34 feet above base.
Longobardites ? sp.
Gymnotoceras ? sp.

Both lots, identified by F.H. McLearn, indicate an Anisian (Middle Triassic) age. Manko (1960, p. 38) has observed that ammonites of the *Beyrichites*-*Gymnotoceras* fauna commonly occur in this interval in the northern part of Jasper National Park and adjacent regions.

In the Miette area, an Upper Scythian ammonite was found about the middle of the Sulphur Mountain Formation. Early Triassic fossils are known to occur in equivalent strata at Banff and areas farther south, but have not been found in the lower part of the formation in the Jasper region.

Comparing lithologies with the Triassic units of the Kvass Flats area (Irish, 1954) to the north, the Sulphur Mountain Formation appears to be equivalent to unit C and the lower two thirds of unit B of Irish.

Whitehorse Formation (Map-unit 18)

The Whitehorse Formation consists of a heterogeneous mixture of silty carbonates, sandstone, carbonate breccias, mudstone and minor gypsum. These rocks are predominantly very light grey to pale yellow with some red colours, and the formation stands out in contrast to the dark weathering rocks above and below.

The main part of the Whitehorse Formation consists of yellow and red, silty carbonates, carbonate breccias and mudstones, with scattered gypsum. At Mowitch Creek, about 200 feet of gypsiferous carbonates occur approximately 500 feet below the top of the Whitehorse Formation (Allan, 1933, pp. 626-628). Gypsum was also observed in the Whitehorse Formation at several other localities (see section on economic geology). Two areas of sink-holes occur in rocks of this formation. A series of holes aligned along the strike occurs in Snake Indian Valley on the south side of the river, 1 mile south of Welburne warden cabin (118°30'W, 53°19 1/2'N). About twenty small sink-holes occur 1 mile east-northeast of Mount Tory (118°20'W, 53°14'N). Their average diameter is about 15 feet.

The carbonate breccias are very angular and are believed to have originated by the removal through solution of anhydrite and gypsum.

A distinct cherty limestone about 300 feet thick occurs at the top of the Whitehorse Formation west of Rock Creek and on and near De Smet Range. Fossil fragments are abundant. This part of the Whitehorse is very similar to the cherty dolomites near the top of the Rundle Group.

In the Foothills the Whitehorse Formation consists almost entirely of finely laminated, silty, very light grey dolomite. A few thin zones of breccia are also present.

The Whitehorse Formation increases in thickness in a southwesterly direction to a greater extent than the underlying Sulphur

Mountain Formation. It is 100 feet thick in the Foothills, increases to 650 feet east of Rock Creek, to 1,000 feet in the Starlight Range, and to about 1,500 feet in the Ancient Wall outcrops.

Palaeontology and Correlation—No well-preserved fossils were collected from this unit in the map-area. Middle Triassic fossils have been collected from equivalent strata in adjoining map-areas (Lang, 1947b, p. 21; Irish, 1947, p. 13). In the Kvass Flats area to the north, Irish (1954, p. 18) collected Karnian (Late Triassic) fossils from rocks which are very similar to the Whitehorse Formation (his 'unit A'). The Whitehorse Formation of the Mount Robson map-area is probably equivalent to the upper part of 'unit B' and all of 'unit A' of the Kvass Flats area.

Paréjas (1931) reported Monotis cf. M. subcircularis Gabb from outcrops in Vine Creek. Doubt has been cast on the authenticity of this determination by Frebold (in Best, 1958) and Manko (1960). No Triassic outcrops occur in Vine Creek near its mouth, but several outcrops of the Nordegg Member of the Fernie Group are present on the northeast side of the creek about a mile upstream from the park road. Triassic formations which outcrop farther northeast are largely covered with forest. One of the Nordegg outcrops contains abundant pelecypods which may have been misidentified as Monotis by Paréjas. Consequently there is no faunal evidence to indicate that the upper part of the Whitehorse Formation at Vine Creek is of Upper Triassic age.

JURASSIC

Fernie Group (Map-unit 19)

The Fernie Group is well exposed on the valley sides bordering Sulphur River and Deer and Mowitch Creeks, and in the lower part of Snake Indian River. Locally good exposures of part of the group occur elsewhere. New stratigraphic and fossil data are reported and summarized in Figure 6. More detailed stratigraphic descriptions will appear in a separate publication.

The Fernie Group generally consists of a series of dark-coloured shale, silty shales and silty limestones, divisible into these distinct units (following Frebold, 1957): in ascending order, Nordegg Member (Sinemurian), Paper shales (Toarcian), Rock Creek Member (Middle Bajocian), Grey beds (Lower Callovian), Green beds (Oxfordian), and upper part of Fernie Group (Oxfordian to Portlandian). Jurassic fossils were identified by Frebold, except where noted otherwise.

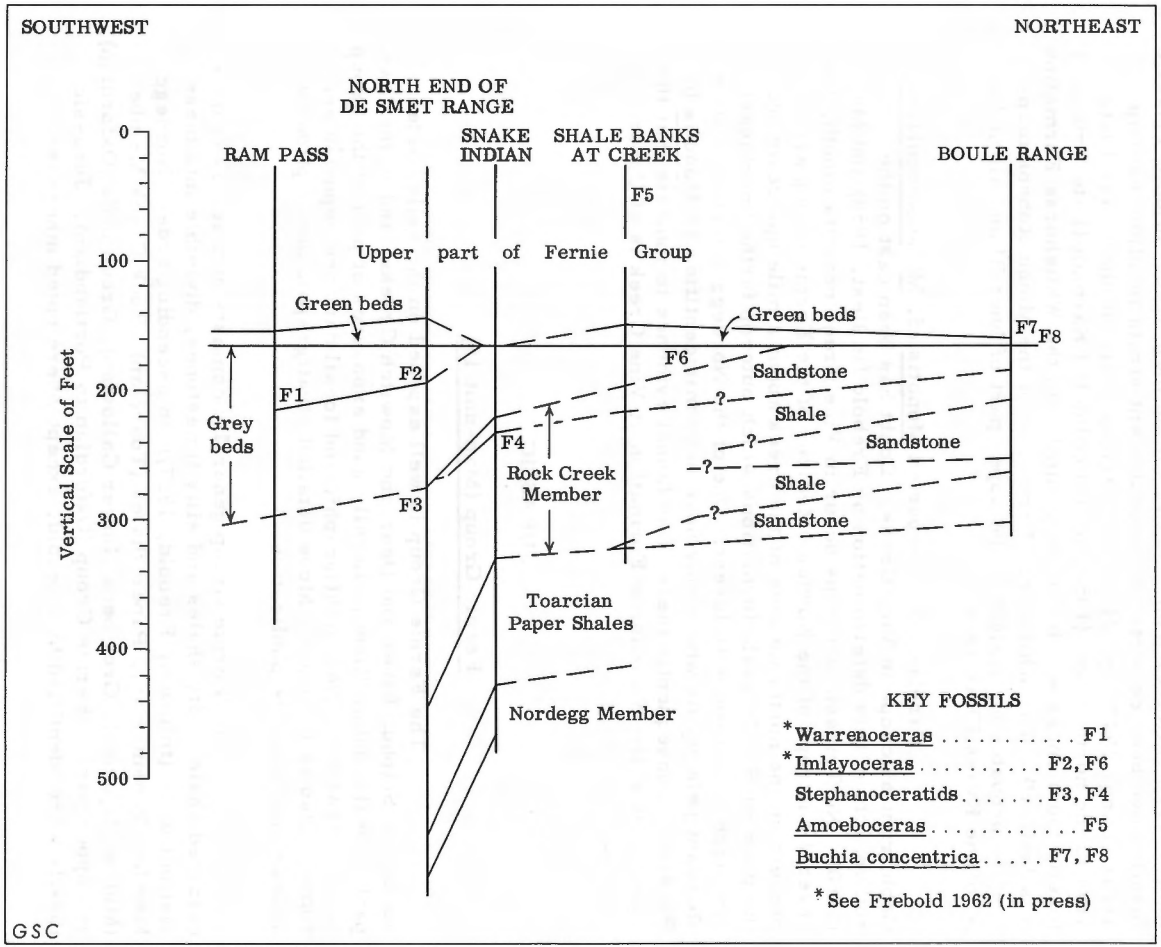

Figure 6. Fernie sections illustrating distribution and thickness of members

Nordegg Member

The Nordegg Member consists of dark grey to black, silty, cherty limestone with some interbeds of black chert. It is very resistant and is generally well exposed in both stream and ridge sections. A thin conglomeratic coarse-grained sandstone was observed at the base in some sections. In other exposures this disconformity was often difficult to detect because the underlying Whitehorse strata consist of similar dark silty limestones. Commonly, the thickness is about 30 feet, though locally it is as much as 50 feet. In several places the Oxytoma beds at the top of the Nordegg Member could not be recognized.

Several fossil collections were made. Some of the more important are listed below.

GSC loc. 40241; mouth of Mowitch Creek, from middle and upper part of Nordegg Member.
Arietites (sensu lato) gen. and sp. indet.
Pecten div. sp.
Trigonia (?) sp.
Pleuromya (?) sp.

GSC loc. 42091; near mouth of creek northeast of Shale Banks in Snake Indian Valley, from near the base of Nordegg Member.
Oxytoma (?) sp. indet.
Pecten (Weyla) sp.
Pecten sp.

NMC No. 9896; 1/2 mile upstream from Snake Indian Falls at Seldom Inn, near top of Nordegg Member.
Ichthyosarus (=Eurypterygius) cf. communis front limb and paddle identified by W. Langston Jr., National Museum of Canada.

Paper Shales

This unit consists of black fissile shales which weather recessive and black in very thin platy beds. The lower part is generally calcareous, and thin beds of black argillaceous limestone commonly occur in the lowermost 10 to 20 feet. The Paper shales overlie the Nordegg Member with apparent conformity. They were observed to have a uniform thickness of close to 100 feet in much of the area.

Poorly preserved impressions of ammonites and pelecypods are common. The following fossils were collected about a mile downstream from Snake Indian Falls.

GSC loc. 42089; Dactylioceras sp.
Ammonites indet.
Saurian vertebra.

Rock Creek Member

The Rock Creek Member overlies the Paper shales with apparent conformity. It consists of a series of dark grey silty shales with occasional concretions and thin interbeds of siltstone. These shales weather dark grey with a dark red tinge. Large ellipsoidal concretions up to 5 feet in long dimension are commonly present. Silt content is greatest near the top, and the top is commonly marked by a thin bed of siltstone or very fine grained sandstone, overlain by a 1- or 2-inch bed containing abundant belemnites and pelecypods. This topmost silt-and-sand unit increases in thickness in a northeasterly direction from 5 to 10 feet in the Snake Indian River and Mowitch Creek areas, to more than 30 feet on the west side of the Boule Range; there, two further sandstone beds, 5 to 20 feet thick, appear lower in the Rock Creek shales. The increase in thickness, number and grain size of sandstone beds towards the northeast suggests proximity to a shoreline and a northeasterly source for these clastics. A similar conclusion was reached by Frebold (1957) for the areas to the south. The Rock Creek Member varies in thickness from 100 to 200 feet.

Belemnites are common and ammonites occur in some abundance in the topmost bed, but are generally too poorly preserved for specific identification.

GSC loc. 40232; top Rock Creek Member, east side of Deer Creek anticline.
Stemmatoceras (?) sp. indet.
Pleuromya simplex Warren
Oxytoma sp.

A mixed collection was obtained from the mouth of Mowitch Creek.

GSC loc. 40219; from top of Rock Creek Member and base of Grey beds.
Gryphaea cf. cadominensis Warren
G. cf. impressimarginata McLearn
abundant belemnites.

Stephanoceratid fragments were also collected in the uppermost beds near Snake Indian Falls and in outcrops on ridges about 3 miles to the northwest (F4 and F3, Figure 6).

Grey Beds

Strata assigned to the Grey beds are divisible into two units: a lower, black, platy shale unit which commonly carries abundant

impressions of ammonites; and an upper, light yellow-brown shale with numerous concretions up to 2 feet long diameter, particularly in the upper part. These units grade into each other. The lower platy shale interval is about 20 feet thick in most places, though in one section it is 50 feet thick.

Total thickness of the Grey beds west of Snake Indian and Wildhay Rivers varies between 80 and 110 feet. Incomplete sequences occur near Snake Indian Falls (55 feet) and northwest of Bosche Range. No Grey beds were observed northeast of Moosehorn Valley, and present stratigraphic relationships indicate that these beds were eroded before deposition of the overlying Green beds. Grey bed strata overlie Rock Creek strata with apparent conformity but fossils from above and below this contact indicate that strata representative of the Bathonian and Upper Bajocian stages are absent.

Three fossil zones occur in the Grey beds, one in the lower unit and two in the upper. The first zone is represented by abundant but poorly preserved ammonite impressions.

GSC loc. 40222; from Desolation Pass.
Kepplerites (?) sp. indet.
Inoceramus sp.

The second zone is represented by a collection found east of the Colin thrust trace, 2 miles east of Mount Stornoway. The following fossils were collected from the lower half of the upper unit in strata with abundant concretions (F1, Figure 6).

GSC loc. 42076 and 42080;
Warrenoceras codyense (Imlay)
W. imlayi (Frebold)
W. sp. indet.
Cadoceras sp.

According to Frebold (personal communication, and GSC Bulletin, in press) these fossils are of an early Callovian age. The third and uppermost zone is characterized by a globose ammonite, Imlayoceras miettensis Frebold (F2 and F6, Figure 6; also Frebold, in press). It has been collected from several localities in this area and also occurs in the Rocky River Fernie outcrops in the Miette area (Mountjoy, 1960a). It has a known stratigraphic range of between 15 and 40 feet below the top of the Grey beds. Frebold reported that this fossil indicates a late early-Callovian age.

Green Beds

The Green beds occur throughout the area and are easily recognized because they weather more resistant and in lighter colours

than adjacent strata. They consist essentially of glauconite and silty concretionary shale with minor amounts of glauconite. Glauconite is most abundant between 1 foot and 5 feet from the bottom of the unit. Distinct thin, dark grey, concretionary siltstone layers are commonly present at the top and bottom of the glauconite. Thicknesses vary from 10 to 20 feet and may be as much as 40 feet. Plant fragments and tree branches are common, and this unit weathers moderately resistant and greenish grey in colour.

Green beds occur directly on top of the Rock Creek Member immediately west of Moosehorn Lakes, on the west side of Boule Range, and near the head of Solomon Creek. It is concluded that the Grey beds are overlapped and truncated by the Green beds in a northeasterly direction. Exactly parallel stratigraphic relationships occur in the Miette area (Frebold, Mountjoy and Reed, 1959). Green beds are absent in an outcrop about a mile downstream from Snake Indian Falls.

Except for wood fragments, fossils are rare, however Buchia cf. concentrica (Sowerby) was collected in the Green beds near the head of Solomon Creek. This Buchia and ammonites from the adjoining Miette area indicate that the unit is of Oxfordian age (Frebold, Mountjoy and Reef, 1959).

Some geologists have suggested that glauconites occur in the Rock Creek Member. Minor amounts of glauconite were observed in this member in only one section—on the northwestern end of De Smet Range. The glauconite unit at Desolation Pass, thought by Hawryszko (1959) to be the stratigraphic equivalent of the Rock Creek Member, belongs to the Green beds; these strata are underlain by shales which carry lower Callovian fossils and are equivalent to glauconites that elsewhere contain Buchia cf. concentrica and Cardioceras. The Green beds of this report are equivalent to 'unit a' of the Miette and other areas to the south (Frebold, Mountjoy and Reed, 1959).

Upper Part of Fernie Group

The strata between the Nikanassin Formation and the Green beds are here referred to as the upper part of the Fernie Group and correspond to 'unit b' of the Miette area (Frebold, Mountjoy and Reed, 1959, pp. 7-9). These beds consist of dark grey to black shales and silty shales with many thin beds and concretions of yellow- or orange-weathering siltstone. These thin beds and concretions of siltstone increase in number upwards and give the outcrops a characteristic banded and well-bedded appearance. The basal contact appears to be conformable, and may well be gradational. The contact with the Nikanassin Formation is completely gradational and is generally placed where sandstones and siltstones become the predominant rock type.

Well-exposed and complete sections were not observed. The thickness was estimated to be between 300 and 400 feet in some sections. These thicknesses have been corroborated by several graphic calculations.

In the more westerly outcrops, particularly near the head of the south fork of Sulphur River, shales of the upper part of the Fernie Group are overlain by thin-bedded brown siltstones and silty shales, with the shales predominating. It is suggested that these silty shales are probably equivalent to basal Nikanassin strata farther to the northeast. In this area and in the valleys of Mowitch and Rock Creeks, some Nikanassin strata may occur in the areas mapped as Fernie Group.

Buchia occurs very widely in the lower half of this unit and can be found in almost every section. Frebold has identified most of these pelecypods as Buchia concentrica (Sowerby). Amoeboceras sp., an ammonite new to the Fernie of this region, was found associated with Buchia concentrica (Sowerby) about 100 feet above the Green beds. These fossils were collected in outcrops in the creek that flows into Snake Indian River opposite Shale Banks, approximately 3 miles upstream from its mouth (F5, Figure 6). Amoeboceras sp. was also collected from some of the Snake Indian outcrops, together with Buchia concentrica (Sowerby).

Correlation

All these units of the Fernie Group are equivalent to units occurring in this group in areas to the south (Frebold, 1957); the upper part of the Fernie Group and the Green beds are equivalent to the Swift Formation of the Alberta and Saskatchewan subsurface, and the Montana outcrops; and the Grey beds are equivalent to the Rierdon Formation of these same regions (personal communication, Frebold, 1961).

UPPER JURASSIC AND LOWER CRETACEOUS

The Nikanassin, Cadomin and Luscar Formations are used in the sense originally proposed by MacKay (1929a, 1929b). The Mountain Park Formation has been found to be local in extent and was not observed in the adjoining Brûlé area by MacKay (1929b) or Lang (1947). It was also found difficult to distinguish in the Miette area (Mountjoy, 1960a). Mellon (1959) found it difficult to extend the Mountain Park Formation outside the type area, as these rocks are completely gradational with underlying strata and inconsistently developed. Mellon has shown that the green colour depends on the amount of volcanic detritus and authigenic chlorite present. In the area mapped, greenish grey sandstones occur in the upper part of the Luscar Formation but are not distinct enough to map separately.

Nikanassin Formation (Map-unit 20)

The Nikanassin outcrops extensively, forming a series of high ridges northeast of the lower Snake Indian Valley and northwest and southeast of Rock Lake. No undisturbed and complete stratigraphic sections were observed. In general the Nikanassin Formation consists of thin- to thick-bedded, fine- to medium-grained, brown to dark grey, quartzose sandstones, with thin interbeds of siltstone and silty shales. These sandstones have distinct fine laminations and are commonly crossbedded. The sandstone matrix commonly weathers to limonite. Some thin carbonaceous shale beds generally occur in the upper part directly beneath the Cadomin conglomerate. Only the resistant sandstone strata are well exposed. Two resistant sandstone intervals appear to be present in the Nikanassin Formation, one about the middle and the other near the top.

No marker beds were observed. Thicknesses range from about 1,000 feet in the Foothills to more than 2,000 feet on the ridges east of Snake Indian Valley.

The following fossils, identified by J.A. Jeletzky of the Geological Survey, were collected from strata assigned to the base of the Nikanassin Formation.

GSC loc. 42613; in foot-wall of Boule thrust, 6 miles east-northeast of Rock Lake and 4 1/2 miles northeast of Moosehorn Lakes.
Buchia mosquensis (Buch non Lahusen) s. lato
Aucellina nov. sp. ex aff. A. schmidti Sokolow
Meleagrinella sp. indet. ?
Pteria (Oxytoma) sp. indet.
Arctica sp. indet. ?
Pentacrinus sp. indet.

Jeletzky states that the Buchia mosquensis "... ranges from the late Kimmeridgian to late, but not the latest, Portlandian senso stricto,"... and that the Aucellina sp. "... is only known from the Portlandian senso stricto of western and Arctic Canada. The association of the two is strongly suggestive of the Portlandian senso stricto age of the basal beds of the Nikanassin Formation represented by loc. 42613. This lot could be either somewhat older than or contemporary with the basal beds of the Kootenay Formation where Titantites occidentalis Frebold has been found." Buchia sp. was also collected from higher in the Nikanassin Formation on the ridges east of Moosehorn Lakes.

In areas to the north and northwest the Nikanassin reaches thicknesses approaching 4,000 feet. In Grande Cache map-area, Thorsteinsson (1952) reported Buchia sp. occurring about 1,000 feet below the top of the Nikanassin Formation. Much farther northwest,

near Kakwa Lake, a similar thick sequence of strata equivalent to the Nikanassin Formation has been reported by Ziegler and Pocock (1960). They place the Jurassic-Cretaceous boundary low in this sequence, as the upper three quarters has yielded Lower Cretaceous plant spores and the base of the section contains Upper Oxfordian foraminifera.

LOWER CRETACEOUS

Cadomin Formation (Map-unit 21)

The Cadomin conglomerate is a very useful stratigraphic marker. It consists of closely packed, rounded, grey chert and quartzite pebbles, averaging between 1/2 and 1 inch in diameter, with some cobbles as large as 5 inches. These pebbles and cobbles are cemented together by medium- to coarse-grained, light grey, quartzose sands. Some red and green pebbles also occur. In many outcrops the largest pebbles and cobbles occur at the base of the formation. The sandstone is well indurated and in some places it forms lenses and beds in the conglomerate. The conglomerate commonly weathers as a single, resistant massive bed. When broken it breaks across the pebbles.

The upper and lower contacts of the Cadomin conglomerate are abrupt and distinct. The lower boundary of the conglomerate was observed to truncate Nikanassin strata in some outcrops. This contact is locally disconformable and regionally may be unconformable. Thickness of this formation varies from 10 to 30 feet, commonly being about 15 feet.

Luscar Formation (Map-unit 22)

The Luscar Formation occurs in the northwest corner of the area. Poor exposures combined with considerable folding and faulting makes determination of the stratigraphic succession difficult. In the Miette area (Mountjoy, 1960a) the Luscar Formation can be split into two units by a conglomeratic sandstone which occurs near the middle of the formation. In this map-area, similar conglomeratic sandstone was observed in the vicinity of Moosehorn Lakes and immediately southeast of Eagles Nest Pass. However, outcrops are too scattered for use in subdivision and this unit does not appear to be present northeast of the Folding Mountain thrust.

Much of the formation consists of loosely cemented, light grey and greenish grey, fine-grained sandstone. These sandstones are generally crossbedded and interbedded with varying thicknesses of dark grey siltstones and carbonaceous mudstones. The lower part of the formation appears to be more argillaceous than the upper part. Commonly, the uppermost sandstones are greenish grey.

Coal, even in thin seams, was rarely observed in outcrops. The coal generally occurs in thick shale intervals which are generally covered. Development work by Jasper Park Collieries (unpublished data, Geological Survey files) indicates the occurrence of a number of thin coal seams in Moosehorn Creek near the eastern boundary of the map-area. MacKay (1955, p. 144), from field work in 1927, indicated the presence of three coal seams in the basal 500 feet of the Luscar Formation near Moosehorn Creek.

From structure cross-sections the Luscar Formation has been determined to be about 2,000 feet thick. The contact with the overlying Shaftesbury Formation was not observed within the map-area. Mellon (1959, p. 9) observed that this contact was sharp but conformable at Cadomin. The absence of the Upper Blairmore flora in the Luscar Formation suggests an unconformity at the top (Mellon, 1959, p. 11).

A Luscar flora has been collected from the lower quarter of the Luscar Formation in the area northeast of the Folding Mountain thrust. According to D.C. McGregor of the Geological Survey, one of these collections contains the first recorded occurrence of Nilssonia schaumburgensis in the Luscar Formation. It is common in the Kootenay Formation. McGregor also identified the following forms:

Athrotaxites berryi Bell
Elathides splendida Bell
Elatocladus acifolia Bell
Pityophyllum cf. P. nordenskiddi (Herr) Krysht
Podozamites lanceolatus (L. & H.) Schimper
Ptilophyllum (Anomozamites) montanense (Fontaine) Bell

UPPER AND LOWER CRETACEOUS

Shaftesbury and Dunvegan Formations (Map-unit 23)

Strata of these formations are very poorly exposed in the map-area, due to the argillaceous nature of the Shaftesbury Formation and the thinness of the Dunvegan Formation.

No outcrops of the Shaftesbury Formation were observed but data from the Moon Creek (Irish, 1947) and Moberly Creek (Lang, 1947b) areas to the north indicate that it consists of about 400 feet of black shale and silty shale. Stott (1961) has recently summarized the stratigraphy of these formations and the overlying Smoky Group. A more complete report by Stott is in press.

Outcrops believed to be equivalents of the Dunvegan Formation consist of light grey, medium- to coarse-grained, crossbedded, quartzose sandstones. In the areas to the north the Dunvegan consists

of similar sandstones with interbedded dark grey, silty shales and is between 200 and 400 feet thick.

The strata here referred to as 'Shaftesbury Formation' were previously assigned to the Fort St. John Group. Stott (1960) has shown them to be equivalent to the Shaftesbury Formation of the Lone Mountain area. According to Stott, it is preferable to refer them to the Shaftesbury Formation as the Fort St. John Group is laterally equivalent to much of the Luscar Formation in the Peace River area.

Neogastroplites collected by Thorsteinsson (1952) from about the middle of the Shaftesbury Formation in the Grande Cache area to the north are considered to be of Albian age (latest early Cretaceous) by Reeside and Cobban (1960) and Jeletzky (in Stott, 1961, p. 5).

UPPER CRETACEOUS

Outcrops of Upper Cretaceous strata are infrequent and poorly exposed in the map-area. The stratigraphic succession appears to be similar to that which occurs in adjacent areas, described and discussed by Stott (1961, and in press). Stott has also proposed new names and revised the nomenclature.

Smoky Group

The Smoky Group comprises the Kaskapau, Cardium and Wapiabi Formations, and except for the lower part of the Kaskapau Formation, is confined to the northeast corner of the map-area. The best exposures of the Smoky Group occur along parts of Icewater Creek and Wildhay River.

Kaskapau Formation (Map-unit 24)

Kaskapau strata are largely confined to the northeast corner of the map-area, along the north boundary near long. 118°30', and are inferred northwest of Moosehorn Lakes. In the core of the anticline formed by the Cardium Formation on Icewater Creek, the Kaskapau Formation consists of dark grey silty shale. These shales weather dark grey with a reddish tinge and contain a few thin interbeds of siltstone and limonitic concretions. The contact with the overlying Cardium Formation is well exposed on the east flank of the anticline. Uppermost Kaskapau strata consists of dark grey silty shale with numerous thin interbeds of siltstone and very fine grained sandstone. The uppermost 10 feet gradually become more arenaceous until sands of the Cardium Formation predominate. The basal 200 feet, of dark grey, rusty-grey-weathering shales with a few ironstone concretions

and abundant fish scales, was observed on the west flank of the Solomon Creek anticline.

Cardium Formation (Map-unit 25)

No complete sections of the Cardium Formation were seen. The formation appears to consist of at least two ridge-forming sandstone units. The lower sandstone comprises about 50 feet of light grey, fine-grained, quartz sandstone with prominent crossbedding. The upper part is medium grained. The upper sandstone is not well exposed but appears to consist of sandstone with similar characteristics. The thickness of the Cardium Formation is not known but is in the order of 300 feet. Stott (1956) reported a 248-foot-thick section of the Cardium Formation on Maskuta Creek in the Miette area.

Wapiabi Formation (Map-unit 26)

The Wapiabi Formation is very poorly exposed. A few scattered outcrops occur along Icewater Creek, and the Chungo Member is exposed in outcrops along Wildhay River. The outcrops observed are probably not representative. They consist of dark grey to black shales with some thin beds of orange-weathering siltstone. The upper or Chungo Member, formerly 'Solomon sandstone', consists of brownish grey, fine-grained, quartz sandstone about 100 feet thick.

No estimate of the total thickness of the Wapiabi Formation could be made. The formation widths along Icewater Creek and Wildhay River (see map) are obviously too thick. The limited outcrops suggest that this thickening is due to both faulting and folding. More reliable thicknesses of the Wapiabi Formation have been measured in areas to the north where it varies from about 1,400 to 1,700 feet (see reports of Lang; Irish; and Stott, 1961, and in press).

Brazeau Formation (Map-unit 27)

The youngest exposed strata within the map-area belong to the lower part of the Brazeau Formation. About 500 feet of cross-bedded, conglomeratic sandstones occur in the northeast corner along Wildhay River. The sandstones are fine grained, arkosic, greenish grey and contain small carbonaceous fragments and considerable dark mineral grains. The pebbles are mostly chert, averaging about 1/2 inch in diameter. Some small fragments of shale are also present.

STRUCTURAL GEOLOGY

Mount Robson map-area extends across most of the Foothills, all of the Front Ranges, and the eastern half of the Main Ranges of

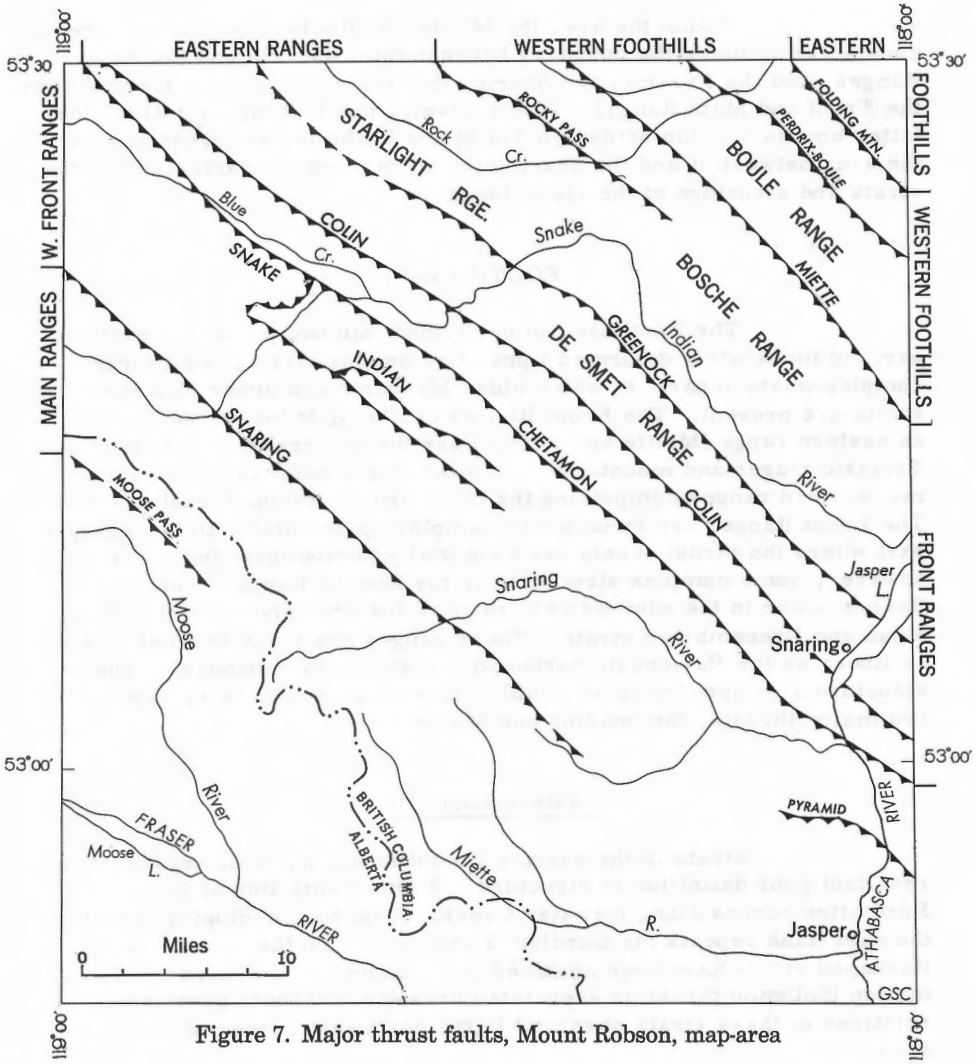

Figure 7. Major thrust faults, Mount Robson, map-area

the Rocky Mountains. Between eight and ten, parallel, southwest-dipping thrust faults (Figure 7) of considerable magnitude have broken the stratigraphic sequence into a series of thrust sheets. Palaeozoic rocks brought to the surface along these thrusts generally form linear mountain ranges which are oriented parallel to the northwest-southeast structural trend. Precambrian strata are brought to the surface in the Main Ranges. Cross-sections C-D and E-F illustrate the structure of a nearly continuous section across the area mapped.

Within the area the Miette and Rocky Pass thrusts are considered to mark the boundary between the Foothills and the Front Ranges, and the Pyramid and Snaring thrusts mark the boundary between the Front and Main Ranges. Alternatively, north of Snaring River the latter boundary could be designated by the Snake Indian thrust because the area between it and the Snaring thrust is more characteristic of the strata and structure of the Main Ranges.

FOOTHILLS

The Foothills can be divided into two parts: an eastern part, of moderately deformed Upper Cretaceous strata; and a more complex western part, in which older Mesozoic and upper Palaeozoic strata are present. The Front Ranges can be split into three parts: an eastern range (Miette and Rocky Pass thrust sheets) of Jurassic and Triassic ridges and mountains with minor Carboniferous strata; and two western ranges comprising the Colin and Chetamon thrust sheets. The Front Ranges are structurally simpler, particularly in the western part where the thrust sheets are essentially homoclines; there are, however, some complex structures in the Bosche Range. The Main Ranges occur in the southwestern third of the area and consist of Cambrian and Precambrian strata. These ranges are much broader and not as linear as the Palaeozoic carbonate ranges to the northeast. The structure also appears to be simpler, the stratigraphy being repeated by two major thrusts, the Snaring and Moose Pass.

Eastern Foothills

Strata in the eastern Foothills are not well exposed, with resultant poor definition of structure. A small anticline of Cardium Formation occurs along Icewater Creek. A northeast-dipping thrust on the east flank repeats the Cardium Formation. To the southwest, Kaskapau strata have been assumed to be faulted on the Cardium Formation (Solomon thrust or associated branch fault) from geometric relations of these strata observed in the northwest corner of the Brûlé area.

Collie Creek Fault

Farther southwest, an anticline of Luscar strata appears to be faulted on the above Kaskapau strata along the Collie Creek fault. This anticline is the northwestward extension of the Solomon Creek anticline of the Brûlé area. It appears to continue northwest as the Wildhay anticlinal structure in the Moberly Creek area (Fox, 1960). An assumed fault on the west flank of the Solomon Creek anticline appears to repeat and thicken the Luscar strata. To the northwest this fault increases in stratigraphic throw and underlies the Hoff fault block.

Solomon Thrust Sheet

The structure beneath the Solomon Creek anticline (see section E-F) is complicated by several thrust faults. The structure has been extrapolated to depth largely on data from the Solomon Creek well, 6 1/2 miles along strike to the southeast, and from the Wildhay well, 7 miles along strike to the northwest. As interpreted the structure is dependent on the stratigraphic position of the various faults and although it may not be accurate in detail, this interpretation is believed to be representative of the general structure.

The interpretation is based on two important structural characteristics of this part of the Foothills: differing amounts of displacement across strike in a thrust sheet; and faults which do not reach the surface. Differing amounts of displacement for thrusts across the strike have been demonstrated in some structures, as for example the Nikanassin thrust in the Miette area (Mountjoy, 1960a, section F-G) and the Turner Valley structure (Gallup, 1954, p. 403; Fox, 1959). Southwest-dipping thrust faults which do not reach the surface appear to be characteristic of the eastern part of the Foothills (see Link, 1949; Hage and Webb, 1955; and Fox, 1960) not only in this region but also apparently in the Nordegg Foothills (Thomas, 1958) and parts of the southern Alberta Foothills (see Clark, 1954; Hume, 1957; and Fox, 1959).

The Solomon well, spudded in Upper Cretaceous strata, encountered three thrust faults at depth: (1) the Collie Creek fault at about 1,350 feet elevation (the 3,785 feet of Luscar strata penetrated is about double its normal thickness); (2) at -3,258 feet elevation, 315 feet of Rundle Group strata occur above 395 feet of Sulphur Mountain Formation; and (3) at -7,306 feet elevation the Solomon thrust with Devonian Perdrix Formation occurs above grey siltstones (probably Triassic). There is some doubt about the exact stratigraphic position of the lowermost grey siltstones. They have been referred to the Ghost River Formation by Hage and Webb (1955) and O'Brien (1960). However, thinning of the Devonian interval, absence of the Flume Formation, fracturing and dips up to 30 degrees in the lower part of the Devonian

rocks indicate the presence of a fault at -7,306 feet elevation. These siltstones are lithologically most like siltstones of the Whitehorse Formation.

The Wildhay well, spudded in the Nikanassin Formation, encountered two major faults: (1) the Collie Creek fault at 2,320 feet elevation, where 400 feet of Rundle Group strata occur above the Triassic Whitehorse Formation; and (2) a 345-foot fault zone occurs between elevations of -1,675 and -2,020 feet. Approximately 200 feet of Perdrix Formation are faulted on Triassic strata at -1,675 feet elevation, and Triassic strata are faulted onto Luscar Formation at -2,020 feet elevation. This fault zone is interpreted to be the Solomon thrust because of similar stratigraphic relationships. If this interpretation is correct the elevation of the Solomon thrust rises towards the northwest, and along the line of cross-section E-F it would occur at about an elevation of -5,000 feet beneath the Solomon Creek anticline. This thrust is difficult to map at the surface as strata across it appear to form an unfaulted, normal stratigraphic sequence. However the fault shown on the map may only be a branch fault from the Solomon thrust. Other faults probably duplicate the stratigraphic sequence farther northeast but may not reach the present erosion surface. (section E-F).

Western Foothills

In the western Foothills, strata are in general much better exposed and the structure is more distinctive. There are two closely linked thrust sheets—the Folding Mountain and Boule. To the northwest the Folding Mountain thrust sheet joins with the Hoff fault block, and the Boule thrust sheet joins with the Nelson fault block.

Folding Mountain Thrust Sheet

Within the area the Folding Mountain thrust sheet is folded into two synclines and the Folding Mountain anticline. Palaeozoic strata occur above the thrust trace and in the core of the anticline. These folds plunge northwest and do not appear to be present at Wildhay River. The Folding Mountain anticline continues southeast across the Brûlé area into the Miette area (Mountjoy, 1960a). Strata on both sides of the Folding Mountain thrust are well exposed and its trace can be accurately located. The thrust probably dips between 65 and 80°SW, on the basis of attitude of hanging-wall strata. Between Solomon Creek and Wildhay River a small fold, possibly a drag-fold, is present in Rundle hanging-wall strata. To the northwest the Folding Mountain thrust becomes a back-limb fault on the southwestern flank of the Hoff Ridge anticline.

Boule Thrust Sheet

The Boule thrust sheet consists of two parts: the narrow and well-exposed Boule Range of Palaeozoic strata; and the broad Moosehorn Valley (3 miles) of poorly exposed, folded and faulted, largely Lower Cretaceous strata to the southwest (section E-F).

In comparison with adjacent Palaeozoic ranges the Boule Range is structurally complex. Two thrust faults are present: the Boule thrust on the northeast (which may form a sole thrust beneath the range), and the Perdrix thrust. The Perdrix thrust, which brings Devonian strata above Triassic and Mississippian, overlaps the Boule thrust in a northwesterly direction. The Perdrix thrust continues southeast into Brûlé area just northeast and below the crest of the Boule Range, with Mount Hawk strata remaining in the hanging-wall (see map in Lang, 1947). Outcrops near the faults are good and the fault traces can be located reasonably well. The dip of the Boule thrust could not be determined. The Perdrix thrust is well exposed. South of Mount Kephala it dips about 50°SW, increasing to about 65° near the south branch of Wildhay River. Stratigraphic throws of these faults gradually decrease in a northwesterly direction. The Boule - Perdrix thrust zone extends northwest into the Nelson fault block.

Both hanging-wall parts of the Boule and Perdrix thrusts are folded. The part immediately above the Boule thrust is folded into a prominent anticline which plunges northwest. At the head of Solomon Creek this anticline is replaced en échelon to the northeast by a syncline-anticline pair which also plunges northwest beneath the Perdrix fault. Above the Perdrix fault a very narrow anticline-syncline pair with steep-dipping limbs occurs southeast of Mount Kephala and continues into the Brûlé area. These folds terminate against the Perdrix fault about 3 miles northwest of Mount Kephala.

The broad area of folded and faulted Lower Cretaceous strata has two larger faults within it: the Rock Lake fault which extends north and south of Rock Lake; and a fault which breaks the syncline east of the Moosehorn anticline. Both faults bring Rundle strata to the surface in areas of maximum stratigraphic throw. Much of the structure in this part of the area was difficult to determine, as few marker beds are present and outcrops are discontinuous; also, the Luscar and Nikanassin successions appear very much alike, making them difficult to distinguish in isolated outcrops. The interpretation of the structure in this area is one that best fits observed data. A more detailed investigation may reveal more complex structures. Strata in and adjacent to Moosehorn Valley are poorly exposed and consequently the structure there is difficult to interpret. This valley appears to be underlain by steeply-southwest-dipping Luscar strata. Nikanassin strata on the southwest side are probably in fault contact with the

Luscar beds, similar to the better exposed structure on the northeast side of Miette Range (Mountjoy, 1960 a).

FRONT RANGES

On the basis of geological structure the Front Ranges can be divided into two parts: an eastern part in which the thrust sheets are folded, and a western part in which the thrust sheets are largely homoclinal. The approximate dividing line is the trace of the Colin thrust (see section G-H).

Eastern Front Ranges

Miette Thrust Sheet

The Miette thrust sheet is the northwestern continuation of the McConnell and Miette structural elements of the Miette area (Mountjoy, 1960 a) and areas to the southeast. The oldest rocks of the Front Ranges and Foothills are Middle Cambrian and occur just above the Miette thrust trace. The Miette and McConnell thrusts occur at this stratigraphic level along most of their outcrop traces for more than 250 miles. Just south of Mount Aeolus a branch fault diverges from the main Miette thrust and repeats much of the Palaeozoic succession. It has a length of about 8 miles and gradually decreases in stratigraphic throw in a northwesterly direction, from about 2,500 feet at the Miette thrust, to zero. It appears to end on the northeast limb of an anticline and is associated with an anticline-syncline pair.

Northwest of Moosehorn Lakes the Miette thrust gradually loses stratigraphic throw and could not be mapped west of Rock Lake. There it could be one of two or three faults that repeat Lower Cretaceous strata. Parallel to and over the same area where the Miette thrust loses stratigraphic throw, the Rocky Pass thrust, some 2 to 3 miles to the southwest, increase in stratigraphic throw. Consequently it appears probable that displacements along these two thrust surfaces, as suggested by stratigraphic throw, complement each other with the major amount of displacement shifting from one thrust to the other.

Near the east boundary of the map-area and at the south end of the Bosche Range the structure of the Miette thrust sheet is more complicated (section G-H). Devonian strata of the thrust sheet are repeated along the Disaster Point thrust and an associated branch fault. The Disaster Point thrust gradually decreases in stratigraphic throw and can no longer be mapped on the northeastern limb of the anticline north of Coronach Mountain.

Folds with northeast-dipping axial planes (southwest overfolds) occur in the Miette and Disaster Point thrust sheets near the east boundary of the area. Excellent photographs by Dahlstrom (1960) and the Alberta Society of Petroleum Geologists (1955) illustrate these structures. These folds occur in northeastward-directed thrust sheets and clearly indicate rotation. This rotation is attributed to movements along concave, upward thrust surfaces and to later movements of underlying thrust sheets. Thus the general temporal relationship—that underlying thrust sheets developed later—can be demonstrated for this part of the Front Ranges and Foothills. This relationship also appears to be applicable to the remainder of the Front Ranges in this region (Mountjoy, 1960a, 1960b).

The narrow folds of the Disaster Point thrust sheet gradually plunge northwest and have been correlated with folds in the creeks northeast of Shale Banks. They can be traced another 5 miles to the northwest and there become covered by glacial drift and recent river-alluvium in Snake Indian Valley. Similar narrow folds occur along strike to the northwest in the Starlight Range and Rocky Pass thrust sheet (section A-B) and probably are part of the same zone of folding.

A belt of Fernie strata about 2 miles wide occurs southwest of this zone of narrow folds. The best exposures are present in the gorge of Snake Indian River where most of the outcrops belong to the upper part of the Fernie Group and are generally highly distorted. Once parallel beds of thin siltstone and concretions in these shales have been contorted and broken to form a series of irregular shapes and structures. Generally, structures in the river outcrops could not be traced from one outcrop to the next because of their complexity.

The Fernie Group, which is only 900 feet thick, outcrops across strike with widths up to 2 miles. A thrust fault that brings Palaeozoic rocks to the surface north of Jasper Lake gradually decreases in stratigraphic throw until Fernie strata occur in both the hanging-wall and foot-wall, about 3 miles southeast of Shale Banks. This fault undoubtedly is responsible for much of the contortion and thickening of the Fernie in that area. Upstream and downstream from the Snake Indian bridge, at least four narrow anticline-syncline pairs duplicate the lower part of the Fernie.

Southeast along strike in the Miette area, the structure could be mapped in more detail. Several thrusts were present with stratigraphic throws of about 700 feet, and each of these small thrust sheets are folded (Mountjoy, 1960a, section A-B). It is suggested that these wide zones of Fernie strata are the result of largely incompetent strata being caught beneath major thrust sheets and torn up and carried northeastward, much the same as a layer of snow being

pushed in front of a snow plow. Deformation would extend into the underlying Triassic strata but may not involve the more competent Palaeozoic carbonates. Décollements probably occur within the Triassic strata.

Similar wide areas of Fernie strata occur in the valleys of Rock and Mowitch Creeks and south Sulphur River. The structures there can be interpreted in a similar manner.

Rocky Pass Thrust Sheet

The main part of the Rocky Pass thrust sheet occurs northwest of Rock Lake, extending some 20 miles farther northwest across the Adams Lookout area (Eccles, 1957a; Irish, 1954). Within the map-area the thrust sheet has been folded into two or more narrow, en échelon anticline-syncline pairs (section A-B) which plunge southeast. Strata on both sides of the thrust trace are very distinct and the trace can be accurately mapped. South of Eagles Nest Pass the Rocky Pass thrust dips about 60°SW.

Fernie strata underlie Rock Creek valley for much of its length and outcrop over widths that are 2 to 3 times the thickness of the group. Nearly continuous outcrops are present along Mowitch Creek near its mouth. There Fernie strata are synclinally folded with numerous minor folds and faults.

Rock Creek Fault—Considerable evidence indicates that a fault or fault zone—named 'the Rock Creek fault'—occurs along the northeast side of Starlight Range. Stratigraphic relationships suggest a fault is present near the mouth of Mowitch Creek. It is inferred to continue northwest along the west side of Rock Creek valley, placing Whitehorse strata above Fernie. This fault has an en échelon arrangement with another thrust that begins in the core of an anticline on the east side of Starlight Range. It places high Rundle strata over Fernie and Whitehorse rocks. This fault trace can be accurately located and the fault dips about 50°SW. It gradually decreases in stratigraphic throw northwest until Fernie strata occur in both the hanging-wall and foot-wall, and can no longer be mapped.

Starlight Range consists of folded Triassic rocks, mostly of the Whitehorse Formation. The most westerly folds plunge both southeast and northwest, disappearing into and increasing the width of Fernie strata of lower Deer Creek, Mowitch Creek and Desolation Pass. Fernie strata on the southwest side of Mowitch Creek valley crop out over a wide area. Outcrops observed in tributary creeks revealed several folds and at least two thrust faults of considerable stratigraphic throw.

Greenock Thrust Sheet

The Greenock thrust sheet in the southern part of the area and adjoining Miette area is a homocline which dips between 60 and 70°SW (section G-H). Along much of its length the Greenock thrust follows a stratigraphic zone within Upper Cambrian carbonates immediately below the sub-Devonian unconformity. Opposite Shale Banks, folds develop in the thrust sheet and the thrust gradually decreases in stratigraphic throw until Fernie strata are present in both the hanging-wall and foot-wall at the north end of De Smet Range.

Along strike north of Snake Indian Valley, the Greenock thrust is interpreted to place Triassic strata over Fernie Group. This fault could not be mapped northwest of Deer Creek but is interpreted to extend as far as Mowitch Creek, causing considerable thickening and distortion of the Fernie Group. It is associated with another thrust fault which is well exposed in Deer Creek valley and occurs about 1/2 mile southwest of the Greenock thrust. Much of the stratigraphic throw of the Greenock thrust appears to have been transferred to this fault. Between Deer and Mowitch Creeks this second fault appears to follow close to the Whitehorse-Fernie contact on the east flank of the Deer Creek anticline. North of Mowitch Creek gap, this fault is difficult to trace because Fernie strata once again occur in both the hanging-wall and foot-wall. However it undoubtedly continues within and beyond the map-area as indicated by faults repeating the various members of the Fernie Group and Whitehorse Formation. The Deer Creek anticline terminates in an en échelon arrangement with the west flank of the Monoghan anticline close to the north boundary (118°50'W). Along the east flank of the Monoghan anticline, Irish (1954) did not observe any major faults, only considerable shearing and contortion in the Fernie shales. A major southwest-dipping thrust probably occurs beneath both the Monoghan and Deer Creek anticlines.

Western Front Ranges

Colin Thrust Sheet

The Colin thrust sheet is one of the longer thrust sheets, having a length close to 175 miles. In the map-area it is homoclinal for most of its length, dipping about 60°SW north of Athabasca River. The dip decreases to 50° near Snake Indian River, increasing again to 60° in the Ancient Wall. Foot-wall strata have about the same order of dip, though generally steeper. For most of its length the Colin thrust follows a zone within the thick Lynx Formation.

Some folding occurs within the thrust sheet northwest of Esplanade Mountain. There, a branch fault produces a repeat of the

Devonian and lower part of the Mississippian sequences. This thrust continues to Mount Sassenach and then gradually loses stratigraphic throw and terminates south of Snake Indian River. Folds also occur northwest of Glacier Pass where the Colin thrust gradually decreases in stratigraphic throw. There it splits into two faults which extend into the Adams Lookout area within Rundle strata on the west flank of the West Fork anticline (see Irish, 1954). Some of the stratigraphic displacement of this part of the Colin thrust appears to have been transferred to the next thrust fault to the northeast.

On the northeast side of the Ancient Wall Palliser, Banff and Rundle strata, dipping vertically to steeply overturned, occur as isolated blocks between the hanging-wall and the Triassic and Jurassic foot-wall (section C-D). Some of these blocks, particularly those north of Glacier Pass, consist of competent carbonate rocks and are compressed into a series of narrow overturned folds. These structures are interpreted as parts of the hanging-wall which have been overridden.

Chetamon Thrust Sheet

The Chetamon thrust sheet, named after Mount Chetamon near the mouth of Snaring River, extends from Athabasca River to Snake Indian River where it appears to be overlapped by the Snake Indian thrust sheet. Hanging-wall and foot-wall strata dip between 50 and 65°SW. In the hanging-wall the Chetamon thrust appears to follow a stratigraphic zone near the top of the Gog Group. West of Mount Sassenach the anticline-syncline pair on The Rajah is associated with a rapid decrease in stratigraphic throw (about 4,000 feet) of the Chetamon thrust from the top of the Gog Group to near the top of the Lynx Formation. Southeast of the map-area a similar anticline and syncline on Roche Bonhomme is associated with a nearly identical decrease in stratigraphic throw. There the Chetamon thrust, in a southeasterly direction, also changes from a position within the Lower Cambrian Gog Group to one within the Lynx Formation (Mountjoy, 1961).

Numerous and very narrow folds occur in the Lynx Formation between Cliff Mountain and Mount Strange, immediately northeast of Snaring River. They are associated with the southeast termination of the Snake Indian thrust. In their deeper parts these folds do not appear to extend into the Titkana Formation. Therefore some décollement has likely occurred within the Arctomys and Pika Formations.

Where the Chetamon thrust sheet is overlapped by the Snake Indian thrust north of Mount Simla it appears to abruptly lose stratigraphic throw. Folds in this part of the thrust sheet continue northwest across Snake Indian River and are essentially continuous with the overlying folded Snake Indian thrust and folds in that thrust sheet (see section A-B and discussion of temporal relationships below). The

Mount Simla folds may be associated with a décollement in the Banff Formation as the underlying Palliser and Fairholme strata are not involved in this folding. Contrary to Ziegler's (1960) interpretation, the anticline and syncline pair on The Rajah are not connected with these folds.

Snake Indian Thrust Sheet

The Snake Indian thrust sheet was named after Snake Indian River by Ziegler (1960) who discussed its development. It is known to extend from the vicinity of Harvey Lake to the northwest corner of the map-area. Farther northwest, it continues at least as far as the Smoky River (see Pearson, 1960, map). It can be divided into a northern folded part and a southern homoclinal part which is complicated by many branchings of the thrust fault. The division between these two parts is conveniently marked by Snake Indian River.

In the northwestern part, the thrust and the hanging-wall and foot-wall beds have been folded together into a broad anticline (the Blue Creek anticline) and syncline. The Blue Creek anticline gradually plunges northwest until Middle Cambrian strata can be traced across the axis northwest of the map-area. The syncline is outlined by Middle Cambrian strata of Sunset Peak in the northwest corner of the area.

The thrust trace can be easily followed on the ridges northwest of Snake Indian River. The thrust on the west limb of the Blue Creek anticline dips between 45 and 50°SW and the east limb dips about 35°NE. The stratigraphic position of the thrust is well documented (section A-B). In a northeasterly direction across the anticline, a distance of about a mile, the thrust has cut upward through about 1,000 feet of strata. Across the adjoining syncline, a distance of about 2 miles, the thrust has cut through an additional 2,000 feet so that east of Blue Creek it is in the lower part of the Gog Group. Therefore, the Snake Indian thrust has gradually cut upward in the stratigraphic sequence a distance of 3,000 feet in a horizontal distance of about 16,000 feet. In order to account for the folding of the Snake Indian thrust and adjacent strata, Ziegler (1960) has suggested that irregularities were originally present in the stratigraphic position of this thrust across strike. The above data do not support this suggestion.

There is little doubt that this part of the Snake Indian thrust sheet has been folded by folds developing beneath it in the Chetamon thrust sheet after movement along the thrust has ceased (see following discussion on regional interpretation).

The homoclinal and southeastern part of the Snake Indian thrust sheet is complicated by several branches from the Snake Indian thrust fault. Just west of Mount Simla the thrust bifurcates, dividing the thrust sheet into two parts. The eastern part consists of a syncline

of Upper Cambrian carbonates. The western part consists of a Lower and Middle Cambrian homocline. In the region south of The Rajah the incompetent Middle Cambrian hanging-wall strata of the western branch fault are complicated by several folds and minor faults. The strata in the foot-wall are even more structurally complex. There are at least two east-dipping thrust faults on the west limb of the syncline (section C-D). A study of air photographs of the vicinity of Harvey Lake indicates that the Snake Indian thrust sheet plunges southeast and suggests that the associated thrust faults terminate in the zone of narrow folds in Lynx strata near Mount Rutherford.

MAIN RANGES

The Main Ranges have only been studied in the vicinity of the west and south forks of Snake Indian River, and the southwestern part of the area remains to be mapped. Two major thrust sheets are known—the Snaring and Moose Pass. The Main Ranges of this report are considered to lie southwest of the Snaring thrust trace.

Snaring Thrust Sheet

The Snaring thrust is here defined as the thrust that extends southeast from the southwestern side of Monte Cristo Mountain to the southwestern side of the Victoria Cross Ranges and beyond[1]. Within the area mapped the Snaring thrust appears to occur rather consistently about 3,000 feet below the top of the Miette Group. Strata on both sides of the thrust regularly dip about 50°SW. As suggested by the dip of the thrust trace which is well exposed near Comoy Lake and Idamalene Lakes, the thrust is assumed to have approximately the same dip.

Moose Pass Thrust Sheet

To the southwest, just east of the continental divide, folding and probably some thrust faulting appears to repeat parts of the Lower Cambrian and Precambrian strata of the Snaring thrust sheet. Farther southwest, another major thrust is present at Moose Pass. The Moose Pass thrust places Lower Cambrian strata above Upper Cambrian. It has been traced southeast from Moose Pass to Colonel Pass by Collett and Paréjas (1932, note 8).

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1 Information from 1961 field work indicates that the Snaring thrust does not join with, but occurs southwest of, the Pyramid thrust near Jasper. The Pyramid thrust terminates about 8 miles northwest of Jasper on the southwestern side of Mount Zengel.

STRUCTURAL SUMMARY

The structural complexity reaches a prominence in the Foothills and eastern Front Ranges. In general the decrease in length of thrust faults across the Front Ranges and Foothills in part accounts for this increase in structural complexity in a northeasterly direction. Some of this complexity in the eastern ranges may be due to such factors as disharmonic folding, and interrelation and interlocking of thrust sheets.

Many of the thrust sheets of the Front Ranges and Foothills overlap and are offset one from the other in an en échelon pattern. Commonly, where one fault decreases in stratigraphic throw an adjacent thrust increases in throw; for example the Miette and Rocky Pass thrusts, the Boule and Perdrix thrusts, and the Chetamon and Snake Indian thrusts.

Thrusts of the Front Ranges at the present erosion surface are essentially bedding thrusts which appear to follow certain stratigraphic zones:

(a) The Miette thrust occurs in map-unit 3 for a strike distance of approximately 8 miles in the map-area and 24 miles in the adjoining Miette area to the southeast—a total of 32 miles.

(b) The Greenock thrust occurs in the upper part of the Cambrian Lynx Formation just below the Devonian (Figure 2) for a distance of about 11 miles.

(c) The Colin thrust is located in the middle to upper third of the Lynx Formation for a distance of 45 miles in the map-area, and about 150 miles southeast of the area.

(d) The Chetamon thrust also occurs in a zone about the middle of the Lynx Formation for a distance of 6 miles northwest of The Rajah and about 80 miles southeast of the Athabasca Valley.

Only the Miette thrust can be demonstrated to occur in the Middle Cambrian map-unit 3, contrary to statements of O'Brien (1960). The western Front Range thrusts appear to follow zones in the Upper Cambrian Lynx Formation. This observation may be fortuitous as the Lynx Formation is in the order of 2,500 feet thick, and the thrust position cannot be accurately determined with relation to the stratigraphy due to lack of good marker horizons in this formation.

Parallelism of the foot-wall units with the thrust faults is also apparent. The immediate foot-wall strata of the Miette thrust

consist of Nikanassin or Luscar Formations, the foot-wall strata of the Greenock thrust consist of the Fernie Group, the foot-wall strata of the Colin thrust consist of the Whitehorse Formation and Fernie Group, and the foot-wall strata of the Chetamon thrust consist of the Sulphur Mountain Formation or upper part of the Rundle Group.

The stratigraphic position of these thrusts at depth cannot be stated with reasonable certainty. The topographic relief of the area indicates that most of the above thrusts follow their respective stratigraphic zones for a distance of about a mile across strike. Data from the folded part of the Snake Indian thrust indicate that it gradually intersects older strata across strike in a southwesterly direction.

Regional Interpretation

A general comparison of the surface structures of the map-area and structures of the southern Alberta Foothills and Front Ranges (see, for example, Douglas, 1950, 1958; Hume, 1957; and Fox, 1959) suggest that the Jasper structures are similar in many respects. The thrust sheets of northern Jasper Park may also have similar geometrical relationships at depth and therefore may consist of two or more thrust sheets piled one on top of the other. The folded faults, geometric relationships, and limited drilling in the region support this suggestion. The geometric relationships of the surface structures suggest that across strike the following major thrust sheets remain separate at depth: the Solomon, Boule, Miette, Greenock, Chetamon - Snake Indian and Snaring. The Colin thrust sheet is closely associated with the Chetamon thrust sheet and their underlying thrusts may join at depth. In general these thrust sheets differ from those of southern Alberta in that they dip more steeply and in the eastern Front Ranges are complicated by disharmonic folding.

A regional décollement beneath all of the Front Ranges in Middle Cambrian map-unit 3 has recently been interpreted by O'Brien (1960) but is not well documented and appears improbable (Mountjoy, 1961, 1962).

Some suggestions can be made about the temporal development of the thrust sheets of the Front Ranges. Development from southwest to northeast for the major thrust sheets is suggested by: (1) the lack of truncated structures; (2) the presence of rotated structures; (3) geometric relationships observed; (4) folded thrusts; and (5) increase in structural complexity and decrease in length of thrust faults towards the northeast.

1. If the thrust sheets developed from northeast to southwest it appears probable, but is by no means necessary, that movement of some of

the later thrust sheets would modify and truncate some of the previously formed structures. One would expect, for example, that previously formed folds would have been pushed and rotated so that their axial planes would dip southwest. Markedly asymmetric folds are not present. Only one small and local truncated structure is known to occur in the region. Consequently the lack of truncated structures strongly supports the movement of thrust sheets in a northeasterly direction on a relatively undeformed foot-wall, with later thrusts developing beneath and to the northeast of earlier thrusts.

2. The orientation of the southwest overfolds of the Bosche Range, as already noted, is probably the result of a combination of movements both during displacement along an immediate underlying thrust surface, and after this thrust movement through later movements associated with development of underlying thrust sheets. The steep dips of the western Front Ranges and their related thrust faults are probably not initial dips. They can also be reasonably explained by later tilting through movements of underlying thrust sheets.

3. The parallelism of hanging-wall and foot-wall strata, which is characteristic of most thrust faults, supports the thesis that the stratigraphic sequence, particularly the foot-wall, was largely undeformed prior to thrust movement. Abrupt changes in stratigraphic position of faults and abrupt truncation of formations would suggest previously formed structures.

4. The only major folded thrust in the area is the Snake Indian. Ziegler (1960, p. 743) has argued, following interpretations of Douglas (1950) and others, that folding of the Snake Indian thrust is ... "due to initial irregularities in the fault trace which are controlled by the alternation of competent and incompetent sequences in the faulted sedimentary series." Since no irregularities are present in the surface trace of this fault across strike, the Snake Indian thrust sheet appears to have been folded after its displacement by the development of underlying structures in the Chetamon thrust sheet. Whether or not changes in stratigraphic position of the Chetamon thrust controlled the development of these folds is not evident from surface data. The folds on The Rajah are related to a change in stratigraphic position of the Chetamon thrust from Gog Group to Lynx Formation (section C-D). These folds only extend to the south fork of Snake Indian River and not beneath the Snake Indian thrust sheet, contrary to Ziegler's Plate 1 (1960). Similar temporal relationships have been suggested in order to explain some folded thrusts in southern Alberta (Hume, 1957; Douglas, 1958).

5. The increase in complexity of structures and decreasing persistence of thrust faults across the area in a northeasterly direction is

suggestive of the order of development (Mountjoy, 1960 b, 1960 c). The formation and development of each new thrust sheet would probably modify the original stress field. The more thrust sheets formed, the more modification one would expect to occur. Thus with the successive development of a series of thrust sheets, a change from simple, long and linear thrust sheets to more complex, interrelated and interlocked thrust sheets may result. The increased complexity of structure is also due to changes in thickness, number and arrangement of competent and incompetent rock units.

Thus the major thrust sheets of the Front Ranges probably developed from southwest to northeast, each new thrust developing beneath and northeast of the previous thrust. Locally this order of development may be reversed, especially where two thrusts, which initially were widely separated, have been extended laterally so that they overlap (for example the Miette and Rocky Pass thrusts).

ECONOMIC GEOLOGY

PETROLEUM AND NATURAL GAS

Exploration for minerals is not permitted within Jasper National Park so that these comments only refer to the northeast corner of the area. Three suitable porous and potential oil-and-gas-bearing zones appear more favourable than other parts of the stratigraphic column. These zones are the eastern depositional edge of the Jurassic Rock Creek sandstones, Formation C of the Mississippian Rundle Group, and the Cairn and Flume Formations.

West of the Boule and Perdrix thrusts these formations are exposed. To the northeast, suitable structures may be present beneath the Collie Creek thrust or northeast of the Solomon Creek anticline (section E-F). The Solomon Creek anticline structure has been drilled northwest and southeast of the map-area, and data from these bore-holes indicate that the Flume or Cairn Formations are absent due to faulting in the upper thrust sheets. Drill-stem tests indicated no significant occurrences of petroleum in Mount Hawk and stratigraphically higher beds, only minor gassy mud and water

Cores from the Solomon well indicate that Formation C of the Rundle Group has poor porosity and contains considerable anhydrite. This suggests that the unit changes lithology and decreases in porosity in a northeasterly direction. Occurrences of the Devonian Cairn Formation would be expected only locally, similar to its rather erratic distribution in the mountains. Accordingly, it may be difficult to locate, especially at the probable depths of more than 12,000 feet below sea-level. Porous sandstones of the Rock Creek Member and

other parts of the Mesozoic clastic sequence appear to be prospective; however, interpretation of the subsurface structure is difficult.

COAL

In adjoining areas, coal is known to occur in the lower half of the Luscar Formation (MacKay, 1929b, 1955; and Lang, 1947). Workable coal deposits may occur in this formation in the map-area, but no coal seams thicker than 2 feet were observed. In most occurrences the Luscar Formation appears to be strongly deformed.

GYPSUM

Gypsum occurs in the Whitehorse Formation at several localities near the north end of De Smet Range and in Starlight Range. Allan (1933) has described in detail the outcrops of Starlight Range northeast of Mowitch Creek. He reported considerable gypsum on the southwest side of this range. This gypsum-bearing zone may extend beyond the northwestern boundary of the park north of Desolation Pass. Though of good grade (Allan, 1933) these deposits are remote from road and rail transportation.

Gypsum was also observed in the Whitehorse Formation at the following localities within Jasper National Park.

1. (118°47'W, 53°20'N); on a ridge-crest 6 miles west of the junction of Blue Creek and Snake Indian River, in the foot-wall part of Snake Indian thrust sheet.

   Stratigraphic position of this gypsum is close to the base of the Whitehorse Formation. Outcrop width is about 100 feet and stratigraphic thickness is estimated to be 20 feet.

2. (118°26'W, 53°19'N); 3 miles northeast of Mount Stornoway in a saddle between two ridges.

   Three mounds of gypsum, between 10 and 30 feet thick, each surrounded by talus, occur at the same stratigraphic horizon about the middle of the Whitehorse Formation.

3. (118°25 1/2'W, 53°17'N); 1 mile east of Mount Stornoway—100 feet of gypsiferous dolomite, 200 feet above base of Whitehorse Formation.

4. (118°11'W, 53°15'N); 3/4 mile up northeast tributary creek of Snake Indian River at Shale Banks.

Two beds of gypsum, each about a foot thick, occur near the top of the Whitehorse Formation.

Gypsum and anhydrite also occur in parts of the Rundle Group in the Foothills (see stratigraphic description), but these minerals were only observed in cuttings and cores from the Solomon Creek and Folding Mountain wells.

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APPENDIX

Section 1. Middle Cambrian measured on ridge-crest on southeast side of creek that drains north side of Whitecap Mountain (118°15'W, 53°07'N).

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Overlying beds, Pika Formation Largely talus and snow covered; two thin beds of limestone present. Limestone, argillaceous with numerous shale partings, weathers in beds 1/2 to 1 inch.	65	
	Titkana Formation		
	Entire formation forms one very resistant and massive cliff.		
45	Limestone, dark grey, fine- to cryptocrystalline; weathers light grey, resistant; partings 1/2 to 2 inches.	196	842
44	Dolomite, brown-grey, medium-crystalline; weathers brown in beds 1 to 2 feet; irregular contacts with adjacent limestones.	60	646
43	Limestone, medium grey, fine-crystalline; weathers grey, massive in beds 1 to 2 feet.	161	586
42	Dolomite, medium grey, medium-crystalline; weathers resistant in beds 1 to 2 feet.	45	425
41	Limestone, brownish grey, fine-crystalline; weathers light grey; partings 1 inch to 1 foot.	197	380
40	Limestone, dark grey; thin argillaceous partings give rock a wavy banded appearance; some small-scale crossbedding; weathers massive.	60	183
39	Limestone, dark grey, crypto-crystalline; argillaceous partings; weathers massive.	65	123

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
38	Limestone, dark grey, cryptocrystalline; argillaceous (?) separated by thin 1/4- to 1/2-inch argillaceous limestone bands; weathers grey-brown, resistant. Small fault and cover to underlying map-unit 3.	58	58
	Map-unit 3		
	Fourth Shale Unit (320 feet)		
37	Shale, slightly calcareous, greenish grey, interbedded with limestone, microcrystalline, light grey, silty, finely laminated, which weathers brown in beds 1/2 inch to 2 inches; unit weathers greyish green, recessive.	184	1,658
36	Shale, calcareous, greenish grey, interbedded with limestone, microcrystalline, light grey; unit weathers greenish grey, recessive; trace of trilobite fragments in talus. Two 1 1/2- to 3-foot prominent limestone units 57 and 123 feet above base, consisting of limestone intraformational conglomerate at base and limestone pisoliths in upper part.	136	1,474
	Upper Limestone (124 feet)		
35	Limestone, medium grey, microcrystalline with argillaceous or dolomitic tracery and banding, giving outcrop thin, striped appearance; unit weathers resistant, cliff-forming, light grey, in beds greater than 5 feet.	124	1,338
	Third Shale Unit (114 feet)		
34	Shale, calcareous, grey-brown, with 1/4- to 2-inch interbeds of limestone, light grey, microcrystalline; unit weathers recessive, light grey; traces	63	1,214

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	of trilobite fragments. Thin pisolitic limestone 20 feet above base.		
33	Shale, slightly calcareous, greenish grey to green; trace of trilobite fragments; weathers pale green.	51	1,151
	Middle Limestone (122 1/2 feet)		
32	Limestone, intraformational conglomerate, light grey; trilobite fragments.	1/2	1,100
31	Limestone, light grey, micro-crystalline, with argillaceous partings 1/16 to 1/2 inch; weathers light greenish grey, argillaceous partings weather orange.	17	1,009 1/2
30	Limestone, medium grey, micro-crystalline, with prominent orange-weathering argillaceous interbeds; weathers light brownish grey, very massive, resistant, in beds greater than 10 feet.	105	1,082 1/2
	Second Shale Unit (273 feet)		
29	Covered. Probably shale as below.	30	977 1/2
28	Shale, slightly calcareous, green, with interbeds of limestone, light to medium grey, microcrystalline; trace of trilobite fragments; weathers brown, 1 inch to 2 inches in upper half and up to 1 foot in lower half; unit weathers pale green.	90	947 1/2
27	Shale, non-calcareous, green, interbedded with limestone, medium grey, microcrystalline, with trace of trilobite fragments.	53	857 1/2
26	Limestone, dark grey, micro-crystalline, with thin bands of argillaceous carbonate; weathers light brownish grey in beds 1 foot to 3 feet.	37	804 1/2

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
25	Shale, indurated, slightly calcareous, dark brownish green; trace of trilobite fragments; weathers recessive, light yellowish green; contains about four thin interbeds of limestone 1 foot to 5 feet thick.	63	767 1/2
	Lower Limestone (265 feet)		
24	Limestone, medium grey, microcrystalline, with very thin, irregular partings, especially prominent in lower 15 feet; weathers, light grey, very massive, in beds greater than 5 feet.	208	704 1/2
23	Limestone, dark grey, micro- to finecrystalline; trace of round carbonate grains; interbedded with argillaceous limestone; weathers brownish grey, alternating resistant and recessive.	57	496 1/2
	Lower Shale Unit (157 1/2 feet)		
22	Shale, green; several layers of limestone, 2 inches to 2 feet thick with numerous pisoliths; trilobite fragments in upper part.	50	439 1/2
21	Shale, dark brownish red, noncalcareous, fissile; abundant trilobite fragments in some layers; weathers red.	17	389 1/2
20	Shale, pale green, calcareous, indurated, in part micaceous; weathers pale brownish green in beds less than 1 inch.	11	372 1/2
19	Limestone, light grey, microcrystalline, interbedded with very argillaceous limestone; some layers of comminuted trilobite fragments; weathers light greenish grey, recessive in beds less than 2 feet.	31	361 1/2

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
18	Covered. A few beds of limestone, medium grey, microcrystalline; weathers greyish brown; thin-bedded.	16	330 1/2
17	Limestone, dark grey, micro-crystalline, with thin partings and interbeds of argillaceous limestone; weathers resistant, brownish grey, in beds 4 inches to 1 foot; partings about every inch. Upper 5 feet argillaceous, green, with abundant trilobite fragments; small limestone balls (algal?) in uppermost layer. GSC loc. 42068. Albertella sp. Ptarmignia sp.	21	314 1/2
16	Covered.	10	293 1/2
15	Limestone, medium grey, crypto-crystalline, trace of glauconite; weathers light brownish grey; layer of 1-inch-diameter carbonate balls (pisoliths or algal?).	1 1/2	283 1/2
	Basal Clastic Unit (282 feet)		
14	Siltstone, pale green to red, slightly calcareous; finely laminated especially at base; abundant ripple-marks near base; weathers light green to red.	3	282
13	Covered.	14	279
12	Siltstone and silty shale, dark green, micaceous; trace of worm trails; weathers pale green, recessive, lower 4 feet weathers brown; fine silt laminations on weathered surfaces.	25	265
11	Siltstone, slightly calcareous, fine laminations, light pink and green; weathers pale red in beds 1 inch to 4 inches; trace of ripple-marks.	2	240

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
10	Siltstone and silty shale, strongly calcareous, brownish red; weathers brownish red in beds less than 1 foot; interbedded with green siltstone and silty shale which weathers yellow-brown and pale green; green colour predominates in upper half.	54	238
9	Dolomite, silty, light yellow-brown, microcrystalline, finely laminated; some green and red argillaceous partings; weathers light brown.	6	184
8	Covered.	4	178
7	Limestone, medium to dark grey, microcrystalline; weathers brownish grey in beds 4 inches to 1 foot.	5	174
6	Mostly covered. Talus of shale, silty, dark green; 5 feet of shale 10 feet below top, silty, calcareous, light brownish grey with green partings, in beds 1/8 to 1 inch.	42	169
5	Siltstone, calcareous, light greenish grey; weathers brown.	2	127
4	Siltstone, calcareous, light yellow, red and brown, finely laminated and crossbedded; ripple-marks; weathers light yellow-brown to red, moderately resistant in beds 1/8 inch to 2 inches.	11	125
3	Mostly covered. Scattered outcrops of shale, dark brownish red, slightly calcareous, in part silty; weathers red, recessive.	45	114
2	Siltstone, red, slightly calcareous, finely laminated; ripple-marks, a few thin beds of mudstone breccia; middle third covered; unit weathers brownish red.	25	69

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
1	Sandstone, fine- to coarse-grained, calcareous, with green and red, siltstone interbeds; some beds of mudstone breccia; weathers light brown in beds 1/16 to 1 inch; middle 10 feet is strongly argillaceous, upper 20 feet is dominantly calcareous siltstone.	44	44
	Gog Group		
	Sandstone, fine- to medium-grained, quartzose, white to light pinkish grey; weathers light grey, red near top, in massive beds greater than 3 feet; coarsely laminated and some crossbedding.	75	

Section 2. Arctomys and Pika Formations, Mount Thornton (118°19'W, 53°09'N); measured on crest of ridge about 2 miles north of Mount Thornton and 4 miles northwest of Section 1.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Overlying beds, Lynx Formation. Limestone, grey, microcrystalline, silty, finely laminated; weathers light grey to yellow-grey in beds 1 foot to 5 feet, resistant.		
	Arctomys Formation		
38	Dolomite, light grey, silty; weathers light yellow-grey with prominent silt laminations. Basal 10 feet partly covered and more argillaceous.	37	642
37	Siltstone, dolomitic, light grey, finely laminated; weathers light yellow-grey, moderately resistant.	14	605
36	Covered.	11	591
35	Sandstone, fine- to medium-grained, light grey, slightly calcareous; weathers recessive, light yellow-grey in beds 4 to 12 inches.	19	580
34	Siltstone similar to unit 33 with interbeds of shale, silty, pale green; weathers recessive in beds 2 to 12 inches.	23	561
33	Siltstone, slightly dolomitic, light grey, finely laminated, with thin partings and interbeds of mudstone, dark red, moderately resistant.	102	538
32	Mudstone, dark red and green, silty, interbedded with siltstone, light yellow, finely laminated; trace of ripple-marks, casts of salt pseudomorphs in upper half; unit weathers recessive.	166	436
31	Dolomite, light grey, silty, argillaceous; weathers light yellow.	11	270

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Traced unit 30 southwest across syncline and anticline.		
30	Limestone, medium grey, microcrystalline; weathers light grey in beds 1/4 to 1 inch; intraformational conglomerate near top.	10	259
29	Dolomite, silty(?), light grey, microcrystalline, with green mudstone interbeds at base; weathers light yellow in beds 1 inch to 12 inches, forms a small cliff.	14	249
28	Covered. Talus of green shale.	21	235
27	Shale, red, interbedded with siltstone, light yellow to light green; beds 1/4 inch to 2 inches.	12	214
26	Shale and siltstone, green and red.	29	202
25	Siltstone, calcareous, light green to yellow; weathers light green in beds 1/4 to 1/2 inch, moderately resistant.	6	173
24	Siltstone, dolomitic, pale green to dark red, interbeds of red and green shale.	106	167
23	Shale, dark red, with a few thin interbeds of green shale; weathers dark red.	39	61
22	Shale, slightly calcareous, light green; weathers light yellow-green, recessive in beds less than 1/2 inch.	22	22
	Pika Formation		
21	Shale, grey, calcareous, interbedded with limestone, light grey, cryptocrystalline, in part intraformational conglomerate; weathers light greenish grey in beds 1/4 inch to 2 inches; forms a small cliff.	14	464

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
20	Partly covered. Limestone, argillaceous, numerous intraformational conglomerates; weathers recessive, light greenish grey; abundant trilobite fragments, GSC loc. 42069. ?Glyphaspis sp. ?Parehmania sp.	87	450
19	About 50% cover. Interbedded intraformational conglomerate, and limestone, light grey, microcrystalline, argillaceous; trilobites collected 12 feet from top. GSC loc. 42054. ?Parehmania sp.	29	363
18	Mostly covered. Limestone near base, dark grey, crypto- to microcrystalline with argillaceous interbeds, intraformational conglomerate at top; trilobite fragments collected from talus in middle of unit. GSC loc. 42067. ?Parehmania sp.	10	334
17	Two limestone cliffs separated by a 7-foot recessive zone near top. Limestone is dark grey, cryptocrystalline, with prominent argillaceous banding; intraformational conglomerate at top of lower limestone and at base and middle of upper limestone; unit weathers light brownish grey.	28	324
16	Limestone, medium grey, micro- to cryptocrystalline with argillaceous interbeds and partings; upper half weathers recessive and contains abundant trilobite fragments. GSC loc. 42073. ?Parehmania 2 spp., ?Ehmaniella sp., ?Kootenia sp.	14	296
15	Covered. Talus of limestone, argillaceous, light brownish grey, microcrystalline; weathers light yellow.	26	282

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
14	Limestone, dark grey, micro-crystalline, with irregular patches and layers of argillaceous limestone along bedding; 1 foot of intraformational conglomerate in middle; weathers yellow-grey, moderately resistant.	8	256
13	Limestone, medium grey, crypto- to microcrystalline, with thin argillaceous limestone in irregular layers and lenses which weather pale orange; 6-inch bed of intraformational conglomerate 7 feet from top; uppermost 5 feet is more argillaceous; unit weathers light yellow-grey to medium grey in beds 1/4 inch to 6 inches; forms small ridge.	40	248
12	Limestone, light grey, micro-crystalline, with irregular, thin, less than 1/2-inch argillaceous limestone interbeds; weathers recessive, pale yellow, in beds 1/4 to 1 inch.	5	208
11	Covered. Talus similar to overlying unit.	26	203
10	Limestone, light grey, micro-crystalline, with irregular and prominent argillaceous 1/16- to 1/4-inch partings; weathers pale yellow to light grey, moderately resistant.	4	177
9	Limestone, light grey, micro- to cryptocrystalline, some argillaceous partings; weathers light grey in beds less than 1 inch, recessive.	5	173
8	Covered.	4	168
7	Limestone, light grey, crypto-crystalline, silty (?), finely laminated; weathers light yellow-orange.	1	164

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
6	Limestone, dark grey, crypto- to microcrystalline with prominent irregular argillaceous limestone layers and lenses, 1/4 to 1 inch, which weather pale orange; unit weathers light grey and resistant. Upper 15 feet has prominent silt laminations.	53	163
5	Largely covered. Talus of limestone, light grey, micro-crystalline; weathers light grey to pale yellow; trilobite fragments at base. Talus of green shale near top.	71	110
4	Limestone, intraformational conglomerate; weathers dark grey.	1	39
3	Limestone, dark grey, micro-crystalline, with thin irregular layers of argillaceous limestone every 1/4 inch to 2 inches, which weather pale orange; unit weathers medium grey, moderately resistant; basal few feet covered. Limestone conglomerate 15 feet above base; trilobite fragments collected in upper 10 feet. GSC loc. 42059. ?Parehmania sp.	25	38
2	Limestone, light to medium grey, cryptocrystalline with argillaceous partings every 1/4 to 1/16 inch; recessive.	6	13
1	Limestone, light grey, crypto-crystalline, with clear calcite specks, fine argillaceous partings; weathers light grey in beds 1 inch to 12 inches.	7	7
	Underlying strata, dip slope of Titkana Formation. Limestone, dark grey, micro- to cryptocrystalline with thin discontinuous layers and lenses of brown argillaceous limestone up to 1/4 inch thick, giving rock a thin-bedded appearance; weathers light brown-grey, moderately resistant; forms a resistant cliff to the northeast.		

Section 3. Summary of Cambrian, Arctomys and Pika Formations and Map-unit 3; Chetamon Mountain (118°10'W, 53°03'N).

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Overlying beds, Lynx Formation, forming an inaccessible cliff.		
	Arctomys Formation		
15	Dolomite, silty, dark grey; pronounced fine crossbedding and laminations; weathers yellow-grey, resistant, in beds 4 to 12 inches.	78	591
14	Shale, calcareous, dark red and green.	150	513
13	Limestone, argillaceous, medium grey, microcrystalline; weathers light yellow-grey.	37	363
12	Shale, calcareous, yellowish green and dark red; fine laminations, some ripple-marks.	179	326
11	Shale, green and dark red, fissile, in part calcareous; fine laminations and crossbedding; ripple-marks and salt-crystal pseudomorphs in upper 90 feet.	147	147
	Pika Formation		
10	Limestone, dark grey, fine-crystalline; weathers greenish grey in beds 1/2 to 1 inch.	13	656
9	Covered by talus. Fossils collected from talus in middle of unit. GSC loc. 42573. "Kochaspis" sp., ?Glyphaspis sp., ?Parehmania sp.	140	643
8	Partly talus-covered. Small outcrops of limestone, dark grey, fine-crystalline, argillaceous; weathers dark grey with yellow argillaceous partings; some layers of intraformational conglomerate.	162	503

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
7	Limestone, dark grey, microcrystalline; in thin nodular beds 1/2 inch to 2 inches; intraformational conglomerates prominent in lower half with fragments 1/4 inch to 2 inches long; trilobite fragments from base. GSC loc. 42580. ?Parehmania spp.	36	341
6	Shale, grey-green, calcareous.	8	305
5	Limestone, dark grey, argillaceous; with some interbeds of recessive-weathering calcareous mudstone; trilobite fragments in upper 25 feet.	113	297
4	Shale, greenish grey, calcareous, fissile, with a few thin interbeds of limestone, dark grey, fine-crystalline, argillaceous; trilobite fragments near top.	49	184
3	Limestone, dark grey, medium-crystalline, some intraformational conglomerate; brown-weathering in beds 4 to 8 inches.	50	135
2	Limestone, dark grey, fine-crystalline, with several thin layers of intraformational conglomerate fragments 1/4 inch to 4 inches long.	63	85
1	Limestone, grey, fine-crystalline, fine laminations; weathers light yellow-grey in beds 2 to 6 inches.	22	22
	Underlying strata, Titkana Formation. Limestone, medium to dark grey, microcrystalline; weathers light grey, resistant, in beds 1 foot to 4 feet; forms massive cliff. Thickness by graphic calculations, approximately 850 feet.		

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Map-unit 3		
12	Fourth Shale—Mostly covered. Shale, green with some argillaceous limestone beds.	270	1,386
11	Upper Limestone—Dark grey, micro- to cryptocrystalline with thin interbeds of argillaceous limestone.	154	1,116
10	Third Shale—Mostly covered. Some argillaceous limestone talus; trilobite fragments in lower 50 feet. GSC loc. 42593. ?Glossopleura sp., Iphidella cf. I. grata Resser.	116	962
9	Middle Limestone—dark grey, micro- to cryptocrystalline; weathers light grey; some argillaceous partings, giving a mottled appearance to outcrop.	151	846
	Second Shale		
8	Shale, light green, mostly covered.	62	695
7	Limestone, medium grey, cryptocrystalline, argillaceous; weathers light brown; trilobite fragments in upper 50 feet. GSC loc. 42574. ?Glossopleura sp.	115	633
6	Covered. Talus of argillaceous limestone; trace of trilobite fragments.	43	518
5	Lower Limestone—Dark grey, cryptocrystalline with thin partings and layers of argillaceous limestone; weathers light grey; cliff-forming.	224	475
4	Covered. GSC loc. 36753 collected at top of this unit in creek about 1 mile southeast. Vanuxemella sp.	221	251

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Basal Clastic Unit		
3	Dolomite, silty, microcrystalline; weathers light red to orange in beds 1 inch to 12 inches.	15	30
2	Covered.	14	15
1	Intraformational conglomerate of dolomite and shale in sandstone matrix; angular fragments up to 1 1/2 inches long.	1	1
	Underlying beds, Gog Group. Sandstone, quartzose, coarse-grained, grains well rounded; weathers light grey with limonitic stain.	100+	

Section 4. Lower part of Upper Devonian; measured on south and southeast spur of Mount Tory, 1 1/2 miles from summit (118°19'W, 53° 12 1/2'N)—Section 8 of Figure 4.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Palliser Formation		
44	Limestone, microcrystalline, medium grey-brown; consists of fine carbonate grains; traces of crinoid fragments; weathers light grey, very resistant, beds 1 inch to 5 inches.	50+	
43	Limestone, cryptocrystalline, medium grey-brown; weathers light grey; slight rubbly appearance; traces of brachiopod cross-sections; basal and upper 1 foot weather recessive, forming two distinct notches.	9	
42	Limestone, microcrystalline, medium grey-brown; weathers light grey to brown-grey; essentially one bed.	15	
41	Limestone, microcrystalline, medium brown-grey; weathers light grey; beds 1 inch to 1 foot, recessive; one brachiopod collected from middle of unit.	12	
	Sassenach Formation (2 feet)		
40	Limestone, microcrystalline, light brown, very silty; weathers light brownish grey, recessive.	2	
	Southesk Formation		
	Simla Member (213 feet)		
39	Limestone, microcrystalline, medium to dark grey; weathers light to medium grey; beds 2 inches to 1 foot; forms dip slope and recessive gully; contains	19	1,627

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	some corals (?) and poorly preserved brachiopods.		
38	Limestone, crypto- to microcrystalline, light grey to light grey-brown; abundant clear calcite specks; consists of fine- to medium-carbonate grains; some beds show traces of fine laminations, beds 1 foot to 5 feet, well-bedded; weathers light grey.	145	1,608
37	Limestone, silty, finely laminated; thin-bedded; very recessive. Top of prominent recessive unit.	1	1,463
36	Dolomite and limestone, light grey, silty, finely laminated; weathers light yellow-grey; beds 2 inches to 1 foot.	3	1,462
35	Limestone, microcrystalline, dark grey; weathers medium grey with yellow stain; one solitary coral observed.	4	1,459
34	Siltstone, light grey, finely laminated; weathers light yellow-orange brown.	3	1,455
33	Limestone, cryptocrystalline, light grey, silty, finely laminated; greenish argillaceous, thin partings; very recessive.	2	1,452
32	Sandstone, very fine grained, light grey, dolomitic; weathers light orange-brown, soft; one bed.	3	1,450
31	Limestone, micro- to fine-crystalline, medium grey; becomes very argillaceous and nodular in upper foot; abundant Thamnopora, gastropods.	2	1,447
30	Siltstone, light greyish brown, calcareous, finely laminated; weathers brown, recessive.	2	1,445

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
29	Prominent covered gully; interval exposed at top of ridge as follows (top to bottom): 10 feet—Partly covered. Siltstone grading up into fine-grained sandstone, light grey, finely laminated; weathers light yellow-orange brown. 9 feet—Partly covered. Limestone, dark grey, argillaceous, dolomitic (?), micro- to fine-crystalline, pyritic; abundant Thamnopora, rugose corals, gastropods, Amphipora. 10 feet—Shale, pale green to brown.	29	1,443
	Lower Member (612 feet)		
28	Limestone, cryptocrystalline, light grey to light brown-grey, some clear calcite specks, in part fine to medium carbonate grains; Amphipora abundant in some (generally darker grey) beds; recessive-weathering; thin, argillaceous carbonate beds not as numerous as in underlying beds; weathers light grey; beds 1 foot to 5 feet; forms dip slope; corals, brachiopods and stromatoporoids collected from upper 2 feet.	59	1,414
27	Partly talus-covered outcrop. Limestone, similar to underlying unit.	35	1,355
26	Limestone, crypto- to micro-crystalline, made up of fine to coarse carbonate grains, light grey, abundant clear calcite specks; weathers light grey; beds 1 foot to 3 feet; resistant.	113	1,320

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Interbedded with recessive-weathering intervals every 2 to 5 feet which consist of limestone, crypto- to fine-crystalline, light to medium grey, finely laminated with green shale partings and lenses up to 1/8 inch; in part limestone conglomerate, particularly near base. Some recessive intervals are thicker and consist almost entirely of green shale. Amphipora occurs throughout; Amphipora and gastropods abundant in recessive intervals.		
25	Limestone, light grey, crypto-crystalline; abundant clear calcite specks and 'eyes'; weathers light grey in beds 2 to 6 feet, resistant.	30	1,207
24	Limestone, light grey, crypto-crystalline; abundant clear calcite specks; weathers light grey in beds 3 to 5 feet, resistant; 5-foot interval 13 feet above base of limestone, argillaceous, in beds 1/2 to 1 foot.	58	1,177
23	Limestone, medium grey, cryptocrystalline; weathers light grey in beds 2 to 3 feet, resistant.	101	1,119
22	Interbedded limestone as below, and dolomite, brown, medium-crystalline; weathers brown in beds 2 to 6 inches.	18	1,018
21	Limestone, dark grey, fine-crystalline; numerous white carbonate specks, scattered shell fragments; weathers grey in distinct beds 1 foot to 3 feet, resistant.	76	1,000
20	Dolomite, light grey, medium-crystalline; weathers light grey, resistant; indistinct beds.	41	924

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
19	Dolomite, light grey, medium-crystalline, fine vuggy porosity; weathers resistant; at base are a few thin beds of dark grey limestone containing small solitary corals.	81	883
	Cairn Formation (802 feet)		
	Upper Unit (517 feet)		
18	Limestone, dark grey, fine-crystalline; weathers light grey, in beds 1 inch to 4 inches, recessive.	52	802
17	Dolomite, light grey, medium-crystalline, fine vuggy porosity; contains solitary corals; weathers light grey, resistant.	44	750
16	Limestone, dark grey, fine-crystalline; some Amphipora; weathers brown in beds 1 foot to 2 feet, resistant; sharp upper contact.	53	706
15	Limestone, dolomite, medium brownish grey, medium-crystalline with scattered zones of medium-grained calcarenite; Amphipora; weathers brown, resistant.	110	653
14	Limestone, dark grey, fine-crystalline, with thin beds of argillaceous limestone; Amphipora, globular stromatoporoids and occasional gastropods.	59	543
13	Limestone, medium grey, fine-crystalline, with numerous white calcite specks; scattered Amphipora; weathers grey in beds 2 to 18 inches.	29	484
12	Limestone, light grey, medium-crystalline; trace of stromatoporoids; weathers light grey in beds 2 to 12 inches, resistant.	16	455

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
11	Limestone, in part argillaceous, medium grey, medium-crystalline; abundant Amphipora and other stromatoporoids, trace of brachiopods; weathers brown, resistant.	37	439
10	Limestone, brown, medium-crystalline; numerous Amphipora throughout; weathers dark brown, resistant.	47	402
9	Limestone, dolomitic, brown-grey, medium-crystalline; Amphipora throughout; weathers brown in nodular beds; lower half slightly recessive.	70	355
	Chert Unit (150 feet)		
8	Limestone, dark grey, micro- to fine-crystalline; abundant globular stromatoporoids up to 8 inches in diameter. Dark grey chert except near top; numerous brachiopods collected just below top.	87	285
7	Chert, light grey, with some dark brown dolomite.	3	198
6	Limestone, dolomitic, medium brown, fine-crystalline; containing beds with abundant globular stromatoporoids; numerous thin, black chert nodules and beds.	60	195
	Basal Limestone Unit (135 feet)		
5	Limestone, medium brown, fine-crystalline; abundant globular stromatoporoids and scattered Amphipora; weathers brown in beds 1 foot to 3 feet, resistant.	31	135
4	Limestone as below, bedding thinner; mostly talus-covered.	20	104

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
3	Limestone, medium grey, microcrystalline; scattered globular stromatoporoids and *Amphipora*; weathers light grey in beds 1 foot to 3 feet.	51	84
2	Limestone, dark grey, argillaceous; *Amphipora*; weathers recessive in beds 2 to 10 inches; mostly covered except for top 6 feet.	17	33
1	Limestone, medium grey, cryptocrystalline, numerous calcite fractures; weathers light grey, resistant, in beds 1 foot to 3 feet.	16	16
	Lynx Formation (Upper Cambrian)		
	Dolomite, light grey, fine- to medium-crystalline.	25	
	Dolomite, light to medium grey, with some carbonate fragments; weathers yellow-grey in beds 1 foot to 4 feet, resistant.	73	

Section 5. Formations A to D of Rundle Group; on southeast spur of Mount Greenock, Jasper National Park; measured along pipeline right-of-way (53° 05'N, 118° 04'W).

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Overlying beds, Rocky Mountain Formation. For description see Brown (1952, p. 32, Section 1A; upper and middle members of Greenock Formation).		
	Rundle Group (1,192 feet)		
	Formation D (335 feet)		
	Covered.	18	1,192
34	Dolomite, cryptocrystalline, light grey; weathers light grey-yellow in beds 2 inches to 2 feet; a few irregular dark grey chert lenses throughout, abundant in upper 2 feet.	35	1,174
33	Partly covered. Dolomite and argillaceous dolomite, light grey, microcrystalline, some chert; weathers light yellowish grey, recessive, in beds 1 inch to 1 foot.	56	1,139
32	Dolomite, microcrystalline, light grey, trace of fine laminations, abundant chert nodules; weathers very light grey, resistant, in beds 1 foot to 3 feet.	18	1,083
31	Dolomite, microcrystalline, medium grey; trace of crinoid and other fossil fragments; weathers light grey-yellow in beds 1 foot to 2 feet; upper 10 feet argillaceous.	76	1,065
	Covered.	33	989
30	Dolomite, microcrystalline, medium grey; weathers light yellow-grey, slightly recessive.	28	956

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
29	Dolomite, microcrystalline, light grey with abundant light grey chert lenses. Lenses contain abundant silicified brachiopods including Dictyoclostus sp., Composita sp., and abundant small Spirifer fragments (GSC loc. 36754). This is the zone which contains Brown's (1952) Spirifer n.sp. A. This unit weathers light grey in beds 6 inches to 2 feet and forms a distinct resistant unit on mountain.	23	928
28	Dolomite micro- to fine-crystalline, light grey, occasional chert nodules at base; weathers light yellow-grey in indistinct beds 1 foot to 2 feet, slightly recessive.	20	905
27	Dolomite, very fine crystalline, light brownish grey; weathers light grey, resistant; contains thin light grey chert lenses and beds which weather light yellow to orange.	6	885
26	Dolomite, very fine crystalline, brownish grey; traces of fossil fragments; weathers light brownish grey in beds 6 inches to 2 feet.	17	879
25	Dolomite, microcrystalline, light to medium grey, with abundant light grey chert nodules.	5	862
	Formation C (378 feet)		
24	Dolomite, very fine crystalline, light grey, traces of fine porosity; weathers light yellow-grey in beds 1 foot to 3 feet. Laminated and trace of fossil fragments in upper 10 feet.	50	857

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
23	Dolomite, very fine crystalline, medium grey; traces of coral and crinoid fragments, abundant in some layers; weathers light grey-brown in beds 2 inches to 2 feet.	92	807
22	Dolomite crypto- to micro-crystalline, light grey, with abundant light grey chert nodules; weathers light yellow-grey in beds 1 foot to 3 feet.	12	715
21	Dolomite, microcrystalline, light brown to dark grey, some white chert; traces of colonial corals; some sedimentary breccia (?); weathers grey.	19	703
	Top of more porous recessive-weathering dolomites and possible alternative contact between Formations C and D.		
20	Dolomite, fine-crystalline, light brown, slightly calcareous and porous, trace of vugs; weathers grey, massive.	45	684
19	Dolomite, argillaceous, fine-crystalline, dark grey, finely laminated; a few Spirifer and bryozoa; weathers light grey, recessive, in beds 1 inch to 6 inches.	21	639
18	Limestone, dolomitic, very fine crystalline, light grey trace of fine porosity; weathers light yellow-grey, massive.	22	618
17	Dolomite, microcrystalline, light yellow-grey; weathers grey in beds 2 to 3 feet.	10	596
16	Limestone, dolomitic fine- to medium-grained, light brownish grey; loosely cemented, abundant	85	586

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	crinoid and fossil fragments; traces of fine laminations and porosity; some small vugs near top; weathers light grey in beds 1 foot to 3 feet.		
15	Dolomite, calcareous, fine- to medium-grained, dark brown; abundant fossil fragments (mostly crinoid and brachiopod), loosely cemented; weathers medium brown in 2-foot beds, moderately resistant. Basal bed coarsely crossbedded, suggesting current direction from northeast to southwest.	22	501
	Formation B (235 feet)		
14	Dolomite, microcrystalline, medium grey; weathers light grey in beds 2 inches to 1 foot. Contact with overlying unit irregular. Overlying unit cuts into this unit up to 1 foot.	2	479
13	Mostly covered. Dolomite, micro- to medium-crystalline, dark grey, in beds 2 to 4 feet thick, in part porous.	34	477
12	Dolomite, very fine crystalline, medium grey; weathers yellow-grey in beds 1 foot to 2 feet; 3-foot bed of porous dolomite 5 feet above base.	20	443
11	Limestone, dolomitic, micro-crystalline, brownish grey, trace of fine porosity; weathers light brown in beds 6 inches to 2 feet.	18	423
	Covered. A few outcrops of limestone (GSC loc. 36756) 15 to 20 feet from top. *Ekvasophyllum proteus* Sutherland *Vesiculophyllum* sp.	27	405

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
10	Limestone, dolomitic, fine-crystalline, dark brown-grey, trace of fine laminations, some talus-cover; weathers light brown-grey. GSC loc. 36802. Dictyoclostus sp., Spirifer cf. keokuk? Hall and Spirifer cf. forbesi? Norwood and Pratten.	50	378
9	Limestone, microcrystalline, grey, with abundant specks of clear calcite, some pellets and pseudo-oolites; weathers light grey in beds 2 inches to 1 foot; brachiopods and cup-corals. GSC loc. 36798, 25 feet above base. Dictyoclostus cf. gallatinensis Girty, Camarotoechia cobblestonensis Brown, Camarotoechia allani Warren, Composita sp.	53	328
8	Limestone, fine-crystalline, dark brownish grey; trace of fossil fragments; weathers medium grey, platy in beds 1/2 inch to 2 inches, recessive. A few thin interbeds of pelletoid limestone.	31	275
	Formation A (244 feet)		
7	Limestone alternate beds fine- and coarse-grained, dark grey; abundant fossil fragments; weathers medium grey in beds 6 inches to 3 feet. GSC loc. 36806, from top—Orthotetes cf. keokuk Hall, and fragments.	71	244
6	Limestone, very coarse-grained, grey; abundant rounded fossil fragments (mostly crinoid detritus); weathers light grey, resistant.	50	173
5	Limestone, fine- to medium-grained, argillaceous; weathers grey, recessive in beds 1 inch to 3 inches.	6	123

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
4	Limestone, medium- to coarse-grained; abundant fossil fragments (mostly crinoid detritus) cemented by clear calcite; grey; weathers light grey, resistant. GSC loc. 36800, from middle of unit— Leptaena analoga Phillips, Dictyoclostus cf. burlingtonensis (Hall) D. cf. gallatinensis? Shimer, Spirifer rundlensis? Warren, Brachythris sp. GSC loc. 36806, 20 feet above base. Pseudozaphrentoides? sp. cf. P. burlingi Sutherland.	52	117
3	Limestone, fine- to coarse-grained, light to dark grey; abundant fossil fragments; weathers light grey, resistant, in beds greater than 5 feet.	33	65
2	Limestone, micro- to fine-grained, light to dark grey; abundant fragments of crinoids, bryozoa, and corals; weathers light grey, massive, resistant; numerous solitary corals in basal 2 feet.	16	32
1	Limestone, very coarse grained, dark grey; abundant fossil detritus; weathers light grey, resistant, massive.	16	16
	Banff Formation		
	Siltstone, dark grey, finely laminated; weathers light grey-yellow in beds 1/2 inch to 2 inches.	6	
	Covered. One outcrop near middle; limestone dark grey, argillaceous.	124	
	Partly covered. Limestone, dark grey, argillaceous, crinoidal interbedded with calcareous shale in beds 1/2 inch to 3 inches. (See Brown, 1952, pp. 35-38, for underlying strata and additional descriptions of Banff Formation.)	40	

Section 6. Rundle Group and Banff Formation; at Brewsters Wall (53°28'N, 118°54'W), southwest of south Sulphur River, Alberta.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Overlying strata, Triassic Sulphur Mountain siltstones.		
	Rocky Mountain Formation (110 feet)		
	Sandstone, fine-grained, quartzose, light greyish brown, occasional lenses of light grey chert; weathers resistant, medium grey.	80	
	Chert, light grey, resistant, prominent joints.	30	
	Rundle Group (1,346 feet)		
	Formation D (383 feet)		
25	Dolomite, microcrystalline, light yellow-grey, trace of porosity; weathers light yellow-grey in beds 6 inches to 2 feet. Partly covered in upper half. Lenses and nodules of bluish grey chert near top.	163	1,346
24	Dolomite, micro- to fine-crystalline, light grey; irregular nodules and lenses of grey chert abundant in upper half; traces of fossil (mainly crinoid) fragments near middle; weathers light yellow-grey in beds 1 foot to 3 feet, resistant.	120	1,183
23	Dolomite, microcrystalline, brownish grey; weathers yellow-grey in 1-foot beds; traces of coral and other fossil fragments; slightly porous, minor chert near base.	68	1,063

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
22	Dolomite, microcrystalline, brownish grey; weathers yellow-grey in beds 6 inches to 2 feet; abundant lenses of grey chert in lower half, some with silicified brachiopods and corals; 8-foot covered interval near top.	32	995
	Formation C (310 feet)		
21	Dolomite, microcrystalline, light brownish grey; traces of crinoid and coral fragments; finely laminated; weathers light yellowish grey in beds 6 inches to 3 feet, resistant; traces of porosity at base and near top, minor chert in upper part.	80	963
20	Dolomite, cryptocrystalline, light yellow-grey, argillaceous (?); weathers recessive, yellow-grey, in beds 1 inch to 6 inches.	15	883
19	Dolomite, light greyish brown, micro- to fine-crystalline; traces of crinoid and coral fragments; weathers light grey in beds 1 foot to 2 feet; traces of fine porosity throughout, grey chert in middle.	134	868
18	Dolomite, fine- to medium-crystalline, loosely cemented, porous, grey; weathers light grey in 1- to 2-foot beds.	34	734
17	Mostly covered. Small exposure in basal 20 feet is dolomite, fine-crystalline, light brown, slightly porous, loosely cemented.	47	700
	Formation B (347 feet)		
16	Limestone, micro- to fine-crystalline, medium grey; small specks or 'eyes' of clear calcite;	86	653

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	weathers grey in beds 4 inches to 2 feet, recessive compared to Formation C; contains Syringopora, Vesiculophyllum and other corals. Upper 10 feet mostly covered. GSC loc. 40252, from top— Lithostrotion (Siphonodendron) sp. cf. L. (S.) warreni Nelson.		
15	Limestone, crypto- to micro-crystalline, dark brownish grey; abundant small, clear calcite specks; weathers light grey in beds 4 inches to 2 feet. A few solitary and colonial corals in upper part. GSC loc. 40255, Ekvasophyllum proteus Sutherland, Syringopora spp.	41	567
14	Dolomite, microcrystalline, silty (?), medium grey; weathers light yellowish grey in beds 4 inches to 1 foot, recessive.	9	526
13	Limestone, microcrystalline, light grey, with layers of small, rounded grains or pellets, some pseudo-oolites; abundant specks of clear calcite; weathers light grey in beds 6 inches to 3 feet, moderately resistant.	23	517
12	Limestone, crypto- to micro-crystalline, light brownish grey; abundant specks of clear calcite; weathers light grey in beds 1 foot to 4 feet; abundant grey chert nodules at base.	65	494
11	Limestone, dark brownish grey, fine- to medium-grained; traces of fossil fragments in some beds; weathers light brownish grey in beds 6 inches to 1 foot. Lower third partly covered and contains solitary corals.	58	429

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
10	Limestone, fine-grained, grey; contains a few thin interbeds of very coarse grained, fossil-fragment limestone; weathers light brownish grey in beds 6 inches to 4 feet, grey chert in upper 10 feet; trace of corals.	65	371
	Units 10 and 11 above are transitional to Formation A.		
	Formation A (306 feet)		
	Upper Part (154 feet)		
9	Limestone, fine- to medium-grained, dark grey; lower third argillaceous and partly covered; weathers grey in beds 4 inches to 3 feet. Fossil fragments abundant in some layers.	73	306
8	Covered. Some argillaceous siltstone talus.	12	236
7	Limestone, very coarse grained, grey; weathers light grey; bedding indistinct.	15	224
6	Siltstone, argillaceous, calcareous, dark grey, finely laminated; weathers yellow-grey, thin-bedded, recessive.	15	209
5	Limestone, coarse-grained, grey; abundant fossil fragments; weathers light grey in beds 6 inches to 2 feet. Brachiopods particularly abundant in upper 10 feet and unit is also more argillaceous at top.	42	194
	Lower Part (152 feet)		
4	Limestone, grey, fine- to coarse-grained; abundant fossil fragments; weathers light grey, massive.	14	152

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
3	Dolomite, microcrystalline, light grey, with abundant, small, dark grey chert nodules; weathers yellow-grey.	10	138
2	Limestone, coarse-grained, crinoidal, dark grey, with thin 4-foot interbeds of microcrystalline limestone.	55	128
1	Limestone, light to light grey-brown, very coarse grained; abundant crinoid fragments; well-stratified; weathers light grey in beds greater than 2 feet. Middle part contains several 1-foot interbeds of dark grey, microcrystalline limestone.	73	73
	Banff Formation (488 feet)		
	Limestone, fine-crystalline, medium grey, interbedded with shale, green calcareous; weathers yellow-brown in beds 1/4 inch to 6 inches.	7	488
	Siltstone, argillaceous, calcareous, brown; weathers yellow-brown in beds 1/4 inch to 1 foot.	4	481
	Limestone, very-fine- to coarse-grained; abundant fossil fragments at base; thin-bedded and argillaceous in upper half.	32	477
	Covered.	89	445
	Limestone, fine- to coarse-grained; abundant fossil detritus, grey; interbedded with 1/2- to 2-inch beds of argillaceous limestone.	60	356
	Covered. Appears to consist of thin-bedded, greenish grey shale and calcareous limestone.	296	296
	Underlying beds, Palliser Formation (Upper Devonian).		

Section 7. Fernie Group; measured on north end of De Smet Range in small creek valley on northeast side (118° 24'W, 53° 20 1/2'N).

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Overlying beds covered.		
13	Shale, dark grey to black, with thin beds and concretionary layers of dark grey siltstone which weather orange-red.	300-400 (est.)	
12	Shale, dark grey to black; few small concretions.	25	455
	Glauconite Beds (21 feet—unit a, Frebold et al., 1959).		
11	Glauconite, green, argillaceous.	1	430
10	Shale, grey, slightly calcareous, traces of glauconite; indurated and weathers resistant, light orange-grey; abundant belemnites at base, *Gryphea* sp.	19.5	429
9	Glauconite, green.	0.5	409 1/2
	Strata Equivalent to Grey Beds (109 feet)		
8	Shale, indurated in part, light to medium grey; with concretions up to 4 feet in diameter, average 1 foot, largest at base. Fossils collected near base. GSC loc. 42083. *Imlayoceras miettensis* Frebold.	30	409
7	Shale, indurated, dark grey to black, gradually becomes lighter in colour upwards; a few concretions; siltstone, dark grey; weathers dark grey in beds 1/16 to 1 inch.	75	379
6	Shale, silty, greenish grey; abundant belemnites.	4	304
	Strata Equivalent to Rock Creek Member (170 feet)		
5	Siltstone and very fine grained sandstone, light greenish grey,	20	300

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	some layers argillaceous and concretionary, trace of glauconite (?); fossils collected 3 feet below top. GSC loc. 42093. Stephanoceratids.		
4	Shale, dark grey; zone of large concretions about middle; weathers dark reddish grey.	150	280
	Paper Shales (100 feet)		
3	Shale, black; weathers dark grey in beds 1/16 to 1/2 inch.	50	130
2	Limestone, black, fine-crystalline, argillaceous, interbedded with shale, black; weathers like shale above; limestone and shale in beds 1/2 inch thick.	50	80
	Nordegg Member (30 feet)		
1	Limestone, fine-crystalline, silty, dark grey; weathers pale yellow-grey, resistant; some beds of calcareous siltstone.	30	30
	Underlying beds, Triassic Whitehorse Formation.		

Section 8. Middle part of Fernie Group; near Desolation Pass (118°43'W, 52°28'N). Measured on a prominent cut on southwest side of stream that flows southeast about 1/2 mile from summit of Desolation Pass.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Overlying beds, upper part of Fernie Group.		
16	Mudstone, dark brown-grey, with prominent thin layers of orange-weathering siltstone and siltstone concretions; mudstone weathers dark grey.	40	168
	Unit a (Frebold et al., 1959) (23 feet)		
15	Siltstone, concretionary, medium grey; weathers orange-red, resistant.	1	128
14	Siltstone, grey, trace of glauconite.	3	127
13	Siltstone and sandstone, fine-grained; abundant glauconite decreasing upwards, greyish green; occasional belemnites; indistinct bedding; weathers green to yellow-grey.	9	124
12	Siltstone, purple-grey; weathers purple to orange-red, resistant; forms a prominent layer.	1	115
11	Siltstone and sandstone, fine-grained, dark greenish grey, very glauconitic; glauconite content decreasing upwards; weathers greenish grey to light brown.	9	114
	Grey Beds (81 feet)		
10	Shale, light brown, abundant concretions up to 2 feet diameter; weathers light yellow-brown.	15	105
9	Shale, transitional downwards in colour from light brown to dark grey; concretions as above.	10	90
8	Clay, light grey; weathers pale yellow.	8" to 1'	90

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
7	Shale, indurated, light to dark grey; weathers light yellow-grey in beds 1/8 to 1/2 inch.	3	79 1/2
6	Siltstone, dark grey to black, argillaceous, interbedded with dark grey, silty shale; weathers medium grey to yellow-grey in beds 1/4 inch to 2 inches; abundant ammonite impressions, belemnites and pelecypods. GSC loc. 40222. Kepplerites (?) sp. indet., Inoceramus sp.	4	76 1/2
5	Shale, indurated, dark grey, non-calcareous; weathers dark grey in beds 1/8 to 1 inch, 1/2-inch clay layer at top.	12	72 1/2
	Rock Creek Member (60 1/2 feet)		
4	Siltstone, pale yellow-brown, non-calcareous; weathers yellow-brown to orange; 2-inch red-weathering clay layer at top; numerous belemnites, occasional pelecypods, and a few ammonites. GSC loc. 40231. Stemmatoceras (?) sp. indet.	2 1/2	60 1/2
3	Clay, light to medium grey with thin layers of glauconite.	1	58
2	Shale, dark brownish grey, slightly silty, non-calcareous; weathers dark grey and in part reddish grey; a few concretions.	10	57
1	Shale, dark brownish grey, silty; weathers medium grey; interbedded with siltstone strata and concretions 1 inch to 1 foot thick; weathers pale yellow to red.	47	47
	Covered.		
	Paper shales and Nordegg Member are exposed in creek bed about 1 1/2 miles downstream.		

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