CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

MEMOIR 287

THE JURASSIC FERNIE GROUP IN THE CANADIAN ROCKY MOUNTAINS AND FOOTHILLS

By
Hans Frebold

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

The Fernie group, a belt of strata following the Foothills and eastern parts of the Rocky Mountains, has been studied in some detail and is known to be of Jurassic age. This report embodies a comprehensive study of the group along its entire range and includes a detailed systematic description of its index fauna.

As a result of this study much information has been gained on the nature, history, and extent of the Jurassic sea and conditions preceding and following deposition of these strata. This information is of great importance in the search for oil.

Although the report deals primarily with the Fernie group, other Jurassic formations to the west are discussed briefly, resulting in considerable modification of previous ideas on the extent of the Jurassic sea in that direction.

GEORGE HANSON,
Director, Geological Survey of Canada

OTTAWA, October 25, 1955


SCALE OF MILES
250
0
250
QUEEN
ELIZABETH
ISLANDS
ARCTIC
OCEAN
ELLESMERE
ISLAND
GREENLAND
AXEL
HEIBERG
I.
AMUND
RINGNES I.
ELLEF
RINGNES
I.
BORDEN I.
MACKENZIE KING
I.
PRINCE
PATRICK
I.
CORNWALL
I.
BATHURST
I.
DEVON I.
BAFFIN BAY
MELVILLE
ISLAND
Viscount Melville Sd.
SOMERSET
I.
PRINCE
OF
WALES
I.
BANKS
I.
BAFFIN
ISLAND
M'Clintock Chan.
BOOTHIA
PEN.
Gulf
of
Boothia
MELVILLE
PEN.
BEAUFORT
SEA
ALASKA
Amundsen
Gulf
VICTORIA ISLAND
Firth R.
Porcupine
R.
AKLAVIK
Yukon
Peel R.
YUKON
DAWSON
TERRITORY
Pelly R.
Great Bear
Lake
ARCTIC
CIRCLE
NORTHWEST
TERRITORIES
Mackenzie
R.
Thelon
R.
Kazan
R.
HUDSON
BAY
WHITEHORSE
Teslin
R.
YELLOWKNIFE
Great Slave
Lake
Liard
R.
Slave R.
CHURCHILL
FORT
NELSON
Peace
R.
L. Athabasca
Churchill R.
Nelson
R.
BRITISH
COLUMBIA
OCEAN
PACIFIC
Skeena R.
ALBERTA
Athabasca
R.
SASKATCHEWAN
MANITOBA
L.
Winnipeg
PRINCE RUPERT
QUEEN
CHARLOTTE IS.
North
Saskatchewan
R.
EDMONTON
Saskatchewan
R.
L.
Winnipegosis
Fraser
R.
SASKATOON
Saskatchewan R.
L.
Manitoba
CALGARY
S. Saskatchewan
REGINA
WINNIPEG
VANCOUVER
ISLAND
VANCOUVER
VICTORIA
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60°
80°
50°
170°
160°
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150°
80°
140°
60°
60°
90°
50°
50°
130°
120°
110°
100°

FIGURE 1.

FIGURE 1. Jurassic localities in Western and Northern Canada. 1, Northwest coast, Vancouver Island; 1a, Parson Bay; 2, Queen Charlotte Islands; 3, Southwest Hope map-area; 4, Harrison Lake area; 5, Ashcroft area; 6, Tyaughton Lake area; 7, Whitesail area; 8, Hazelton area; 9, McConnell, Takla, Manson Creek, Fort Fraser areas; 10, Groundhog area; 11, Lower Stikine and Western Iskut areas; 12, Taku River area; 13, Dease Lake area, Cassiar District; 14, Salmo area; 15, Southern Yukon; 15a, Arctic Coast; 16, Prince Patrick Island; 17, Cameron Island; 18, Axel Heiberg Island; 19, Southern plains of Alberta; 20, Southern plains of Saskatchewan; 21, Southern plains of Manitoba. Fernie group localities are shown by ruled pattern. (*See* Figure 2.)

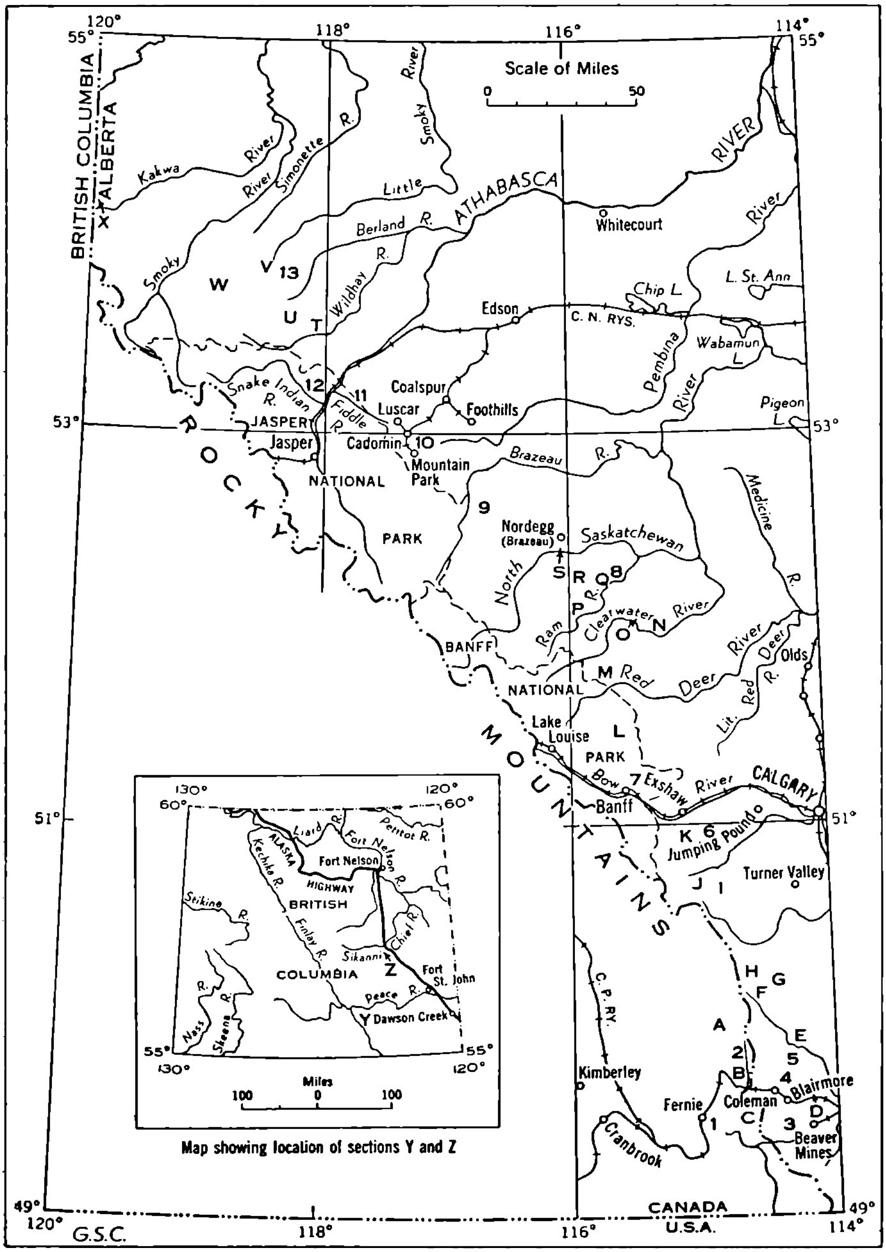
Scale of Miles
0
50
BRITISH COLUMBIA
ALBERTA
ATHABASCA RIVER
Smoky River
Kakwa River
Simonette R.
Little Smoky
Berland R.
Wildhay R.
Whitecourt
L. St. Ann
Chip L.
Edson
C. N. RYS.
Wabamun L.
Pembina River
Coalspur
Foothills
Luscar
Cadomin
Mountain Park
Snake Indian R.
Fiddle R.
JASPER
Jasper
NATIONAL
PARK
Pigeon L.
Brazeau R.
Medicine R.
Nordegg (Brazeau)
North Saskatchewan
Ram R.
Clearwater River
BANFF
NATIONAL
PARK
Red Deer River
Lit. Red Deer R.
Olds
Lake Louise
Bow River
Exshaw
Banff
CALGARY
Jumping Pound
Turner Valley
ROCKY MOUNTAINS
C.P.RY.
Kimberley
Cranbrook
Fernie
Coleman
Blairmore
Beaver Mines
CANADA
U.S.A.
G.S.C.
120°
118°
116°
114°
55°
53°
51°
49°
Map showing location of sections Y and Z
ALASKA HIGHWAY
Liard R.
Fort Nelson R.
Petitot R.
Fort Nelson
Kechika R.
BRITISH COLUMBIA
Stikine R.
Finlay R.
Chief R.
Sikanni
Fort St. John
Peace R.
Dawson Creek
Nass R.
Skeena R.
Miles
100
0
100
130°
60°

FIGURE 2.

FIGURE 2. Jurassic localities in the Rocky Mountains and Alberta Foothills. Sections illustrated in Figure 3: 1, Fernie area; 2, Alexander Creek; 3, Adanac; 4, Grassy Mountain; 5, Daisy Creek Summit; 6, Canyon Creek; 7, Cascade Valley; 8, Ram River; 9, West of Bighorn Range; 10, Cadomin; 11, Fiddle Creek; 12, Snake Indian River; 13, Northern Foothills Region (Generalized Section). Other sections and localities described in the text: A, Fording River area; B, Crow Phosphate Mine; C, Corbin; D, Rock Creek near Frank; E, Livingstone Gap; F, Southwest of Isola Peak; G, Plateau Mountain area; H, Wilkinson Creek area; I, Burns Mine; J, Pocaterra Creek; K, Ribbon Creek; L, Cuthead and Wigmore Creeks area; M, Bighorn Creek; N, Tay River area; O, Fall Creek area; P, Cripple Creek area; Q, Saunders area; R, Alexo area; S, Nordegg; T, Hay Mountain region; U, Head of Moon Creek; V, Cabin Creek; W, Junction of Sulphur and South Sulphur Rivers; X, Copton Creek; Y, Pine Pass–Peace River; Z, Pink Mountain and Sikanni Chief River.

THE JURASSIC FERNIE GROUP IN THE CANADIAN ROCKY MOUNTAINS AND FOOTHILLS

CHAPTER I

INTRODUCTION

The Fernie group comprises most of the Jurassic strata in the Canadian Rocky Mountains and Foothills. Only the uppermost part of the Jurassic is not included in the Fernie group, but forms the lowermost part of the Kootenay formation and its equivalent, the Nikanassin formation, which normally overlie the Fernie group. The Fernie group extends from the International Boundary in the south to the Peace River country in the north in a band about 700 miles (1,120 kilometres) long and about 60 miles (about 100 kilometres) wide.

The outcrops are mainly in the valleys and on the slopes of the mountains and most are comparatively easily accessible by motor car or horses. Complete sections are rarely seen mainly owing to vegetation cover.

The name "Fernie shales" was first used by McEvoy and Leach (1902)[1] on the geological and topographical map of Crowsnest coalfields, East Kootenay District, and their age was determined as "Lower Cretaceous or Jurassic". However, as shown in Telfer's (1933) sections and further proved by the writer's investigation in this area, the strata mapped by McEvoy and Leach as "Fernie shales" include beds of Triassic age. Furthermore no continuous section is exposed in the area that gave its name to the group. The name "Fernie shales" was used again on the map of the Blairmore-Frank coalfields (Leach, 1903) for a 700-foot series of shales, which were regarded as Lower Cretaceous. Later Leach (1912, pp. 193, 194) placed the "Fernie shales" in the Jurassic and separated them from the overlying Kootenay beds.

Since then the "Fernie shales", "Fernie formation", and "Fernie group" have been regarded as belonging to the Jurassic system.

Many palæontological and stratigraphical contributions have been made to the knowledge of the Fernie group in the course of the years, particularly by McLearn and Warren who proved the presence of beds belonging to the Lower, Middle, and Upper Jurassic. These earlier studies have shown the necessity for a systematic stratigraphical and palæogeographical investigation of the Fernie on a palæontological basis. Such a study was commenced by the writer in 1950 between the International Boundary and Snake Indian Valley and in the Pine Pass region in the north. It was not possible during the time available to study all the outcrops within this large area and many details may be added by future investigations. Information on the area between Snake Indian Valley and Pine Pass region was obtained by several Geological Survey field parties.

It will be shown in the present report that the sequence of the Jurassic Fernie group in the Canadian Rocky Mountains and Foothills is very

[1]Names and dates in parentheses are those of references listed at the end of this report.

incomplete and that various different facies are developed within this region that can only be correlated by index fossils common to different facies. Interpretation of the data obtained from field studies has made possible a reconstruction of conditions in the region during Jurassic time, a region hitherto considered as a geosynclinal zone bordered on the west by the "Cordilleran geanticline Jurozephyria". It has also been possible to establish correlations with the Jurassic strata in British Columbia, the Yukon, the Canadian Arctic Archipelago, in the southern plains of Alberta, Saskatchewan, and Manitoba, and in the adjoining parts of the United States.

SUMMARY OF CONCLUSIONS

The Fernie group of the Canadian Rocky Mountains and Foothills is comprised of beds belonging to the Lower (Lias), Middle, and Upper Jurassic. Uppermost Jurassic (Upper Portlandian) is represented in the Lower Kootenay sandstone and is established by the occurrence of the big ammonite (*Titanites occidentalis* n.sp.) in the Lower Kootenay sandstone near Fernie, B.C.

Compared with the northwest European standard section of the Jurassic system, with its fifty-nine ammonite zones, the Jurassic of the Canadian Rockies and Foothills has only yielded about twelve zones and the maximum thickness, which in northwest Europe reaches about 3,500 feet, is only about 1,200 feet in the Fernie group. The following stages are indicated by index fossils in the Rocky Mountains and Foothills Jurassic (*see* Figure 4): Part of the Sinemurian (locally), Toarcian, Middle Bajocian, Lower Callovian, part of the Oxfordian and part of the Upper Portlandian. Not indicated are the Hettangian, Pliensbachian, Lower Bajocian, Upper Bajocian, Bathonian, and Upper Callovian. Kimmeridgian and Lower Portlandian seem to be represented, but typical index fossils have not been found. Some of the more important hiatuses in the Fernie group are indicated in Figure 4.

There are no visible angular unconformities in the Fernie group and the hiatuses can only be recognized on a palæontological basis, that is by the absence of index fossils. In some cases the presence of a hiatus is indicated by the character of the fauna in the beds below the gap, as for instance by the abundance of *Gryphaea* or the presence of "Belemnite battlefields" and other fossil concentrations, which are characteristic of very shallow water conditions. In the writer's opinion some of the gaps, particularly those of the Lower Jurassic are caused by temporary regressions of the sea, or at least by conditions that prevented the immigration of a fauna and hindered the deposition of any appreciable amount of sediment.

Thus the marine horizons that are present in the Fernie group would indicate several transgressions or invasions of faunas following times of non-deposition. These transgressions did not all have the same areal extent. Thus, during the Sinemurian, in which time the first Jurassic Fernie transgression took place, the sea invaded a part of the region only, whereas the seas of the Toarcian and Middle Bajocian times covered practically the whole basin. It seems to be a rule that Triassic sediments are present wherever the Sinemurian forms the base of the Fernie, whereas the Triassic is missing in those places where the Toarcian is the oldest Fernie sediment (*see* Figure 3).

The most important index fossils of the Fernie group are ammonites. In the lower Fernie appear *Arnioceras*, *Harpoceras*, *Dactylioceras*, and *Peronoceras*. In the middle Fernie *Sonninia*, *Teloceras*, *Stephanoceras*, *Stemmatoceras*, and *Chondroceras* are represented by a number of species. In the lower part of the upper Fernie, i.e., in the Lower Callovian, *Cadoceras*, *Arcticoceras*, *Lilloettia*, *Kepplerites*, *Xenocephalites*, and *Procerites* occur. In the Oxfordian *Aucella* ex gr. *bronni* and *Turbo ferniensis* n.sp. are index fossils of at least local value, whereas *Titanites occidentalis* n.sp. appears in the Upper Portlandian (lower Kootenay sandstone). Other index fossils are *Oxytoma cygnipes* (Sinemurian), *Gryphaea rockymontana* (Sinemurian), *Gryphaea cadominensis* (Middle Bajocian), and *Gryphaea impressimarginata* (Lower Callovian).

The Fernie group consists lithologically of different rocks, not only of "Fernie shale", and the lateral facies changes (*see* Figure 3) have proved to be of considerable palæogeographical interest. For instance, the transition in the lower Fernie from dark shales in the west (Fernie and Crowsnest areas) to sandstones in the east (Blairmore and Frank areas) and also the shaly development of the Rock Creek member (Middle Bajocian) in Snake Indian Valley and its replacement by sandstones in the east (Cadomin and Fiddle Creek areas) both indicate the neighbourhood of Laurentia. In other cases submarine shoals with very shallow water are indicated, as for example by the local glauconitic sandy development of the Oxfordian or by the *Gryphaea* facies of the Lower Callovian.

Correlations of the Fernie beds (*see* Figure 4) with the Jurassic sedimentary rocks of the southern plains of Alberta, Saskatchewan, and Manitoba have been made. No marine equivalents of the lower Fernie are known in these regions, but both Bajocian and Callovian, and locally also part of the Oxfordian and Kimmeridgian, are present in a marine facies, which, however, is different from that of the Rocky Mountains and Foothills. The Jurassic sequence in adjoining parts of the United States offers good possibilities for detailed correlations with parts of the Fernie group, i.e., the Middle Bajocian, Lower Callovian, and in part the Oxfordian. There are no marine equivalents of the lower part of the Fernie group in Montana. There seems to be good reason to correlate the Morrison formation, which now is regarded as belonging to the Kimmeridgian, with the upper part of the Fernie Passage beds and their equivalents.

The assumed existence of a Jurassic landmass "Jurozephyria" in the interior of British Columbia (Schuchert, Crickmay, Imlay, Loranger, and others) does not seem to agree with the facts now known:

(1) Marine Jurassic deposits have been discovered in southern British Columbia, a region which according to previous opinions should form part of this "landmass".

(2) The Jurassic sediments east of this "landmass" become coarse towards the east and not towards the supposed landmass to the west.

(3) The conglomerates near the base of the Jurassic in the Ashcroft area (B.C.) which were previously considered to have come from the "landmass" not far east of Ashcroft have proved to have been derived from a batholith immediately beneath the Ashcroft Jurassic beds.

The non-existence during Jurassic times of this "Central Cordilleran geanticline" (Schuchert) (="Jurozephyria" in the sense of Crickmay or "Cordillerische Zwischenschwelle" in the sense of Stille) means that the "Pacific Geosyncline" (Crickmay, Schuchert) in the west and the Fernie sea in the east were not separated from one another, but were a unit of which the latter formed the eastern border-zone. The very small thickness of the Jurassic Fernie sediments does not indicate geosynclinal conditions in the Canadian Rocky Mountains and Foothills region during Jurassic time. This is in agreement with the statements made by Warren for the Devonian, Carboniferous, Triassic, and Cretaceous.

The previously assumed connection of the Fernie sea with the Arctic sea via the Mackenzie River region (Schuchert, Imlay, Loranger) is not supported by any facts. There are about 1,000 miles without Jurassic beds between the northernmost Fernie occurrences and the Jurassic in the Richardson Mountains. This area is therefore considered to have been land throughout Jurassic time (*see* Figure 5). The Fernie sea was, however, at least temporarily connected with the southern Yukon.

CHAPTER II

REGIONAL STRATIGRAPHY AND PALÆOGEOGRAPHY

The Fernie group can easily be subdivided (*see* Figure 4) in three main subdivisions, the lower, middle, and upper Fernie, which are equivalent to parts of the Lower Jurassic (Lias), Middle Jurassic, and Upper Jurassic of other parts of the world. The lowermost parts of the Kootenay formation and their equivalents, which overlie the Fernie group, also belong to the Upper Jurassic.

These major parts of the Fernie group can be subdivided further on a palæontological basis, into smaller units corresponding to stages and zones, which, in the case of the Jurassic system, are commonly based on ammonites. Ammonites as well as other fossils are, however, absent or rare in certain parts of the Fernie, and no accurate decision can be made as to which zone or stage these parts of the Fernie belong.

Parallel with the subdivision of the Fernie based on ammonites, is a subdivision based on entire faunas or on lithology. A number of 'beds' and 'members' have been established and named in the course of the years; these names have proved to be very useful. It would be regrettable if some of them have to be abandoned because they do not meet with all the requirements of the stratigraphical nomenclature as used in this continent. Most of these 'beds' and 'members' can be recognized as identical with certain 'stages'. These stage names form the major subdivisions of the Fernie. The names of certain 'beds' that, in almost all cases, refer to a particular lithological facies of a stage or a zone can be used within this framework.

The following table and Figure 4 give a review of the commonly used names of 'beds' and 'members', indicating their original author, their type section, and their stratigraphical position within the northwest European standard section as established by Arkell (1933, 1946, 1951, pp. 8, 19-22).

In the opinion of the writer the change of existing names and the introduction of new formations and other subdivisions would only tend to obscure correlations of the Rocky Mountains and Foothills Jurassic with that of other parts of the world.

The following regional treatment of the development of the lower, the middle, and the upper Fernie contains a description of the various stages that are present with remarks on age determination and fauna, distribution, facies (herein usually included the names of 'beds' and 'members'), correlations, and palæogeography.

The Lower Fernie

The lower Fernie, which comprises beds belonging to the Lower Jurassic or Lias, forms the base of the group in every district where the Fernie is present. However, two facts must be strongly emphasized:

(1) The fossils hitherto found, indicate the presence of only two of the European subdivisions of the Lias, i.e., the Toarcian (Upper

TABLE I

No.	Names of 'beds' and 'members' in alphabetic succession	Author	Type section	Age	Equivalents
1	Belemnite zone	Hume 1930	Turner Valley	Middle Bajocian	No. 13. (Rock Creek member)
2	Brown Sand	Madgwick 1929	Turner Valley	Kimmeridgian–Lower Portlandian	Part of No. 10. (Passage beds)
3	*Corbula munda* beds	McLearn 1929	Grassy Mountain	Lower Callovian	Part of No. 5. (Grey beds)
4	Green beds	McLearn 1927	Blairmore	Oxfordian	Dark shale with big concretions
5	Grey beds	Frebold 1953	Alexander Creek	Lower Callovian	Nos. 3 and 6. (*Corbula munda*, *Gryphaea* beds)
6	*Gryphaea* bed	McLearn 1929	Blairmore-Carbondale River	Lower Callovian	Upper part of No. 5. (Grey beds)
7	Lille member	McLearn 1927	Grassy Mountain	Bajocian?	Part of No. 13? (Rock Creek member)
8	Nordegg member	Spivak 1949	Nordegg	Sinemurian	Not equivalent to No. 12. (Poker Chip shale)
9	*Oxytoma* bed	Frebold 1953	Snake Indian Valley	Sinemurian	Top of 7. (Nordegg member)
10	Passage beds	McLearn 1927	Blairmore Grassy Mountain	Upper Oxfordian–Lower Portlandian	In part No. 2. (Brown sand)
11	Pigeon Creek member	Crockford 1949	Pigeon Creek	Lower Callovian	Lower part of No. 5. (Grey beds)
12	Poker Chip shale	Spivak 1949	Turner Valley	Toarcian	Also called Paper Shale, not equivalent to No. 8. (Nordegg member)
13	Rock Creek member	Warren 1934	Rock Creek near Frank	Middle Bajocian	No. 1. (Belemnite zone)

Lias) and part of the Sinemurian (part of the Lower Lias). The Hettangian, part of the Sinemurian, and the Pliensbachian of the Lower and Middle Lias respectively are missing.
(2) The base of the Fernie is not always formed by the same stratigraphic horizon. At some places the lowermost Fernie bed belongs to the Sinemurian (locally the Nordegg member), at others to the Toarcian (*see* Figure 3).

Sinemurian

Age

Sinemurian has been recognized at various Fernie localities. The age determination is based on poorly preserved "*Arnioceras*" which in Europe is characteristic of a part of the Sinemurian. Owing to their poor preservation it cannot be definitely established that all the Fernie specimens of "*Arnioceras*" belong to the same species. Consequently there is no proof that all the occurrences carrying "*Arnioceras*" belong to one and the same zone, although the possible difference in age is almost negligible. These forms of "*Arnioceras*" are associated with other faunal elements, particularly brachiopods, gastropods, and pelecypods. Representatives of *Pleurotomaria*, *Gryphaea*, *Pleuromya*, *Pecten*, *Oxytoma*, *Rhynchonella*, *Terebratula*, and others occur and are locally frequent or abundant. The faunal association is however not consistent and some of these forms are definitely connected with a certain lithological facies.

The "*Arnioceras*" fauna has been observed at several localities (Cuthead Creek, Crowsnest) in contact with the underlying Triassic. This shows clearly that the Hettangian and the lowermost part of the Sinemurian, which normally would be expected between the Triassic and the "*Arnioceras*" beds, are entirely missing. Another, still larger gap is present above the "*Arnioceras*" beds. There the Upper Sinemurian and Pliensbachian, are absent and the "*Arnioceras*" beds are overlain directly by the Toarcian.

Distribution

"*Arnioceras*" beds of the Sinemurian have been proved to exist in the following areas (*see* Figures 2, 3).

Fernie and Crowsnest Pass
Cuthead-Wigmore Creeks
From Ram River northward to Cadomin-Mountain Park incl.
Snake Indian Valley
West Peace River and Pine River
Sikanni Chief River and Pink Mountain

Facies

Three main lithological facies are developed: (*a*) dark, indurated, phosphatic shales at least 100 feet thick in the Fernie and Crowsnest areas (*see* Plate I); (*b*) coquina bed and conglomerate (possibly also dark shales) in the Cuthead-Wigmore Creeks area; (*c*) cherty and phosphatic limestones of the "Nordegg member", 50 to 150 feet thick with the "*Oxytoma* bed" on top (Plates II A, B; III A; IV). This facies occurs in the region between the Ram River and Cadomin-Mountain Park, in Snake Indian Valley, and locally in the northern Foothills.

The fauna of the "*Arnioceras*" beds in the Fernie and Crowsnest areas consists, according to Warren (1931, pp. 105-111), of: "*Arnioceras*" *telferi* Warren, "*Arnioceras*" sp., *Pleurotomaria* sp. indet., *Gryphaea rockymontana* Warren, *Lima columbiae* Warren, *Entolium* sp. indet., *Chlamys* ? sp. indet., *Pleuromya* sp. indet. There are also some belemnites and fossil wood.

The fauna of the "*Arnioceras*" beds in Cuthead Creek, of which only the ammonites are described (*see* pp. 45, 46) in this memoir consists of: "*Arnioceras*", *Pleurotomaria* sp., *Gryphaea* sp., *Lima* sp., *Pinna* sp.

The fauna hitherto found in the cherty and phosphatic limestones of the Nordegg member (collected at Nordegg) consists of some pelecypods (*Pecten*) and *Pentacrinus*. The fauna of the *Oxytoma* bed, which overlies the cherty limestone, is very widespread and contains: "*Arnioceras*" (hitherto found only in the Snake Indian River), *Pleurotomaria* sp., x[1] *Oxytoma cygnipes* Phillips, x *Ostrea* n.sp. cf. *bristovi* Etheridge, x *Lima* n.sp. cf. *terquemi* Tate and *succincta* Schloth., x *Pecten* n.sp., x *Trigonia* (*Vaughonia*) n.sp., x *Pleuromya* sp., x *Rhynchonella* sp., *Terebratula* sp.

In the Pine Valley, West Peace River, Sikanni Chief River Valley, and Pink Mountain areas the "*Arnioceras*" beds appear to consist mainly of shales with "*Arnioceras*" sp. indet. In the Upper Pine Valley the following fauna has been found (determinations by Stelck in 1941 (Mathews, 1947, p. 8)): *Pleurotomaria* cf. *borealis* Warren, *Oxytoma* n.sp. cf. *O. mcconnelli* Whiteaves, *Chlamys* cf. *mcconnelli* McLearn, *Gryphaea* n.sp., *Pecten* (subgenus) sp. indet., *Orbiculoidea* (*Discina*), *Furcirhynchia* n.sp. cf. *Rhynchonella furcillata* Theodori, *Furcirhynchia* n.sp., *Homeorhynchia*? n.sp., *Rhynchonella* (subgenus) n.sp.

For the present it remains doubtful whether this fauna really belongs to the "*Arnioceras*" beds or whether it could be slightly younger.

These faunal lists demonstrate that the changes in lithological facies are combined with changes of the faunistic facies. Both changes indicate different conditions in the Fernie sea at the time of these "*Arnioceras*" beds. Furthermore the distribution of these beds leads to the conclusion that inundation was more complete in the region between Cuthead Creek (17 miles north of Banff) and Pink Mountain than it was farther to the south, where unquestionable beds of the same age have been found only in the Fernie and Crowsnest areas. There is, of course, the faint possibility that the very base of the Fernie, characterized either by a conglomerate (Blairmore, Adanac) or a coquina bed (Rock Creek near Frank, Daisy Creek summit, Livingstone Gap) could be a representative of the "*Arnioceras*" beds. However, as Upper Lias fossils have been found only a few feet above the base, it seems better to regard this conglomerate or coquina horizon as belonging to the Upper Lias.

Correlation

All the material hitherto available from deep wells in the plains of Alberta, Saskatchewan, and Manitoba clearly show that no marine Lower

[1]Forms marked by x have been mentioned by F. H. McLearn in reports of the Geological Survey of Canada. The other forms were determined by the present writer.

Lias was deposited in these regions (*see* Figure 4, columns 14, 15). Similarly in the adjoining parts of the United States, in North Dakota, Montana, and Northern Idaho, no Lower Lias is known to occur. In Saskatchewan Milner's and Thomas' (1954, pp. 255-257) Watrous formation and its equivalent the Gypsum Spring formation (Francis, 1954), which consists mainly of anhydrites and reddish shales, may be a non-marine equivalent of the lower Fernie but no proof can be offered in favour of this possibility (*see* Figure 4). Some occurrences of Lower Lias are known in parts of British Columbia, the most complete section being in the Tyaughton Creek area. There both the Hettangian and Sinemurian, except its uppermost part (zones of *Oxynoticeras oxynotum* and *Echioceras raricostatum*), are developed with most of the zone ammonites known from Europe (Frebold, 1951). Sinemurian strata also occur in the Takla map-area (Frebold, 1953, p. 1234), and in Quatsino Sound (Figure 4, column 4) and Parson Bay on the northwest and northeast coasts of Vancouver Island respectively (Crickmay, 1928, 1931, pp. 23, 24), where ammonites probably belonging to "*Arnioceras*" have been found. "*Arnioceras*" is according to Lees (1934) also present in the Laberge series of Yukon Territory (Figure 4, column 11).

Palæogeography

The Sinemurian transgression into the Canadian Rocky Mountains and Foothills region left the oldest record of Jurassic strata in this area. The duration of this transgression was apparently very short, as none of the other twelve Lower and Middle Lias zones of the west European standard section is represented, either by fossils or by sediments. The sea must consequently have retreated immediately after the deposition of the *Arnioceras* beds. The short duration of this transgression is also apparent when compared with its duration in certain regions of British Columbia, as for instance the Tyaughton Creek area, where the transgression took place in *Psiloceras* time, i.e., during the Earliest Lias (Hettangian), and seas remained there during the whole earlier part of the Sinemurian. During the time of "*Arnioceras*" the sea that occupied the Canadian Rocky Mountains and Foothills may have been in direct connection with the sea in parts of British Columbia, where sedimentary rocks and faunas of this age are present (Tyaughton Creek, Takla, and Vancouver Island areas). The "*Arnioceras*" sea of the Rocky Mountains and Foothills region did not extend as far as later Fernie transgressions. Thus, the Adanac, Blairmore, Rock Creek, Daisy Creek Summit, and Moose Mountain areas were presumably not submerged. It is remarkable that at all these localities Triassic beds are entirely absent or only very thin, a fact that indicates non-deposition in Triassic times or erosion before the deposition of the Toarcian of the Fernie. It is assumed that these regions were dry land during the Early and Middle Lias. The plains of Alberta and Saskatchewan as well as those of North Dakota, Montana, and Northern Idaho were also dry land during these times.

Toarcian

The upper part of the lower Fernie belongs to the Upper Lias or Toarcian (*see* Figure 4). Both lower and upper parts of the Toarcian are present, but lack of well preserved index fossils makes it impossible to decide whether the sequence is interrupted or not.

Age

The age determination is based on ammonites which are, however, preserved almost exclusively as imprints or films. For the lower part *Dactylioceras* aff. *commune* Sow., *Peronoceras* (*Porpoceras*) cf. *subarmatum* Young and Bird, and *Harpoceras* cf. *exaratum* Young and Bird are indicative, for the upper part *Hammatoceras insigne* Schübler. Other components of the fauna are belemnites, *Discina*, *Ostrea*, *Inoceramus*, *Lima*, *Pseudomonotis*, and *Posidonomya bronni* Voltz. Locally vertebrate remains have been found.

The Toarcian is distributed much more widely than the Sinemurian. It seems to be present wherever rocks of the Fernie occur (*see* Figure 3) but, owing to the scarcity of fossils at some localities, it is not always possible to decide which part of the Toarcian is represented, for parts may be locally absent.

As stated on page 36 a considerable gap is present between the Toarcian and the underlying "*Arnioceras*" beds. This gap comprises most of the Lower and the whole of the Middle Lias. In many places the "*Arnioceras*" beds are also missing leaving the Toarcian the only representative of the Lower Jurassic. Above the Toarcian is the Middle Bajocian, the Lower Bajocian being apparently missing.

Distribution

Beds of Toarcian age have been recognized in the following areas (*see* Figures 2, 3; Plates II B, III A, B, IV, V):

Fernie
Adanac (south of Blairmore)
Grassy Mountain (north of Blairmore)
Rock Creek near Frank
Daisy Creek Summit
Livingstone Gap
Wilkinson Creek
Highwood-Elbow area
Ribbon Creek area
Moose Mountain
Cascade River area near Bankhead (Banff)
Cuthead-Wigmore Creeks
Bighorn Creek
From Ram River northward to Cadomin-Mountain Park
Fiddle and Morris Creeks
Snake Indian Valley

Facies

Several different lithological facies are developed. The very base of the Toarcian is formed by: (*a*) a fossil concentration at Rock Creek near Frank and at Livingstone Gap (*see* Plate VI B), and by (*b*) a conglomerate whose pebble content varies from place to place (Adanac (*see*

Plate III B), Grassy Mountain north of Blairmore, Daisy Creek Summit, Moose Mountain). This basal conglomerate locally contains some fossils (Adanac, Daisy Creek Summit). The age of these beds could not be proved to be Toarcian, as distinctive fossils are missing. The fact, however, that typical Toarcian ammonities appear a few feet above the basal bed makes this age probable. These two facies types (fossil concentrations and conglomerates) appear at those places where the Lower Lias is missing and where the Toarcian rests on younger Palæozoic or on very reduced Triassic beds. Where the Lower Lias is present, as for instance Fernie, Cuthead-Wigmore Creeks, Nordegg, and Snake Indian Valley areas (*see* Plates II B, III A), no conglomerate was seen at the base of the Toarcian. In such cases the Toarcian appears to begin with the black shale that is the predominant Toarcian rock over wide areas.

The Toarcian beds later than the basal beds are mainly developed in three different facies: (*a*) sandstones, about 100 feet thick, on Grassy Mountain north of Blairmore (*see* Plate VI A); (*b*) shales in the lower and sandstones in the upper part (thickness about 100 feet) at Rock Creek, Daisy Creek Summit, Livingstone Gap (*see* Plate VI B), Wilkinson Creek and other places; (*c*) dark thin-bedded, commonly papery shales, not unlike the German *Posidonomya* shale of the Toarcian, with harder limy bands in the Fernie and Adanac regions and almost everywhere between Banff and Snake Indian Valley (*see* Plates **II B, III A, B,** V).

These three main facies types could, of course, be further subdivided as the character of the sandstones and shales changes from place to place. The dark shale in the Fernie area, for instance, is much more massive than that in the Moose Mountain and Adanac areas and other regions, where the shale is very thin bedded and softer. These differences may be caused by differential pressure during the folding.

No fossils have been discovered as yet in the sandstones of facies (*a*) and only a few were found in the shales of facies (*b*). They are *Peronoceras* cf. *subarmatum* Young and Bird, belemnites, and a few pelecypods (Daisy Creek Summit). In the dark shales of facies (*c*) however, fossils are locally abundant at certain horizons for instance in Moose Mountain area, at Fiddle Creek, and in Snake Indian Valley. The following faunas were collected from this shale: at Fernie, "*Grammoceras*" (Warren, 1934, p. 66); at Adanac, *Hammatoceras*, *Belemnites*, *Gryphaea*, *Posidonomya*, *Pecten*, fish remains (this fauna was collected by the present writer 15 to 20 feet above the base); on Moose Mountain, *Dactylioceras* aff. *commune* Sow., *Harpoceras* cf. *exaratum* Young and Bird, *Harpoceras* sp. indet., *Inoceramus*, *Discina* (this fauna occurs from about 5 to 50 feet above the base of the Fernie); at Bighorn Creek (Red Deer River), *Dactylioceras* sp., *Peronoceras* (*Porpoceras*) cf. *subarmatum* Young and Bird, *Harpoceras* sp.; at Cadomin, *Harpoceras* sp.; at Fiddle Creek, *Harpoceras* sp., *Hammatoceras* ?, *Posidonomya bronni* Voltz, *Inoceramus* cf. *dubius* Sow., *Lima* cf. *gigantea* Sow., *Ostrea irregularis* Münster, *Pseudomonotis substriata* Münster (Collet, 1931, p. 17); and at Snake Indian Valley, *Dactylioceras* sp., *Harpoceras* sp., Pelecypods.

Correlation

No Toarcian is known to occur in the plains of Alberta, Saskatchewan, and Manitoba (*see* Figure 4, columns 14, 15). Toarcian beds are also missing in North Dakota, Montana (Figure 4, column 13) and Northern Idaho. In British Columbia beds of similar age occur as follows: in the Salmo area (poorly preserved ammonites); in the Tyaughton Lake area ("*Harpoceras*"); in the McConnell Creek area (*Pseudogrammoceras* ex gr. *saemanni*, *Reynesoceras* ex gr. *ragazzonii* Hauer, *Haugia* sp. aff. *grandis* Buckman); in the Takla map-area ("*Harpoceras*"), in the lower Stikine and western Iskut River areas *Peronoceras* (*Porpoceras*) sp.; on the northwest coast of Vancouver Island (*Harpoceras*, *Fanninoceras*, *Trigonia*); and in the Queen Charlotte Islands (*Harpoceras*, *Fanninoceras*, *Dactylioceras*). The Toarcian ammonites of the lower part of the Maude formation of Queen Charlotte Islands (McLearn 1932a, pp. 59-80; 1949, p. 9) are the same as those from Vancouver Island. It is remarkable that none of these forms has been found in the Toarcian of the Fernie group.

Toarcian is also represented in the Yukon (Figure 4, column 11) by *Pseudogrammoceras* cf. *fallaciosum* Bayle and *Dumortieria* (Buckman in Cockfield and Bell, 1926, p. 21).

In Prince Patrick Island (Figure 4, column 12) the Toarcian is characterized by *Dactylioceras* cf. *commune*, Harpoceratids, and *Coeloceras* (Frebold in Tozer, 1956). The beds with *Dactylioceras* cf. *commune* there rest on Devonian strata.

Palæogeography

In comparison with the transgression that took place during a part of the Early Lias the inundation of the Late Lias seems to have been more extensive. Regions that were not covered by the sea during the Early Lias, as for instance the Adanac, Blairmore, Rock Creek, Daisy Creek Summit, Livingstone Gap, and Fiddle Creek areas, were covered during the Toarcian. Apparently this Toarcian transgression was very widespread.

It is probable that the Toarcian Fernie sea was in open connection with the sea farther to the west, in British Columbia. This is shown by the presence of beds with index fossils in the Tyaughton Creek, McConnell Creek, Takla, lower Stikine, and western Iskut River areas. There is no indication of a separating landmass between the Fernie sea and the sea of these British Columbia localities. An open connection between the British Columbia sea and the sea in the Whitehorse-Laberge district of the Yukon also seems probable. It is more doubtful if the Toarcian sea that covered parts of Vancouver Island and Queen Charlotte Islands and that is characterized by a different ammonite fauna (*Fanninoceras* and others) was in unrestricted communication with the sea farther to the east.

The absence of any marine Upper Lias Toarcian sediments in the plains of Alberta, Saskatchewan, and Manitoba shows that these parts of Western Canada were land. Locally the eastern shore of the Toarcian sea is indicated by a development of a sandy facies, as for instance in the Blairmore, Rock Creek, Daisy Creek Summit, and Livingstone Gap areas.

The Middle Fernie

The middle Fernie comprises beds of Middle Jurassic age. As in the lower Fernie the development seems to be very incomplete, as only beds belonging to the Middle Bajocian have been recognized. There is no palæontological evidence for the presence of the Lower and Upper Bajocian or of the Bathonian.

Middle Bajocian

Age

The determination of the Fernie rocks that overlie the Toarcian as of Middle Bajocian age is based on index ammonites, which represent (*see* Figure 4) the zone of *Sonninia sowerbyi* (indicated by *Sonninia gracilis* and others described in the palæontological part of this paper) and, the zones of *Otoites sauzei* and *Stephanoceras humphriesianum* (indicated by *Teloceras*, *Stemmatoceras*, *Stephanoceras*, *Zemistephanus*, *Normannites* (*Kanastephanus* and *Itinsaites*), and *Chondroceras* (*Defonticeras* and *Saxitoniceras*)). Both the *Sonninia* and *Teloceras* faunas are associated with belemnites, pelecypods, some brachiopods, and gastropods. The *Sonninia* fauna has only been found at one locality, but the *Teloceras* fauna is very widespread.

It is remarkable that both the Lower Bajocian zones of *Leioceras opalinum*[1] and *Ludwigia murchisonae* and the Upper Bajocian zone of *Parkinsonia parkinsoni* are not indicated by index fossils and the question arises as to whether beds of these ages may not be entirely absent.

At several places, where the Toarcian-Bajocian contact could be studied, the Middle Bajocian index ammonites were found to be somewhat above the contact. At Canyon Creek in the Moose Mountain area (*see* Figure 3 and Plate V), for instance, they lie about 37 feet (12 metres) above the Toarcian. The lithology of these 37 feet of beds is the same as that of the horizon with the Middle Bajocian index ammonites. It is unlikely that these beds represent all of the Lower Bajocian zones of *Leioceras opalinum* and *Ludwigia murchisonae.*

The question as to whether the absence of any index fossils of the Upper Bajocian and the whole Bathonian indicates that these stages are entirely missing cannot be decided as the outcrops are unsatisfactory, in many places the contact of the Bajocian and Lower Callovian being concealed. However, the possibility cannot be excluded that some beds between the Middle Bajocian and the Lower Callovian may represent part of the missing zones, even though it cannot be proved by the presence of index fossils.

It is remarkable that the supposed gaps between the Toarcian and the Middle Bajocian and between the Middle Bajocian and Lower Callovian (*see* Figure 4) are indicated only by absence of index faunas. There are no real conglomerates at the base of the Middle Bajocian or the base of the Lower Callovian that would mark such gaps. However, some of the fossil concentrations in the Rock Creek member (*sensu stricto*), which in the writer's opinion are mechanically concentrated fauna assemblages, may represent some of the missing conglomerates.

P. S. Warren, who fully recognized the importance of the *Teloceras* beds as a stratigraphic marker horizon, introduced the name Rock Creek

[1]Collet (1931, pp. 16, 17) mentions one specimen of *Pleydellia* sp. indet. from the Fiddle Creek section and places the beds concerned in the Lower Bajocian. As *Pleydellia* has not been found at any other Fernie locality and the preservation of this Fiddle Creek specimen seems to be poor, the accuracy of the identification is open to question.

member (1934, p. 59). The type locality is Rock Creek near Frank (Blairmore area) and Warren's description is as follows:

"An excellent horizon marker which is usually present in the Fernie is a bed of calcareous sandstone which occurs from 50 to 150 feet above the base of the formation. It varies in thickness from 5 to 30 feet.

"It is proposed to name this bed the Rock Creek member of the Fernie, from Rock Creek near Blairmore where the bed is well exposed."

On pages 66, 67 of the same paper Warren states: "This fauna (the *Sonninia* fauna) has not been found elsewhere. At a slightly higher horizon and in the Rock Creek member of the formation a more widespread and very prolific fauna occurs including such ammonites as *Teloceras*, *Stemmatoceras*, *Defonticeras*, *Saxitoniceras* and *Zemistephanus* together with a variety of other forms including *Belemnites*, *Rhynchonella*, *Cucullaea*, *Inoceramus*, *Oxytoma*, *Cardinia*, *Trigonia*, *Camptonectes*, *Entolium*, *Plagiostoma*, *Pleuromya*, *Thracia*, *Arctica*, *Protocardia*, and *Pleurotomaria*. This fauna has now been obtained in practically every locality examined from Crowsnest pass to Jasper park. Crickmay reports it to be present at McConnell's locality at Lake Minnewanka closely associated with the Sonninian fauna. The pelecypods of the two faunas appear to be very closely related. This *Teloceras* fauna will probably prove the best horizon marker in the Fernie shale on account of the abundance of specimens which may usually be obtained when the horizon is found."

From this it is evident that Warren restricted the name Rock Creek member to a calcareous sandstone bed, 5 to 30 feet thick, containing the *Teloceras* fauna. The facies of this horizon is, however, very variable and the calcareous sandstone bed is locally replaced in part or entirely by more or less sandy shales, as for instance in Canyon Creek (Moose Mountain area) (*see* Plate V) and in Snake Indian Valley (*see* Plate VII A) and the *Teloceras* fauna may be found in shales and concretions below the typical Rock Creek member. Therefore the name Rock Creek member is here used for all those beds that carry the *Teloceras* fauna. This is essentially the usage adopted by Allan and Carr (1947, p. 21) in their description of the geology of the Highwood-Elbow area, Alberta: "The Rock Creek sandy member which forms an outstanding marker in the eastern portion of the area, is represented west of the Misty range by sandy shales and limestone lenses, carrying a typical fauna."

A very characteristic faunistic feature of the Rock Creek member *sensu lato* is the presence of 'Belemnite battlefields', concentrations of countless belemnites in certain horizons, either in the shales or in thin limy beds. These 'Belemnite battlefields' are not restricted to certain areas but appear everywhere and have been used as marker horizons in wells. In Canyon Creek (Moose Mountain area) (*see* Plate V) there are at least four of these belemnite concentrations. The shale of the Rock Creek member, *sensu lato*, is lithologically uniform. It is dark grey, almost black and easily recognizable by its rusty weathering. This type of shale has been observed almost everywhere the Rock Creek member is exposed.

In a broad sense the Rock Creek member *sensu lato* may be defined as follows: dark grey, almost black, rusty weathering shale with harder beds of more or less calcareous sandstones, some of them (Rock Creek member *sensu stricto*) filled with ammonites and pelecypods. The ammonites are almost exclusively Stephanoceratids and belong to Middle

Bajocian genera and species. 'Belemnite battlefields' occur commonly at several horizons. Locally sandstones replace a considerable part of the shales, as for instance, at Fiddle Creek (*see* Plate VIII) or the sandstones are replaced by shales with concretions, as for instance, in Fording River, Canyon Creek, and Snake Indian Valley (*see* Plates V, VII A, B).

The Rock Creek member *sensu lato* may include the beds with *Sonninia* as they are closely associated with the *Teloceras* beds. Such a conclusion seems, however, premature as our present knowledge of the *Sonninia* beds is so limited.

Distribution

The beds with *Sonninia* have been found at one locality only: 3 miles north of the east end of Lake Minnewanka. It is not known whether they are really absent elsewhere or whether they are merely concealed.

The typical facies of the Middle Jurassic Rock Creek member has not been found as yet in the Blairmore and Adanac districts. Some of the localities where it has been recognized are listed below (*see* Figure 3):

Fernie area (Lizard Mountain)
Fording River
Crowsnest
Corbin area
Rock Creek near Frank
Gap (Oldman River)
Highwood area
Burns Mine
Ribbon Creek
Canyon Creek (Moose Mountain area)
Bighorn Creek
From Ram River northward to Cadomin-Mountain Park
Fiddle and Morris Creeks
Snake Indian Valley
Canal Flats area.

Facies

The Rock Creek member, *sensu lato*, is developed in most places as a uniform facies characterized by dark, almost black, rusty weathering shale with intercalations of some harder bands of a sandy limestone or limy sandstone. Most of it is very fossiliferous, containing ammonites, belemnites, and pelecypods (Rock Creek member *sensu stricto*). Locally these harder bands are replaced by big concretions. 'Belemnite battlefields' occur both in the shale and in the harder bands. This facies is developed in the Fernie, Fording River (*see* Plate VII B), Crowsnest, Corbin, Rock Creek (near Frank), Gap (*see* Plate VI B), Burns Mine, Ribbon Creek, Canyon Creek (*see* Plate V), Cascade River, Bighorn Creek, and Snake Indian Valley (*see* Plate VII A) areas.

The 'Lille member', developed at Grassy Mountain (*see* Plate VI A) is probably a facies equivalent of the Rock Creek member. It is a calcareous grit containing a peculiar pelecypod fauna whose species are all unknown in the Rock Creek member.

Another peculiar facies of the Rock Creek member is developed in the Cadomin-Mountain Park and Fiddle Creek-Morris Creek regions (*see* Plates IV, VIII). There the shale is largely replaced by sandstones. In Morris Creek there are five major sandstone bands 22, 18, 24, 10, and 30 feet thick respectively, the four intervening shaly parts of the section each being about 20 feet thick. This shows that sandstones predominate in this region, there being about 104 feet of sandstones to 80 feet of shale. Very similar conditions are found in the Cadomin-Mountain Park area. Some of the sandstones are characterized by ripple-marks, tracks, and plant remains. The uppermost sandstone bed carries the fauna of the Rock Creek member *sensu stricto*, i.e., Stephanoceratids, belemnites, and pelecypods. *Gryphaea* is particularly abundant.

It is remarkable that this sandy facies of the Rock Creek member disappears a very short distance to the west. In the Snake Indian Valley (*see* Plate VII A), about 9 miles west of the Fiddle Creek-Morris Creek district, the facies of the Rock Creek member is predominantly shaly with yellowish brown ironstone beds and concretions. Only a few sandy bands are developed there. This facies change is also illustrated in Figure 3.

Correlation

Rocks of Middle Bajocian age are widely distributed in Western Canada (*see* Figure 4). McLearn's (1927, pp. 71-73; 1929b, pp. 1-27; 1932a, pp. 51-59; 1949, pp. 10-17) Lower Yakoun formation of Queen Charlotte Islands (Figure 4, column 10) contains the same Middle Bajocian ammonite genera as the Rock Creek member, i.e., *Stephanoceras*, *Teloceras*, *Zemistephanus*, *Normannites*, and *Chondroceras*. There is, however, no indication of the *Sonninia* beds on Queen Charlotte Islands. On the northwest coast of Vancouver Island (Figure 4, column 9) deposits of Bajocian age appear to be entirely absent.

Other occurrences of Bajocian in British Columbia are as follows: Southwest Hope area, Middle Bajocian with *Stephanoceras*; Ashcroft area, *Kallistephanus* and *Fontannesia* (Crickmay, 1930b, p. 37; 1931, pp. 32, 33); Whitesail area, Lower Bajocian with *Tmetoceras regleyi* (Frebold 1951, pp. 18-20) and Middle Bajocian with Stephanoceratids, belemnites, pelecypods, and brachiopods; Hudson Bay Mountains, *Sonninia* fauna, (McLearn 1926; 1927 p. 65); McConnell Creek area, Middle Bajocian with *Stephanoceras* and *Witchellia*, (Lord, 1948, pp. 15-28; Frebold, 1953, p. 1234); Nechako area, Sonninian fauna as yet undescribed. In almost all these British Columbia localities the Bajocian rocks are associated with volcanic rocks.

No Middle Bajocian was found in Prince Patrick Island although *Leioceras opalinum*, which is characteristic of the Lower Bajocian, is abundant (Frebold in Tozer, 1956).

It is probable that equivalents of the Fernie Bajocian are present in the southern plains of Alberta, Saskatchewan, and Manitoba. In the southern plains of Alberta (Figure 4, column 14) the lower part of the Sawtooth formation, which consists of the 15- to 20-foot thick Crow Indian sandstone, may be synchronous with the Fernie Bajocian. No distinctive fossils have been found in it as yet, but in southwestern Montana (Figure 4, column 13) the lower part of the Sawtooth formation has yielded *Chondroceras* (*Defonticeras*) (Imlay, 1953, p. 968), which is characteristic of the Fernie Rock Creek member.

In Saskatchewan (Figure 4, column 15) the marine Jurassic begins with fossiliferous shales and dolomitic limestones, followed by shales, commonly calcareous with marine fossils (Milner and Thomas, 1954, p. 258). This basal part of the marine Saskatchewan Jurassic, which overlies the post-Palæozoic Watrous formation is called the 'Gravelbourg formation' (Milner and Thomas, 1954, pp. 257-260). Other names used for the Saskatchewan Gravelbourg formation of Milner and Thomas are Sawtooth, Piper-Sawtooth, and Piper formation (Schwab, 1954, p. 3 and Francis, 1954, correlation table). Sedimentary rocks of a similar character are developed in Manitoba. No distinctive fossils have been found as yet but lithological similarities with the adjacent Piper formation in eastern Montana, which has yielded the typical Bajocian genera *Chondroceras* (*Defonticeras*) and *Teloceras* (Imlay, 1953, p. 968), suggest that time equivalents of this part of the Fernie group are probably present in Saskatchewan and Manitoba. It is remarkable, however, that the lithological character of these Saskatchewan and Manitoba rocks is very different from that of the Fernie Rock Creek member.

No Middle Bajocian is known to be present in the Canadian Arctic, but Lower Bajocian with *Leioceras* has been found at various places (Figure 4, column 12).

Palæogeography

During the time of the Lower Bajocian the Fernie sea had retreated or was cut off from other marine regions so that migration of the Lower Bajocian faunas was prevented. Similar conditions seem to have prevailed during the time of the Upper Bajocian and Bathonian. In Middle Bajocian time, however, the Fernie sea reached wide extent. For the first time the Jurassic sea transgressed eastward into the southern plains of Alberta, Saskatchewan, and Manitoba[1].

This applies, however, apparently only for the southern parts of Alberta and Saskatchewan, as no equivalents of the Fernie Bajocian (lower part of Sawtooth formation) are known to occur farther north (Weir, 1949, p. 552). It is true, as has been pointed out by Weir (1949), that this northern boundary of the Sawtooth formation is determined by post-Jurassic pre-Blairmore erosion, but as there is no indication at all that Jurassic sediments were deposited much farther to the north, it seems reasonable to assume that this northern eroded edge of the Sawtooth formation is close to its former northern coast-line. North of Little Bow River the coast-line of the Middle Bajocian probably followed the trend of that of the Upper Lias (Toarcian). This is suggested by the attenuated thickness of all the members of the Fernie in the Moose Mountain area west of Calgary and particularly in the Cadomin-Mountain Park and Fiddle Creek-Morris Creek regions, where the neighbourhood of the coast-line is clearly shown by the development of sandstones, the occurrence of plant remains, and other indicatives of shoreline development during the Middle Bajocian.

At the same time as the sea transgressed in the southern plains of

[1]Loranger (1955, p. 38) mentions in connection with palæoclimatic considerations Middle Jurassic coal from Greenland and indicates pine trees in her map (loc. cit. p. 37, plate 6) west of Hudson Bay, which according to Loranger are "of course, postulated". Jurassic sediments in this region are indeed unknown. The Jurassic coal in northeast Greenland (Hochstetter Vorland) is not of Middle Jurassic age but belongs to the Oxfordian and possibly part of the Callovian (Frebold, 1932, pp. 25, 26, 61).

Alberta, Saskatchewan, and Manitoba, parts of Montana and North Dakota were also covered by the sea–for the first time during the Jurassic. To the west, there is no indication of a landmass separating the Fernie sea from that of British Columbia. There may, however, have been islands at several places.

The presence of fossil concentrations, particularly in the Rock Creek member *sensu stricto*, the wide distribution of typical 'Belemnite battlefields', the abundance of *Gryphaea* in certain areas, and the presence of pebbles make it evident that the Bajocian sea was shallow.

Bathonian

R. W. Imlay (1948, pp. 14, 19, 20) placed the *Corbula munda* beds of the Grassy Mountain section near Blairmore in the Bathonian, as he was of the opinion that "*Miccocephalites*" and "*Metacephalites*" described from these beds (Buckman, 1929) belonged to *Arctocephalites* which, according to Spath, (1932) is a Bathonian genus. *Arctocephalites* was also mentioned by Spivak (1949, p. 544) from Blairmore and Sheep River. However, as shown in this report (page 19) the *Corbula munda* beds of the Blairmore region contain the typical Lower Callovian genus *Cadoceras* and the generic position of the small forms described as "*Miccocephalites*" and "*Metacephalites*" remains unknown. The only place, within the region of Fernie development, where Bathonian is possibly present is at the headwaters of Smoky River. There two specimens of *Oppelia*, with affinities to Lower Bathonian forms of this genus, were found (*see* pp. 54-56). This does not exclude the possibility that Bathonian strata are present at other places. There are, for instance, some unfossiliferous beds between the Bajocian Rock Creek member and the Callovian that may belong to the Bathonian. As a consequence there is no proof of the entire absence of the Bathonian in the regions concerned. As already mentioned it is conceivable that the immigration of a Bathonian fauna into the basin of the Fernie sea was hindered by an interruption of connections with other marine regions.

It is possible that the Saskatchewan Lower Shaunavon formation of Milner and Thomas (1954) is an equivalent of the Upper Sawtooth of Montana which contains the *Arctocephalites* beds (Figure 4, columns 13, 15). No definite proof of the correctness of this assumption is available yet.

Beds with *Arctocephalites* occur also in the Canadian Arctic, i.e., in the Richardson Mountains and in Prince Patrick Island (Figure 4, column 12).

The Upper Fernie

The upper Fernie belongs to the Upper Jurassic, it includes fossiliferous beds of the Callovian and Oxfordian. Kimmeridgian and Lower Portlandian have not been indicated as yet by index fossils but seem to be present. The Upper Portlandian, however, is represented by some beds already assigned to the Kootenay formation.

There are remarkable facies differences in the upper Fernie, particularly in its lower part, the Callovian.

Lower Callovian

Age

The determination of the age of the lower part of the upper Fernie as Lower Callovian is based on ammonites. Unfortunately ammonites are generally rare or poorly preserved, so that it is difficult to establish a zone sequence at all localities.

On Grassy Mountain north of Blairmore (*see* Figures 2, 3, 4 and Plate IX A, B), however, it was possible to detect the presence of at least two ammonite zones, one in the upper part of the *Corbula munda* beds with *Cadoceras muelleri* Imlay and *Cadoceras lillei* Frebold n.sp. and one in the *Gryphaea* bed on top of the *Corbula munda* beds with *Lilloettia imlayi* Frebold n.sp., *Xenocephalites* cf. *bearpawensis* Imlay, *Kepplerites* (*Seymourites*) sp. indet., and *Procerites engleri* Frebold n.sp. The lower of these two zones is probably a representative of Imlay's (1953, pp. 6, 7) beds with "*Gowericeras*" *costidensum* and "*Gowericeras*" *subitum*, whereas the upper one corresponds with Imlay's (1953, pp. 6, 7) *Kepplerites mclearni* beds. On Grassy Mountain the zone with *Cadoceras muelleri* and *C. lillei* contains the small undeterminable forms called "*Miccocephalites*" Buckman and "*Metacephalites*" Buckman which L. F. Spath (1932, p. 13) and R. W. Imlay (1948, pp. 19, 20) erroneously referred to *Arctocephalites* Spath (*see* pp. 18, 57). No older Callovian zones are indicated by index fossils in the Grassy Mountain region.

In the Cascade Valley near Banff (Figure 3) *Arcticoceras henryi* Meek and Hayden is associated with fragments of *Cadoceras* and *Kepplerites* (*Seymourites*)[1].

The stratigraphic position of this bed with *Arcticoceras* relative to the ammonite horizons in the Grassy Mountain section is not absolutely clear. It may be slightly older.

Callovian ammonites collected at other localities are too poorly preserved for further stratigraphic conclusions. This is particularly the case with the Callovian beds in the Isola Peak-Plateau Mountain region where numerous *Procerites* ? associated with fragments of *Cadoceras* are present.

All the Callovian ammonites hitherto collected in the Fernie indicate the presence of marine beds of early Callovian age. *Peltoceras*[2], *Quenstedtoceras*, and other ammonites, characteristic of upper parts of the Callovian, have not been found as yet. There are, however, some unfossiliferous shales overlying the *Gryphaea* bed which, in the Blairmore, Adanac, and Daisy Creek Summit regions, have a thickness of 28 to 60 feet. It is, of course, impossible to determine the exact age of these unfossiliferous beds; they may still belong to the Lower Callovian or they may represent part of the zones not indicated by index fossils. At other localities the outcrop conditions are unsatisfactory for further investigation of this question.

[1]Imlay (1953, p. 5) writes about this locality: "One collection contains single specimens of *A. henryi* (Meek and Hayden) and *Gowericeras* from a locality near the top of the Fernie shale on the Cascade River near Banff, Alberta." This is a mistake. Above this ammonite horizon are still several hundred feet of Upper Fernie, i.e., the dark shale with big concretions and the Passage beds. Imlay's *Gowericeras* from this locality is here described as *Kepplerites* (*Seymourites*) sp. indet. 2 (p. 64). These specimens, which do not permit any detailed comparison, show affinities with *Kepplerites* (*Seymourites*) *mcevoyi* McLearn (1928, p. 20, Pl. IV, figs. 1, 2) from Ribbon Creek, Kananaskis, Alberta.

[2]"*Peltoceras*" *occidentale* Whiteaves (1907, pp. 80-82) from the Fernie group of Upper Red Deer River, Alberta, is really *Peronoceras* (*Porpoceras*) cf. *subarmatum* Young and Bird and belongs in the Toarcian (Frebold, 1951, pp. 15-17).

Distribution

Callovian sediments are widely distributed within the region of the Fernie development. Some of the more important localities (*see* Figures 2, 3, and Plates IX A, B, X, XI A, B, XII A, B) are:

Fernie area
Alexander Creek
Corbin
Blairmore-Carbondale River
Daisy Creek Summit
Isola Peak-Plateau Mountain
Ribbon Creek
Cascade River near Banff
Cuthead and Wigmore Creeks

The most northern localities where Lower Callovian has yet been proved by index fossils are on the south side of Cairn Pass, west side of Front Range, Jasper Park, and at the headwaters of Harlequin Creek between Nikanassin Range and Rocky Mountains. The fossils concerned were found after completion of the manuscript and will be described in another paper.

Facies

In the region between the United States border and Cuthead and Wigmore Creeks, Callovian rocks are generally characterized by a grey colour, commonly tinged with green. This feature distinguishes them from the underlying dark shales of the Middle Bajocian Rock Creek member and from those of the Lower Jurassic, and makes them readily recognizable. The name Grey beds may therefore be used for the Callovian rocks of the Fernie.

There are three main facies developments of the Lower Callovian within this region (*see* Figure 3): (*a*) the facies of the *Corbula munda* and *Gryphaea* beds in the area from Carbondale River in the south to about Daisy Creek Summit in the north, the type section being on Grassy Mountain north of Blairmore (*see* Plates IX A, B, X); (*b*) the predominantly shaly facies in most other areas; and (*c*) a facies characterized by grey shales with sandstone intercalations, in the Ribbon Creek and Cascade River sections (*see* Plates XI A, B, XII A, B). These main facies developments could be further subdivided by more detailed investigations.

FACIES OF THE *Corbula munda*
AND *Gryphaea* BEDS

The type sections of the *Corbula munda* and *Gryphaea* beds[1] is on the south slope of Grassy Mountain near Blairmore (*see* Plate IX A, B). A more detailed description of this locality is given on page 75.

The *Corbula munda* beds exposed there are about 99 feet thick, but, as their lower boundary is not exposed, the real thickness may be greater.

[1]Loranger (1955, p. 38) mentions *Corbula* and *Gryphaea* and some ammonites from Blairmore and Banff as occurring in the Middle Jurassic. This is erroneous. The *Corbula* and *Gryphaea* beds near Blairmore and the associated ammonites belong to the Lower Callovian and not to the Middle Jurassic (*see also* Frebold, 1953, pp. 1237, 1238). No Middle Jurassic ammonites are known from the Blairmore region. Furthermore the *Corbula* and *Gryphaea* beds are not developed at Banff where they are replaced by another facies with Lower Callovian ammonites.

They consist of grey shales with brown or green tinges intercalated with bands and lenses of hard greyish calcareous sandstone. Most of these sandstones are fossiliferous containing abundant pelecypods and less commonly ammonites. *Cadoceras muelleri* Imlay, *Cadoceras lillei* Frebold n.sp., *Procerites* and small undeterminable Macrocephalitids and Cadoceratids were found.

The *Gryphaea* bed on top of the *Corbula munda* beds is really the uppermost hard band of the *Corbula munda* beds. This *Gryphaea* bed is 4 feet thick and consists almost entirely of fossils, of which *Gryphaea impressimarginata* McLearn is the most abundant. The fauna also includes *Lilloettia imlayi* Frebold n.sp., *Xenocephalites* cf. *bearpawensis* Imlay, small indeterminable Macrocephalites, *Kepplerites* (*Seymourites*) sp. indet., *Procerites engleri* Frebold n.sp., *Belemnites* div. sp., *Cucullaea livingstonensis* McLearn, *Gervillia ferrieri* McLearn, *Inoceramus obliquiformis* McLearn, *Oxytoma blairmorensis* McLearn, *Pseudomonotis ferniensis* McLearn, *Trigonia ferrieri* McLearn, *Camptonectes* cf. *bellistriatus* Meek, *Entolium leachi* McLearn, *Lima albertensis* McLearn, *Anomia albertensis* McLearn, *Modiolus rosii* McLearn, *Modiolus frankensis* McLearn, *Pleuromya obtusiprorata* McLearn, *Pleuromya submissiornata* McLearn, *Pleuromya postculminata* McLearn, *Anatina* cf. *punctata* Stanton, *Thracia canadensis* McLearn, *Cyprina* ? cf. *iddingsi* Stanton, *Protocardia schucherti* McLearn, and *Corbula munda* McLearn.

The pelecypod fauna, which has been described by F. H. McLearn (1924) is common to both the *Gryphaea* and *Corbula munda* beds.

Immediately above the *Gryphaea* bed is a shaly layer, 5 feet thick; its lower part filled with belemnoids but also containing *Procerites* and a few pelecypods.

Above this horizon are about 54 feet of shales that did not yield any fossils. These are overlain by the Green beds which, at least in part, belong to the Oxfordian.

The development of the Lower Callovian in the Adanac-Carbondale and Daisy Creek Summit (*see* Plate X) regions is almost the same as at the type locality on Grassy Mountain and only minor changes have been observed (*see* Figure 3, columns 3, 4, 5).

SHALY FACIES

In the Fernie, Fording River, Alexander Creek and Corbin areas (*see* Figure 3) the Lower Callovian is characterized by indurated grey, limy, somewhat sandy shales that in places form steep cliffs, as for instance in Alexander Creek. Most have a greenish tinge and are easily recognizable from a distance (*see* Plate XI A). The upper part of these Grey beds commonly contains some hard bands and numerous belemnites. The thickness of the Grey beds is at least 225 feet. They are overlain by the Oxfordian Green beds.

It is remarkable that none of the numerous pelecypods so characteristic of the *Corbula munda* and *Gryphaea* beds has been found in this facies of the Grey beds. This change in the faunistic facies is significant and very striking[1].

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[1]After completion of the manuscript an ammonite fauna, rich in individuals and containing *Cadoceras muelleri* Imlay, was found by the writer in the Grey beds of the Fording River area, 13 miles north of Natal, B.C. This fauna will be described in another paper.

Farther to the north, in the Isola Peak-Plateau Mountain region the Grey beds have still the same general character but are less indurated and there are bands of reddish brown ironstone concretions, commonly with ammonites or their imprints. Some belemnite filled layers are present but the rich pelecypod fauna of the *Corbula munda* and *Gryphaea* beds is entirely missing. The only pelecypod hitherto found is an *Inoceramus*. The ammonite fauna consists of *Procerites* ? sp. indet. and some *Cadoceras* fragments.

Still farther to the north, in Cuthead and Wigmore Creeks, similar rocks are present. The Grey beds consist there of at least 250 feet of indurated grey shales. In the lower part there are some layers of concretions and in the upper part some hard bands carrying abundant fossil wood and poorly preserved ammonites, belemnites, and pelecypods. The Grey beds are overlain by dark shales that are equivalent to the dark shale with big concretions in the Cascade River, Ribbon Creek and other areas.

FACIES OF GREY SHALES WITH SANDSTONE INTERCALATIONS

In the Ribbon Creek and Cascade River sections a sequence of grey shales with intercalations of sandstone bands replaces the grey shales of the regions farther to the south, but the general character of the Grey beds is still recognizable. In the Cascade River section sandstones intercalated with shale (Plate XII A) form the lowermost exposed part of the sequence. These beds are equivalent to Crockford's (1949, pp. 24, 25, 28) Pigeon Creek member in the Mount Allan section. They grade upward into shales with numerous thin sandstone bands (*see* Plate XI B). In the transition zone some of the bedding surfaces are filled with poorly preserved specimens of *Inoceramus*. *Kepplerites* (*Seymourites*) occurs in some of the thin sandstone bands and, in a zone with concretions in the higher part of this series, *Arcticoceras henryi* Meek and Hayden, *Cadoceras* and *Kepplerites* (*Seymourites*) were found. On account of disturbances the real thickness of the shales with thin sandstone bands is unknown.

Beds of a similar character are developed farther to the north in the Cuthead-Wigmore Creek area.

In Ribbon Creek the sandstones with shale intercalations of the lower part of the Grey beds (Pigeon Creek member) rest on top of dark shales of probably Bajocian age and form a steep cliff (*see* Plate XII B).

No distinctive fossils have been found as yet in this Ribbon Creek sequence but *Kepplerites* (*Seymourites*) *mcevoyi* McLearn (1928, p. 20, Pl. IV, Figures 1, 2), which was found in Ribbon Creek and which is apparently related to *K.* (*Seymourites*) sp. indet. collected in the Grey beds with sandstone intercalations of the Cascade River section, may have been derived from these beds.

Correlations

Callovian strata are widely distributed in Western Canada (*see* Figure 4). Apart from the Fernie group occurrences, they are known from Vancouver Island, Queen Charlotte Islands, Harrison Lake area, Ashcroft area, Tyaughton Creek area, Nechako area, all in British Columbia and in the southern plains of Alberta, Saskatchewan, and Manitoba. In the western interior of the United States Callovian is present in Montana, Wyoming, and Utah where its stratigraphy has been studied in detail. There it comprises the Rierdon formation (Montana) and the lower part of the Sundance formation (Wyoming).

In the western interior of the United States (Figure 4, column 13) Imlay (1953) distinguished the following ammonite beds in the Callovian and the upper part of the Bathonian (*see* Table II).

The Callovian of the western interior has yielded more ammonites than the Fernie Callovian, which accounts for its finer zonal subdivision. The ammonites found so far in the Fernie Callovian indicate the presence of the *Gowericeras* and *Kepplerites mclearni* beds. In the Grassy Mountain section the "*Gowericeras* beds" are indicated by *Cadoceras muelleri* Imlay and *Cadoceras lillei* Frebold n.sp. They are identical with the *Corbula munda* beds[1]. In the Cascade River section near Banff *Arcticoceras henryi* Meek and Hayden, *Kepplerites* (*Seymourites*), and *Cadoceras* probably belong to the same zone, i.e., the "*Gowericeras* beds" of Imlay.

The supposed equivalent of the American *Kepplerites mclearni* beds, the *Gryphaea* bed in the Grassy Mountain section, contains *Lilloettia imlayi* Frebold n.sp. *Xenocephalites* cf. *bearpawensis* Imlay, *Kepplerites* (*Seymourites*) sp. indet., and *Procerites engleri* Frebold n.sp., i.e., forms related to those of the *Kepplerites mclearni* beds in the western interior of the United States. However, no *Kosmoceras* and no *Gryphaea nebrascensis* characteristic of the American *mclearni* zone have so far been found in the *Gryphaea* bed of the Blairmore region. This may be explained by the scarcity of ammonites in the *Gryphaea* bed and by ecological conditions respectively.

To summarize, it seems justifiable to assume that most of the Lower Callovian ammonite zones of the western interior of the United States are represented in the Callovian of the Fernie group.

The Callovian of the northwestern part of Vancouver Island (Figure 4, column 9), which was studied by Jeletzky (1950), has yielded *Cadoceras* ex gr. *doroschini* Eichwald which, according to Jeletzky, is slightly younger than the *Seymourites* fauna of the upper Yakoun formation of the Queen Charlotte Islands. *Seymourites* has hitherto not been found on Vancouver Island. The group of *Cadoceras doroschini* is not represented in the Fernie Callovian which may be explained by minor stratigraphic or ecological differences. The stratigraphic position of another Lower Callovian fauna on Vancouver Island, which according to Jeletzky contains *Oppelia* ex gr. *subradiata* Sowerby *sensu lato*, "*Perishphinctes*", and "*Phylloceras*", is still unknown.

On the Queen Charlotte Islands (Figure 4, column 10) the marine Callovian forms the upper part of the Yakoun formation (McLearn, 1929b, p. 2; 1949, pp. 10-17) which consists of more than 430 feet of marine sandstone and shale. The rich fauna consists of brachiopods, pelecypods, and ammonoids which all belong to *Kepplerites* (*Seymourites*) (McLearn, 1929b, pp. 4-12; 1949, pp. 16, 17). It is remarkable that no representatives

[1]Imlay (1948, p. 14) is of the opinion that *Arctocephalites* occurs in the Grassy Mountain section near Blairmore, and that the beds concerned are of Bathonian age correlative with the lower part of the Cornbrash beds of England. This is an error (*see* pp. 18, 19, 57).

Table II

European stages	Northwest Europe Standard zones (Arkell 1946, 1951)	Western Interior according to Imlay (1948, 1953)	Fernie Group	
			Index fossils in Grassy Mountain section	Subdivision in Grassy Mountain section
Callovian	Quenstedtoceras lamberti	Quenstedtoceras collieri	not recognized	not recognized
	Peltoceras athleta		not recognized	not recognized
	Erymnoceras coronatum			
	Kosmoceras jason			
	Sigalloceras calloviense	Kepplerites mclearni beds	Procerites engleri, Lilloettia imlayi, Kepplerites (Seymourites), Xenocephalites, Gryphaea impressimarginata	Gryphaea bed
		Kepplerites tychonis beds	?	not recognized
	Proplanulites koenigi	Gowericeras subitum beds	Cadoceras muelleri Cadoceras lillei Cadoceras ex gr. victor	Corbula munda beds
		Gowericeras costidensum beds		
	Macrocephalites macrocephalus	Arcticoceras codyense beds	not recognized	not recognized
Upper part of Bathonian	Clydoniceras discus	Arctocephalites	not recognized	not recognized
	Clydoniceras hollandi			
	Oppelia aspidoides			

of other ammonite genera were found. This *Seymourites* fauna must be regarded as synchronous with the *Seymourites* beds of the Fernie group. No other Callovian ammonite zones seem to be indicated in the Jurassic of the Queen Charlotte Islands.

The Lower Callovian is also present at other localities in British Columbia (Figure 4, column 8). In the Harrison Lake area (Crickmay 1930a, p. 37; 1931, pp. 41, 42) Callovian faunas occur in the Mysterious Creek formation which consists of 2,500 feet of black shale. One fauna, about 1,500 feet above the base, consists of *Cadoceras*, *Paracadoceras*, and *Pseudocadoceras*. Near the top of the formation *Lilloettia* occurs. None of these forms is identical with those from the Fernie Callovian, but it seems probable that the *Cadoceras* fauna correlates with the *Corbula munda* beds on Grassy Mountain and other Callovian beds of the Fernie that have yielded *Cadoceras*. The zone with *Lilloettia*, which is also present in the Nechako area[1], may be synchronous with the *Gryphaea* bed in the Grassy Mountain section of the Fernie where representatives of this genus occur. A loose *Cadoceras* found in the Tyaughton Lake area and some "*Gowericeras*" in the Minabariett formation (Crickmay, 1930b, pp. 27, 62; 1931, pp. 42, 68) in the Ashcroft area, indicate the presence of Lower Callovian rocks. Lower Callovian is also present in northern Yukon, where *Cadoceras* has been reported on Firth River (Buckman in O'Neill, 1924, pp. 14-15), in the Richardson Mountains, and in Prince Patrick Island (Frebold in Tozer, 1956, p. 22).

In the southern plains of Alberta (Figure 4, column 14) the Callovian is known from the subsurface where greenish grey or dull olive-green calcareous shale with some argillaceous limestone beds are present. These beds (Weir, 1949), which have yielded belemnoids and *Gryphaea*, are correlated with the Rierdon formation of Montana.

In Saskatchewan (Figure 4, column 15) the Callovian is represented by all or parts of Milner's and Thomas' Shaunavon formation which is equivalent to the Rierdon of other authors (*see* Francis, 1954 and Schwab, 1954). The Shaunavon formation (Milner and Thomas, 1954, p. 260) is subdivided into a lower and an upper member. The lower member, which according to Milner and Thomas is the best map unit in Saskatchewan, is possibly older than Callovian (*see* p. 18) and may be an equivalent of the upper Sawtooth. It consists of cream coloured lithographic limestone that is commonly sandy and oolitic at the top. The upper member "consists of alternating thin, sandy, very fossiliferous, locally oolitic, argillaceous beds and calcareous green and variegated shales". This sequence is locally (southwestern Saskatchewan) replaced by a thin sandy limestone.

In Manitoba the upper member of the Shaunavon formation seems to be replaced by thin beds of calcareous sandstone, shale, and sandy, oolitic limestone whereas the lower member appears to be represented by beds of calcareous sand, variegated shale and thin argillaceous limestone (Milner and Thomas, 1954, p. 260).

Pelecypods occurring in the lower member of the Shaunavon are: *Pinna* cf. *jurassica* Whitefield and Hovey, *Corbula munda* McLearn, *Cyprina* sp., *Protocardia* sp., *Ostrea* sp., *Gervillia* sp., *Camptonectes* sp., (Milner and Thomas, 1954, p. 262). The upper member has yielded

[1]In this area many specimens of *Lilloettia* yet undescribed occur.

Foraminifera, Ostracoda, numerous gastropods and the following pelecypods: *Ostrea strigilecula* White, *Ostrea* sp. indet., *Thracia* sp. indet., *Gryphaea nebrascensis* Meek and Hayden, *Camptonectes platessiformis* White.

The pelecypod fauna of the Shaunavon formation does not contain any absolutely distinctive fossils, but *Gryphaea nebrascensis* is locally abundant in the upper Rierdon of the Montana Callovian (Imlay, 1948, p. 19), and *Corbula munda* is well known from the *Corbula munda* beds of the Fernie Callovian. A correlation of the Shaunavon formation with the Rierdon formation as suggested by Crickmay (Milner and Thomas, 1954, p. 262) seems reasonable in spite of the fact that some apparently older forms are present. As the upper Rierdon is equivalent to the Callovian *Gryphaea* and *Corbula munda* beds in the southern foothills of Alberta, a tentative correlation of at least the upper Shaunavon formation with these beds of the Fernie is justifiable.

In the writer's opinion the lower member of the Saskatchewan Vanguard formation may also be equivalent with part of the Fernie Callovian. The lower Vanguard overlies the Shaunavon and consists (Milner and Thomas, 1954, pp. 263, 264) of shales with *Lima albertensis* McLearn and *Entolium leachi* McLearn, which are common in the Grassy Mountain Callovian of the southern Alberta foothills. Another Callovian pelecypod in the lower Vanguard formation is *Gryphaea nebrascensis* Meek and Hayden, which is locally abundant in Callovian beds of Montana.

The accurate age of the Shaunavon and other Plains Jurassic formations could be determined by identifiable ammonites, which, unfortunately have not been found.

Palæogeography

The Callovian sea covered large parts of western Alberta and southern parts of Saskatchewan and Manitoba. However, it remains doubtful for the time being how far to the north the sea extended in the Alberta Rocky Mountains and Foothills region. As yet Fernie deposits with Callovian index fossils have not been found farther to the north than in Harlequin Creek, between Nikanassin Range and Rocky Mountains and Cairn Pass, Jasper Park. Still farther to the north, as in the Fiddle Creek, Snake Indian Valley, and northern Foothills regions, the strata on top of the Rock Creek member are dark shales with yellowish brown concretions and ironstone bands. The lower part of these may have been deposited in Callovian time but there is no proof, and their age must remain doubtful until determinable index fossils are found.

The Callovian Fernie sea was shallow and the special facies developments suggest the presence of islands or submarine shoals. Such a shoal region was apparently present in the facies district of the *Corbula munda* and *Gryphaea* beds, i.e., in the Carbondale River-Adanac, Blairmore-Grassy Mountain, and Daisy Creek Summit areas. The numerous fossils in the *Gryphaea* bed and the many belemnites at the top of it are typical fossil concentrations of the same character as developed in the Rock Creek member. They were formed in times of relatively shallow water, which is also indicated by the abundance of *Gryphaea* itself. It is interesting to note that after these shallow-water sediments of the Bajocian Rock Creek member and of the Lower Callovian *Gryphaea* bed respectively were deposited, the connection of the Fernie sea with other marine regions was apparently interrupted, for in the shales that overlie these shallow-water deposits fossils are apparently entirely absent. However, this absence of fossils may also be explained by an interruption of sedimentation such as the one that caused the absence of the Bathonian (after the deposition of the Rock Creek member *sensu stricto*). This extreme shallowing of the sea or emergence of the seabottom at the end of the early Callovian is also indicated by retreat of the sea towards the west, as shown by the absence of the Lower Callovian in the Moose Mountain area and by the development of the sandy facies in the Lower Callovian in the Ribbon Creek and Cascade River areas. This shallowing or regression of the sea is explained by epirogenetic movements that affected, almost uniformly, great parts of the Fernie sea basin simultaneously.

During the early Callovian there are no indications of a coherent landmass separating the Fernie sea from the sea in British Columbia. There is, however, a distance of about 150 miles between the most westerly Fernie occurrences in the Banff area and the closest Callovian outcrops in the Lillooet and Ashcroft areas, British Columbia. It is remarkable that the Callovian ammonite faunas of Vancouver Island and other parts of British Columbia are so different from those of the Fernie Callovian. This is particularly true of the representatives of the genus *Cadoceras*. However, these differences do not necessarily require a separating landmass; they may have been caused by small differences in age or by different ecological conditions.

The northern coast-line of the Callovian sea in the southern plains of Alberta, Saskatchewan, and Manitoba was, in the writer's opinion, not far north of the pre-Blairmore eroded edge of the Callovian in these regions.

Lower Oxfordian

Age

Only a few index fossils indicating the presence of Oxfordian have been found as yet in the Fernie group. These are *Aucella* ex gr. *bronni* Rouiller, found in the uppermost part of the Green beds in Carbondale River (southern Alberta foothills), *Cardioceras* sp. indet., and Aucellas of the *bronni* group collected in black shales with yellowish brown concretions in the region north of Snake Indian River. The specimen of *Cardioceras canadense* Whiteaves so often quoted as indicating the presence of Upper Jurassic in the Fernie group is shown in this paper to be of questionable value as it is doubtful if it actually came from this group.

The exact age determination of the Green beds on the basis of an *Aucella* ex gr. *bronni* is of course impossible as Aucellas of this group appear both in the Oxfordian and Kimmeridgian.

In Montana, similar glauconitic sandstones with typical Lower Oxfordian ammonites are present in a stratigraphic position similar to that of the Fernie Green beds. The same age for this part of the Fernie group is therefore suggested in this paper.

The *Aucella* ex gr. *bronni* in the Green beds of the Carbondale River region is associated with many belemnoids, some gastropods ("*Turbo*" *ferniensis* n.sp.), and some vertebrate and many plant remains. All these fossils, with the exception of the *Aucella*, occur everywhere the typical facies of the Green beds is developed. The gastropods are particularly important as local index fossils as they also appear in facies other than those of the Green beds, i.e., in the black shales with big concretions developed farther to the north.

Distribution

Beds of Oxfordian age have a wide distribution within the area of the Fernie group (*see* Figure 3, and Plates V, X, XI A, XIII A, B). Some of the more important occurrences are:

Corbin area (Tent Mountain)
Carbondale River
Adanac
Blairmore
Alexander Creek
Daisy Creek Summit
Pocaterra Creek
Ribbon Creek
Spray Falls (Canmore region)
Cascade River
Cuthead and Wigmore Creeks
Snake Indian Valley
Kvass Flats area.

They are probably also present at other Fernie localities, as for instance in the Cadomin-Mountain Park region and at Fiddle Creek. Locally, they are absent, as for instance at Canyon Creek, Moose Mountain area.

Facies

There are three main types of facies development: (*a*) the facies of the Green beds, (*b*) the facies of dark shales with big concretions, and (*c*) the facies of dark shales with yellowish brown concretions.

FACIES OF THE GREEN BEDS

The facies of the Green beds is developed in the following areas (*see* Figure 3): Carbondale River, Adanac, Corbin area, Alexander Creek (*see* Plate XI A), Blairmore, and Daisy Creek Summit (*see* Plate X). This type of development is characterized by glauconitic sands up to about 50 feet thick with yellowish brown concretions, many belemnoids and plant remains, gastropods ("*Turbo*" *ferniensis* n.sp.), and some vertebrate remains. At Carbondale River *Aucella* ex gr. *bronni* Rouiller was found near the top of the sandstone. At Grassy Mountain, north of Blairmore, only a few inches of dark green shale were observed. At Daisy Creek Summit the sandstone is replaced by about 30 feet of greenish blue shaly beds (*see* Plate X). The facies of the Green beds apparently pinches out northward.

FACIES OF DARK SHALES WITH BIG CONCRETIONS

Farther to the north the facies of the Green beds is replaced by dark, almost black shales with big concretions and ironstone stringers (*see* Figure 3). Some of the concretions are very similar to those found in the Green beds. The dark shales with big concretions were observed at several localities within the Pocaterra Creek, Ribbon Creek, Spray Falls near Canmore, Cascade River below Bankhead, and Wigmore-Cuthead Creeks regions. The following facts indicate that they are of the same age as the Green beds: (*a*) both the Green beds and the dark shales with big concretions are younger than the fossiliferous Callovian beds, (*b*) both facies contain the same gastropod, i.e., "*Turbo*" *ferniensis* n.sp., which is fairly common in the Green beds and which was found by the present writer in the dark shales with big concretions in Pocaterra Creek and in the Cascade River section. This gastropod may be regarded as an index fossil of local value.[1]

The northern limit of the facies of dark shales with big concretions is apparently somewhere near Red Deer River.

FACIES OF DARK SHALES WITH YELLOWISH BROWN IRONSTONE BEDS AND CONCRETIONS

In the region comprising the Cadomin-Mountain Park, Fiddle Creek, Snake Indian River, and Kvass Flats areas are developed dark shales with yellowish brown weathering ironstone bands and concretions that grade into beds with yellowish brown sandstone bands (*see* Figure 3, Plates XIII A, B). At least part of these shales is equivalent in age to the Green beds and to the dark shales with big concretions in regions farther to the south. This is apparent from the presence of *Aucella* ex gr. *bronni* Rouiller at Snake Indian River, and *Cardioceras* ? (*sensu lato*) associated with Aucellas of the *bronni* group in the Kvass Flats area. The age of these beds is Upper Jurassic, younger than Callovian, and is probably Oxfordian. It is a remarkable fact that these marine fossils were not found in the Fiddle Creek and Cadomin-Mountain Park areas, where only plant remains and worm tracks seem to occur.

Correlation

Strata belonging to the Oxfordian are widely distributed in Western Canada (*see* Figure 4). On the northwest coast of Vancouver Island (Jeletzky, 1950) the Oxfordian is represented by sandstones with *Cardioceras* ex gr. *lillooetense* Reeside and Aucellas of the *bronni* group. In the Harrison Lake area a *Cardioceras* found in beds possibly equivalent to the Agassiz Prairie formation indicates the presence of the Oxfordian (Crickmay, 1930a, pp. 58-60, 64; 1931, pp. 45, 49), and in the Tyaughton Lake area part of the Eldorado group has yielded an Oxfordian fauna consisting of *Cardioceras* cf. *cordiforme* Meek and Hayden and *Aucella* ex gr. *bronni* Rouiller. Oxfordian beds with *Cardioceras canadense* Whiteaves, *C. lillooetense* Reeside, *C. whiteavesi* Reeside and *Aucella* ex gr. *bronni* Rouiller occur also in Big Creek about 90 miles northwest of Lillooet (Reeside, 1919, pp. 9, 11,

[1]After the proof of this paper had been printed a *Cardioceras* fauna which also includes "*Turbo*" *ferniensis* was discovered in this facies in Cuthead Creek. The age determination of the dark shales with big concretions as Oxfordian is confirmed by this fauna which will be dealt with in another paper.

20, 27, 33). In the Groundhog area *Cardioceras*, *Phylloceras*, and *Aucella* were found in the lower part of the Hazelton group (Frebold, 1953, p. 1235), which consists of dark grey to black tuffs and tuffaceous sandstones interbedded with black, more or less carbonaceous shales (Buckham and Latour, 1950). In the McConnell Creek area (Lord, 1948) the presence of the Oxfordian is indicated by *Cardioceras* aff. *praecordatum* Douvillé, *C.* aff. *scarburgense* Young and Bird and several genera of *Perisphinctes*.

In the southern plains of Alberta (Figure 4, column 14) equivalents of the Fernie Oxfordian are represented by at least a part of the Swift formation, which was subdivided by Weir (1949, p. 557) into a glauconitic zone with black chert pebbles at the base, a shale member, and the Ribbon member. The glauconitic zone and probably part of the shale member must be regarded as equivalents of the Green beds of the Alberta foothills and Rocky Mountains whereas the Ribbon member probably corresponds with the lower Passage beds. According to Weir the glauconitic zone persists as far north as the formation now extends. The Swift formation, which is restricted in extent owing to pre-Blairmore erosion, reaches a thickness of about 120 feet in the southeast corner of Alberta (Weir, loc. cit. fig. 3). The thickness of the original succession in this region is not known.

In the southern plains of Saskatchewan (Figure 4, column 15) the Oxfordian Green beds of the Fernie are probably represented by the middle member of the Vanguard formation, which according to Milner and Thomas (1954, p. 264) consists of well sorted, commonly slightly calcareous sands with traces of glauconite and chert interbedded with green sandy shale. Thin beds of sandy, oolitic, shaly limestone with glauconite are intercalated locally. Milner and Thomas (loc. cit. p. 265) mention waterworn belemnites associated with black chert pebbles and glauconite from near the base. They regard this member to be roughly equivalent to the Swift formation in Montana and southern Alberta.

In the southern plains of Manitoba equivalents of the Fernie Oxfordian may be present but cannot be definitely established because of the lack of index fossils and the apparent absence of the glauconitic beds so characteristic of part of the Oxfordian in the Canadian Foothills, the southern plains of Alberta and Saskatchewan, and in north-central Montana.

Oxfordian is widely distributed in the western interior of the United States, where it is represented by the Swift formation in Montana (Figure 4, column 13), by the Stump sandstone in Idaho and western Wyoming, by the Curtis formation in Utah, and by the Redwater Shale member of the Sundance formation in the Black Hills of South Dakota and eastern Wyoming (Imlay, 1948, pp. 16-17; 1952, p. 968).

Imlay (1948, pp. 16-17) has distinguished two zones: a lower one with *Quenstedtoceras collieri* and an upper one with *Cardioceras cordiforme*. The *collieri* zone has only been found in the Little Rocky Mountains and in the Bearpaw Mountains of north-central Montana in concretionary beds that occur from 20 to 30 feet above the base of the Swift formation. The *cordiforme* zone, which is widely distributed, occurs at these localities resting directly on top of the *collieri* zone. It consists of shales and is generally near the top of the lower third or half of the Swift formation or its stratigraphic equivalents mentioned above. It is characterized by abundance of *Scarburgiceras*. According to Imlay (loc. cit) his *collieri* zone is equivalent to the upper part of the *Quenstedtoceras lamberti* zone and the lower part of the *Quenstedtoceras mariae* zone of Europe, and his *cordiforme* zone corresponds with the upper part of the *Quenstedtoceras mariae* zone and the lower part of the *Cardioceras cordatum* zone in Europe. As none of the ammonites characteristic of the Oxfordian of the western interior of the United States has yet been found in the Fernie group no detailed comparisons of these two regions can be made[1]. However, as the Green beds of the Fernie are regarded as Oxfordian, it appears justifiable to correlate them with part of the Swift formation. It is remarkable that glauconitic sandstones are very common in this formation in the western interior of the United States. They are present (Imlay and others 1948) in northeastern and central Wyoming and in southwestern and north-central Montana. Some of the north-central Montana occurrences are in Pondera, Teton, and Liberty Counties. The occurrences in Pondera are about 100 miles from the nearest known Canadian Green beds in Carbondale River.

Palæogeography

The Oxfordian sea in Western Canada was apparently a new invasion that took place after the supposed regression during the late Callovian. This new invasion covered large parts of British Columbia, western Alberta and the southern plains of Alberta, Saskatchewan, and perhaps Manitoba. It is not possible to find any definite lithological or faunal proof of the existence of a landmass separating the sea in British Columbia from that in which the Fernie sediments were deposited. The Oxfordian sea seems to have occupied almost the same regions as the early Callovian sea. There is no indication that the sea that covered the southern plains of Alberta, Saskatchewan, and perhaps Manitoba extended very far northward beyond the pre-Blairmore eroded edge of the Jurassic and it seems probable that east of the Foothills the coast-line followed a more or less northerly trend. The absence of any Oxfordian (or Callovian) in Canyon Creek, Moose Mountain area, and the absence of marine fossils in beds correlated with the Oxfordian in the Fiddle Creek area may indicate vicinity of the coast-line.

The glauconitic sandstones, locally with many plant remains and waterworn belemnites, in the Carbondale River, Adanac, Corbin, Blairmore, Daisy Creek Summit, and Alexander Creek regions suggest obviously that they were deposited in shallower water than the shales with concretions developed farther to the north[2]. It is remarkable that the Green beds facies appears mainly in regions where shallow water facies were also deposited during the Early Callovian, i.e., the facies of the *Corbula munda* and *Gryphaea* beds that are developed at all the above mentioned localities except Corbin and Alexander Creek. These conditions may indicate the persistence of a submarine shoal during the Oxfordian. It is also remarkable that the conditions for marine life were more favourable in the shaly facies as developed in Snake Indian Valley and Kvass Flats regions. This is shown by the presence in them of *Aucella* and ammonoids, which are almost entirely absent in the south.

[1]See footnote on p. 29.

[2]That shallow water conditions also existed during the deposition of the Oxfordian glauconitic sandstones in the western interior of the United States, which in the writer's opinion are synchronous with the Canadian Green beds, is shown by Imlay (1950, pp. 90, 91).

Upper Oxfordian, Kimmeridgian, and Lower Portlandian

Age

Distinctive index fossils have not been found as yet in those Upper Jurassic Fernie rocks that are younger than the Lower Oxfordian Green beds. Therefore no direct age determination can be made for this part of the Fernie. However, as these beds lie between the Lower Oxfordian Green beds or their equivalents and the Upper Portlandian Lower Kootenay sandstone or the base part of the Nikanassin formation, it seems reasonable to assume that they belong mainly to the Upper Oxfordian, Kimmeridgian and Lower Portlandian or to parts of these stages.

Distribution

Beds belonging to these stages are widely distributed (*see* Figure 3). The following are some of the main localities:

Carbondale River
Adanac
Blairmore
Grassy Mountain
Fernie
Corbin
Alexander Creek
Daisy Creek Summit
Livingstone Gap
Plateau Mountain
Highwood-Elbow area
Pocaterra Creek
Ribbon Creek
Spray Falls (near Canmore)
Canyon Creek (Moose Mountain area)
Cascade River
Cadomin-Mountain Park
Fiddle Creek
Snake Indian Valley
Smoky River
Muddy Water River
Mason Creek
Kvass Flats area.

Facies

Two main facies are developed: (*a*) the facies of the 'Passage beds', and (*b*) the facies of dark shales with yellowish brown sandstone bands.

FACIES OF THE 'PASSAGE BEDS'

The predominant and best known facies is that of the Passage beds, typically developed in the Blairmore region (*see* Figure 3, and Plates V, X, XI A). The Passage beds that have been observed almost everywhere between the International Boundary and the Cascade River can be subdivided in a lower part consisting mainly of dark shales with intercalations of thin, ribbon-like sandstone bands, and an upper part in which the number and thickness of the sandstone intercalations increase towards the top. The contact with the Lower Kootenay sandstone is generally gradational except in Canyon Creek, Moose Mountain area, where an unconformity is present between the Passage beds and the so-called 'Moose Mountain' member (Hume, 1928; Beach, 1943, p. 35).

Marine fossils are rare in the Passage beds, but belemnoids were found at several horizons in the Blairmore and Carbondale River sections, indicating that some of the beds are still marine. McLearn (1929, p. 87) mentions "a depauperate and poorly preserved fauna with both marine and non-marine elements" including indeterminate pelecypods, shark teeth, and fish bones and scales and fish-fin rays, a fish-like tooth, and a caudal vertebra of an herbivorous dinosaur. Plant remains and trails are locally present in the sandy intercalations.

FACIES OF DARK SHALES WITH YELLOWISH BROWN SANDSTONE BANDS

As mentioned above, the Oxfordian Green beds are replaced in the northern parts of the Foothills and Rocky Mountains by a facies of dark shales with yellowish brown weathering ironstone bands and concretions (*see* Figure 3, and Plates XIII A, B). In the higher parts of the facies of dark shales, yellowish brown sandstone bands appear. In the region of Snake Indian Valley and farther northward Aucellas were found that are definitely younger than the Oxfordian forms found in the lower parts of the shale. It has not been possible as yet to identify any of these forms most of which are poorly preserved. However, some of them are related to *Aucella mosquensis*. The beds concerned are certainly Upper Jurassic in age but for the time being it is not certain whether they belong to the Kimmeridgian or Portlandian. Both stages may possibly be represented.

The thickness of the dark shales with yellowish brown weathering sandstone bands (including the shale that belongs to the Oxfordian and possibly Callovian) is considerable and may locally amount to more than 600 feet. However, the beds are repeated in many places by faulting and folding (*see* Plate XIII B) and their thickness may be overestimated. Part of these beds belong to the Lower Nikanassin formation.

Locally, as in the Fiddle River region, no marine fossils were found in these beds and their age cannot be stated any more precisely than that they belong to the Upper Jurassic.

Correlation

There is no definite proof of the presence of Kimmeridgian or Lower Portlandian rocks in other parts of Western Canada. In Vancouver Island, (Figure 4, column 9), however Jeletzky's (1950, pp. 31, 32) 'Upper Shale member' and the beds between this and the underlying 'Sandstone member' probably may belong to the Kimmeridgian (*see* Figure 4). Jeletzky mentions *Phylloceras* ex gr. *glenense* Anderson, *Aucella* ex gr. *bronni*, and *Aucella* ex gr. *kirghisensis* from the Upper Shale member, and suggests an early Kimmeridgian age for the beds concerned. It is possible that Kimmeridgian beds are present also in other regions of British Columbia, for instance in the Tyaughton Creek area (Jeletzky 1950, p. 49) but no unquestionable index fossils have been found as yet. In the Canadian Arctic Portlandian is indicated both in the Aklavik region and on Axel Heiberg Island.

In the western interior of the United States (Figure 4, column 13) the upper part of the Swift formation may correspond with the lower part of the Fernie Passage beds and part of the American Morrison formation could be the equivalent of the Upper Passage beds. The Morrison formation is now regarded as mainly Kimmeridgian in age (Imlay, 1952, pp. 953, 958-960), which would agree with the age assigned to the Fernie Passage beds and their equivalents (*see also* p. 35). However, as there are no index fossils common to both the Morrison formation and the Passage beds no absolute decision on their equivalence can be made.

The lower part of the Passage beds may be correlated with the upper part of the Swift formation in the southern plains of Alberta and with the upper part of the Vanguard formation in Saskatchewan and Manitoba (Figure 4, columns 14, 15).

On a micro-palæontological basis Loranger (1955) regards the uppermost part of the Vanguard formation as Kimmeridgian and as part of the Montana Morrison formation.

Palæogeography

It is generally believed that the sea retreated entirely from the Rocky Mountains and Foothills region after the end of the Oxfordian. This opinion is expressed, for instance, in the palæogeographic map of Mid-Upper Jurassic time given by Crickmay (1931, p. 90). However, more recent investigations have revealed that the sea persisted in the northern part of the Fernie basin during the time of the deposition of the Passage beds or their equivalents. As shown above, these beds were deposited after the Lower Oxfordian and before the Upper Portlandian, which means probably during the Upper Oxfordian, Kimmeridgian, and perhaps the Lower Portlandian. This Upper Jurassic sea occupied wide regions between the International Boundary and the Peace River country. The sandy character of the Passage beds in the south, their comparatively small thickness (maximum 190 feet), and the poor marine fauna with some non-marine elements, if compared with about 600 feet of dark shales with Aucellas in the north, suggest a deeper subsidence of the basin in the north than in the south. The shallowness of the sea in which were deposited the Passage beds is indicated by the increasing number and thickness of the sandy intercalations from the base to the top of the Passage beds, which finally grade into the lower Kootenay sandstone, the last Jurassic deposit with any trace of marine life.

For the present there is no indication that during the Upper Oxfordian, Kimmeridgian, and Lower Portlandian direct connections of the Fernie sea with the sea that probably was present in the Pacific coast region existed. The few localities with beds of questionable Kimmeridgian age in British Columbia, as for example in the Tyaughton Creek area, do not definitely establish such a connection. It is also questionable whether the sea extended eastward into Saskatchewan and Manitoba.

Upper Portlandian

Age

As already mentioned it is possible that the upper part of the Passage beds is of Lower Portlandian age although there is no proof of this assumption. In the lowermost Kootenay sandstone, however, immediately above the Passage beds, one gigantic ammonite, here described as "*Titanites*" *occidentalis* Freb. n.sp. was found in the neighbourhood of Fernie, British Columbia (*see* Figure 3, and Plates XLII, XLIII, XLIV). It is of Upper Portlandian age and probably belongs to the zone of *Titanites giganteus* of the European standard section. This ammonite is of the greatest importance as it fixes the age of the Lower Kootenay formation and shows the underlying Passage beds to be not younger than Kimmeridgian or Lower Portlandian. No other marine fossils have ever been found in the lower Kootenay sandstone. However, farther to the north at Mountain Park, in the northern Foothills, and in the Pine and Peace River Valleys, the lower part of the Nikanassin formation and the Dunlevy formation respectively have yielded Aucellas of Upper Jurassic, probably Portlandian, aspect (McLearn, 1945, pp. 2, 10).

Distribution

The Kootenay formation, which will not be discussed here in detail, has a wide distribution in the region of the former Fernie sea basin, but is absent in the southern plains of Saskatchewan and Manitoba. It is replaced farther to the north by the Nikanassin and Dunlevy formations whose lower beds have yielded marine fauna elements.

Correlation

The presence of the "*Titanites*" *occidentalis* in the lowermost Kootenay sandstone near Fernie, British Columbia, makes the following conclusions possible (*see* Figure 4):

(*a*) If the Morrison formation of the United States is mainly Kimmeridgian in age, as suggested by Imlay (1952, p. 958), then it cannot be correlated with the Canadian Kootenay formation, whose lowermost part has proved to be Upper Portlandian.

(*b*) The Canadian Kootenay formation is younger than the American Morrison formation, which probably correlates with parts of the Canadian Passage beds, as suggested above.

(*c*) The flora of the Canadian Kootenay formation indicates a Lower Cretaceous age according to Bell (1944; 1946), although Brown (1946) suggests a Jurassic age. Bell's opinion is supported by the fact, that the lowermost Kootenay sandstone is high up in the Portlandian. There is, however, still a possibility that the lower part of the Canadian Kootenay formation, above its basal sandstone, could be of Purbeck age, i.e., belong to the very uppermost Jurassic, a possibility that has not been stated before. Even if this is so the bulk of the Kootenay formation must still be of Lower Cretaceous age.

Remarks on Facies and Palæogeography

"*Titanites*" *occidentalis* found in Ammonite Gully near Fernie rests on the surface of the lowermost Kootenay sandstone. The outer whorl of this ammonite consists of the same lower Kootenay sandstone material. The sandstone is crossbedded and shows close similarities to the lowermost Kootenay sandstone characteristic of the Foothills region. Almost immediately above this sandstone is a coal seam. The lowermost Kootenay sandstone has generally been regarded as non-marine, but the occurrence of the ammonite near Fernie indicates that it is at least locally of marine origin. After its deposition the sea definitely retreated, as indicated by the presence of the coal seam on top of the sandstone. In the north the presence of Aucellas in the lower part of the Nikanassin formation likewise indicates the persistence of marine conditions during part of Portlandian time. In the western interior of the United States, however, the sea retreated completely much earlier, i.e., after the deposition of the marine Oxfordian.

Remarks on the Correlation Chart

The correlation of the Fernie with strata in various parts of Canada and Montana made in the preceding chapter are summarized in the correlation chart (*see* Figure 4). The age determinations of the various stratigraphic units are based as far as possible on index fossils; correlations are made with European stages, English formations, and the northwest European standard zones as revised by Arkell (1933, 1946, 1951). In some cases, however, distinctive macrofossils are absent or have not been found, as for instance in the well sections of the southern plains of Alberta, Saskatchewan, and Manitoba. Furthermore, as the lithology of the Jurassic strata in these regions is unlike that of the Fernie and more similar to that of the Jurassic in Montana and other adjoining parts of the United States, direct correlations with the Fernie are difficult and will be subject to future changes.

The correlation with other parts of Canada is mainly a restatement of the author's chart of Jurassic formations in Canada (Frebold, 1953). However, some regions with only very little information on Jurassic stratigraphy are omitted. There are also some additions, as for instance the sequence on Prince Patrick Island, Canadian Arctic.

The correlation chart also shows some very interesting peculiarities of Fernie development that are important in the reconstruction of the palæogeographical picture of Western Canada at various times during the Jurassic. Column 6 shows how very incomplete is the development of the Fernie group compared with that of the northwest European standard section (columns 2, 3). Only eleven or twelve (about a fifth) of the fifty-nine northwest European ammonite zones have been proved by index fossils to be present. As discussed in the foregoing chapters and illustrated in the chart some of the missing zones indicate actual gaps in the Fernie sequence.

Thus, the following stages, representing about twelve ammonite zones, are known to be absent: The Hettangian, most of the Sinemurian, and the whole Pliensbachian, i.e., most of the Lower and all of the Middle Lias. On the other hand it seems possible that missing zones in the upper part of the lower Fernie, as well as in the middle and upper Fernie, may be represented in part by unfossiliferous strata.

At a conservative estimate at least half of the horizons present in the northwest European standard section are absent in the Fernie group. This opinion is supported by the much smaller maximum thickness of the Alberta Jurassic (1,200-1,500 feet) compared with that in England and northwest Germany, where it is of the order of 3,500 feet.

There are, of course, some still larger gaps locally, as for instance in Canyon Creek, Moose Mountain area, where, as stated above, the Lower Callovian and the equivalents of the Oxfordian Green beds are missing.

It might have been expected that many of these gaps would be indicated by conglomerates, but these are missing or only locally present. In certain places they are absent even at the base of the Fernie group, in spite of the fact that the whole Triassic is missing in places and that the Fernie rests immediately on the Palæozoic.

Gaps in the Fernie group are commonly indicated by the following criteria:

(*a*) absence of index fossils

(*b*) more or less abrupt lithological change

(*c*) accumulations of abundant fossils that seem to have been concentrated mechanically by wave action in very shallow water.

The most notable fossil concentrations in the Fernie group are those in the Rock Creek member and in the Lower Callovian *Gryphaea* bed. Both consist of very similar faunal assemblages, i.e., ammonites, belemnites, and pelecypods, mostly with abundant *Gryphaea* (*G. cadominensis* in the Rock Creek member and *G. impressimarginata* in the Lower Callovian *Gryphaea* bed). This replacement of real conglomerates by such fossil conglomerates in the Fernie group appears quite natural as it is assumed that the land adjacent to the Fernie sea was of low relief so that deposition of coarse material was restricted to the shoreline.

General Palæogeographic Conclusions

Previous Views

In attempting a reconstruction of the Jurassic palæogeography of Western Canada, previous authors have postulated two marine regions, one in the west and one in the east, the latter covering the present-day Rocky Mountains and Foothills region and parts of the Alberta, Saskatchewan, and Manitoba plains. These two seas were formerly thought to have been separated, at least temporarily, by a coherent land area in the region of the British Columbia Interior Plateau (*see* for instance Schuchert, 1923, p. 226, fig. 14; Crickmay, 1930, p. 38, 1931, pp. 36, 84, map No. 5, p. 86, map No. 7, p. 87, map No. 8, p. 89, map No. 10; Schuchert, 1939, pp. 64, 65, fig. 4, pp. 70, 71; Stille, 1940, p. 172; Imlay, 1953, p. 13, fig. 2; and Loranger, 1955).

This hypothetical central land area, which would be the northern extension of Neumayr's (1885, map 1) "Utah Peninsula" ("Uta Halbinsel") into Canada, has been called "Jurozephyria" by Crickmay (1931, p. 84 and elsewhere), "the Central Cordilleran Geanticline" by Schuchert

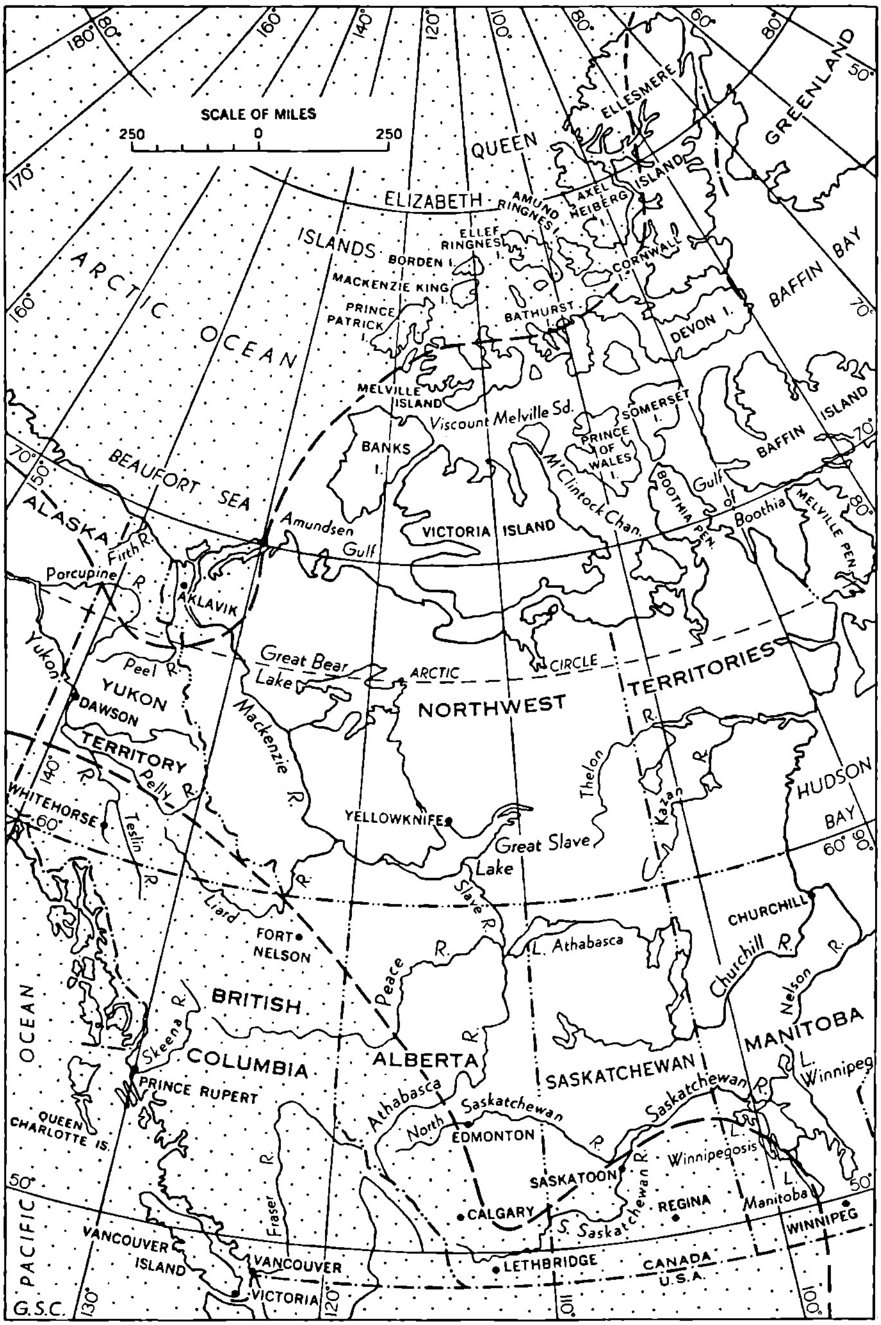

FIGURE 5. Map illustrating regions of marine deposition, shown by stipple pattern, in Western and Northern Canada during Jurassic time.

(1939, pp. 64, 65), the Cordilleran "Zwischenschwelle" by Stille (1940, p. 172), and "mesocordilleran geanticline" by Loranger (1955, pp. 35, 37). In the following discussion it is referred to as "Jurozephyria".

The two regions of marine deposition have generally been regarded in the past as geosynclines. The western one was called the "Pacific Geosyncline", for instance by Crickmay (1931), and Schuchert (1939, p. 65), or "the West Cordilleran Geosyncline" ("der westcordillerische Geosynklinalraum") by Stille (1940, p. 168). This West Cordilleran Geosyncline, with its considerable igneous activity and great thickness of sedimentary rocks, belongs in the sense of Stille to the eugeosynclinal type of orthogeosynclines (Stille, 1940, Kay, 1951).

The eastern trough of marine deposition is, in the opinion of various authors, of different extent and character. Stille's (1940) Canadian part of the "Rocky Mountain Geosyncline" ("die felsengebirgische Geosynklinale") comprises the Rocky Mountains and Foothills region and continues northward, via the present-day Mackenzie Mountains, to the region of the Brooks Range of Alaska. This picture is in general agreement with that given by Crickmay (1931, p. 84). The plains of Alberta, Saskatchewan, and Manitoba, and the Mackenzie River region do not form part of Stille's " Rocky Mountain Geosyncline", which, because of the absence of igneous activity is classified as a miogeosynclinal orthogeosyncline (Stille, 1940).

In the opinion of Schuchert (1939, pp. 64, 65) the eastern trough of deposition, which is called the "Coloradoan Geosyncline", includes not only the Rocky Mountains and Foothills region but also large parts of the plains of Alberta, Saskatchewan, and Manitoba. It extends northward to the Arctic coast and includes the present-day Mackenzie River Valley region. Opinions similar to those of Schuchert are expressed in the palæogeographic maps given by Loranger (1955), however, the name "Coloradoan Geosyncline" is replaced by "Sundance sea", which comprises the Rocky Mountains and Foothills region, parts of the Alberta, Saskatchewan, and Manitoba plains together with the present-day Mackenzie River region. This "Sundance sea" is indicated in Loranger's palæogeographic maps as a geosyncline.

In the account that follows, the nature of these palæogeographic units, with the exception of the "West Cordilleran Geosyncline", will be discussed.

Jurozephyria

Crickmay attempted to offer a proof of the existence of the Canadian part of this supposed geanticline which, according to some palæogeographic maps, extends into Canada for a distance of more than 500 miles and which has considerably influenced and dominated opinions on the palæogeography and structure of the region concerned. Crickmay (1930b, pp. 36, 37; 1931, pp. 36-38) considered that this land area, originally suggested by Schuchert, was "a narrow belt coinciding with the Gold Ranges[1] of

[1]As the name "Gold Range" or "Gold Ranges" has been used in a somewhat different sense and as Crickmay (1930, 1931) does not explain what he understands by this name, it may be remarked that, according to Daly (1912, pp. 37, 38), "Gold Range" is part of the "Columbia Range". "Gold Range" has, however, also been used as a synonym for "Columbia Range". In many places Dawson has even used "Gold Ranges" or "Gold Range" to include the Selkirk, Purcell, Columbia, Cariboo, and Omineca ranges. As the east border of Crickmay's Jurozephyria, as indicated in his maps (1931, maps 7, 8, 10, pp. 86, 87, 89), follows close to the British Columbia/Alberta boundary, it is obvious that Crickmay has used "Gold Range" and "Gold Ranges" in a broad sense, i.e., as including the Selkirks and other ranges between the Rocky Mountains and Ashcroft.

British Columbia and extending south . . ." (Crickmay, 1931, p. 36). He gave the following reasons for his opinion:

(*a*) The narrow belt in the Gold Ranges of British Columbia and its southern extension into the United States "is indeed entirely without evidence of Jurassic deposits" which "led Schuchert to regard it as permanent land area during Jurassic time" (Crickmay, 1931, p. 36).

(*b*) "Evidence confirming Schuchert's view is to be seen in the coarse clastic deposits which surround the area" (Crickmay, 1931, pp. 36, 37). As far as Canada is concerned Crickmay refers to McLearn's (1916) description of the Jurassic in the Blairmore area and says (loc. cit. p. 37) "The coarse beds in the Jurassic of the Rocky Mountains and their striking contrast in this respect to the Jurassic of the Great Plains, indicates derivation of rock waste from the west; and so, by inference, a rising land to the west of the site of the present day Rocky Mountains". Most recently Loranger (1955, p. 38) refers to "coarse clastics" and even suggests "desert deposits paralleling the geanticline".

(*c*) Crickmay (1930b, pp. 36, 37; 1931, p. 37) mentions conglomerates with plutonic pebbles from near Ashcroft, British Columbia, which in his opinion could not have come from the volcanic regions to the west. "Hence, it seems likely that the pebbles came from a source between the Rocky Mountains and Ashcroft" and as "many of the plutonic fragments are large and ill rounded as though they had travelled but a short distance", Crickmay (loc. cit. p. 37) concludes that "not far east of Ashcroft, namely in the region of the Gold Ranges, a land area rose notably, so as to be deeply eroded, during the Jurassic".

Crickmay's (1931) opinion that the Central Cordilleran geanticline "Jurozephyria" extended northward into British Columbia was in keeping with the state of knowledge of the Canadian Jurassic in 1931. It is, therefore, understandable that his view was taken for granted as for instance by Stille (1940) and Imlay (1953). However, since then new facts have become known which show that no real proof of the extension of the Central Cordilleran geanticline into Canada has as yet been offered. These facts are as follows:

(*a*) Marine Jurassic rocks (probably of Toarcian and Bajocian age), which indicate transgressions during Jurassic time, have been found in the Nelson area of southern British Columbia (Frebold in Little, 1950, pp. 26-28) i.e., within the region that was generally regarded as included in "Jurozephyria". The rocks concerned are widespread in the area but poorly exposed and the localities from which fossils were collected by Little had been overlooked by previous investigators. More Jurassic rocks may therefore be expected within this part of British Columbia.

(*b*) Regarding Crickmay's opinion mentioned above under (*b*), it can be stated that hardly any of the Jurassic rocks in the Blairmore region of the Rocky Mountains are of coarse texture. The only coarse sediment within the Fernie group of the Blairmore region mentioned by McLearn (1916) to whom Crickmay refers, is the basal conglomerate between 6 to 12 inches (15 to 30 cm.) thick that was evidently formed during the transgression of the Jurassic sea over the Palæozoic surface. The other Jurassic sediments of the Blairmore region that have been studied by McLearn (1916, 1929a), and Frebold (1953, 1954, and this paper) consist of fine-grained, platy sandstones in the lower part (100 feet), some hundreds of feet of shale with some bands of fine-grained calcareous sandstones (*Corbula munda* beds and *Gryphaea* bed), glauconitic sandstone (locally 50 feet), and about 190 feet of shales with thin sandstone bands (Passage beds). Loranger's recent opinion (1955, p. 38) that "coarse clastics" and "desert deposits" paralleled the geanticline is not supported by any field observations made so far. Such deposits do not exist in the Jurassic of the region concerned.

In this connection the statements made on page 3 of this paper may be briefly reiterated: the sandy sediments of the lower Fernie group in the Blairmore region are replaced farther westward, near Crowsnest and the town of Fernie by dark shales, i.e., still finer sediments. The considerable reduction in the amount of sandy material from the east towards the west, that is towards the hypothetical geanticline in Middle Jurassic time, is also characteristic of sections farther north. Thus the sandy facies of the Rock Creek member in the Fiddle Creek area is replaced to the west, in the Snake Indian River region, by shales. If this hypothetical land had really existed the sandstones would be expected in the west and not in the east.

(*c*) Crickmay's statement (1930b, pp. 36, 37; 1931, p. 37) that the plutonic pebbles at the base of the Jurassic sequence in the Ashcroft area, British Columbia, came from the region of the Gold Ranges between Ashcroft and the Rocky Mountains and indicate a rising land area that became deeply eroded during the Jurassic, cannot be sustained. Duffell and McTaggart (1952, p. 31) have shown that the rounded boulders of granite occurring in the lower parts of the Jurassic sequence in the Ashcroft area were derived from the underlying granitic rocks of the Guichon Creek batholith, which, according to Duffell and McTaggart (loc. cit. p. 79), "was emplaced between early Upper Triassic and early Middle Jurassic time, most probably during the Lower Jurassic". Thus this Jurassic basal conglomerate was formed during the transgression of the Middle Jurassic and does not as a consequence, indicate a land area to the east.

In summary, all the reasons previously given as proof of the existence of the Central Cordilleran geanticline "Jurozephyria" during Jurassic time are not in keeping with the facts.

This statement, however, must not be regarded as denying the existence of small or even large islands in the interior of British Columbia during Jurassic time. It only means that the reasons previously given in favour of a real coherent landmass do not hold.

The Rocky Mountain Trough

As there is no proof of the existence of a coherent central Cordilleran geanticline "Jurozephyria" in Western Canada during Jurassic time the Jurassic sea of the "Pacific" or "West Cordilleran" eugeosyncline in the west and the Fernie sea in the Rocky Mountains and Foothills region in the east may be regarded largely as one unit, of which the latter formed the eastern border zone against the partly and temporarily submerged margin of the craton Laurentia.

Stille's (1940) definition of the Rocky Mountains region as a mio-orthogeosyncline is based on its long linear extension, absence of igneous activity and the assumed presence of thick Triassic and Jurassic sediments. However, according to the same author (loc. cit. p. 166) this orthogeosynclinal character is absent locally in the southern extension of the trough into southwest Montana, where the thickness of the Triassic and Jurassic is very small. It can now be shown that some thicknesses given for the Triassic and Jurassic in the Canadian part of the basin, on which Stille relied, were considerably overestimated. Raymond and Willard (1931) mention 3,400 feet of Triassic and 1,600 feet of Jurassic strata in the Banff area. The thicknesses are, however, considerably smaller, i.e., about 600-1,500 feet for the Triassic and about 1,100 feet for the Jurassic strata (*see* "Field Trip Guide Book", A.S.P.G., 1950, Figures 2 and 3). In the writer's opinion the thickness of the Fernie may be even less as some of the beds are repeated by faulting. At any rate the total thickness of the Triassic and Jurassic beds in this area is between about 1,500 and 2,600 feet, i.e., about one-third or one-half of the thickness mentioned by Raymond and Willard. The thickness of the Jurassic Fernie group within the Rockies and Alberta Foothills is in many places less than 1,100 feet (about 220 feet at Moose Mountain) and may only locally increase up to 1,500 feet. The minor degree of subsidence of the region now occupied by the Canadian Rocky Mountains and Foothills during the Jurassic becomes evident when compared with the eugeosynclinal subsidence in the west Cordilleran Geosyncline (about 5,000 feet near Ashcroft, and about 20,000 feet in the Harrison Lake area, British Columbia), or in the non-orthogeosynclinal basins in England and northwest Germany (3,300-3,600 feet of strata). Warren (1951, p. 3) has already stated that "for a part of Palæozoic time and a good part of Cretaceous time, the area occupied now by the Canadian Rockies could hardly be termed a geosyncline". The same opinion seems to be acceptable for the Jurassic, and possibly also for the Triassic, and the whole concept of an orthogeosynclinal character of the Canadian Rocky Mountains and Foothills region in later Palæozoic and Mesozoic times stands in need of revision.

The Fernie Sea

The Jurassic sea that covered the Rocky Mountains and Foothills region is here called the 'Fernie sea' and the strata of the Fernie group are restricted to this area. This Fernie sea did not persist throughout the Jurassic period; several transgressions and regressions, indicated by sedimentary and faunal gaps, followed one another. Some of the regression periods may have been of shorter duration than is indicated by the absence of index fossils (*see* Figure 4). Sedimentation may in these cases have continued for a certain, but indeterminable, time under conditions that prevented the migration of faunas into the Fernie sea basin.

The succession of transgressions and regressions appears to be as follows: Early Sinemurian: transgression of parts of the basin, invasion of the *Arnioceras*-fauna; Middle and Late Sinemurian, and Pliensbachian: regression; Toarcian: extensive transgression; Early Bajocian: regression;

Middle Bajocian: transgression; at least part of the Late Bajocian and Bathonian: regression; Early Callovian: transgression; at least part of Middle and Late Callovian: regression; Oxfordian, Kimmeridgian, and Portlandian: at least temporary marine submergence; end of Late Portlandian: final regression of the Jurassic Fernie sea.

These positive and negative movements of the sea were presumably caused mainly by epirogenetic movements, which also prevented the migration of faunas, for in times of epirogenetic uplift rising shoals or land-bridges would restrict access into the Fernie sea. It is probable that some part of the positive epirogenetic movements were contemporaneous with igneous activity in the Cordilleran geosyncline. The final retreat of the Jurassic sea from the Fernie sea basin at the time of the deposition of the lower Kootenay sandstone, i.e., in Late Portlandian time, bears an apparent causal relationship with the Nevadian orogeny in the geosyncline west of the present day Rocky Mountains.

Plains of Alberta, Saskatchewan, and Manitoba

Throughout Early, Middle, and early Late Jurassic times, the Fernie sea was in open connection with the sea in the geosynclinal region of British Columbia. Towards the east, in the southern parts of the Alberta, Saskatchewan, and Manitoba plains, the sea transgressed during Middle and Late Jurassic times, forming a nongeosynclinal basin with a general west-east trending northern coast-line. The greatest thickness of the Jurassic deposits within this basin, about 1,400 feet, is reached in south central Saskatchewan. The present northern limit of this basin is determined by pre-Blairmore (post-Jurassic) erosion (Weir, 1949, p. 563).

In the maps given by Schuchert (1939) and Loranger (1955) the Jurassic sea in the southern plains of Alberta, Saskatchewan and Manitoba is indicated as a geosynclinal region. Both the sedimentary character and the small thickness of the Jurassic strata in this basin are, however, unlike that to be expected in a geosyncline. This area actually belongs to Laurentia in the definition of Suess (1909, p. 573) and Stille (1940, pp. 26-27), i.e., to the Canadian shield in a broad sense[1].

The difference in behaviour of this relatively stable area as compared with the adjacent, more mobile border zone of the present Rocky Mountains and Alberta Foothills is also expressed by the well known facies-differences between the Jurassic beds in the Rocky Mountains and Alberta Foothills on the one side and the Jurassic in the southern plains of Alberta, Saskatchewan and Manitoba on the other.

Pre-Blairmore, i.e., post-Jurassic, erosion determined also the present day eastern limit of the subsurface Fernie deposits in the Alberta plains south and north of Calgary. The neighbourhood of the mainly north and south running coast-line, however, is indicated by a general decrease in the thickness of the Fernie from west to east. This is illustrated by the fact that the Fernie at Canyon Creek, in the Moose Mountain area, is only 220 feet thick. Another indication of the neighbourhood of the eastern

[1]The Canadian shield *sensu stricto* is, in the definition of Suess (loc. cit.) and Stille (loc. cit.), not identical with "Laurentia" but forms the most positive part of it, in which the Precambrian forms the surface. "Laurentia" is, however, identical with the Canadian shield *sensu lato* of many authors and comprises also those parts of the shield that have been invaded by shelf seas, as for instance the Great Plains during Cretaceous times. Characteristic of "Laurentia" is, according to Suess (loc. cit.) and Stille (loc. cit. p. 26), that "wherever Cambrian beds are present, they lie horizontal".

coast-line is the increase of sandy material in the Fernie from west to east, observed at various places between Ribbon Creek in the south and the northern Foothills. Increase of sandy material towards the east is particularly well illustrated in the region between the Snake Indian Valley in the west, where the Middle Jurassic Rock Creek member consists predominantly of shales, and the Morris-Fiddle Creek area in the east, where the same beds are largely replaced by sandstone (*see* columns 10, 11, 12, Figure 3 and Plates IV, VII A, VIII). Other places with a strong, sandy development of Middle Jurassic are, for example, Cadomin and Nordegg. In the Callovian the sandy facies, developed in the region between Ribbon Creek and Cascade Valley near Banff, seems to indicate near shoreline conditions.

The connection of the Fernie sea with the Jurassic sea in the Canadian Arctic, via the Mackenzie River region, has been postulated by many authors as for instance Schuchert (1939), Imlay (1953), and Loranger (1955). It is, however, a fact that, between the northernmost Fernie occurrences and the Jurassic in the Canadian Arctic coast region (Richardson Mountains) there is a distance of about 1,000 miles (1,600 km.) without any evidence of the existence, or former existence, of Jurassic deposits. It is therefore the more surprising that this region, which during the Jurassic apparently was dry land, was regarded as part of a great geosyncline in Schuchert's (1939) and Loranger's (1955) maps.

As the existence of a landbridge closing off this alleged connection of the Fernie sea with the Jurassic Arctic sea has to be assumed, any speculation on the route of Jurassic fauna immigrations from the Arctic to Western Canada via these hypothetical seaways should be avoided.

The connection of the Fernie sea with southern Yukon, via parts of northern British Columbia, is perhaps better substantiated, as Lower, and possibly Middle, Jurassic beds are present in all regions concerned. However, as no Upper Jurassic beds have yet been found in southern Yukon the palæogeographic relations between this region and the Fernie sea during these times remain doubtful.

Figure 5 illustrates the writer's opinion of the total maximum extent of marine transgression in various regions of Western and Northern Canada during the Jurassic period. A number of individual transgressions are involved, and consequently, palæogeographic maps illustrating the conditions for each stage would differ from the picture as shown in Figure 5. Thus, for instance, a map of the Toarcian sea would leave both the Mackenzie Bay basin and the southern plains of Alberta, Saskatchewan, and Manitoba as non-marine regions, whereas a map showing the distribution of land and sea during Middle Bajocian time would have to indicate the whole Canadian Arctic as land and the southern plains as sea.

The southern boundary of Jurassic occurrences in the Canadian Arctic Archipelago is drawn in accordance with these new still unpublished discoveries.

CHAPTER III

SYSTEMATIC DESCRIPTION OF INDEX FOSSILS

This chapter contains systematic descriptions of those Fernie index fossils that are of importance for the age determination of the beds concerned. Descriptions of other index fossils of the Fernie have already been published: Buckman (1929, pp. 1-27), Frebold (1951, pp. 15-17), McLearn (1924, pp. 39-61; 1927, pp. 67-73; 1928, pp. 19-22; 1932b, pp. 111-115), and Warren (1931, pp. 105-112; 1932, pp. 1-36; 1947, pp. 67-76). Some of the material published in earlier papers is redescribed or refigured, and in a few cases earlier descriptions are quoted.

AMMONOIDEA

Genus *Arnioceras* Hyatt

Arnioceras ? sp. indet. 1

Plate XIV, figure 1; Plate XV, figure 1

Several incompletely preserved Arietites were found in Cuthead Creek, 17 miles north of the Minnewanka Park Warden station. They are associated with numerous pelecypods and some gastropods, as yet undescribed, in a hard limestone that is apparently in contact with the Triassic Whitehorse formation.

The specimen pictured (Plate XV, figure 1) has an almost rectangular cross-section, higher, than wide. The flanks are slightly convex, with rounded transition to the almost vertical umbilical slope and to the venter, which has a keel surrounded by a furrow on each side. The ribs are very slightly curved and bent forward. Nodes seem to be absent. No suture line could be observed.

The larger specimen, illustrated on Plate XIV, figure 1, differs from the smaller one by having straight and sharper ribs. The cross-section of the last whorl is more rounded and about as wide as high. No nodes were observed on the ribs.

It is possible that the two specimens belong to different species, but the poor state of preservation prevents a decision being reached.

The two specimens are tentatively attributed to the genus *Arnioceras*.

Arnioceras ? sp. indet. 2

Plate XV, figure 2

The specimen pictured (Plate XV, figure 2) is the best preserved ammonite of a collection reported to have been made in 1931 by L. Telfer in the basal Phosphate bed on the west slope of Cascade Mountain. The cross-section of the last whorl of this specimen and of other similar fragments from the same locality is high rectangular. The keel on the venter lies between fairly wide but rather shallow furrows. This form differs from the *Arnioceras* ? sp. indet. 1 (Plate XV, figure 1) by having straight and much sharper ribs that have nodes near the ventral margin.

The suture line, observed on another, smaller specimen of about 44 mm., is very simple and of the same character as that of other Arietitids of corresponding age. It is possible that this form is a young specimen of the form pictured in Plate XIV, figure 1. It may belong to the *Arnioceras semicostatum* group, but the poor preservation does not permit any identification. This form is tentatively included in the genus *Arnioceras.*

Genus *Coeloceras* Hyatt

Subgenus *Peronoceras* Hyatt

Peronoceras cf. *subarmatum* Young and Bird

Plate XVIII, figure 1

The incomplete specimen, which was found opposite George Creek Valley in association with an *Harpoceras*, has a diameter of 75 mm. It shows a ribbing typical of *P. subarmatum.* Mostly two straight ribs are connected with one another in a more or less circular tubercle at the junction between flanks and venter, but there are also some ribs which are not connected with another one in a tubercle. The ribs cross the venter without interruption.

This form belongs to the same species as *Peronoceras* (*Porpoceras*) cf. *subarmatum* Young and Bird from Red Deer River (Frebold 1951, p. 15, Plate VI, figures 4a, 4b) formerly described by Whiteaves (1907, pp. 80-82) as *Peltoceras occidentale.* Another poorly preserved specimen was found at Daisy Creek Summit a few feet above the base of the Fernie.

Representatives of *Peronoceras* (*Porpoceras*) *subarmatum* Young and Bird similar to the George Creek Valley specimen are figured by F. A. Quenstedt (1885, Pl. 46, figures 15, 16, 17), and E. Dumortier (1874, Pl. 28, figures 6, 7, 8, 9). The incomplete preservation of the George Creek Valley specimen, which does not permit the study of the inner whorls and the suture line, prohibits a positive identification with the European species.

Genus *Dactylioceras* Hyatt

Dactylioceras aff. *commune* Sow.

Plate XVIII, figure 4

Poorly preserved specimens of *Dactylioceras* are very common in the black shale of the lower part of the Fernie group in Canyon Creek, Moose Mountain, where they occur in association with *Harpoceras* cf. *exaratum* Young and Bird. They have been found also in the black shale above the *Oxytoma* bed in Snake Indian Valley and at other places.

The small form illustrated has a diameter of about 28 mm. In general shape, number, and type of the ribs this form is similar to *Dactylioceras commune* Sow., but an exact identification of this specimen and other Fernie representatives of the same form is impossible because the cross-section, the venter, and the suture line cannot be studied.

Dactylioceras kanense McLearn (1932, Pl. 5, figs. 6-9, pp. 59-62) from the Upper Lias of Queen Charlotte Islands is distinguished from the Fernie *Dactylioceras* by finer, more numerous, and forwardly inclined ribs.

Genus *Harpoceras* Waagen em. Haug

Harpoceras cf. *exaratum* Young and Bird

Plate XVII, figure 1; Plate XVIII, figures 2, 3

In the basal 20 feet of the Fernie group in Canyon Creek, Moose Mountain area, Harpoceratids are very common. Unfortunately the specimens are almost entirely flattened or preserved only as imprints.

The largest specimen has a diameter of about 134 mm., the width of the umbilicus is about 17 mm., and the height of the last whorl is about 77 mm. A prominent keel is present. The numerous ribs are distinct and uniform; they are bent twice and continue on the keel.

Wright's (1878-1886, pp. 441-443, Pl. 62, figs. 1-3) *Harpoceras exaratum* Young and Bird and E. Dumortier's *Harpoceras subplanatum* Oppel (Dumortier, 1874, pp. 51-53), which is identical with *H. exaratum* agree very well with the Canadian form, which probably belongs to this species. Unfortunately neither the cross-section nor the suture line of the Canadian specimens is observable and no exact identification can be made.

Harpoceras exaratum Young and Bird is a very common species in the Middle Toarcian of Europe.

Genus *Hammatoceras* Hyatt em. Haug

Hammatoceras ? sp. indet.

On the road to the Adanac strip-mine, south of Blairmore, 20 feet above the base of the Jurassic, a single, poorly preserved imprint of a moderately evolute ammonite was found. Most of the comparatively strong and straight ribs bifurcate near the umbilical edge, at any rate below the middle of the flanks. Near the end of the last whorl the ribs divide into three branches.

An exact determination of this form is impossible; the general shape and the type of the ribs, however, suggest that it belongs to *Hammatoceras*.

Hammatoceras insigne Schübler has been reported to occur in the Upper Toarcian of the Fiddle Creek area (Collet, 1931, p. 17).

Genus *Sonninia* Bayle

The fauna collected by McConnell in 1886, 3 miles north of Devils Point, Lake Minnewanka, Alberta, consists mainly of poorly preserved ammonites that were originally referred by Whiteaves (1889) to the genus *Schloenbachia*. McLearn (1927, p. 69) pointed out that these ammonites were really representatives of the subfamily Sonnininae and that they belonged to the early Middle Jurassic.

There are at least three species of *Sonninia* represented in this material, one of them being *Sonninia gracilis* Whiteaves and the other two probably new species that Whiteaves left unnamed.

Sonninia gracilis Whiteaves

Plate XIX, figures 1a, b

Schloenbachia gracilis Whiteaves 1889, p. 171, Plate 23, figs. 2, 2a.

Two imperfectly preserved specimens and one imprint of *S. gracilis* were collected. Whiteaves mentioned most of the characteristics of this species with the exception of the suture line. His description is repeated here in abbreviated form, and some additional remarks are made. The umbilicus is wide and shallow, the umbilical edge rounded and the umbilical wall fairly steep. The whorls gradually increase in size and the slightly rounded venter has a keel without adjoining furrows. The ribs are strong on the last three whorls, slightly curved, undivided, bent forward near the edge of the flanks and venter, not crossing the keel. Somewhat above half the height of the flanks the ribs are highest and have a low pointed tubercle.

The suture line is very poorly visible and does not appear to be deeply incised. The external lobe is somewhat shorter than the first lateral, which has three points and is about twice as deep as the second lateral lobe.

The measurements of Whiteaves holotype are as follows: diameter 110 mm., width of umbilicus 58 mm., height of the last whorl at the end 30 mm., width of the last whorl on the summits of two opposite ribs 24 mm., and in the depressions between the ribs 19 mm.

The Lake Minnewanka specimens of *S. gracilis* show certain similarities with some strongly ribbed species of Dorn's (1935) group of *Sonninia adicra* Waagen, as for instance with *S. costosa* Qu. and *S. mayeria* Waagen, but the very imperfect state of the Lake Minnewanka specimens does not warrant detailed comparison.

Sonninia sp. indet. 1

Plate XX, figure 1

This form which was found by McConnell in 1886, 3 miles north of Lake Minnewanka, Alberta, differs from *Sonninia gracilis* Whiteaves by its smaller umbilicus and entirely different type of ribbing. The measurements are as follows: diameter 85 mm., width of umbilicus about 29 mm., height of the last whorl near its end about 35 mm., width of the same about 23 mm. The last whorl embraces almost half of the preceding one. Its cross-section is high oval whereas the cross-section of the preceding one is almost quadrate. The venter of the last whorl is narrow and no keel is preserved. It is almost flat on the preceding whorl and a low keel is present. The ribs on the inner whorl are very strong and bifurcate somewhat below half the height of the flank. At the point of division the ribs are considerably thickened.

This type of ribbing is still present in the posterior three-quarters of the last whorl, but the last part of it is characterized by faint and apparently undivided ribs. No suture line is visible.

Sonninia div. sp. indet.

Plate XIX, figures 2a, b; Plate XX, figures 2, 3

Some fragments of Sonninines collected by McConnell 3 miles north of Lake Minnewanka probably belong to the same group, but to different species. They are distinguished from both *Sonninia gracilis* Whiteaves and *Sonninia* sp. indet. 1 particularly by a much finer ribbing. The specimen (Plate XIX, figures 2a, b) has a high oval whorl and cross-section; a well developed keel on the venter surrounded by flat shallow furrows that are terminated toward the edge of the flanks by ridges, as mentioned by Whiteaves (1889, p. 171). Only faint ribs are present on the last whorl. Another fragment (Plate XX, figure 2) with a smooth outer whorl has a keel but no ridges on the edges to the flanks. The suture line is much more incised than that of *S. gracilis*. The first lateral lobe is fairly broad. A third fragment (Plate XX, figure 3) seems to have a high keel. Some of the ribs bifurcate near the umbilical edge.

No detailed comparison of these fragments with one another or with known species is possible.

Genus *Stephanoceras* Waagen

Stephanoceras ex gr. *skidegatense* Whiteaves

Plate XXI, figure 1; Plate XXII, figure 2; Plate XXV, figure 2

Several poorly preserved specimens of *Stephanoceras* were found at various exposures of the Rock Creek member. As this genus seems to be fairly rare in the Fernie Bajocian, description of these forms appears to be justified.

The measurements of the most complete specimen (Plate XXI, figure 1) are as follows:

Diameter	130 mm.
Whorl height	35 mm. (26·9)[1]
Whorl thickness about	48 mm. (36·9)
Width of umbilicus	68 mm. (52·3)

The diameter was taken about 84 mm. from the anterior end of the specimen which was, however, originally much larger for there are fragments of still another septate whorl. The flanks and venter of this specimen are gently rounded. There are about 40 primary ribs on the last preserved whorl and about three times as many secondaries, which arise by bifurcation and intercalation. The point of bifurcation is marked by a thickening of the primaries and tubercles, which are more clearly developed on the preceding whorl. On the flanks the secondaries may be very slightly inclined but they cross the venter transversely.

[1]Figures in brackets are percentages of the diameter at which they were taken.

This specimen was collected from the Rock Creek member at Livingstone Gap. It was associated with *Chondroceras* and other representatives of the Rock Creek member fauna.

The single whorl (Plate XXII, figure 2; Plate XXV, figure 2) was found in the Rock Creek member in Snake Indian Valley. The measurements are as follows:

Diameter	70 mm.
Whorl height	22 mm. (31·4)
Whorl thickness	33 mm. (47·0)
Width of umbilicus	31 mm. (44·2)

This form seems to be very similar both in shape and type of ribbing to the specimen described above and is considered to belong to the same species.

The two specimens seem to be closely related to the group of *Stephanoceras skidegatense* Whiteaves, *St. yakounense* McLearn, and *St. caamanoi* McLearn from the lower Yakoun beds of Queen Charlotte Islands (McLearn 1932, pp. 52-59). The poor preservation of the Fernie specimens, however, does not permit detailed comparison. Warren (1947, pp. 72, 73; Pl. 5, fig. 2; Pl. 7, fig. 1) described some apparently similar forms from the Fernie, but his specimens also are too poorly preserved for exact identification.

Stephanoceras sp. indet.

Plate XXII, figures 1a, b

Associated with the single whorl of *St.* ex gr. *skidegatense* Whiteaves the fragment figured in Plate XXII, figures 1a, b was found in the Rock Creek member in Snake Indian Valley.

This evolute form has well rounded flanks and a moderately arched venter. The whorl is much thicker than high. This specimen differs considerably from the one already described as *St.* ex gr. *skidegatense.* It has fewer and much stronger ribs; there are only 23 primaries on the preserved part of the whorl (about 5 on the missing part); each of these primaries is bifurcated into two secondaries, the point of division being marked by tubercles; a third secondary rib is generally intercalated; and the secondaries cross the venter almost transversely. The whorl belongs to the living chamber.

This form has not hitherto been reported from the Rock Creek member. Possible identification with known species must await better preserved material.

Genus *Stemmatoceras* Mascke

Stemmatoceras albertense McLearn

Plate XXI, figures 2a, b; Plate XXIII, figures 1a-c

Stemmatoceras albertense Warren, 1947, pp. 67, 68, Pl. 5, fig. 1.
Stemmatoceras albertense McLearn, 1928, pp. 20, 21, Pls. 5-7.

Stemmatoceras albertense McLearn is one of the common ammonites of the Rock Creek member. The specimen (Plate XXIII, figure 1a) that was found in Ribbon Creek shows most of the characteristics of the holotype. The whorls are depressed but not very thick, with a very slightly arched venter. The arching of the venter is somewhat stronger in the anterior part of the last whorl where it resembles that of the closely related species *St. palliseri* McLearn. The primary ribs are stout, somewhat inclined and end in low conical tubercles. There are about three times as many secondaries, which cross the venter almost transversely. More than three-quarters of the last whorl belongs to the living chamber. The measurements of this specimen taken at the maximum diameter are:

Diameter	133 mm.
Whorl height	45 mm. (33·8)
Whorl thickness	57 mm. (42·8)
Width of umbilicus	61 mm. (46·0)

As no young specimens of *Stemmatoceras* have been described before from the Fernie, younger whorls of the specimen (Plate XXIII, figure 1a) were prepared (Plate XXI, figures 2a, b; Plate XXIII, figures 1b, c). Measurements taken at diameters of 56 mm. and 31 mm. respectively are as follows:

Diameter	56 mm.	31 mm.
Whorl height	20 mm. (35·7)	11 mm. (35·5)
Whorl thickness	30 mm. (53·5)	18 mm. (58·6)
Width of umbilicus	25 mm. (44·6)	15 mm. (48·4)

Plate XXIII, figure 1c, illustrates the shape of the whorl cross-section at a diameter of 56 mm. where it is relatively much wider than at the later stage of growth, measured at a diameter of 133 mm. At a diameter of 56 mm. this species is very similar to the corresponding stage of growth of *Teloceras dowlingi* (Plate XXIV, figures 1a, b). At a diameter of 31 mm. (Plate XXI, figures 2a, b) the specimen has a general resemblance to some representatives of the genus *Coeloceras*, as for instance *Coeloceras pettos* of the upper part of the Lower Lias. The ribs and tubercles are however much stronger.

Similarities of young specimens of *Stemmatoceras* and *Teloceras* and of *Teloceras* and *Coeloceras* have already been mentioned by Mascke (1907, p. 31).

Genus *Teloceras* Mascke

Teloceras dowlingi McLearn

Plate XXIV, figures 1a, b

Teloceras dowlingi McLearn, 1930, p. 2.
Teloceras dowlingi McLearn, 1932, p. 112, Pl. 1; Pl. 5, figs. 2, 3.

McLearn's original description of the holotype which is re-figured on Plate XXIV, figures 1a, b, is as follows:

"Diameter	138
Height, whorl	32·0 (over venter of preceding whorl)
Thickness, whorl	44·5
Width, umbilicus	—

"Most of the living chamber is gone. Up to about the end of the first half of the penultimate whorl the shell is cadiconic and of *Teloceras* aspect. The whorls are comparatively wide and low, widest at the umbilical shoulders and the ventral area is broad and lowly arched. There is no true lateral area. The slope of the umbilical area into the umbilicus is not so steep, however, as in typical *Teloceras*. The primary ribs are stout, straight, nearly upright and end in short blunt spines. The secondary ribs are exposed on the posterior half of the penultimate whorl and are a little more than four to each primary. They are small, but have considerable relief and are curved forward slightly on the venter.

"On the anterior part of the penultimate whorl, the whorl is becoming higher by reason of arching of the venter. There is no umbilical enlargement at this stage, however, and the shape of the umbilicus and the *Teloceras* ribbing have not yet changed.

"On the ultimate whorl, a part only of which is preserved, there is umbilical expansion with narrowing of the whorl and movement of the whorl suture outside the lines of tubercles. There is also rounding of the sides of the whorl and increased arching of the venter. The primary ribs at this stage are short, curved, fairly stout and end in small tubercles. The secondary ribs are small but have fair relief, are nearly five to each primary and are curved forward a little on the venter.

"The suture line is moderately complex. ES is deep. L1 is about equal to EL. S1 is much more shallow than ES. L2 is short, trilobate, with long medium lobule; it is not inclined. The auxiliary lobes are short and inclined. The tubercle or spine is on the inner part of S1.

"The species name is given for the late D. B. Dowling, geologist."

According to McLearn (loc. cit.) this specimen was collected by James McEvoy on Kananaskis River. In the writer's opinion the exact locality is probably Ribbon Creek near Kananaskis River, where a rich Rock Creek member fauna occurs.

Genus *Zemistephanus* McLearn

Zemistephanus crickmayi n. sp.

Plate XXV, figure 1; Plate XXVI, figure 1; Plate XXVII, figure 1

The fragmentary specimen, which was found in Ribbon Creek in association with a rich Rock Creek member fauna, is characterized by a deep conical umbilicus, and an extremely thick and low cross-section. The venter is broad and only slightly arched. The primary ribs end in high conical tubercles. There are about four secondary ribs for each tubercle. The last whorl is septate to the end, but the details of the suture line cannot be traced.

This form is easily distinguished from both *Zemistephanus richardsoni* Whiteaves and *Zemistephanus funteri* McLearn from the lower Yakoun beds of Queen Charlotte Islands (McLearn, 1929, pp. 18-20) by its much greater whorl thickness and its coarser secondaries. The type of ribbing is more similar to that of *Teloceras dowlingi* McLearn and *T. warreni* McLearn but both these species have much higher and less thick whorls than *Zemistephanus crickmayi*. Warren (1947, pp. 71, 72) has mentioned a *Zemistephanus* from the Rock Creek member of the Highwood-Elbow area, but gave neither picture nor detailed description. He has pointed out that the distinction between the two genera, *Zemistephanus* and *Teloceras*, appears to rest on rather doubtful ground.

The species name is given for Dr. C. H. Crickmay.

Genus *Chondroceras* Mascke

Chondroceras allani McLearn var.

Plate XXVII, figures 2a, b

Saxitoniceras allani McLearn, 1928, pp. 21, 22, Pl. 8, figs. 1, 2.

Chondroceras allani McLearn is locally a very common index fossil of the Rock Creek member. The specimen figured is somewhat larger than McLearn's holotype but shows all the general characteristics of this species except the outer lip. The measurements are as follows:

Diameter	48 mm.
Whorl height	21 mm. (43·7)
Whorl thickness	27 mm. (56·2)
Width of umbilicus	12 mm. (25·0)

On the anterior part of the last whorl the umbilicus is considerably enlarged, as is the case in the holotype of the species. The flanks and venter are well rounded. There are sixteen low, rounded, and slightly inclined primary ribs on the last whorl, the point of division, generally into two branches, is a little below half the height of the flanks. There are about forty secondaries, of which some are intercalated. The secondaries are bent a little backwards on the upper half of the flanks and cross the venter transversely.

The suture line agrees with the description of the holotype. About half of the last whorl belongs to the living chamber.

The specimen differs slightly from the holotype as the whorl height and width of umbilicus are greater and the flanks are more rounded. These differences, however, are so small that they are considered to lie within the range of variability of the species.

The genus "*Saxitoniceras*" of which *Chondroceras allani* McLearn formed the genotype (McLearn, 1928, p. 21) is now united with *Chondroceras* Mascke (McLearn, 1949, pp. 10, 16).

According to information given by the collector to McLearn (1928, p. 22) the holotype of *Chondroceras allani* was found at the base of the Fernie formation on the headwaters of Sheep Creek, Alberta. This species, however, is an index fossil of the Middle Bajocian Rock Creek member which is generally on top of the Toarcian and in no case forms the base of the Fernie.

The specimen here described was found in the Rock Creek member of Ribbon Creek associated with other fossils characteristic of this member.

Chondroceras marshalli McLearn var.

Plate XXV, figures 3a, b; Plate XXVI, figures 2a, b

Saxitoniceras marshalli McLearn, 1928, p. 22, Pl. 8, figs. 3, 4.

Diameter	62.5 mm.	51 mm.
Whorl height	25 mm. (40·0)	22 mm. (43·1)
Whorl thickness	34 mm. (54·4)	30 mm. (58·8)
Width of umbilicus	16.5 mm. (26·4)	9 mm. (17·6)

The specimen figured on Plate XXVI, figures 2a, b, has well rounded flanks and venter, the whorl section is much thicker than high and the umbilicus is enlarged on the last whorl. There are seventeen almost straight, rounded, and a little inclined primary and about three times as many secondary ribs which cross the venter transversely. Some of the secondaries originate by bifurcation of the primaries, others are intercalated. There is a deep constriction just behind the end of the last whorl, other more shallow constrictions are present in the anterior part of the last whorl. Apparently at least three-quarters of the last whorl belongs to the living chamber.

No suture line was observed.

The specimen described has close affinities to *Chondroceras marshalli* McLearn. Both have more depressed, much thicker than high whorl sections by which they are distinguished from the closely related *Chondroceras allani*. The whorl section of the holotype of *Chondroceras marshalli* is, however, even more depressed and thicker than that of the described specimen, which is to be considered a variety. Some of these differences may be in part accounted for by slight distortion of the holotype. The described specimen is also larger than the holotype showing a coarse ribbing in the anterior half of the whorl.

The smaller specimen (Plate XXV, figures 3a, b) shows the same ribbing as the holotype. It is clearly distinguished from *Chondroceras allani* by the greater thickness of the whorls which, however, are less depressed than those of the holotype.

Chondroceras marshalli was formerly considered to belong to "*Saxitoniceras*", which is now united with *Chondroceras* Mascke (McLearn, 1949). The described specimens were found in the Rock Creek member at Ribbon Creek associated with other forms characteristic of this member.

Genus *Oppelia* Waagen

Oppelia (*Oxycerites*) ex gr. *fallax* Guéranger

et *aspidoides* Oppel

Plate XXVIII, figures 1a, b, 2

Two specimens of an *Oppelia* have been found in the Fernie group in the regions of the headwaters of Smoky River, northern Alberta. Both are in the collections of the Geological Department, University of Alberta, Edmonton. The fairly well preserved specimen No. Jr. 541 (Plate XXVIII, figures 1a, b) was collected by Mr. Hargreaves near Sulphur River and specimen No. Jr. 542 (Plate XXVIII, figure 2), which is partly broken, somewhat crushed, and has no visible suture line, was obtained by Dr. C. R. Stelck on Sheep River.

Dimensions

Specimen Jr. 541 (Plate XXVIII, figures 1a, b)

Maximum diameter	109 mm.
Whorl height	62 mm. (57)
Whorl thickness	26 mm. (24)
Width of umbilicus	10 mm. (9)

Specimen Jr. 542 (Plate XXVIII, figure 2)

Maximum diameter—about 96 mm.
Last exactly measurable dm.—87 mm.
Whorl height at 87 mm. dm.—48 mm. (55)
Whorl thickness at 87 mm. dm.—about 18 mm. (about 21)
Width of umbilicus—not exactly measurable.

Both specimens are very involute and discoidal. The larger specimen (Plate XXVIII, figures 1a, b), which is septate up to a diameter of about 86 mm., appears to be almost smooth but the presence of ribs in the outer half of the flanks, particularly at the beginning of the last whorl and on the body-chamber, became apparent by pencil rubbings. The sharp venter of this specimen shows a fine crenulation on the body-chamber.

The smaller specimen (Plate XXVIII, figure 2) shows the presence of well developed ribs on the outer half of the last whorl.

The few elements of the suture line that are visible on the large specimen do not allow any detailed comparisons with the suture lines of other *Oppelia*.

It is possible that both Canadian specimens belong to one and the same species. The larger specimen would represent the adult, almost smooth stage, the smaller one belongs to an earlier stage in the ontogenetic development with clearly visible ribbing over the whole of the last whorl.

The two Canadian specimens show great similarities to some Bathonian forms of *Oppelia*. Thus, the larger specimen seems to be very close to the *Oppelia* (*Oxycerites*) *fallax* Guéranger figured by Arkell (1951, Pl. VIII, figs. 11a, b). Also d'Orbigny's (1846, Pl. 131) figure of Guéranger's holotype (re-figured by Arkell, 1951, p. 57, text figure 15) is similar. Other specimens of *O. fallax* Guéranger figured by Arkell (1951, Plate V, figs. 1-3) show ribbing comparable to that of the smaller Canadian specimen (Jr. 542). *Oppelia* (*Oxycerites*) *fallax* Guéranger, however, has a distinct median spiral band, as mentioned by Arkell (1951, p. 58)[1], in the middle of the flanks.

As the two Canadian specimens, possibly because of the incomplete state of preservation, do not show clearly the presence of such a spiral band, they cannot be identified with *O. fallax* Guéranger, which is apparently identical with *Oppelia* (*Oxycerites*) *fusca* described by other authors (*see* Arkell, 1951, p. 56). The larger of the two Canadian specimens

[1]Arkell's picture on Plate VIII, figure 11a, b, of a large specimen of *O. fallax* does not show the spiral band.

Plate XXVIII, figures 1a, b) agrees better, in this regard, with *Oppelia (Oxycerites) aspidoides* Oppel, which does not have such a distinct raised median band.

The general shape of *Oppelia (Oxycerites) aspidoides* Oppel is very similar to the larger Canadian specimen. The picture, however, of an English specimen of this species (Arkell 1951, p. 65, text figure 17), which is larger than the Canadian form, shows a different whorl section. This may indicate that the whorl section of this species is different in the adult stage. Oppel's type of *O. aspidoides* (1862, p. 147, Pl. 47, figures 4a, b) which is only a little larger than the Canadian specimen, agrees very well with it in general appearance, and in the shape of cross-section. In Oppel's type, however, a fine median band is present, which is not recognizable in the Canadian form, perhaps because of incomplete preservation.

An identification of the two Canadian specimens with any particular species of the *Oppelia fallax* and *aspidoides* group does not seem advisable, as Arkell (1951, p. 66) has shown that large and imperfectly preserved specimens of *Oppelia fallax, O. aspidoides* and other related forms such as *O. waterhousi* Morris et Lycett and *O. limosa* S. Buckman are indistinguishable.

Some Callovian species of *Oppelia*, as for instance *Oppelia (Oxycerites) calloviensis* Parona et Bonarelli (1895, p. 127, Plate 2, fig. 5) are easily distinguishable from the Canadian form.

The two Canadian forms, which came from an horizon about 150 feet above the base of the Fernie group, may indicate a Bathonian age. As, however, the two specimens could not be determined specifically and no other faunal elements have been collected, the exact age remains unknown.

Genus *Lilloettia* Crickmay

Lilloettia imlayi n.sp.

Plate XXXII, figures 1a, b; Plate XXXIII, figures 3a, b

Two fairly well preserved Macrocephalitids, collected immediately on top of the *Gryphaea* bed of the Grassy Mountain section, are characterized by an extremely narrow and deep umbilicus and are tentatively assigned to the genus *Lilloettia* Crickmay. The larger of the two specimens, which is septate to the end, does not show any ribs on the inner half of the last whorl. On the outer half there are straight, comparatively coarse, rounded ribs that are very slightly inclined forward. On the narrowly rounded venter they are bent a little forward. The smaller, somewhat compressed specimen has the same type of ribs. At the beginning of the last whorl of this smaller specimen the ribs can be followed to the umbilicus. They are divided into two, three, and four branches.

The suture line is very similar to that of *Lilloettia lilloetensis* Crickmay and *L. mertonyarwoodi* Crickmay as figured by Imlay (1953b, Pl. 30, figs. 2, 5, 8).

The two Grassy Mountain specimens are easily distinguishable from the Alaska and British Columbia representatives of this genus particularly by the type of their ribs which are much coarser than those of *L. lilloetensis* and *L. mertonyarwoodi* and not flexuous. The small specimen of *Lilloettia* sp. indet. from the Rierdon formation of Montana (Imlay, 1953a, p. 18, Pl. 1, figs. 10, 12) may belong to this species but is too small for detailed comparison. The larger specimen of *Lilloettia* sp. indet. (Imlay, loc. cit., Pl. 1, figs. 11, 13) has much stronger ribs than *Lilloettia imlayi*.

The species name is given for Dr. R. W. Imlay.

Lilloettia ? sp. indet.

Plate XXXIII, figure 1

Another *Macrocephalites* collected at Daisy Creek Summit, Livingstone Range, may, on account of its very narrow umbilicus, belong to *Lilloettia*. The ribs are much finer than in *Lilloettia imlayi* n.sp. Unfortunately the specimen is completely squashed and no detailed comparison can be made.

Remarks on *Miccocephalites*, *Metacephalites*, and *Paracephalites* Buckman

Buckman's (1929) "genera" *Miccocephalites* and *Metacephalites* are based on small Macrocephalitids occurring in the *Corbula munda* and *Gryphaea* beds. They probably belong to the same genus, which, however, cannot be determined. Spath (1932, p. 13) first referred these forms to his genus *Arctocephalites*: "now it is important to mention that when Buckman described certain young Canadian examples of *Arctocephalites* . . .", but elsewhere in the same paper (1932, p. 33) he rightly states that "such nuclei of Macrocephalitids are again almost impossible to identify" and that "these two genera (*Miccocephalites* and *Metacephalites*) therefore cannot stand". In the correlation table of the same paper, however (loc. cit., p. 145) Spath mentions again the presence of *Arctocephalites* in the "Fernie formation, Blairmore" correlating the beds concerned with the Upper Bathonian. Apparently influenced by Spath's paper Imlay (1948, p. 14) writes that "*Arctocephalites* has been found in sandy beds in the Grassy Mountain section near Blairmore, Alberta" and places the beds concerned in the Bathonian, correlative with the lower part of the Cornbrash beds of England.

The facts are, however: (*a*) the small Macrocephalitids "*Miccocephalites*" and "*Metacephalites*" cannot be identified with *Arctocephalites* Spath, (*b*) as yet no *Arctocephalites* has been found in the Fernie group, and (*c*) the *Corbula munda* beds contain *Cadoceras* and their age is thereby determined as Callovian.

Two other ammonites from the *Corbula munda* beds were described by Buckman (1929, pp. 8-11, Pls. 1 and 2) as belonging to a new genus "*Paracephalites*". In the writer's opinion the poor preservation of the two species referred to this genus does not allow accurate identification. They may even belong to *Cadoceras* and not to the Macrocephalitidae at all.

Genus *Xenocephalites* Spath

Xenocephalites bearpawensis Imlay

Plate XXIX, figures 2a, b, c; Plate XXX, figure 2

Xenocephalites bearpawensis Imlay, 1953, p. 19, Pl. 1, figs. 3, 4, 6, 8.

In Pocaterra Creek, Elk River Basin, Highwood area, Alberta, Dr. I. L. Carr collected a fairly well preserved small specimen and some whorl fragments that all belong to *Xenocephalites.* According to the label attached to the specimens, Dr. R. W. Imlay determined the form as "*Kamptocephalites*" n.sp., identical with a form associated with *Kepplerites mclearni* Imlay from top of Rierdon formation in Little Rocky Mountains, Montana. In his recent paper (1953, p. 19) Imlay has referred these forms to *Xenocephalites.*

The specimen figured in Plate XXIX, figures 2a-c has the following dimensions:

Diameter—max.	42 mm.
Whorl height	22 mm. (52)
Whorl thickness	19·5 (46)
Width of umbilicus	7 mm. (16)

The cross-section is ovate with fairly convex flanks and evenly rounded venter, umbilical slope gentle.

The coarse, high, and almost straight ribs are widely spaced, and inclined a little forward. The point of division, generally into two branches, is below the middle of the flank. The point of division is thickened. On the venter the ribs are inclined a little forward. No suture line is visible. Fragments of other specimens found at the same locality show the same features.

This form from Pocaterra Creek is probably identical with a specimen from Grassy Mountain described below, but the poor state of preservation of the Grassy Mountain specimen makes identification questionable.

The presence of *Xenocephalites* at Pocaterra Creek, Highwood area, shows the presence of Lower Callovian beds at this locality.

Xenocephalites cf. *bearpawensis* Imlay

Plate XXXII, figures 2a, b

This whorl fragment was found on the Gold Creek road, south slope of Grassy Mountain, north of Blairmore in the *Gryphaea* bed.

As the whorl is somewhat crushed the shape of the cross-section cannot be accurately determined. The whorl is, however, higher than wide, the flanks fairly convex, and the venter rounded. The umbilical slope is steep and no umbilical rim is present. The ribs are very coarse, high, and more or less straight, a little inclined forward; they cross the venter transversely or with a little forward inclination; they divide into two branches, the point of division lying below the middle of the flank. At this point a thickening of the ribs seems to be present. No suture line is visible.

Both the cross-section and the type of ribbing of this form seem to be similar to that of *Xenocephalites bearpawensis* Imlay described above, but, as the specimens belong to different stages of growth and the state of preservation of the Grassy Mountain specimen is so poor, no identification can be made.

The presence of *Xenocephalites* in the *Gryphaea* bed indicates its age as Lower Callovian. This age is also indicated by other ammonites found in this bed.

Genus *Arcticoceras* Spath

Arcticoceras henryi Meek and Hayden

Plate XXIX, figure 1; Plate XXX, figures 1a-c; Plate XXXI, figure 1

Ammonites henryi Meek and Hayden (1865, pp. 123, 124, Pl. 5, figs. 9a, b, c).
Arcticoceras henryi (Meek and Hayden) Imlay (1948, p. 21).
Arcticoceras henryi (Meek and Hayden) Imlay (1953, pp. 22, 23, Pl. 5, figs. 6-15).

The figured specimen was collected by Dr. Warren in the Cascade River Canyon near Banff, Alberta. The original labels attached to this specimen indicate that both Warren and Imlay have referred it to *Arcticoceras*; the identification with the species *henryi* Meek and Hayden was made by Imlay.

The specimen has a maximum diameter of about 135 mm. Its form is lenticular (the specimen looks like an ironstone nodule), the whorls are much higher than thick, the venter is narrowly rounded, the umbilicus is not visible but can only be very small. The innermost visible whorl has a diameter of 72·5 mm., still younger whorls are completely concealed.

The specimen does not show any ribbing. Seen in oblique lighting, however, very faint forward inclined lines can be seen on the innermost visible whorl and even at the end of the last whorl.

Apparently the whole last whorl belongs to the body chamber, parts of the suture line, the details of which have been described by Meek and Hayden (1865, pp. 123, 124) and R. W. Imlay (1948, p. 21), are observable at the end of the innermost visible whorl. Both the first and second lateral lobe are trifid and the external lobe is longer than the first lateral. Unfortunately the development of the suture line on the other flank cannot be studied. According to observations made by Meek and Hayden, and Imlay, a bifid second lateral lobe may be expected on this other flank.

The picture given by Meek and Hayden of the holotype agrees very well with the specimen from Cascade River Canyon.

Arcticoceras codyense Imlay (1948, p. 20, Pl. 6, figs. 4, 6, 8) is a very nearly related species.

Among the ammonites collected in the Isola Peak region, Alberta, are some whorl fragments of about the same size as the innermost visible whorl of the described Cascade River form, and one of them is very similar to it. It is entirely smooth but shows on the inside the impression of the ribbed venter of the foregoing whorl. It is possible that this fragment belongs to the same or another related species of *Arcticoceras*, which is ribbed in a younger stage of growth. More and better preserved material has to be found before a final decision can be reached.

The presence of *Arcticoceras henryi* Meek and Hayden in the Cascade River Canyon near Banff indicates the presence of Lower Callovian. This is also shown by the *Kepplerites* (*Seymourites*) described below.

Genus *Cadoceras* Fischer

The genus *Cadoceras* is represented by a few specimens collected at various Fernie localities.

Cadoceras muelleri Imlay

Plate XXXVI, figure 1; Plate XXXVII, figure 1

Cadoceras muelleri Imlay, 1953, pp. 23, 24, Pl. 7; Pl. 8, figs. 2, 7, 9; Pl. 9, figs. 1-3, 6-8, 10.

A single specimen of this globose species was found in the upper part of the *Corbula munda* beds of the old railway section on the south slope of Grassy Mountain.

Diameter	203	126	99
Whorl height	91 (45)	64 (51)	52 (53)
Whorl thickness	120 (59)	about100 (79)	about 82 (83)
Umbilical width	54 (26)	21 (17)	—

The changes of the shape of the whorls, which are much wider than high and which embrace most of the preceding whorl, are also shown on Plate XXXVII. The umbilicus is deep and narrow but widens considerably on the last whorl due to contraction at the anterior end. The wall of the umbilicus is almost vertical and forms a rounded angle of about 90 degrees with the flanks. At the end of the body chamber, the transition from the umbilical wall to the flank is less abrupt. About six-sevenths of the last whorl belongs to the body chamber which is completely smooth. The last suture line is just indicated but does not permit a detailed study. The surface sculpture of the inner whorls of this specimen is unknown.

The specimen agrees in all observable characteristics with *Cadoceras muelleri* Imlay from the Callovian of the western interior of the United States.

The fragments described as *Cadoceras* ex gr. *victor* Spath (*see* p. 61) possibly belong to the same species, but a decision cannot be made on account of their poor preservation.

Cadoceras lillei n.sp.

Plate XXXIV, figures 1a, b; Plate XXXV, figure 1

This species was found on the south slope of Grassy Mountain north of Blairmore, in the upper part of the *Corbula munda* beds.

The state of preservation is fair, but parts of the body chamber are missing. The maximum diameter is 136 mm. At this stage of growth the whorl height is 65 (48), the whorl thickness 66 (49), and the umbilical width 31 (23). At a diameter of 106 mm. the whorl height is 58 (43), the whorl thickness 58 (43), and the umbilical width 16 (12). The shell is semi-globular, the whorl section at the end of the body chamber wider than high. The last whorl embraces most of the preceding one, except near the end where the form becomes extraumbilicate. Flanks are gently convex with an even transition into the rounded venter. The wall of the fairly narrow umbilicus is vertical with sharp transition into the flanks. The vertical walls become less steep towards the mouth of the body chamber where a fairly broad constriction is present. About two-thirds of the last whorl belongs to the body chamber. The shape of the young whorls is unknown.

The somewhat worn mould of the body chamber appears to be smooth but faint ribbing is still present in its posterior part. A piece of the shell preserved in this part shows strong ribs near the umbilicus. The ribs of the preceding whorl (Plate XXXV, figure 1) are bent forward in the lower two-thirds of the flanks, in the upper third they are almost radial and cross the venter transversely. Bi- and tri-furcation of the ribs in the lower third of the flanks seem to be common but there are also intercalated secondary ribs.

Only parts of the suture line are visible. The first lateral lobe is slightly shorter than the external lobe, the second lateral lobe is not traceable in detail. Apparently the second lateral saddle is close to the umbilical edge.

This form is more compressed than *Cadoceras tetonense* Imlay (1953, p. 24, Pl. 10, figs. 1, 2; Pl. 11, figs. 1-10) and *Cadoceras piperense* Imlay (1953, p. 25, Pl. 12; Pl. 13, figs. 1-12; Pl. 14, fig. 7) from the Callovian of the western interior of the United States. As only one specimen of this new species was found, the range of its variability is unknown.

Cadoceras ex gr. *victor* Spath.

Plate XXXVIII, figures 1a-d

Fragments belonging to a single specimen were collected by W. Clow, Research Council of Alberta, at the Adanac strip mine, south of Bellevue, southern Alberta. Different stages of growth, including the very young one, are preserved showing the general development of the form, but as too many pieces of the ammonite are missing, no complete description can be given.

The youngest preserved stage of growth (*see* Plate XXXVIII, figure 1a, b) has a comparatively wide umbilicus and a cross-section wider than high, the flanks being convex and the venter well rounded. Somewhat below the middle of the whorl the straight ribs are divided into two branches which, a little inclined forward, cross the venter.

The next preserved stage of growth (Plate XXXVIII, figure 1c) shows a very steep and deep umbilicus. The primary ribs are comma-like, divided into two and sometimes three secondaries that are inclined forward.

The next stage preserved fragment (Plate XXXVIII, figure 1d) shows the same type of ribbing as the younger one. The ribs cross the venter more or less transversely. The cross-section of the whorl is much wider than high. This fragment shows some sutures, which, however, cannot be traced in detail.

The oldest stage preserved shows an extremely broad and low cross-section; some ribbing still is recognizable. No sutures are present.

The specimen is too poorly preserved for detailed comparisons to be made. The type of ribbing is very similar to that of the specimen of *Cadoceras lillei* n.sp. described above, but the cross-section of the last whorl is much broader and lower. The Adanac form also resembles in some respects representatives of the East Greenlandian group of *Cadoceras victor* Spath, for instance L. F. Spath's *Cad. victor* (1932, Pl. 16, figs. 6a-e), *Cad.* sp. indet. aff. *victor* (loc. cit. Pl. 17, fig. 5), and *Cad.* aff. *victor* (loc. cit. Pl. 21, figs. 1a, b).

As far as the cross-sections of the Adanac specimen can be studied they also show a similar shape to those of *Cadoceras muelleri* Imlay described above. As the inner whorls of *C. muelleri* are unknown a comparison of the two forms cannot be made in this regard. Possibly both forms belong to the same species.

This specimen has not been found in situ, but the type of rock is that of the beds just below the *Gryphaea* bed.

Cadoceras ? sp. indet. 1

Plate XXXVIII, figures 2a, b

A very small specimen collected by W. Clow at Adanac strip mine, July 7, 1949, has a diameter of about 15 mm. It differs from the young form of *Cadoceras* ex gr. *victor* described above in having finer ribs most of which are divided into two, but occasionally three branches.

No identification of this small specimen can be made.

Cadoceras sp. indet. 2

Plate XXXVIII, figure 3

A poorly preserved specimen collected by the writer in the *Corbula munda* beds on the south slope of Grassy Mountain, north of Blairmore, has, at a diameter of about 85 mm., a very deep umbilicus with steep wall and a cross-section wider than high. The ribs are similar to those described of *Cadoceras lillei* n.sp. and *C.* ex gr. *victor* Spath, the primaries being divided into two or three branches, but they are finer than in the compared specimens. Only parts of the suture line are visible.

An identification of this Grassy Mountain specimen is not possible.

Genus *Cardioceras* Neumayr et Uhlig

Cardioceras canadense Whiteaves

Plate XXXIV, figures 2a, b

Cardioceras canadense Whiteaves (1903, pp. 65-67, figs. 1, 1a).
Cardioceras canadense Reeside, Jr. (1919, pp. 20, 21, Pl. 17, figs. 5-11).

The original description of this specimen given by Whiteaves is as follows:

"Shell, at least in its immature stage, compressed, shallowly and rather widely umbilicated, with a small and minutely crenulated keel.

Whorls about five, increasing rather rapidly in size and rather strongly embracing, about one-half the sides of the inner ones being covered by the overlap of those that succeed them. Umbilicus occupying about one-third of the entire diameter, on each side, though its margin is rounded and very indistinctly defined; peripheral carina neither very prominent nor distinctly compressed.

"Surface of each side of the outer volution marked with a few comparatively large and distant but narrow and acute primary radiating ribs, that commence at the suture and terminate about half-way across, in a small pointed tubercle. Of these ribs there are about ten in the specimen figured. Besides them there are rather more than twice as many small short secondary ribs, that are little more than narrow, transversely elongated, compressed and acute tubercles, on the outer half of each side. The primary ribs almost bifurcate from a median tubercle, and seem to occasionally alternate with an intercalated secondary rib, but the secondary ribs are not quite continuous with any of the primaries. Between the secondary ribs, also, and parallel to them, there are a few fine radiating raised lines.

"Sutural line unknown, as are also the exact shape and sculpture of the adult and the contour of the outer lip."

The interesting specimen is re-figured here.

John B. Reeside, Jr. (1919, pp. 20, 21, Pl. 17, figs. 5-11) has given a description of some American representatives of this species found in the Sundance formation of Wyoming. They all agree very well with the Canadian form. According to Whiteaves (loc. cit. p. 21) this species occurs also at Lillooet, British Columbia.

There seems to be some doubt about the exact locality where the Fernie specimen, the type of the species, was found. J. F. Whiteaves says: "Near the top of a ridge running North 20 degrees East and situated 2¼ miles North 70 degrees East from Fernie, B.C., about 4,000 feet above the sea level" whereas the label indicates "East of Fernie near Morrissey" (Morrissey is actually situated southeast of Fernie).

The specimen is embedded in a grit that does not appear to agree with the rocks hitherto known to occur in the Fernie. It is possible therefore, that this *Cardioceras* is from a loose boulder.

Genus *Kepplerites* Neumayr

The Fernie group has yielded some representatives of *Kepplerites* (*Seymourites*). McLearn (1928, p. 20, Pl. 4, figs. 1, 2) described a *Kepplerites* (*Seymourites*) as *Yakounites*[1] *mcevoyi* McLearn (*see* Plate XXXV, figures 2a, b) from Ribbon Creek, Kananaskis River, but the exact position of this form in the Fernie group at this locality is not known. The forms described in this paper are poorly or incompletely preserved. One of the specimens was found in the *Gryphaea* bed on the south slope of Grassy Mountain, others came from the Cascade River Valley near Banff.

[1]The generic name *Yakounites* was replaced by McLearn (1929, p. 4) with *Seymourites*.

Kepplerites (*Seymourites*) sp. indet. 1

Plate XXXIII, figures 2a, b

In the *Gryphaea* bed exposed on the Gold Creek road, south slope of Grassy Mountain, north of Blairmore, a whorl fragment of *Kepplerites* was found. In spite of some secondary compression that has affected the shape of the fragment to a certain degree, it can be stated that its venter is more or less flattened and that the flanks are only very little convex. The primary ribs are slightly bent backward. Below the middle of the flanks the ribs thicken and from this point the secondary ribs, which are finer than the primaries, arise. The secondary ribs cross the venter transversely. Apparently there are also intercalated ribs of the same size as the secondaries. No suture line is visible.

The poor state of preservation prohibits an accurate determination. The *Kepplerites* sp. indet. 2 from the Cascade River near Banff, described below, shows the same general type of ribbing but has apparently more widely spaced ribs.

In spite of the fact that no direct identification can be made, the presence of *Kepplerites* (*Seymourites*) in the *Gryphaea* bed is important from a stratigraphic point of view, as this group indicates a Lower Callovian age for the beds concerned.

Kepplerites (*Seymourites*) sp. indet. 2

Plate XXXI, figures 2a, b

In Cascade River Canyon near Banff, Alberta, some whorl fragments of *Kepplerites* were collected by R. L. Rutherford, P. S. Warren, S. Davies, and the writer.

The whorl fragment (Nr. Jr. 188) shown in Plate XXXI, figures 2a, b, which is in the collection of the Geological Department, University of Alberta, Edmonton, has a subquadrate, higher than wide whorl section. The venter is more or less flattened but becomes more rounded towards the end of the whorl. The flanks are apparently comparatively flat at the beginning of the whorl but become slightly more convex later with even transition to the rounded venter.

The primary ribs are bent slightly backward on the umbilical wall, on the flanks they are bent forward where they end in weak elongated tubercles, from whence the secondary ribs arise. These are weaker than the primary ribs. Between the secondary ribs, other ribs of the same size are intercalated. The secondary and the intercalated ribs are bent a little forward on the venter. The point where the primary ribs divide lies somewhat below the middle of the flanks. No suture line is visible.

This form has apparently the same type of ribbing as *Kepplerites* (*Seymourites*) *mcevoyi* McLearn (1928, p. 20, Pl. 4, figs. 1, 2) from Ribbon Creek (Pl. XXXV, figs. 2a, b), but no detailed comparisons can be made because the preservation of the Cascade River specimen is too unsatisfactory.

The poorly preserved whorl fragment described above as *Kepplerites* (*Seymourites*) sp. indet. 1 from the *Gryphaea* bed on Grassy Mountain seems to be closely related to the form from the Cascade River. The general shape of the ornamentation is the same but the primary ribs are more closely set in the Grassy Mountain form.

The small specimen (Jr. 527) (Plate XXXI, figure 3), collected by Warren in the Cascade River Canyon, is specifically undeterminable. It has a completely flat venter, as in *Kepplerites* (*Seymourites*) *mclearni* Imlay (cf. Imlay 1953, p. 25, Pl. 17, fig. 5) and other species of *Kepplerites*. This small specimen is possibly a young stage of the form described as *Kepplerites* (*Seymourites*) sp. indet. 2.

Genus *Procerites* Siemiradzki

Procerites engleri n.sp.

Plate XXXIX, figure 1; Plate XL, figures 1a, b

The large specimen figured (Plate XXXIX, figure 1) was found by Bruno Engler in the *Gryphaea* bed on the south slope of Grassy Mountain. It has a diameter of 280 mm. As it is crushed laterally no further reliable measurements can be given. The last preserved whorl is septate to the end and is almost smooth. Only the secondary ribs, which are bent forward slightly on the venter, are visible. On the preceding whorl the primaries are well developed. The point of their division into the secondaries is at about half the height of the flanks (*see also* Plate XL, figure 1a). The suture line is suspended and deeply incised.

Another specimen found in the same bed at the same locality is a little larger, but is also septate to the end of the last whorl, so that the development of the living chamber remains unknown.

Many more or less incomplete specimens and fragments that belong to younger stages of growth of the same form occur at this locality and at other places on Grassy Mountain where the *Gryphaea* bed is exposed. In some of these specimens the ribs are finer than in others. Not all secondary ribs arise by bifurcation, some are intercalated. Generally the ribs are slightly inclined forward. Deep constrictions occur (Plate XL, figure 1a).

This species seems to be closely related to *Procerites* sp. described by Imlay (1953, p. 33, Pl. 23, figs. 13, 17; Pl. 24, figs. 9, 10) from the Callovian of the western interior of the United States, but an identification is not possible on account of the very fragmentary character of the pictured specimens. *Procerites engleri* is a fairly frequent index fossil in the *Gryphaea* bed of the Blairmore and Adanac areas.

In association with this form occur small Perisphinctids (Plate XL, figures 2a, b; Plate XLI, figures 7-9b) with a diameter of about 20 to 40 mm. They differ from one another mainly in the type of ribbing. Some are finely ribbed (Plate XLI, figure 7); others have stronger ribs with small nodes at the point of bifurcation (Plate XLI, figures 9a, b). The relationship of these small forms to one another and to *Procerites engleri* n.sp. is unknown. Some of them may be young stages of this species. The finely ribbed form has also been found in a shaly facies at a locality west of Corbin.

The species name is given for Bruno Engler, well-known photographer and alpinist, Banff, Alberta.

Procerites ? sp. indet.

Plate XLI, figures 1-6

In the region southwest of Isola Peak and on Plateau Mountain many Perisphinctids occur in association with Cadoceratids. Most are preserved as imprints, but a few more or less complete specimens are found.

The umbilicus of this form which apparently did not reach the size of *Procerites engleri*, is comparatively wide. The whorls gently increase in height, each whorl embracing about one-half of the preceding one. The slope of the slightly convex flanks towards the umbilicus is gradual and low, the transition into the slightly rounded venter is gentle. The whorl cross-section is oval, higher than wide. Some specimens have well developed constrictions.

The ribs are distinct in all stages of growth. They are slightly bent forward and most of them are bifurcated somewhat above the middle of the height, the point of bifurcation just being covered by the next whorl. The ribs cross the venter at an obtuse angle which in some cases is only a little more than 90 degrees but which in others, may be considerably larger. Some of the specimens show a very faint interruption in the middle part of the venter but no real furrow is developed. In general the character of the ribbing is the same in most specimens. The number of primary ribs on one whorl has, however, been found to vary between thirty-eight and forty-six. None of the specimens collected showed the suture line.

This form seems to be related to *Procerites engleri*. In *Procerites engleri*, however, the ribs run almost straight across the venter whereas in this form they are angled. It is referred to *Procerites* only tentatively.

Some of the small specimens with a diameter of 20 to 40 mm. mentioned under *Procerites engleri*, may be young stages of growth of this form.

"Genus" *Titanites* Buckman

Titanites occidentalis n.sp.

Plates XLII, XLIII, XLIV

Most of this big ammonite is preserved as an imprint, only part of the last whorl appearing as a mould. The maximum diameter is about 137 cm., the width of the umbilicus about 62 cm.; and the cross-section about 33 cm. thick at a diameter of about 122 cm. The outer whorl apparently only slightly embraced the preceding one.

That part of the last whorl preserved as a mould, and that probably belongs to the body chamber, has about sixteen more or less worn ribs, and the part preserved as an imprint has eighteen. All ribs are slightly bent forward. All primaries are apparently bifurcated, the point of division being at about half of the height of the whorl. The space between the primaries on the mould is about 83 mm. and the space between the secondaries about 64 mm. A thickening of the ribs in the transition zone of flanks and venter was observed on the mould.

Gigantic ammonites comparable in size with this Fernie form are common in the Portlandian of England. Buckman (1919-21, vol. 3; 1922-23, vol. 4; 1925, vol. 5; 1925-27, vol. 6) subdivided these forms, which include the former groups of *Amm. giganteus* and *pseudogigas*, into a number of "genera". According to Spath, who discussed them briefly (1931, p. 472, 1936, pp. 31-37) most of these "genera" are synonyms and belong to his subfamily Pavlovinae.

A knowledge of the development of the inner whorls is important for the determination of these forms. Unfortunately they are missing in the Fernie specimen, but the strong, bifurcated ribs on its last whorl exclude all the fine ribbed forms of *Titanites* and its synonyms. Similar types of ribs seem to be developed in "*Gigantites*" *zeta* Buckman (1925, vol. 5, Pl. 452a, b), in "*Glottoptychinites*" *glottodes* Buckman (1922-23, vol. 4, Pl. 403), and in "*Glottoptychinites*" *audax* Buckman (1925-27, vol. 6, Pl. 717). Unfortunately all the specimens pictured by Buckman are much smaller than the Fernie form and a direct comparison cannot be made. The Fernie form is tentatively referred to "*Titanites*".

The ammonite, which could not be removed, lies on top of the lowermost Kootenay sandstone in Ammonite Gully, which joins Coal Creek east of the town of Fernie. The mould of the last whorl consists of material characteristic of the lower Kootenay sandstone.

PELECYPODA

Oxytoma cygnipes Phillips

Plate XVI, figures 1-5

1835. *Avicula cygnipes* Phillips, Pl. 14, figure 3.
1857. *Avicula cycnipes* Dumortier, p. 7, Pl. 4, figures 1-4.
1869. *Avicula cycnipes* Dumortier, pp. 294-297, Pl. 35, figures 6-9.

This form is the index fossil of the *Oxytoma* bed, which, in many places, caps the cherty limestones of the Nordegg member.

The specimens figured in Plate XVI, figures 1-4 are all from a mountain immediately south of Marble Mountain, and were collected by H. H. Beach. The other specimen (Plate XVI, figure 5) was collected by Evans on the forks of Ram River. All specimens are left valves, the right valve apparently being extremely rare.

Figures 1a and 1b illustrate well the general development of this species. It is well rounded with a prolonged, straight cardinal margin forming a more or less triangular ear. There are 5-6 strong ribs. Between these ribs are very fine radial lines that are crossed by still finer lines of growth. Most of the figures given are in perfect agreement with Dumortier's (1869, Pl. 35, fig. 6, pp. 294-297) illustration of this species. According to Dumortier this species occurs in the Middle Lias, zone of *Paltopleuroceras spinatum*.

Another species closely related is *Oxytoma longicostata* Strickland from the Lower Lias. Probably *longicostata* and *cygnipes* belong to a group of forms that range from the Lower to Middle Lias. McLearn (in Erdman, 1950, p. 82) has called the present Canadian form *Oxytoma* n.sp. cf. *cygnipes* Phillips and *longicostata* Strickland.

Aucella ex gr. *bronni* Rouiller

Plate XXXVIII, figures 4a, b

In the upper part of the Green beds, 9 feet below the Passage beds on Carbondale River, a fairly well preserved imprint of the left valve of an *Aucella* was found in 1951. The general outline of this form is similar to some varieties of *Aucella bronni* particularly *Aucella bronni* var. *lata* Trautsch. The sculpture of the Carbondale River specimen is characterized by well developed concentric folds and very fine radial lines of the same type as present in *Aucella bronni.*

All characteristics preserved in this specimen indicate close relationship to the *Aucella bronni* group. More specimens, however, are required before identification with a particular species of this group is possible. Associated with it are some other fragmentary imprints, also showing the characteristic sculpture of concentric folds and fine radial lines.

Aucella has never been found before in the Green beds, and the presence of this form is important as it helps to fix the age of this marker horizon.

GASTROPODA

"*Turbo*" *herniensis* n.sp.

Plate XXX, figure 3; Plate XXXI, figures 4a, b

Gastropods of turbinid aspect are fairly abundant in the Green beds at Blairmore and Alexander Creek but have also been found rarely in the equivalent dark shales with big concretions at Pocaterra Creek and Cascade River Valley below Bankhead. All these forms are unsatisfactorily preserved but belong apparently to a single species. The specimen from Cascade River (Plate XXXI, figures 4a, b) has, on the last whorl, seven clearly developed spiral ridges that are not visible on the cast. Faint tubercles and lines of growth are visible in some places. The same type of sculpture seems to be present in all the other specimens.

There is no described species with which this Fernie gastropod could be identified. The Nowaja Semlja form, described by Tullberg (1881, p. 9, Pl. 2, figs. 1-3) under the name *Turbo capitaneus* Münster, shows a similar sculpture but seems to have a higher spire. Spath's (1932, pp. 91, 92, Pl. 39, fig. 13) poorly preserved *Turbo* sp. indet. from the East Greenland Portlandian appears to resemble it closely, both in the general shape and sculpture, but detailed comparison cannot be made.

CHAPTER IV

DESCRIPTION OF SECTIONS

In this chapter are described the Fernie outcrops and sections that have formed the basis for the chapter on Regional Stratigraphy and Palæogeography. The sections described in the text are numbered 1 to 48. Some of the sections are illustrated by photographs (*see* Plates I to XIII). The stratigraphy of a number of them is shown in summary form in the thirteen columns of Figure 3. The described sections on which Figure 3 is based are shown in the following table:

Figure 3 Column	Numbers of sections from which column is derived
1	1, 2, 3, 4, 5, 6, 7
2	8, 9, 10, 11
3	15, 16
4	18
5	20
6	27
7	29
8	34
9	37
10	38
11	39
12	40
13	41, 42, 43, 44, 45, 46

Many of the sections have been measured by the writer, others are taken from the literature. Stratigraphic interpretation of the earlier published sections was in most cases possible on the basis of index fossils.

Section 1. ***Six to Seven Miles South of Fernie on the Road to Cranbrook***

About 85 feet of the lower Fernie is exposed in several road-cuts. It consists of dark, papery, shaly, or crumbling weathering, indurated shale with some hard bands or concretions. A single specimen of *Gryphaea* was found near the base of one of the outcrops (*see* Plate I).

Section 2. ***Hartley Creek***

This locality is on a lumber road that branches westward from the Natal-Fernie highway a few miles north of Fernie. Near the small salt lake on the north side of the road, rocks of the lower and middle Fernie are exposed about 250 to 300 feet above the Rocky Mountain formation. The contact of the Fernie with the underlying rocks is not exposed.

The lower Fernie at this locality consists of 150 to 200 feet of dark massive, platy, shaly, or crumbly weathering rock of the same type as developed on the Fernie-Cranbrook highway. No fossils were found. On top of the lower Fernie are 8 feet of hard bands with belemnites and a bed with pelecypods (*Trigonia*) 2 feet above the base. One *Stephanoceras* fragment indicates the age of this bed to be Middle Bajocian (Rock Creek member). Overlying these beds are about 85 feet of brownish weathering dark grey shale with some hard bands that did not yield any fossils. The lithology however, is that of the Rock Creek member.

There are several poor outcrops of Grey beds on the road between this locality and the Natal-Fernie highway, but the contact of these Callovian beds with the Bajocian Rock Creek member is not exposed.

Section 3. *Abandoned Phosphate Mine on Lizard Mountain*

At an abandoned Phosphate mine on the north slope of Lizard Mountain west of Fernie, loose lying phosphate nodules, characteristic of the lowermost part of the Fernie group, contain *Gryphaea rockymontana*, *Pecten* and other pelecypods. No outcrops are present at this locality.

At other places on the north slope of Lizard Mountain scattered fragments of calcareous sandstone with many pelecypods (particularly *Trigonia*), and belemnites, some gastropods, and a *Stephanoceras* were collected. They indicate the presence of the Middle Bajocian (Rock Creek member).

Section 4. *Spruce Creek*

The locality on Spruce Creek, on the west side of the Elk River Valley about 10 miles north of Fernie, contains, according to P. S. Warren (1931, p. 106), *Arnioceras telferi* Warren, *Lima columbiae* Warren, *Entolium*, and *Alectryonia*. This fauna belongs to the basal part of the Fernie group in this region.

Section 5. *Near Bridge immediately North of Fernie*

Near the bridge on the main road, close to the northern entrance to Fernie, grey shales with a greenish tinge are exposed on the Natal-Fernie highway. These grey shales are the same as the Grey beds exposed on the Coal Creek road east of Fernie. No fossils were found.

Section 6. *Coal Creek Road East of Fernie*

The Lower Callovian Grey beds are exposed on the Coal Creek road east of Fernie and on the railway tracks immediately below. The grey shales are indurated and highly compressed and some of the rocks are characterized by a greenish tinge. They are very similar to the Grey beds in Alexander Creek. Worm tracks were the only organic remains found.

Section 7. *Ammonite Gully East of Fernie*

This gully is formed by a small creek that runs into Coal Creek from the south. In the lower part of the gully the lower part of the upper Fernie Passage beds is exposed, consisting of dark grey rusty weathering shales with intercalated sandstone bands. Higher in the section, in the upper Passage beds, the sandstones increase in number and thickness. This part of the Passage beds is about 90 feet thick and is overlain by the massive, lowermost Kootenay sandstone, which is here about 40 to 50 feet thick. Only the upper 20 feet of this sandstone is exposed. On the surface of this crossbedded sandstone the big ammonite, here described as *Titanites occidentalis* n.sp., (Plates XLII, XLIII, XLIV) is embedded. It fixes the age of the sandstone as Upper Portlandian. The sandstone is overlain by a coal seam, but the contact is obscured by a thin covered interval.

Section 8. ***Fording River Area***

Rocks of the Fernie group are exposed in the Fording River area about 15 miles northwest of Michel (*see* Plate VII B). The upper part of the lower Fernie consists of the characteristic dark, indurated shale, well known from the Fernie area. It is overlain by about 60 feet (exposed) of brownish, rusty weathering shale with some layers of bentonite and with some very big concretions. One of these, about 50 feet above the lower Fernie, yielded about a dozen Stephanoceratids which indicate that these beds are of Middle Bajocian age and belong to the Rock Creek member. Farther downstream the grey indurated shales of the Callovian Grey beds appear in the same facies as described from the Fernie area, Alexander Creek, and Tent Mountain. Only one belemnite was found. The thickness could not be measured. Fernie horizons younger than the Grey beds were not observed.

Section 9. ***Alexander Creek***

This locality (Plate XI A, Figure 3, column 2) is 13 miles north of the Coleman-Michel highway and is accessible by motor car by a logging road. The complete Fernie section could not be measured accurately because some of the beds are concealed or repeated by faults. The lower Fernie, which consists of dark indurated shale, rests on the Triassic Spray River formation; the contact and the basal Fernie bed with *Gryphaea rockymontana*, observed 10 miles to the southeast at the Crow Phosphate Mine, are, however, not exposed. Higher in the section dark brownish shale with some hard bands are present. These beds are comparable to the Rock Creek member and are overlain by the Grey beds characterized by grey calcareous, somewhat sandy, indurated shale with belemnites. Above the Grey beds the dark indurated shale of the lower Fernie is repeated by a fault. The exposed thickness is about 170 feet. The real thickness may be greater, as the lower part of the lower Fernie shale and its contact with the Spray River formation are missing in this part of the section. Above the lower Fernie are about 85 feet of dark brownish shale, which probably belongs to the Rock Creek member and which is overlain in normal succession by about 225 feet of Grey beds that form a steep cliff and that are easily recognizable from a distance (*see* Plate XI A). The lithology is the same as that of the Grey beds in the Fernie area. Some hard bands, occasionally with numerous belemnites, are present in the upper part of the Grey beds, which are overlain by about 12 feet of green glauconitic sands with some yellowish brown concretions. These Green beds have yielded "*Turbo*" *ferniensis* n.sp. and belemnoids.

A fault seems to be present between the Green beds and the lower part of the Passage beds that overlie them, but apparently no important part of the normal section is missing. The Passage beds show the typical development with a lower more shaly part and an increasing number of intercalated sandstone bands in the upper part. The total thickness of the Passage beds is about 195 feet. They are overlain by the Kootenay sandstone.

Section 10. ***Crow Phosphate Mine***

The abandoned Crow Phosphate Mine, about 2½ miles northwest of Crowsnest station, is easily accessible by motor car on a small road branching off the Coleman-Michel highway. Only the lowermost part of the Fernie is exposed. It consists of dark shales with phosphate nodules. The shales are in contact with platy sandstones of the Triassic Spray River formation. At the contact is a layer containing numerous specimens of *Gryphaea rockymontana* Warren. Warren (1931) also mentions *Arnioceras* sp., *Pleuromya* sp. indet., and *Pleurotomaria* sp. indet. from this locality. Some pieces of fossil wood were found in 1952.

The section is somewhat disturbed (L. Telfer, 1933), some faults causing repetition of the beds, but there cannot be any doubt that the bed with *Arnioceras* and *Gryphaea rockymontana*, which is on top of the Spray River formation, is equivalent to the basal Fernie beds with *Arnioceras telferi* Warren and pelecypods in the Fernie area.

This fossiliferous basal Fernie horizon is apparently concealed in the Alexander Creek section that lies about 10 miles farther to the northwest.

At the Crow Mine a hard band of a sandy limestone filled with small pebbles, belemnite fragments, and small indeterminable pelecypods was found in 1950. This bed probably belongs to the basal Fernie zone. However the true stratigraphic relations can no longer be clearly seen in these abandoned workings.

Section 11. ***Crowsnest Railway and Road Sections***

About 3 miles west of Crowsnest station the railway cuts through both the lower part of the Rock Creek member and the dark indurated shale of the lower Fernie. On the road nearby the lower part of the Fernie is exposed. The two exposures are separated from each other by the deep valley of Michel Creek.

In this section, which is disturbed by folding and faulting, the very base of the Fernie is not exposed. In the dark indurated shale of the road section some poorly preserved specimens of *Arnioceras* occur, which indicate a Sinemurian age, but unfortunately no fossils were found higher up in the shale beds.

The contact of the dark indurated shale with the overlying Rock Creek member is characterized by 3 feet 5 inches of bluish grey rock overlain by 4 feet 5 inches of hard band with belemnites. Younger parts of the Rock Creek member were not observed in this section.

Section 12. ***Phosphate Mine 6·2 Miles from Gillivray Station***

The lowermost beds of the Fernie are poorly exposed at an abandoned Phosphate Mine 6·2 miles from Gillivray Station on the road to Corbin. The Fernie there rests on the Triassic Spray River formation. The contact, however, is not exposed. The rock consists of dark indurated shale with phosphate nodules. The frequent occurrence of *Gryphaea rockymontana* Warren indicates a Sinemurian age and shows that these beds are of the same age as the lower Fernie beds in the Fernie area, in the Crowsnest road section, and at the Crow Mine.

Section 13. ***Tent Mountain***

On Tent Mountain about 2 miles north of Corbin, on the road to the strip mine, the typical indurated shales of the Grey beds are exposed in various outcrops, thus indicating the presence of this facies of the Callovian. They are overlain by typically developed Green beds which consist of glauconitic sands with yellowish brown bands or concretions, and plentiful fragments of fossil wood and belemnites. The exposed thickness of the Green beds is about 42 feet. The Green beds are overlain by the Passage beds. Near the contact many ball-like concretions occur. Concretions of this type have been found at this horizon at many places in the Alberta Foothills.

Section 14. ***Corbin***

B. R. MacKay (1931a, p. 158A) reported the presence of the Fernie group in the first gully southeast of Corbin townsite. A restudy in 1952 and 1953 revealed the presence of the dark indurated lower Fernie shale, of the dark brownish shale with hard bands and belemnite battlefields of the Rock Creek member, and of the indurated grey shales with a greenish tinge that form the Grey beds of the Callovian. Part of the section is covered so that the real thickness could not be measured. It is, however, much less than the 2,800 feet mentioned by MacKay (1931a, p. 158A).

The "basal conglomerate" described by MacKay (1931a, p. 158A) does not belong to the Fernie. Beds higher than the Grey beds were not observed but are exposed in the Tent Mountain section described above.

Section 15. ***Adanac Strip Mines***

Good outcrops of the Fernie group are located on the road to the Adanac strip mines which crosses the southernmost continuation of the Turtle Mountain anticline. This road section was measured previously by Clow and Crockford (1951, pp. 20, 21). Their description is in general agreement with the following description. During the investigation carried out by the writer the presence of the Callovian *Gryphaea* bed and of some index fossils in the lower part of the section was demonstrated. Further outcrops occur on side roads that branch off the main road. All the outcrops are easily accessible by motor car from Hillcrest. Column 3, Figure 3 illustrates the stratigraphy of section 15.

The contact of the lower Fernie with the underlying Palæozoic is exposed on the east side of the south end of the Turtle Mountain anticline (*see* Plate III B). The lowermost Fernie beds consist of 2 feet of dark, somewhat phosphatic sandstone with chert pebbles overlain by about 30 feet of dark papery shale. Many belemnites and very poorly preserved pelecypods occur at about 15 feet above the basal sandstone. Some 5 feet higher in the section a thin calcareous band within the shale yielded a

Gryphaea and a poorly preserved *Hammatoceras* (?) which indicates a Toarcian age. The Lower Lias, which is present in the Fernie, Alexander Creek, and Crowsnest areas, seems to be entirely absent. Along the road to the northeast towards Hillcrest, the section is concealed. Above this interval are exposed the grey shale with sandstone bands characteristic of the *Corbula munda* beds in Grassy Mountain, the *Gryphaea* bed and, at the junction of the Adanac strip mine road and the southgoing Webb Creek road, the dark shale with sandstone intercalations of the Passage beds. The *Gryphaea* bed is particularly rich in fossils, predominantly *Gryphaea impressimarginata* McLearn. This section on the east side of the anticline has suffered moderate tectonic disturbance.

On the west side of the anticline the contact of the Fernie with the Palæozoic is concealed but the dark lower Fernie shales are exposed. In one of the hard bands intercalated in the shale a poorly preserved ammonite was found. Above this dark lower Fernie shale, which belongs to the Upper Lias and which has an approximate total thickness of 30 feet, is a concealed interval of about 10 feet. Above this interval dark, brownish weathering fissile shales about 120 feet thick are exposed. No fossils were found but the shales may represent the Bajocian Rock Creek member. This horizon is overlain by about 270 feet of brown shale, the lower part of which is calcareous with numerous hollow, light nodules. The upper part is somewhat silty. No fossils were found in these beds. They are overlain by sandy limestones with some pelecypods and fragments of indeterminable ammonites that are the equivalents of the Lower Callovian *Corbula munda* beds in the Blairmore region.

At this point a road branches off to the right along which the upper part of the Fernie can be studied, there being a concealed interval of 250 feet in the section along the main road that goes to one of the Adanac strip mines. The uppermost part of the *Corbula munda* beds consists of sandy shale with fine shell fragments and poorly preserved *Cadoceras* overlain by 4 feet 6 inches of hard calcareous sandstone with *Inoceramus*, *Pecten*, *Trigonia*, belemnoids, and ammonoids. Immediately overlying this bed is the *Gryphaea* bed (not exposed in the section described by Crow and Crockford, 1951, pp. 20, 21), which consists almost exclusively of shells of *Gryphaea impressimarginata* McLearn and which is 2 feet thick. There are about 60 to 100 feet of brownish weathering shales above the Callovian *Gryphaea* bed, which is overlain by poorly exposed, green, glauconitic sandstones and shales, the Green beds. In the section measured by Crow and Crockford on the main road the Green beds are 60 to 65 feet thick. These beds are very poorly exposed and no fossils were found. Above the Green beds are the Passage beds, about 150 to 180 feet thick, which are fairly well exposed on both the main road and the side road. The lower part consists of dark grey shale with thin sandstone bands but in the upper part the sandstone beds gradually increase in number and thickness to a maximum of 3 feet 6 inches. They are topped by the lowermost Kootenay sandstone. With the exception of some doubtful worm tracks no fossils were found in the Passage beds.

The thickness of the Fernie group in the vicinity of the Adanac strip mines is about 800 feet.

Various members of the Fernie group are exposed on other mine roads in this area.

Section 16. ***Carbondale River***

This locality is easily accessible by motor car from Hillcrest on the Byron Creek and Webb Creek roads. The Fernie outcrops are in the banks of the Carbondale River on both sides of the junction of the Webb Creek road with the east-west Pincher Creek road. The beds are disturbed by faulting and folding, so that accurate thicknesses cannot be measured. This locality was described by McLearn (1929, p. 84). The Passage beds, Green beds, and the *Gryphaea* bed are all exposed.

The Passage beds show the usual development, more sandy in the upper and more shaly in the lower part; one belemnite was found. The Green beds consist of about 40 to 50 feet of glauconitic sandstone with some hard bands. There are numerous belemnoids and plant fragments, a few largely undeterminable pelecypods, and scattered vertebrate remains. Nine feet below the contact with the Passage beds an *Aucella* ex gr. *bronni* Rouiller was found, indicating an Oxfordian age for these beds. About 300 feet farther downstream the *Gryphaea* bed is exposed. It consists almost exclusively of specimens of *Gryphaea impressimarginata* McLearn and is topped by a belemnite bed. The *Gryphaea* bed and the Passage beds are also exposed on the Webb Creek road.

No strata older than the Lower Callovian *Gryphaea* bed are exposed on the Carbondale River.

Section 17. ***Blairmore***

The Fernie is exposed in the shale quarries south of the railway tracks at Blairmore, on the western limb of the Turtle Mountain anticline, but there is no continuous section. Shales of the middle Fernie with belemnoids are exposed in the eastern quarry and the Green beds and the lower part of the Passage beds in the western quarry. The *Gryphaea* bed and the *Corbula munda* beds are not exposed but there are loose boulders containing the typical fauna of the *Gryphaea* bed, as already stated by McLearn (1929, pp. 84, 85). The glauconitic sandstones with reddish brown concretions of the Green beds contain belemnoids and "*Turbo*" *ferniensis* n.sp. Some belemnoids were found in the lower Passage beds. Another outcrop of Passage beds is at the foot of the southeastern slope of Bluff Mountain, north of the former Rocky Mountain sanatorium.

Section 18. ***Grassy Mountain***

The classic Fernie outcrops on the south slope of Grassy Mountain, about 4½ miles north of Blairmore (*see* Figure 3, column 4), are easily accessible by motor car on the roads to the strip mine. Since McLearn (1929) studied the Jurassic sequence in the "Railway section", several mine roads have been constructed which expose great parts of the Fernie. The best outcrops are on the west side of the south slope of Grassy Mountain where, along three unused roads, there is a continuous section from the *Corbula munda* beds up to the Kootenay formation. The roads are parallel to one another at different levels of the mountain and are roughly vertical to the strike of the beds.

The sequence from top to bottom of this section is as follows (*see* Plate IX which depicts the *Corbula munda* and *Gryphaea* beds of this section):

Kootenay sandstone

	Thickness Feet	Thickness Inches
TOP OF PASSAGE BEDS		
Shale; sandy; three hard, 2-foot thick sandstone bands	17	6
Sandstone; hard, greyish brown, brown weathering	2	0
Shale; sandy, grey; sandstone bands	99	0
Shale; dark grey; thin sandstone bands	88	0
BASE OF PASSAGE BEDS		
Shale; dark	8	0
Hard brownish band	2	0
Shale; dark grey, brownish weathering; some bands of bentonite. About 60 feet above base indication of GREEN BEDS (Oxfordian)	66	0
Shale; brownish grey, silty; similar to underlying shale; small pelecypods	3	4
Shale; as above; *Procerites*, belemnoids, and a few pelecypods; Lower Callovian	3	6
Shale; as above, with *Lilloettia imlayi* n.sp. and numerous belemnoids; "belemnite horizon"; Lower Callovian	1	6
Sandstone; hard, greyish blue, calcareous, fine grained; very fossiliferous; pelecypods (particularly *Gryphaea impressimarginata* McLearn), ammonoids (*Procerites engleri* n.sp.) and belemnoids. *Gryphaea* BED (*sensu stricto*). Lower Callovian	4	0
TOP OF *Corbula munda* BEDS		
Shale; bluish and brownish grey, more or less silty, commonly with a characteristic greenish tinge; bands of fine grained, hard, calcareous sandstone up to 1 foot 6 inches thick as illustrated in Plate IX. Pelecypods of the *Corbula munda* fauna observed in the hard sandstone bands from about 70 feet below the *Gryphaea* bed upward; ammonoids (*Cadoceras lillei* n.sp., *C. muelleri* Imlay, *C.* ex gr. *victor* Spath "*Miccocephalites*", "*Metacephalites*" and others) in the upper 35 feet of these beds (Lower Callovian)	99	0

East of this section there is a concealed interval of several hundred feet between the lower exposed part of the *Corbula munda* beds and the lower part of the Fernie exposed in the core of the anticline in the old railway-cut.

On the east side of the south slope of Grassy Mountain the *Corbula munda* beds, *Gryphaea* bed, and Passage beds are exposed on the Gold Creek road. However, as part of the sequence is missing on this side of the anticline due to disturbances, accurate thicknesses of the various beds cannot be measured. The *Gryphaea* bed is exposed at three points on the road and shows the characteristic subdivision into the *Gryphaea* bed (*sensu stricto*) and, above it, the "Belemnite horizon". The characteristic pelecypod fauna, belemnoids, and the following ammonoids were collected: *Lilloettia imlayi* n.sp., *Xenocephalites* cf. *bearpawensis* Imlay, *Kepplerites* (*Seymourites*) sp. indet., and *Procerites* sp. indet.

The lowermost part of the Fernie, the basal conglomerate that rests on Palæozoic quartzite, is exposed along the base of the north slope of Bluff Mountain. It is 6 inches thick and consists mainly of chert pebbles. Above the basal conglomerate are dark grey, hard, platy sandstones, about 100 feet thick, which are also exposed in the Grassy Mountain railway section (*see* Plate VI A). No fossils were found in these beds, which are overlain by McLearn's "Lille member", a calcareous grit with *Chlamys mcconnelli* McLearn and various species of *Lima*, *Alectryonia*, and *Gryphaea*. In the railway section 6 feet of the Lille member is exposed. These beds are also present in the valley between Grassy and Bluff Mountains, where a thickness of 18 feet was measured.

The section exposed on Grassy Mountain is almost complete. Only the part between the Lille member and the *Corbula munda* beds is concealed. This concealed part consists apparently of shale that probably contains the equivalents of the Middle Bajocian Rock Creek member.

Section 19. ***Rock Creek near Frank***

At this locality beds of the lower and middle Fernie are exposed. They form a slightly overturned syncline with the middle Fernie in the centre. On its western limb, the Carboniferous rest on top of the inverted lower Fernie. This is the type locality of Warren's "Rock Creek member".

The lower Fernie rests stratigraphically on the Carboniferous and consists, at the base, of a fossiliferous bed about 1 foot 6 inches thick, with ammonite fragments, *Gryphaea*, *Pleuromya*, Gastropods, and vertebrate remains. This fossil horizon is overlain by about 40 to 50 feet of dark shale and more than 50 feet of platy sandstones, comparable to the basal Fernie sandstones in the old railway section on the south slope of Grassy Mountain. In these sandstones one indeterminable ammonite was found. On top of the sandstones is the Middle Bajocian Rock Creek member, with its typical faunal elements. Beds younger than the Rock Creek member are not exposed at this locality.

Section 20. ***Daisy Creek Summit***

This locality is in the Fernie band that borders the western slope of Livingstone range. It is about 6 miles northeast of the Gold Creek road outcrops on the south slope of Grassy Mountain.

The succession at this locality is almost complete, only the middle part of the Fernie being concealed (*see* Figure 3, column 5).

The section is as follows (*see* Plate X for upper part):

Basal Kootenay sandstone

TOP OF PASSAGE BEDS	Thickness Feet	Inches
Sandstone; slightly calcareous; upper and lower part massive, middle part platy	2	6
Shale; dark, with sandstone bands	2	0
Sandstone; massive	0	8
Shale; dark, with sandstone bands	1	0
Sandstone; massive	1	0
Shale; dark, with sandstone bands	2	0
Sandstone; platy weathering	2	0
Shale; dark, with sandstones	1	0
Sandstone; platy	1	0
Shale; dark, with platy sandstone	5	2
Sandstone	0	3
Sandstone; platy, with shale	1	6

	Thickness Feet	Inches
Shale; dark, with sandstone layers	3	0
Sandstone; hard	0	2
Shale; dark, with thin-bedded sandstones	5	0
Sandstone; platy	0	6
Shale; dark, with platy sandstone	1	0
Sandstone; platy	0	4
Shales; dark, with some sandstone bands	0	8
Sandstone; thin plated	0	9
Shale; dark, interbedded with sandstones	6	0
Shale; dark, with three layers of sandstones, each 3" thick	1	0
Shale; dark, interbedded with sandstone bands	12	0
Shale; dark with about eight sandstone bands, each 2" thick	10	0
Sandstone; platy; red weathering	0	6
Shale; dark	2	0
Shale; dark, with two bands of sandstone	1	0
Shale; dark, with thin layers of sandstone	2	6
Shale; hard, calcareous	0	6
Shale; dark, with thin sandstone beds	6	0
Sandstone layers; intercalated with shale layers 1" thick	1	6
Shale; dark, with thin sandstone beds	5	0
Shale; dark, with several 3-inch sandstone beds	3	0
Shale; dark, with two 4-inch sandstone beds	1	0
Shale; dark, with several 2-inch sandstone beds	2	6
Shale; dark, with thin sandstone beds	18	0
Shale; dark, reddish weathering	1	0
Shale; dark	40	0
BASE OF PASSAGE BEDS		
TOP OF GREEN BEDS (OXFORDIAN)		
Ironstone concretions	0	9
Shale; dark greyish brown	2	0
Ironstone concretions	0	9
Shale; greyish brown, fissile	1	0
Ironstone concretions	0	10
Shale; bluish green, buff weathering, hard, calcareous forming a cliff; belemnoids	25	0
BASE OF GREEN BEDS (OXFORDIAN)		
Shale; dark grey, fissile, with some thin harder bands	28	0
TOP OF *Gryphaea* BED (*sensu lato*) (LOWER CALLOVIAN)		
Shale; grey, rusty weathering; *Gryphaea* and many belemnoids; Belemnite horizon	2	0
Hard, bluish grey, calcareous band with many *Gryphaea impressimarginata* McLearn and other pelecypods, particularly in upper part of bed. *Gryphaea* bed (*sensu stricto*)	2	0
BASE OF *Gryphaea* BED (LOWER CALLOVIAN)		
TOP OF *Corbula munda* BEDS (LOWER CALLOVIAN)		
Shale; grey	2	0
Hard band	0	3
Shale; grey	2	0
Hard band	0	9
Shale; greyish brown with greenish tinge; some hard bands a few inches thick	11	0
Sandstone; hard, calcareous	1	0

	Thickness Feet	Inches
Shale; grey and greyish brown, some beds with greenish tinge like that of the *Corbula munda* beds in Grassy Mountain; lower boundary concealed	130	0
Concealed interval, possibly including Rock Creek member.		
TOP OF LOWER FERNIE (LIAS)		
Sandstone; platy; no fossils found	24	0
Shale; calcareous; dark in lower and greyish brown in upper part	50	0
Hard band with *belemnites*, a few pelecypods, and *Peronoceras* cf. *subarmatum* Young and Bird. Toarcian	0	8
Shale; dark grey, calcareous	26	0
Basal conglomerate; few gastropods, ? *Pleuromya;* chert pebbles.		
BASE OF FERNIE GROUP		
Palæozoic.		

Section 21. ***Livingstone Gap***

This locality is on both banks of the Oldman River in the eastern Fernie band bordering the Livingstone range, sec. 33, tp. 10, rge. 3. It is easily accessible by motor car.

This section (*see* Plate VI B), which comprises both the lower and middle Fernie, was measured by Douglas (1950, p. 20) and restudied by the writer during the 1950 field season.

UPPER PART OF FERNIE GROUP CONCEALED	Thickness Feet	Inches
Shale; dark grey, fissile with some hard limestone bands and big concretions; poorly exposed; belemnoids. Probably upper part of Rock Creek member and lower part of Grey beds . . . About	140	0
Bentonite	0	6
Limestone; massive, dark; "Belemnite battlefields". *Stephanoceras*, *Teloceras*, *Chondroceras*, pelecypods. Middle Bajocian Rock Creek member	3	0
BASE OF ROCK CREEK MEMBER (MIDDLE BAJOCIAN)		
Sandstone; black, platy, fine-grained, slightly calcareous; similar to lower Fernie sandstones at Daisy Creek Summit . . . About	65	0
Shale; dark, calcareous; mostly covered; similar to lower Fernie shale at Daisy Creek Summit; fossil concentration consisting of gastropods and pelecypods (*Gryphaea*, *Pleuromya*, and others) at base About	35	0
BASE OF FERNIE GROUP (LIAS)		
Underlying beds Rocky Mountain formation, perhaps with a few feet of Triassic.		

About 1·5 miles downstream from this locality, on the north bank of Oldman River (sec. 3, tp. 11, rge. 3), Douglas (1950, p. 20) found the upper part of the Fernie exposed. Typically developed Passage beds can be seen, which grade from grey shales with intercalated, thin-bedded sandstone bands into more sandy beds overlain by the Kootenay sandstone.

Section 22. ***Southwest of Isola Peak***

This locality is in the Fernie band southwest of Isola Peak about 4 to 5 miles west of Kananaskis-Coleman highway. It can be reached by a narrow pack-trail.

The Callovian Grey beds are exposed there in various outcrops, but, as they are repeated several times and are in part concealed, no thicknesses could be measured. They consist of dark grey, fissile shales with reddish clay ironstone concretions and some hard calcareous bands with cone in cone structure. The same facies is developed on the east side of Plateau Mountain. The concretions contain numerous ammonoids (*Procerites*, Cadoceratids) and a few *Inoceramus*.

No contact with the underlying rocks was observed during the limited time available in this area.

Section 23. ***Plateau Mountain Area***

This locality, on the east side of the Livingstone range, is close to the Kananaskis-Coleman highway on the road to Nanton. There the Fernie group is much disturbed and no continuous section could be measured. Some outcrops of lower Passage beds appear directly on the road and the Callovian Grey beds are exposed on a hillslope a little off the road, where they are overlain by Palæozoic rocks. The Grey beds consist of grey shales with some calcareous bands showing cone in cone structure and ironstone concretions. Many of these contain impressions or specimens of ammonoids (*Procerites*, *Cadoceras* ?) and *Inoceramus*. Belemnoids are common at certain horizons. Both the lithological facies and the type of fauna are similar to those of the Grey beds in the area south of Isola Peak. There is no indication of the Callovian *Gryphaea* beds, so well developed in the Grassy Mountain, Blairmore, and Adanac regions.

Section 24. ***Wilkinson Creek Area***

In the Mesozoic band on the west side of Plateau Mountain, about 33 miles north of Livingstone Gap, the Kootenay formation is exposed in a road-cut on the Kananaskis-Coleman highway. Close to this locality, in a small creek coming from the east, the platy sandstones of the upper part of the lower Fernie, the Middle Bajocian Rock Creek member, and the Callovian Grey beds are exposed. Most of the section is concealed.

The platy sandstones of the lower Fernie are very similar to the platy sandstones at the Livingstone Gap. No fossils, other than worm ? tracks, were found in this horizon.

The Rock Creek member, which consists of dark grey rusty weathering shale with about four hard limestone bands with pyrite, yielded some Stephanoceratids, belemnoids, and *Inoceramus*, and other pelecypods.

The Grey beds, which are very poorly exposed at this locality, seem to be of the same character as the Grey beds exposed on Plateau Mountain.

Section 25. ***Burns Mine***

Burns coal mine is situated on the western side of the Highwood Range on Sheep River, north of Gibraltar Mountain. It is accessible from Turner Valley by a road along Sheep River. The last part of the road is very poor.

A fairly good section is exposed on the west side of the Highwood range, about 1½ miles south of Burns Mine. It was measured by Allan and Carr (1947, p. 21) and is given in an abridged form below (comments by the writer are in italics):

	Thickness Feet	Inches
Overlying beds: Kootenay formation.		
Sandstone; brown-grey, light brown weathering, finely crossbedded. *Upper Passage Beds*	91	0
Sandstone; similar to above; interbedded with grey to brownish, sandy shale, sandstone decreasing downwards; plant fragments; pelecypods 110 feet below top. *Lower Passage Beds*	141	0
Shale; grey, sandy, with ironstone nodules and thin, finely cross-bedded sandstone. *Probably equivalent to upper part of Callovian Grey beds*	81	0
Shale; dark grey to dark brown and sandy shale with minor ironstone	65	0
Shale; black, fissile	84	0
Shale; olive-grey, fissile, with yellow weathering limestone lenses to 1' in thickness. *Probably equivalent to lower part of Callovian Grey beds*	46	0
Shale; black, fissile; weathering to thin flakes with large, dark grey orange weathering limestone concretions in upper hundred feet; occasional belemnites near base. Transition *between Grey beds and Rock Creek member*	155	0
Rock Creek member. *Middle Bajocian*	47	5
Siltstone; calcareous, dark grey, highly fossiliferous	4	0
Siltstone; light grey and silty shale with belemnites; phosphate nodules at base	28	0
Sandstone, with abundant pyrite; belemnites; black phosphate nodules to ¼"	1	5
Sandstone; hard, black, medium-grained, thin-bedded, calcareous; worn belemnites at base	14	0
Shale; black to dark brown, fissile, calcareous, with interbedded limestone bands. *Probably Toarcian*	35	0

Contrary to the conditions in Canyon Creek, Moose Mountain area, the Burns Mine section is more complete in so far as the Callovian seems to be represented there by the Grey beds in a similar facies to that in the Plateau Mountain region farther to the south. On the other hand the dark shales with big concretions on top of the Grey beds in the Ribbon Creek and Cascade River sections, the equivalent of the Green beds in the southern foothills, are missing in the Burns Mine section. They are also absent in Canyon Creek but are present about 9 miles northwest of Burns Mine in Pocaterra Creek below Elpoca Mountain.

Section 26. ***Ribbon Creek***

In the bed of Ribbon Creek, close to the Kananaskis coal mine village, most of the members of the Fernie group are exposed. However, as some of the contacts are concealed and faults are present it is not possible to measure accurate thicknesses. The locality is accessible by motor car on the Kananaskis-Coleman highway.

Close to the houses of the mining town the Triassic Spray River formation is exposed. Somewhat farther upstream dark to black hard limestone bands alternating with black shales form the base of the Fernie. They rest on platy sandstones of the Spray River formation. The basal Fernie bed is overlain by poorly exposed black platy shales that probably belong to the Toarcian. Beyond a covered interval yellowish to brownish weathering shale and about 2 feet of calcareous, resistant sandstone is exposed. This sandstone is very fossiliferous. The fauna, which consists mostly of ammonoids (Stephanoceratids), belemnoids, and pelecypods, is typical of the Rock Creek member and indicates a Middle Bajocian age. Above this sandstone are about 100 to 150 feet of dark shale, probably still a part of the Rock Creek member.

This part of the Ribbon Creek section from the base of the Fernie up to, and including, the Rock Creek member agrees very well with the corresponding part of the Fernie section measured by Crockford (1949, p. 24) on Mount Allan.

In Ribbon Creek the dark shale of the Rock Creek member is overlain by the Grey beds which at this locality consist of hard, dense, calcareous sandstones (Crockford's "Pigeon Creek member" of the Mount Allan section) and grey silty shale with numerous thin sandstone bands (*see* Plate XII B). These Grey beds have the same development as the Grey beds in the Cascade River section below Bankhead, but in Ribbon Creek the normal succession of the various horizons is somewhat concealed due to structural disturbances. In the Cascade River section Callovian ammonoids, *Arcticoceras* and *Seymourites*, were found. In Ribbon Creek they have not been observed in situ, but *Seymourites mcevoyi* McLearn (1928), that was probably found in this section, may have been derived from these Grey beds. The same lithology of the Grey beds, which includes the sandstones of the Pigeon Creek member is also developed north of the Cascade River section on the road to Stoney Creek but south of Ribbon Creek the Pigeon Creek member sandstones seem to be absent.

In Ribbon Creek the Grey beds are overlain by dark shale with numerous big, yellowish brown weathering concretions. The same beds were observed in the Cascade River section in the same stratigraphic position. Younger than these beds are the Passage beds, which have their normal development: shale with thin sandstone intercalations in the lower part and increasing amounts of sandstone in the upper part. They are also exposed on the road to the strip mine where they are capped by the lower Kootenay sandstone.

Section 27. ***Canyon Creek, Moose Mountain Area***

In this area, which is accessible by motor car from Bragg Creek, a Fernie section is exposed 1·5 miles from the mouth of Canyon Creek.

The Fernie succession at this locality (*see* Plate V and Figure 3, column 6) is remarkably thin; only about 220 feet. This thinning affects all members of the sequence and is in no way attributable to post-Fernie erosion.

The section previously measured by Hume (1930, p. 4b) and Beach (1943, p. 34) was restudied by the writer in 1950; the details are as follows:

Kootenay formation

EROSIONAL CONTACT TOP OF PASSAGE BEDS	Thickness Feet	 Inches
Sandstone; soft, bedded, slightly calcareous; light brown weathering; plant remains	9	0
Shale; brown	0	6
Sandstone; soft, platy, slightly calcareous; light brown weathering	11	0
Shale; dark greyish weathering	2	0
Sandstone; hard, light brown weathering	2	0
Sandstone; platy, dark grey to brown	1	0

	Thickness Feet	Inches
Shale; carbonaceous, sandy, dark brown	1	0
Sandstone with plant remains; brown weathering	0	2
Shale; carbonaceous, sandy, dark brown	0	11
Sandstone; dark, brown weathering	2	0
Shale; sandy, carbonaceous, dark greyish brown; hard, brown sandstone beds about 3" thick	13	0
Sandstone; brown	0	9
Shale; sandy carbonaceous, dark greyish brown with thin bands of sandstone as above	62	0
BASE OF PASSAGE BEDS		
TOP OF ROCK CREEK MEMBER (MIDDLE BAJOCEAN)		
Shale; dark grey, calcareous; large limestone concretions containing ammonoids (*Stephanoceras*) and a few pelecypods	2	0
Shale; dark, fissile; pyrite nodules and several beds of 'belemnite battlefields'	37	0
BASE OF ROCK CREEK MEMBER		
TOP OF TOARCIAN		
Shale; dark, upper part with some thin sandy limestone bands, lower part platy weathering (paper shale); *Dactylioceras* aff. *commune*, *Harpoceras* cf. *exaratum* and *Harpoceras* sp. found almost throughout; uppermost part small pelecypods and *Discina*. About	74	0
Limestone; black, phosphatic, alternating with black phosphatic shale; chert pebble conglomerate	5	0
BASE OF TOARCIAN		

EQUIVALENTS OF PART OF SPRAY RIVER FORMATION (?) OR PALÆOZOIC

In this section the equivalents of both of the Callovian Grey beds, and of the Oxfordian Green beds are missing. These beds occur between the Rock Creek member and the Passage beds at other localities where they normally average about 400 feet in thickness. The small thickness of the Fernie group at Canyon Creek is due largely to the absence of these Callovian and Oxfordian strata and to the thinning of the Rock Creek member and the Passage beds.

Section 28. ***Spray Falls***

Parts of the Fernie group outcrop just above Upper Spray Falls, southeast of Canmore. The locality is accessible by motor car in dry weather by a very poor road.

Details of the section, which is largely concealed making the measurement of thickness impossible, are as follows:

Passage beds. Developed in similar facies to that farther south
Dark shale with big concretions (equivalent of the Oxfordian Green beds), similar development to that at Cascade River, Ribbon Creek, Pocaterra Creek and other localities
Grey beds (Callovian), concealed
Rock Creek member (Middle Bajocian), concealed
Lower Fernie (Lias). Black shale with fossil remains.

Section 29. ***Cascade River Valley***

The main locality in the Cascade River Valley is below the abandoned mining town of Bankhead, on the road from Banff to Lake Minnewanka.

The section (*see* Figure 3, column 7) is exposed on both sides of the river, but is much disturbed and in part concealed. No reliable measurements of the thicknesses could be made. Parts of the concealed members of the Fernie are poorly exposed in gravel pits and other outcrops near the road.

The section is as follows:

	Approximate thickness Feet
Shale; dark grey with sandstone bands. Equivalent of PASSAGE BEDS	200 estimated
Shale; dark with large concretions, some of them yellowish brown weathering (Oxfordian); "*Turbo*" *ferniensis* n.sp.; equivalent of Green beds in southern part of Foothills; contact with underlying beds concealed; some faults present..........................	95 exposed (real thickness unknown)
Grey beds (Lower Callovian) (*see* Plates XI B, XII A). Upper part, grey shale with thin sandstone bands and some concretion layers on top; *Arcticoceras henryi*, *Kepplerites* (*Seymourites*) sp., belemnoids, *Inoceramus*. Lower part (Pigeon Creek member) sandstones up to 1′ 5″ thick intercalated with grey shale; number and thickness of sandstone beds decrease gradually upward; *Inoceramus* common in some of the transitional beds; several faults present.............	116 exposed (real thickness unknown)

Strata older than the Grey beds are not exposed in this section.

Boulders of a hard splintery limestone with pyrite, ammonoids (Stephanoceratidae), belemnoids, and pelecypods, characteristic of the Rock Creek member, were found in a gravel pit close to the Banff-Lake Minnewanka road. There the contact of the Triassic Spray River formation and the lower Fernie is clearly exposed. The uppermost bed of the Spray River formation consists of a hard, greyish limestone whereas the basal Fernie bed is a dark grey to black limestone similar to the basal Fernie bed at Ribbon Creek. It is overlain by at least 50 feet of hard dark limestone bands and black shales. No fossils were found in the poorly exposed Lower Fernie beds. Telfer, however, made a small collection of ammonoids (*Arnioceras*) in the Cascade Mountain region (unfortunately the exact locality is unknown). These fossils indicate the presence of Lower Lias beds in this area. Apparently the same horizon was found in Cuthead Creek, 17 miles farther to the north.

Section 30. *Cuthead-Wigmore Creeks Area*

Exposures of the Fernie group strata occur in or near Cuthead and Wigmore Creeks, which form the northern extension of the Cascade River Valley. They are accessible by motor car by the road from the Minnewanka Park Warden station to Panther Creek. The southernmost outcrop is about 17 miles north of the Minnewanka Wardens cabin, opposite a construction camp on the east side of Cuthead Creek. The northernmost exposure is about 5·5 miles north of this. Both on the road and in small valleys formed by tributaries joining Cuthead and Wigmore Creeks from the west, various beds of the Fernie are exposed, although no continuous section through the whole group seems to be present.

The Fernie rests on the more or less uneven surface formed by the reddish grey limestones of the Triassic Whitehorse formation. A good exposure that illustrates these conditions is in the northernmost part of the district on the road a few miles south of the Panther River Warden station. There a basal conglomerate about 1 foot thick with large pebbles is present. Only a few undeterminable fossil remains (pelecypods and fish) were found. On top of the conglomerate are black, platy, indurated shales with some hard, dark grey, limestone bands. The black shales contain a few poorly preserved pelecypods (*Pecten*). About 5·5 miles farther south at the construction camp in Cuthead Creek, a hard dark grey limestone filled with fossils was found on top of the Whitehorse member. This fossiliferous limestone seems to be close to the exposed upper part of the Triassic Whitehorse member but the actual contact was not seen.

The fauna of this limestone consists of big Arietitids, probably belonging to *Arnioceras* (*see* pp. 45, 46), gastropods, and pelecypods (*Ostrea*, *Pleuromya*, *Pecten*, *Pinna*, and others) and fixes the age as Lower Lias (Sinemurian). Apparently this fauna is of the same age as that discovered by Telfer near Cascade Mountain. It is remarkable that it is apparently absent only 5·5 miles to the north, in the outcrop in Wigmore Creek described above.

Black shales outcropping in the creek bed a little upstream are believed to be younger than the fauna mentioned above. No fossils were found but the general character is that of the black shales of the lower Fernie. Still farther upstream younger beds of the Fernie, particularly of the Rock Creek member, are concealed except for some grey shales with thin sandstone bands on the eastern bank of the creek that are similar to the Grey beds in the Cascade River Valley. A few poorly preserved pelecypods and one ammonite of a *Macrocephalites* aspect were observed.

These Grey beds, which are Callovian in age, are exposed at several localities on the road to Panther River and in adjacent creeks. The thickness is at least 250 feet, probably more. A good outcrop occurs in the bed of a creek west of the road, between two small lakes. There the lower part consists of about 150 to 200 feet of indurated grey shales with some layers of concretions. No fossils were found. The upper part, about 100 feet thick, is formed of similar indurated dark grey shales with some hard bands. Fossil wood is common in these upper beds, particularly in the lower part. Ammonites, belemnites, and pelecypods, all poorly preserved, appear in the upper part.

Grey beds with ammonites and fossil wood are also exposed in some other small creeks somewhat farther north. Immediately above the Grey beds are dark shales with concretions and stringers of ironstone. These shales are equivalent to the dark shales with big concretions known from the Cascade River section and other places[1]. They are overlain by dark shales with sandstone bands similar to those of the Passage beds.

Apparently the facies developed in the Cuthead-Wigmore Creek area is similar to those in the Minnewanka district. Compared with the Ram River district to the north, however, there are some noticeable differences, particularly in the Lower Fernie, which at Ram River consists of black cherty and phosphatic limestones known as the Nordegg member.

Section 31. **_Bighorn Creek_**

Bighorn Creek is a tributary of Red Deer River. It is easily accessible by the road from Sundre to the Ya-Ha-Tinda Ranch. The creek is in a

[1]*See* footnote on p. 29.

canyon with steep cliffs formed of Triassic rocks. The canyon ends upstream at a waterfall where the Fernie is in contact with the Triassic. This locality, which is about 17 miles northeast of the northernmost Fernie outcrop in the Wigmore district, was studied in July, 1953.

The lowermost Fernie seen at this locality consists of a hard, dark band about 1 foot thick, with pebbles and poorly preserved fossils. Big gastropods and *Pleuromya* sp. indet. could be recognized. This basal bed is overlain by platy, indurated dark shales with some hard bands. About 10 feet above the base occur *Discina* ?, *Ostrea*, *Pecten*, and some indeterminable ammonites with almost straight, apparently undivided ribs. This part of the Fernie is a Lower Jurassic horizon of uncertain age.

Farther upstream, and interrupted by a concealed interval, are dark shales with numerous imprints and flattened specimens of Harpoceratids, which indicate the presence of Toarcian (Upper Lias). The lithological facies of these beds is the same as that of the synchronous beds in other districts, as for instance Moose Mountain, Ram River, Cadomin-Mountain Park, and Snake Indian Valley.

Still farther upstream are more black shales with some hard bands. Belemnoids are very common and these shales probably belong to the Rock Creek member (Middle Bajocian).

The exposed parts of the Fernie, i.e., the lower Fernie and Rock Creek member, have an estimated thickness of several hundred feet, but exact measurements are impossible because parts of the section are concealed.

No beds younger than the Rock Creek member have been found.

Section 32. **_Tay River Map-Area_**

On the flanks of the Prairie and Tay anticlines Henderson (1944, p. 2) found 100 to 150 feet of thin-bedded, fine-grained, platy, black limestone with much interbedded chert, on top of Palæozoic beds. South of Tay River these rocks, which represent the Nordegg member, are overlain by a limestone with fossils of the *Oxytoma* bed (McLearn, unpublished report). This part of the Fernie belongs to the Lower Lias.

In the southern part of the area these beds are overlain by fissile, black shale and sandstone. To the northwest, however, on the southwest flank of the Prairie anticline, 60 feet or more of clean, fine-grained, white to buff weathering sandstone or quartzite capped by 50 feet or more of black fissile shale overlies the cherty limestone (Henderson 1944, p. 2).

The age of the Fernie rocks younger than Lower Lias is unknown. They are overlain in the southern part of the area by the Blairmore conglomerate, but to the northwest there are some sandstones that may be part of the Nikanassin formation (Henderson, loc. cit. p. 2).

The total thickness of the Fernie in this area is about 260 feet, which is very small compared with the thicknesses measured farther to the west.

Section 33. **_Fall Creek Map-Area_**

This area lies to the west of the Tay River area; here the thickness of the Fernie is about 400 feet. According to Henderson (1945, p. 2), the lower part consists of 125 to 150 feet of black cherty limestones, the Nordegg member, with the *Oxytoma* bed at the top. These beds belong to the Lower Lias. They are overlain (Henderson, loc. cit.) by 200 to 250 feet of black shale and sandstone which are capped by 50 feet or more of buff to brown weathering, thickly bedded, medium-grained sandstone possibly representing the Nikanassin formation. This sandstone is overlain by the Blairmore conglomerate.

The age of the Fernie beds younger than the *Oxytoma* bed has not been determined.

Section 34. ***Saunders Map-Area***

According to Erdman (1945, p. 6) the Fernie group including the Nikanassin formation attains a thickness of about 360 to 440 feet in this area. Good exposures occur in the southwestern part of the map-area, on the main Ram River. The following sections (*see* Figure 3, column 8) were measured by Erdman (1945, pp. 7, 8). Stratigraphic interpretations by the writer are in italics.

RAM RIVER, ABOUT 3,500 FEET IN A STRAIGHT LINE ABOVE THE MOUTH OF FALL CREEK

	Thickness Feet
Overlying beds: shale; dark, thin-bedded (probably including Nikanassin formation).	
Concealed; probably includes the *Oxytoma* bed (*Lower Lias*).	
Limestone; cherty, grey with 6′ of quartzitic and calcareous sandstone 60′ above the base. *Nordegg member.* (*Lower Lias*)........	113
Concealed..	6
Limestone; arenaceous, brown, buff weathering in part gritty with pebbles up to ¼″ diameter; poorly preserved pelecypods and gastropods 1′ above base..	7
Underlying beds: Rundle limestone.	

RAM RIVER, 3,000 FEET SOUTHWEST IN A STRAIGHT LINE FROM THE MOUTH OF FALL CREEK

Overlying beds: Cadomin conglomerate.	
Sandstone; grey, buff weathering, hard, fine-grained, thin-bedded, crossbedded and ripple-marked; shaly partings toward base. Probably Nikanassin formation..................................	62
Sandstone and shale interbedded..............................	57
Shale; black-brown weathering, soft, fissile; ironstone bands. Lower 10′ concealed..	56
Sandstone; brown, weathers buff; pebble-conglomerate with marcasite nodules near top; belemnite fragments abundant at the top, *probably Rock Creek member* (*Middle Bajocian*)...........................	32
Sandstone; argillaceous, ochre to brown, soft, *probably Rock Creek member* (*Middle Bajocian*)...................................	43
Shale and limy shale; dark to black, weathers towards base, fetid odour..	11
Limestone; cherty and arenaceous, phosphatic. (*Nordegg member*); a zone of large ostreas 24′ below top (*Oxytoma bed, Lower Lias*).	

Section 35. ***Cripple Creek Map-Area***

At this locality Erdman (1946, p. 2) estimates the aggregate thickness of the Fernie group and Nikanassin formation to be at least 1,500 feet, but no complete sections are available.

The lower part of the Fernie, according to Erdman, consists of 200 or 300 feet of black shales which are in sharp contact with the Triassic Spray River formation. The presence of *Dactylioceras* and *Harpoceras* indicates a Toarcian age for these shales.

Section 36. ***Alexo Map-Area***

CREEK CROSSING GAP TRAIL FROM THE EAST AT 2,300 FEET OF GAP LAKE

At this locality Crombie (1944, p. 10) measured the following section. Stratigraphical interpretations by the writer are in italics.

	Thickness Feet
Overlying beds: Cadomin conglomerate	
Concealed but known to consist of light yellowish sandstone in massive beds, shaly sandstone, and carbonaceous shale. Nikanassin formation according to Crombie	157
Sandstone; fine-grained, light brown, rusty weathering; some thin, dark shale beds. Nikanassin formation according to Crombie	95
Shale; dark grey	40
Sandstone; calcareous, light grey, weathering buff; *Tancredia* at base. *Probably Rock Creek member* (*Middle Bajocian*)	20
Shale; black and soft, partly concealed. *Probably Toarcian* (*Upper Lias*)	50
Limestone; black, fine-grained, cherty and phosphatic, disposed in beds 2" to 2' thick; hackly fracture, buff weathering. *Nordegg member* (*Lower Lias*)	58
Shale; black, soft; may include equivalents of Rocky Mountain (Palæozoic) and Spray River (Triassic) formations (Crombie, 1944, p. 9)	3
Conglomerate; small black chert pebbles in a calcareous and sandy matrix; may include equivalents of Rocky Mountain (Palæozoic) and Spray River (Triassic) formation (Crombie, 1944, p. 9)	0·5
Underlying beds: Rundle formation.	

In this section the thickness of the beds assigned to the Fernie group is 268 feet.

Section 37. ***West of Bighorn Range***

An almost complete Fernie section was measured by R. J. W. Douglas, Geological Survey of Canada, on a tributary from north of Chungo Creek, immediately west of gap through Bighorn Range (sec. 33, tp. 42, rge. 19), extending into unsurveyed territory. The section is as follows (*see* Figure 3, column 9):

	Thickness Feet
Overlying beds: Nikanassin formation	
Sandstone and shale, interbedded; the sandstones are fine- to medium-grained in upper part becoming finer grained, thinner bedded, and less persistent downwards; shale increasing downwards.	75
Siltstone; very fine-grained, finely laminated; 1" to 3" beds; small crossbeds; interbedded, grey. *From here to top equivalents of Passage beds*	25
Shale; grey, with large concretions up to 4' in diameter and 1' thick. *Equivalent of Green beds in the southern Foothills* (*Oxfordian*)	5

Small tear faults break section along creek, and beds lower than the concretionary shale are not exposed in this fault block. Section continues downstream; stratigraphic interval of gap unknown, but probably small.

	Thickness Feet
Top of Grey beds (Lower Callovian)	
Shale; grey, with 6″ to 1′ bands of limestone about 5′ above base	20
Shale; grey, slightly silty..................	5
Shale; greenish grey, silty....................................	3
Sand; soft, fine-grained, green, with rusty brown weathering concretions and bands; grading into beds above and below...........	8
Shale; greenish grey; occasional belemnites....................	13
Shale; grey, fissile; basal 6″ bentonitic......................	16
Siltstone; argillaceous, thinly bedded, calcareous finely laminated; occasional belemnites; *base of Grey beds (Lower Callovian)*........	8
Shale; black, fissile; belemnites in base; top not well exposed. About top of Rock Creek member..................................	21
Bentonite..	0.1
Shale; as above..	6.5
Limestone; cryptocrystalline, black.............................	0.5
Shale; hard, black; belemnites..................................	0.5
Belemnite conglomerate..	1.5
Shale; rusty orange weathering, fissile..........................	7
Sandstone; massive-bedded, fine-grained, hard, grey, siliceous......	16
Sandstone; argillaceous, thinly bedded..........................	2
Sandstone; *base of Rock Creek member (Middle Bajocian)*..........	2
Shale; black, pyritic, fissile to very fissile or paper thin; sulphur stains in places; layer containing abundant ammonite impressions, pelecypods, belemnites, etc., about 25 feet above base (*Toarcian*)	75
Limestone; black, finely crystalline; altered to chert and phosphate (?) in bands and nodules; strong petroliferous odour. Nordegg member (*Lower Lias*)..	13

Base not exposed; in other localities the Nordegg member is 20 feet or more thick.

Section 38. ***Cadomin-Mountain Park***

Good outcrops of the Fernie group occur in railway and road-cuts between Cadomin and Mountain Park (*see* Plates II A, IV, XIII A, and Figure 3, column 10). They are accessible by motor car from Cadomin. Parts of the strata are concealed.

The section is as follows:

Nikanassin formation

		Thickness Feet	Inches
Shale; dark, sandy; thin reddish brown bands of calcareous sandstones; plant remains and a few nondistinctive pelecypods: Younger than Middle Bajocian, probably representing Upper Jurassic. Similar rocks in Fiddle Creek, Snake Indian Valley and other localities in the same stratigraphic position..............	About	400	0
Covered interval, probably shale as above...............	About	100-150	0
Limestone; hard, sandy; many fossils (Stephanoceratids, belemnoids, *Gryphaea cadominensis* and others). Rock Creek member (*sensu stricto*) Middle Bajocian..		6	4
Shale and sandstones; concealed in part.................	About	33	0
Sandy limestone; hard, light grey; shell fragments................		9	0
Concealed interval......................................	About	50	0
Sandstone; hard, dark grey; belemnoids.........................		20	0

	Thickness Feet	Inches
Sandstone; dark grey, yellowish brown weathering; many tubes of various shapes originating from burrowing animals (worms ? and others)	11	4
Shale; greenish grey	28	0
Sandstone band	2	5
Shale; greenish grey; small concretions	31	0
Sandstone; hard, greenish grey; ripple-marks	26	0
Concealed: thickness unknown (about 100 feet ?); probably shale and sandstone	?	
Sandstones and shale alternating; belemnoids, tracks, plant remains	75–100 (estimated)	
Base of Rock Creek member (Middle Bajocian)		
Shale; dark platy; *Harpoceras*, belemnoids. Toarcian	75	0
Limestone; cherty, Nordegg member (Sinemurian). The "*Oxytoma* bed", found at other localities on top of the Nordegg member, was not observed at this locality	50	0
Whitehorse formation of the Triassic.		

The total thickness of the Fernie group at this locality may be about 1,000 feet. There are also other Fernie outcrops in this region, for instance in Whitehorse Creek and near Luscar. The development in the Fiddle-Morris Creek areas is very similar, except that the lowermost part of the Fernie, the Nordegg member, is missing in Fiddle Creek.

Section 39. ***Morris and Fiddle Creeks***

The Fernie group is exposed at several places on the road from Pocahontas to the Miette Hot springs and in the banks of the Fiddle Creek (*see* Plate VIII and Figure 3, column 11), between Morris Creek and the junction of Sulphur River with the Fiddle Creek.

The presence of the Fernie in the Fiddle Creek area was noted by D. B. Dowling (1912, pp. 205, 206). Collet (1931, pp. 14-18) measured the section in Fiddle Creek and demonstrated the presence of Toarcian and Bajocian faunas. The sections were restudied in 1951, 1952 and 1953, by the writer.

The section at the Morris Creek bridge is more easily accessible than the Fiddle Creek section. Details are as follows:

	Thickness Feet	Inches
Overlying beds: Upper part of Fernie		
Sandstone; hard, grey, calcareous; Stephanoceratids, belemnoids, pelecypods, wood. Top of Rock Creek member (Middle Bajocian)	3	
Sandstone; massive	27	
Shale; dark grey	2	4
Sandstone; poorly preserved pelecypods	1	6
Shale; bluish grey; thin sandstone bands	18	3
Sandstone; dark grey to brownish	10	4
Covered; probably shale	20	0
Sandstone; hard, massive; irregular surface; tracks	24	0
Shale; bluish grey, sandy	20	0
Sandstone; slightly calcareous	1	0
Shale; bluish grey, sandy	5	0
Sandstone; massive; some thin shale bands; Pelecypods, tracks	17	9
Shale; bluish grey, sandy; thin sandstone bands	3	0
Sandstones in bands	2	3
Shale; bluish grey	1	5
Sandstone	0	7

	Thickness Feet	Inches
Shale; bluish grey, sandy; in part rusty weathering	19	8
Sandstone; bluish grey. Base of Rock Creek member (Middle Bajocian)	22	0
Shale; dark grey; hard, sandy limestone bands; *Harpoceras, Dactylioceras*; pelecypod horizon at base (Toarcian). Base of Fernie	126	5
Dolomitic limestone, probably Triassic.		

The Fiddle Creek section is very similar to that in Morris Creek. At both localities the Rock Creek member is characterized by a sandy development, whereas the Lower Fernie consists of black shale with some intercalated thin limestone bands. The sequence is as follows:

	Thickness Feet
Sandstone; massive. Base of Nikanassin formation	15
Shale; dark grey, sandy; reddish brown weathering sandstone bands up to 8" thick; shale folded and faulted; plant remains and various kind of tracks. Probably Upper Jurassic	400 to 600 (estimated)
Sandstone; dark grey to brown, calcareous in upper part, massive; Stephanoceratids, belemnoids, *Gryphaea cadominensis*, other pelecypods and fossil wood in upper part. Rock Creek member (*sensu stricto*, Middle Bajocian	18
Shale	6
Sandstone; greyish brown	3
Shale	3
Sandstone; greyish brown	18
Shale; dark	9
Sandstone; greyish brown, massive; lower part consisting of shell fragments	27
Shale; dark grey with intercalated sandstone bands	30
Sandstone; bluish grey, hard; tracks and pelecypod fragments	18
Shale; dark; pyrite nodules and thin sandstone bands. Base of Rock Creek member Middle Bajocian	45
Shale; dark to black, more or less platy with thin limestone bands at various horizons; *Harpoceras, Peronoceras* in upper part; pelecypod horizon near base. Toarcian. Base of Fernie . . . . About	125
Dolomitic limestone. Probably Triassic.	

The measurements agree fairly well with those of Collet (1931, p. 17). *Ludwigella* and *Pleydellia* stated by Collet to be present in the upper part of the 125-foot black lower Fernie shale were, however, not found. It seems remarkable that the cherty limestones of the Nordegg member, so well developed at Cadomin-Mountain Park, are absent in the Morris Creek and Fiddle Creek sections and that the comparatively thick sandstones of the Rock Creek member are almost entirely replaced by shales in the Snake Indian River section only 10 miles to the west (*see* Plate VII A and Figure 3, column 12).

Part of the Rock Creek member is also exposed near the Villeneuve Creek bridge on the Pocahontas-Miette Hot springs road.

Section 40. *Snake Indian Valley*

The Fernie group is widely exposed in Snake Indian Valley, on both sides of the river from Devona Warden station upstream to beyond Snake Indian Falls (*see* Figure 3, column 12). The Fernie is commonly folded into small anticlines and synclines. Part of the sections are in steep cliffs and more or less inaccessible.

BETWEEN SNAKE INDIAN BRIDGE AND DEVONA WARDEN STATION

In this area the Fernie rests on the Triassic Whitehorse formation, the actual contact is, however, concealed. A good section of the lower Fernie is exposed at the Snake Indian bridge.

	Thickness Feet	Inches
Top concealed		
Shale; black, silty, slightly calcareous, commonly platy (paper shale); dark limestone bands; about 40′ above base *Harpoceras, Dactylioceras*, vertebra; pelecypod horizon near base. Toarcian, the same facies as at Cadomin, Fiddle Creek and other places..............	80–100	
Limestone; black, brownish weathering, mostly shaly, silty; many fossils. *Oxytoma* bed (Lower Lias). Local subdivision as follows: Upper part with *Pecten, Oxytoma* cf. *cygnipes, Ostrea, Pleuromya, Rhynchonella, Terebratula*, and others (12′). Shaly horizon (3′). Gastropod horizon; mainly gastropods, but also containing *Oxytoma* and other pelecypods (2′). Base: Fossil conglomerate (6″)........	17	6
Limestone; dark grey to black, massive; some chert. Nordegg member (Lower Lias)..	16 exposed (real thickness about 50 feet)	0
Base: concealed		

ABOUT 1 MILE UPSTREAM FROM SNAKE INDIAN BRIDGE

On the north bank of the river the following section is exposed (*see* Plate VII A)

	Thickness Feet	Inches
Top: Shale; dark with reddish or yellowish brown weathering dark bands and concretions: probably Upper Jurassic; more than 100′ exposed.		
Sandstone; soft, and shale; slightly calcareous with belemnite battlefields, Stephanoceratids, *Inoceramus, Gryphaea cadominensis*, plant remains. Rock Creek member *sensu stricto* (Middle Bajocian)....	8	0
Shale; dark grey; yellowish brown bands and concretions..........	54	5
Shale; dark grey; belemnoids, *Inoceramus* and other pelecypods....	3	6
Sandstone; at the base with big concretions up to 7′ across containing Stephanoceratids, and belemnoids............................	3	8
Shale; greenish grey with harder bands. In uppermost 8″ Stephanoceratids..	49	0
Sandstone; shaly; tracks (worms ?)...........................	5	6
Shale; greenish grey; some harder beds. Base of Rock Creek member (Middle Bajocian)..................................	59	6
Bottom: Shale; black, silty, slightly calcareous; some limestone bands; only upper part exposed, lower part forming river bed. Toarcian. This shale is similar to that which forms the upper part of the section at the Snake Indian bridge. On the south bank of the river the *Oxytoma* bed is exposed.		

ABOUT 1·5 MILES UPSTREAM FROM SNAKE INDIAN BRIDGE

At this locality beautiful sections are exposed on both sides of the river. They form an anticline that includes the upper part of the Triassic Whitehorse formation, the Fernie Nordegg member, the *Oxytoma* bed, and the black Toarcian shales (*see* Plates II B, III A). The contact of the dark lower Fernie with the light Whitehorse formation is visible from a long distance.

On the east side of the anticline the Rock Creek member, described in detail in the section given above, is exposed but somewhat disturbed. Limestones, containing the well known, rich Rock Creek member fauna, were found at the foot of the cliff. Overlying the Rock Creek member are the dark shales with reddish and yellowish brown weathering bands. Only a few ammonite fragments, unfortunately indeterminable, and some worm tubes were found. These beds are Upper Jurassic but their exact age could not be determined.

SHALE BANKS

Farther upstream, at Shale Banks, the dark shales with reddish and yellowish brown weathering bands are exposed on both sides of the river (*see* Plate XIII B). In the easily accessible exposures on the northern bank some Aucellas of the *bronni* group were found that indicate an Oxfordian or Kimmeridgian age.

SNAKE INDIAN FALLS

At the Snake Indian Falls the following Fernie members are exposed: Nordegg member (overlying the Triassic Whitehorse formation), *Oxytoma* bed, and the black Toarcian shales. Still farther upstream younger Fernie beds occur but, as there are some concealed intervals, no continuous section could be measured.

The black Toarcian shales show the same development as farther south. Imprints of Harpoceratids and *Dactylioceras* are fairly numerous in some horizons. Poorly preserved *Arietites* (*Arnioceras*) were found by McLaren (Geological Survey of Canada) at the Falls. The nature of the rock and the accompanying gastropods show that these ammonites came from the *Oxytoma* bed, thus fixing the age of the rock as Sinemurian (Lower Lias).

Section 41. ***Hay Mountain Region***

Approximately 3 miles south of Hay Mountain, Spivak (1949, pp. 536, 539) measured the following Fernie section:

	Thickness Feet
Overlying beds: Nikanassin formation with a 6′ thick prominent sandstone at the base.	
Shale with fine-grained, grey, brown-weathering sandstone beds that increase in number towards the top	267
Shale; black, fissile, non-calcareous; rusty weathering ironstone beds and concretions	187
Shale; black, hard, thinly bedded, calcareous; interbedded limestone	84
Underlying beds: Middle Triassic limestone or dolomites.	

In the writer's opinion the lithology of the lower part of this section indicates the Toarcian. The rocks of the middle part are of the same facies as that of the Rock Creek member as developed in the Snake Indian

Valley. The upper part of the section probably belongs to the Upper Jurassic.

It is remarkable that the cherty limestone facies of the Sinemurian Nordegg member seems to be absent at this locality, as is the case in the Morris and Fiddle Creek districts.

Section 42. ***Head of Moon Creek***

At this locality, Irish (1947, p. 14) measured the following section:

	Thickness Feet
Overlying beds: Nikanassin formation	
Sandstone and shale; grey, hard, siliceous; interbedded with black shale in beds up to 4′ thick	16
Sandstone; grey, hard, buff weathering; numerous thin, silty shale partings	11
Shale; predominantly silty, many ribbons of grey sandstone 4″ thick	43
Sandstone; grey, hard, grey-brown weathering; thin partings of grey, silty shale	4
Shale; dark grey to black; thin ribbons of grey sandstone	12
Sandstone; grey to brown, light brown weathering; thin interbeds of dark grey shale	38
Shale; dark grey to black; numerous interbeds of hard, grey sandstone from 6″ to 6′ thick	27
Shale; dark grey to black, silty; occasional sandstone ribbons at base; grey sandstone in beds up to 3′ thick forms about 50% of the strata at the top	415
Shale; black, fissile; numerous concretionary beds of yellow weathering ironstone from 2″ to 1′ thick	259
Shale; black, fissile; a 15′ zone at the base containing black, calcareous shale and some beds of a black, hard, fine-grained, siliceous rock. These beds contain belemnites	75
Underlying beds: Whitehorse formation.	

The interpretation of this section in the writer's opinion is as follows:

The lower 75 feet of shale belong to the Toarcian (the cherty limestone of the Sinemurian Nordegg member is apparently absent). The lower part of the black fissile shale with beds of yellow weathering ironstone concretions represents the Middle Bajocian Rock Creek member, the upper part may include Callovian. The shales and sandstones which overlie this 259 feet of thick shale are probably of Upper Jurassic age. The upper part of these beds may already belong to the Nikanassin formation.

Section 43. ***Cabin Creek***

North of the Berland River, in the Cabin Creek region, the Fernie was subdivided by Spivak (1949, pp. 536, 539, 540) into three units:

	Thickness Feet
Overlying beds: Nikanassin formation	
Shale; black, interbedded with dark brown to light buff sandstone beds 6′ to 14′ thick	383
Shale; black, fissile to thin-bedded	185
Limestone; black, phosphatic (Nordegg member) and black shale	30
Underlying beds: Middle Triassic limestones.	

The stratigraphic interpretation of this section is in the writer's opinion as follows:

The lower unit includes both Sinemurian (Nordegg member) and Toarcian (black shale), the middle unit belongs probably in part to the Middle Bajocian Rock Creek member, and the upper unit is Upper Jurassic.

A remarkable feature of this section is the presence of the Nordegg member which does not occur in either the Hay Mountain or the Moon Creek sections.

Section 44. ***Near Junction of Sulphur and South Sulphur Rivers***

One and a half miles up a small creek that enters Sulphur River from the east, just below the junction of Sulphur and South Sulphur Rivers, part of the lower Fernie was found exposed by Irish during the summer, 1954. The rocks collected at this locality are identical with those of the *Oxytoma* bed in Snake Indian Valley and contain *Arietites*, *Pecten*, *Pleuromya*, *Terebratula*, and *Rhynchonella*, all forms characteristic of this marker horizon. *Oxytoma cygnipes* Phillips, however, is not represented in the collection.

According to Irish this horizon is in direct contact with the Triassic Whitehorse formation.

Section 45. ***Kvass Flats Area***

At Llama Flats Irish (1954, pp. 19-24) measured a Fernie section which, according to the fossils determined by the writer, contains the Middle Bajocian Rock Creek member (Stephanoceratids, belemnoids, *Gryphaea* cf. *cadominensis* Warren) and the Oxfordian (*Aucella* ex gr. *bronni* Rouiller, *Cardioceras* ? sp. indet.). The Rock Creek member and the Oxfordian are developed in a shaly facies with ironstone bands. Beds younger than the Oxfordian are shales intercalated with sandstones and siltstones. The presence of the Nordegg member of the lower Fernie seems to be doubtful.

The section seems to be disturbed and some of the beds may be repeated. However, the total thickness of the Fernie may be 1,000 to 1,100 feet.

Section 46. ***Copton Creek***

Near Stinking Springs in the Foothills and near the Alberta-British Columbia boundary, Spivak (1949, pp. 536, 540) reported the presence of the basal Nordegg member (with *Arnioceras*). It has a thickness of 32 feet and is overlain by 341 feet of silty and sandy shales with ironstone concretions. These beds in the writer's opinion, include the Middle Bajocian Rock Creek member. Overlying these is 263 feet of interbedded sandy shales and sandstones that form the upper unit of the Fernie. A considerable part of the overlying Nikanassin formation seems to belong to the Upper Jurassic.

The development of the Fernie group in Copton Creek is of the same general type as at the other localities in the northern Foothills already described.

Section 47. ***Pine Pass-Peace River***

No continuous Fernie section appears to be exposed in the Pine Pass area. According to Stelck (*see* Mathews, 1947, pp. 8, 9) 835 feet of shales, siltstones, and minor fine-grained sandstones are present on LeMoray Mountain on the Upper Pine River. More than 650 feet above the base of the formation the following forms were collected from outcrops and talus: *Belemnites*, *Pleuromya*, *Cucullaea*, *Pecten*, two different species of *Aucella*, *Gryphaea*, and *Lima*. Stelck suggests an Upper Jurassic age for this fauna, which, in his opinion, may have been derived from at least two different horizons.

At another locality in the Upper Pine Valley, on Gold Creek, Stelck collected *Pleurotomaria* cf. *borealis* Warren, *Oxytoma* cf. *mcconnelli* Whiteaves, *Chlamys* cf. *mcconnelli* McLearn, *Pecten*, *Gryphaea*, *Discina*, and various Rhynchonellids. This fauna, which, according to Stelck is believed to be near the bottom of the shales, is in the writer's opinion probably identical with the fauna of the Sinemurian *Oxytoma* bed.

Mathews (1947, p. 8) has found at least 350 feet of shales of the Fernie group at the base of Indian Head and on the eastern slope of Carbon Peak. At Brown Hill, on the Peace River, 4 miles west of the mouth of Carbon Creek, the thickness according to McLearn (1940) is about 700 feet.

Section 48. ***Pink Mountain and Sikanni Chief River***

In this area Hage (1944, p. 6) reports 128 feet of dark grey to black, calcareous, platy, marine shale with several interbedded dark grey limestone beds. The base consists of 2 feet of argillaceous limestone which according to McLearn (Hage, loc. cit.) contains *Gryphaea*, *Pecten*, *Rhynchonella*, and *Oxytoma* cf. *cygnipes*. This fauna is characteristic of the Sinemurian *Oxytoma* bed.

Apparently no fossils were found in the upper Fernie beds and their age remains unknown. Aucellas, probably of Jurassic age, occur, however, in the lower part of the Nikanassin or Dunlevy formation, part of which overlies the Fernie (McLearn, 1945, pp. 2, 10).

The thickness of the Fernie group in the Pink Mountain and Sikanni Chief River region varies from place to place. Hage measured 128 feet on Pink Mountain, 32 feet on Sikanni Chief River, 18 miles to the north. Eleven miles upstream from this locality the thickness is 240 feet, and only 18 feet on a tributary creek of Minaker River. A little farther to the north the Fernie group appears to be absent.

CHAPTER V

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1878-1886 : Monograph on the Lias Ammonites of the British Islands; *Palæont.*, London.

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PLATES I TO XLIV

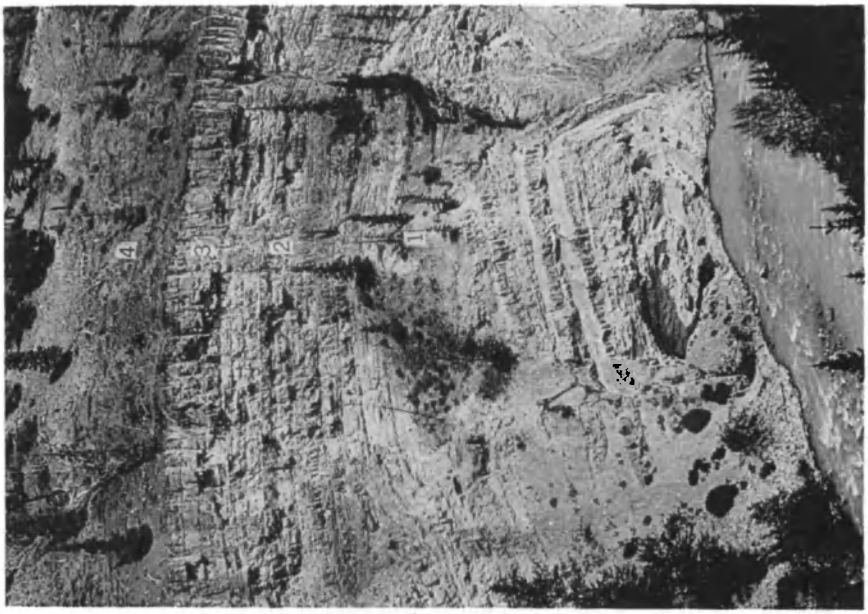
All fossil figures are in natural size unless otherwise stated.

PLATE I

Lower Jurassic dark, more or less massive, shale. 6·8 miles south of bridge in Fernie on the road from Fernie to Cranbrook.

PLATE I

PLATE II



B

A

PLATE II

A. Lower Jurassic Nordegg member (Sinemurian), consisting of dark cherty limestones. Cadomin railway section. (*See* Plate IV and Figure 3, column 10.)

B. Lower Jurassic overlying the Triassic Whitehorse formation, 1·5 miles west of Snake Indian Bridge. 1 = Triassic Whitehorse formation. 2 = Nordegg member. 3 = *Oxytoma* bed (2, 3—Sinemurian). 4 = Toarcian dark shale with calcareous sandstone bands. (*Compare* Plate III A and Figure 3, column 12.)

Plate III

A. Lower Jurassic in Snake Indian Valley about 1·5 miles west of Snake Indian River Bridge. (Repeated by faulting.) (1) Nordegg member. (2) *Oxytoma* bed (1, 2, Sinemurian). (3) Toarcian dark shale with some calcareous sandstone bands. (*Compare* Plate II B and Figure 3, column 12.)

B. Base of Lower Jurassic on the Adanac strip mine road. 1 = Carboniferous. 2 = Phosphate and pebble bed (base of Fernie). 3 = Dark paper shale, at B belemnite and pelecypod horizon, at A Toarcian ammonite (*see* Figure 3, column 3). Compare the different facies development of the lower Fernie on Grassy Mountain (Plate VI A).

A

B

PLATE IV

PLATE IV

Part of Fernie group in the Cadomin railway section. 1 = Triassic Whitehorse formation. 2 = Lower Jurassic Nordegg member (Sinemurian, *see* Plate II A). 3 = Toarcian black shale (mostly covered). 4 = Middle Bajocian Rock Creek member, sandstones with ripple-marks and tubes originating from burrowing animals (shoreline-facies) (*compare* Figure 3, column 10).

PLATE V

The Jurassic sequence in Canyon Creek, Moose Mountain area. 1 = Toarcian dark shale with ammonites. 2 = Middle Bajocian Rock Creek member with belemnite horizons (B). 3 = Passage beds ('Brown sands'). F = Fault. In this section equivalents of the Callovian and the Oxfordian Green beds are absent. (*Compare* Figure 3, column 6.)

PLATE V

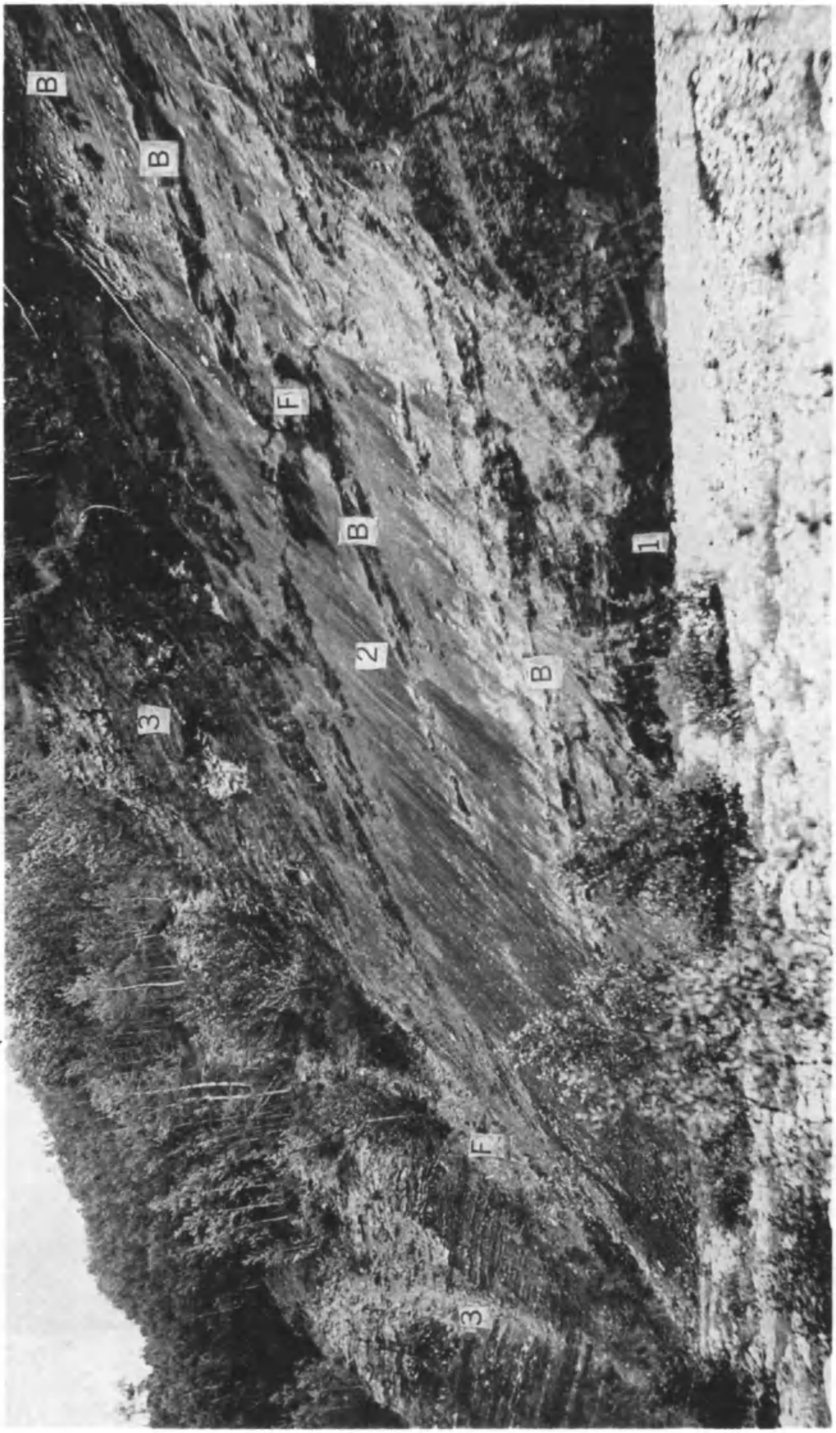


PLATE VI

A

B

PLATE VI

A. Lower Jurassic sandstones (1) overlain by the Lille member (2) in the old railway section, south slope of Grassy Mountain. At other localities the lower Fernie consists mainly of shales. (*Compare* Plates I, III B, and Figure 3, column 4.)

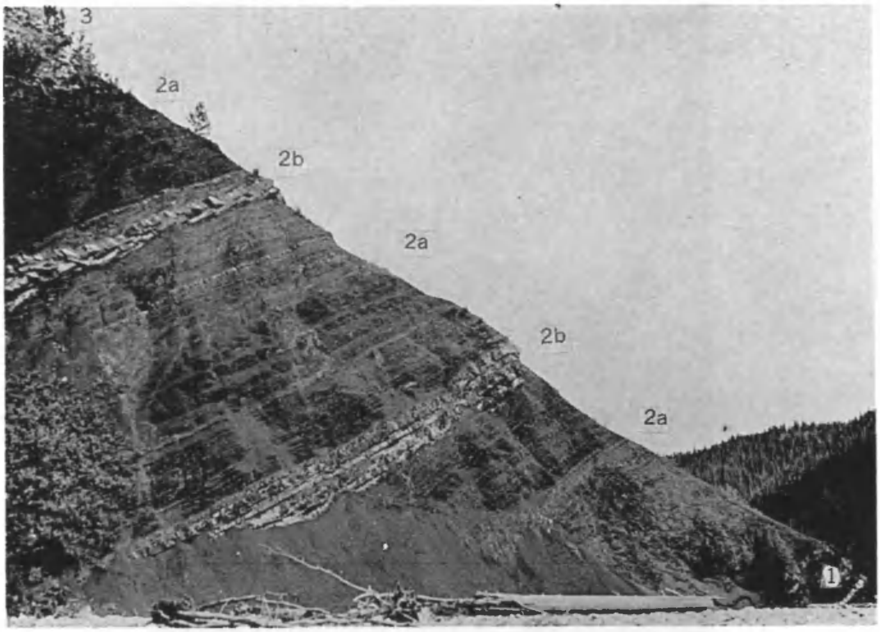
B. Section of the Fernie group at the Livingstone Gap. 1 = Rocky Mountain formation. 2 = Base of Fernie. 3 = Lower Jurassic indurated black shale. 4 = Lower Jurassic platy sandstones. 5 = Middle Bajocian Rock Creek member with ammonites, etc.

PLATE VII

A. Lower and Middle Jurassic succession in Snake Indian Valley, about 1 mile west of the Snake Indian River bridge. 1 = Toarcian dark shale. 2a and 2b about 162′ Middle Bajocian Rock Creek member; shale (2a) with thin hard beds, two sandstone horizons (2b). (*See* detailed description of section on page 92.) 3 = Pleistocene. Compare this shaly facies of the Bajocian Rock Creek member with the sandy development of the same beds in Fiddle and Morris Creek (Plate VIII) and in the Cadomin-Mountain Park area (Plate IV). (*Compare* Figure 3, column 12.)

B. Lower and Middle Jurassic at Line Creek, Fording River area. 1 = Toarcian dark shale. 2 = Rock Creek member with bentonite (B) and large concretions (C) with Middle Bajocian ammonites. Compare this mainly shaly development of the Rock Creek member with the sandy facies in other regions (Plates IV, VIII).

PLATE VII



A

B

PLATE VIII

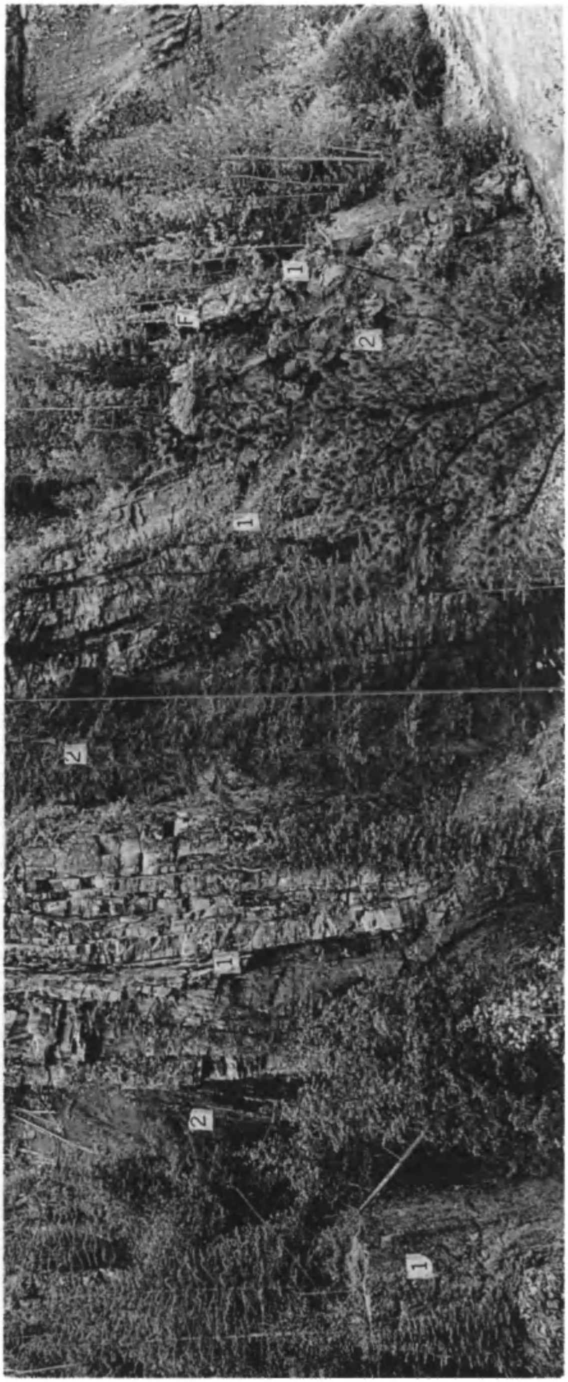


Plate VIII

Sandstones and shales of the Middle Bajocian Rock Creek member in Fiddle Creek. 1 = sandstone, 2 = shale. At (F) rich Rock Creek member fauna. Compare Rock Creek member section in Snake Indian Valley (Plate VII A) about 10 miles to the west in which shales almost entirely replace sandstones. (*Compare* Figure 3, column 11.)

PLATE IX

A. Lower Callovian *Gryphaea* bed (2) with *Lilloettia*, *Kepplerites* etc., and uppermost part of *Corbula munda* beds (1). South slope of Grassy Mountain.

B. Upper part of Lower Callovian *Corbula munda* beds with *Cadoceras*. South slope of Grassy Mountain. (*See* detailed description of section on page 76. *Compare* Figure 3, column 4.)

PLATE IX

A

B

PLATE X

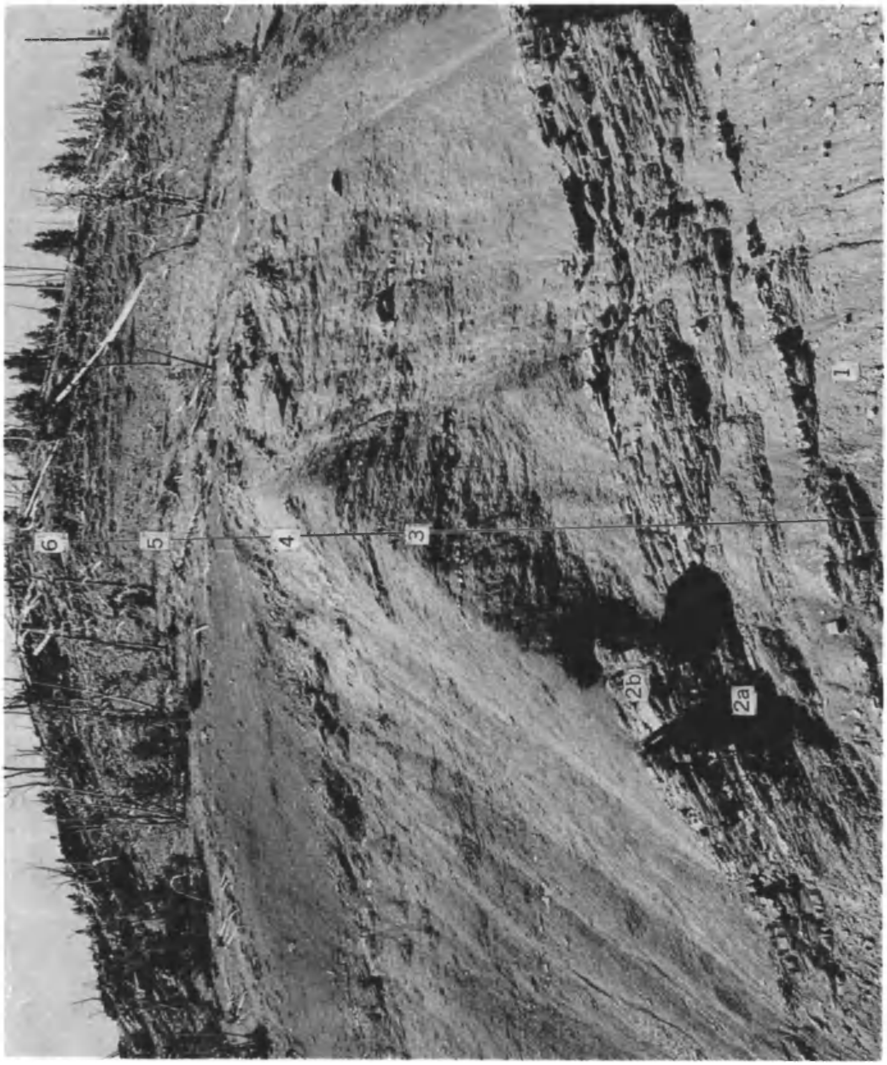


Plate X

Upper Jurassic succession at Daisy Creek Summit. 1—(mostly covered) upper part of Lower Callovian *Corbula munda* beds. 2a, 2b—4′ Lower Callovian *Gryphaea* bed (*sensu lato*), 2a = bed with *Gryphaea impressimarginata* etc., 2b = Belemnite horizon. 3 = 28′ dark shale. 4 = 30′ Oxfordian Green beds. 5 = about 145′ Upper Jurassic Passage beds. 6 = Lower Kootenay sandstone. (*Compare* Figure 3, column 5.)

Plate XI

A. Section of the Fernie in Alexander Creek. 8 = Kootenay sandstone. 7 = Upper Passage beds. 6 = Lower Passage beds. 5 = Oxfordian Green beds. 4 = Lower Callovian Grey beds. 3 = Middle Bajocian Rock Creek member. 2 = Lower Jurassic indurated black shale. 1 = Triassic Spray River formation. (*Compare* Figure 3, column 2.)

B. Lower Callovian grey shales with sandstone intercalations, in the Cascade River section below Bankhead. 1 = part of section illustrated in Plate XII A. 2—horizon with *Inoceramus*. 3—horizons with Lower Callovian ammonites. Part of this section equivalent to the Callovian in Ribbon Creek section (Plate XII B). (*Compare* Figure 3, column 7.)

A

B

PLATE XII

A

B

Plate XII

A. Lower Callovian grey shales with thin sandstone bands, Cascade River section (*see* Plate XI B). The same beds as Plate XII B in Ribbon Creek section.
Note: this facies-development is different from that of the synchronous *Corbula munda* and *Gryphaea* beds farther south (Plates IX A, B, X). (*Compare* Figure 3, column 7.)

B. Sandstones and shales of the Lower Callovian in Ribbon Creek, forming a steep cliff. The same facies in the Cascade River section (Plate XII A). This facies is entirely different from that of the Callovian *Corbula munda* and *Gryphaea* beds, farther to the south (Plates IX A, B, X).

PLATE XIII

A. Upper Jurassic dark shales with thin hard bands on the road from Cadomin to Mountain Park. The same facies as that in Snake Indian Valley (*see* Plate XIII B). (*Compare* Figure 3, column 10.)

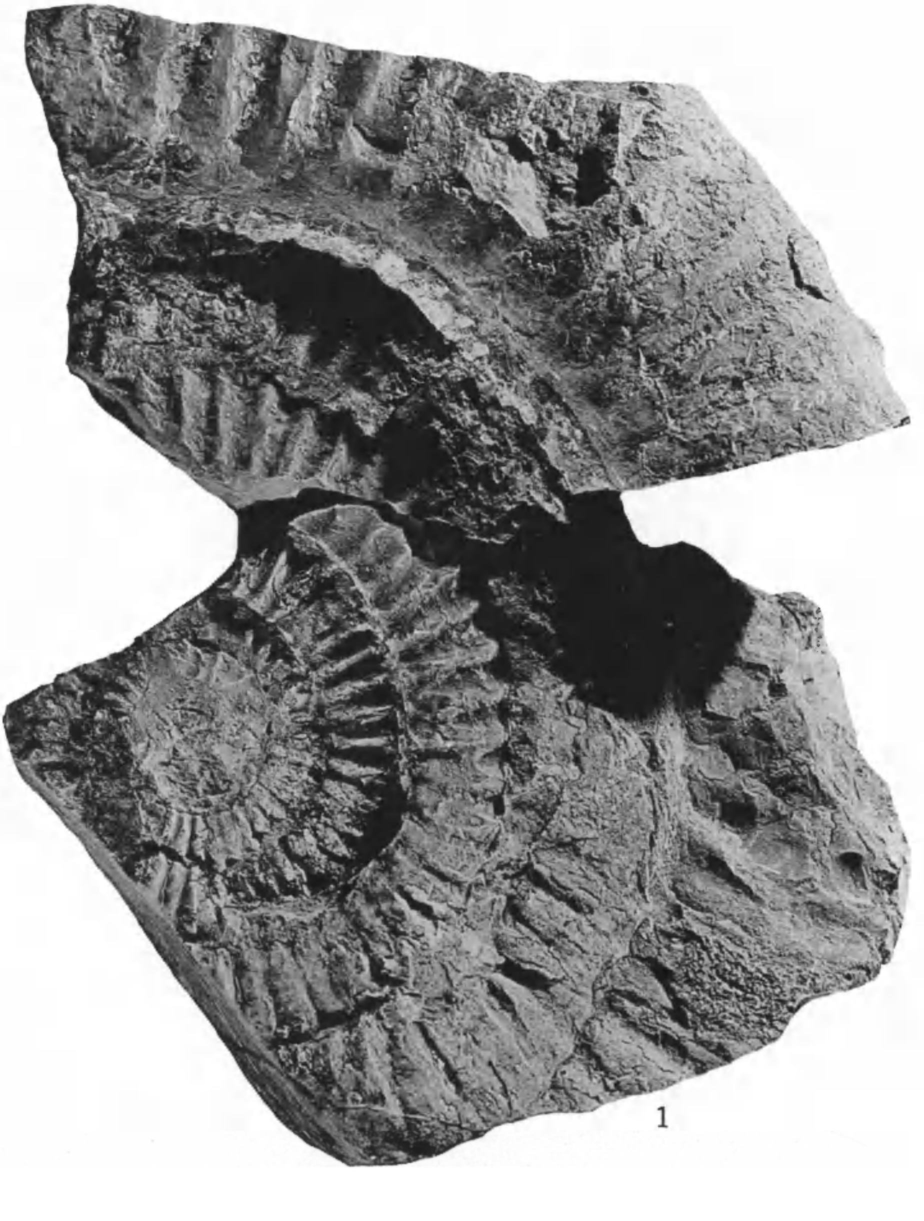
B. Upper Jurassic dark shale with reddish and yellowish brown sandy beds and concretions. Shale Banks, Snake Indian River. This facies is characteristic of the northern Foothills region. (*Compare* Figure 3, columns 12, 13.)

PLATE XIII

A

B

PLATE XIV



1

PLATE XIV

Figure 1. *Arnioceras* ? sp. indet. 1. Lateral view. Cuthead Creek, 17 miles north of Minnewanka Park Warden station. Sinemurian. G.S.C. No. 12868. (Page 45.) x about 0·73.

Plate XV

Figure 1. *Arnioceras* ? sp. indet. 1. Lateral view. Cuthead Creek, 17 miles north of Minnewanka Park Warden station. Sinemurian. G.S.C. No. 12869. (Page 45.)

Figure 2. *Arnioceras* ? sp. indet. 2. Lateral view. West slope of Cascade Mountain. Sinemurian. Palæontological collection of Geological Department University of Alberta. (Page 45.)

Figures 3, 4 *Gryphaea rockymontana* Warren. Left valves. Crow Phosphate Mine. Sinemurian. G.S.C. Nos. 12870, 12871. (No new description.)

PLATE XV

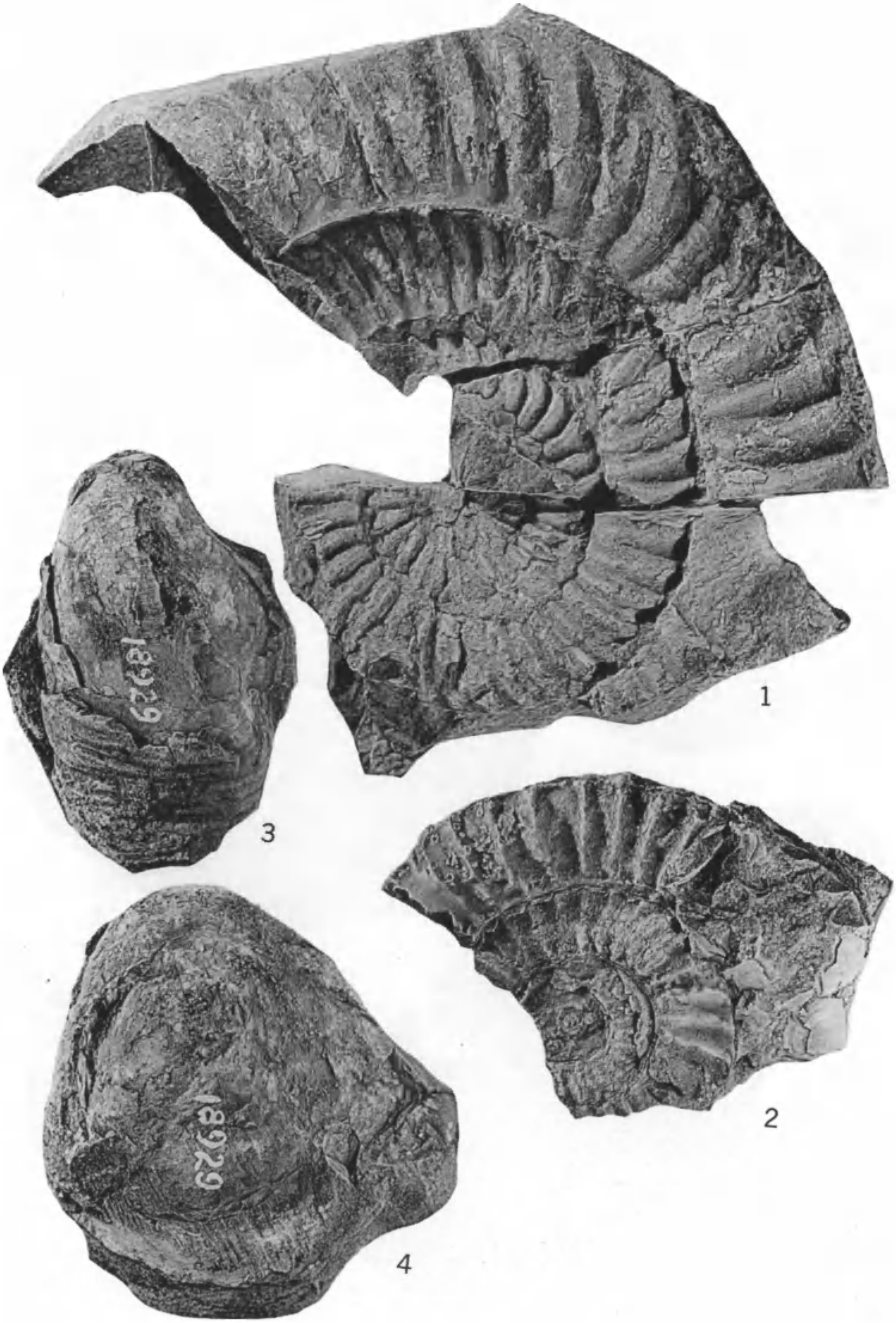


PLATE XVI

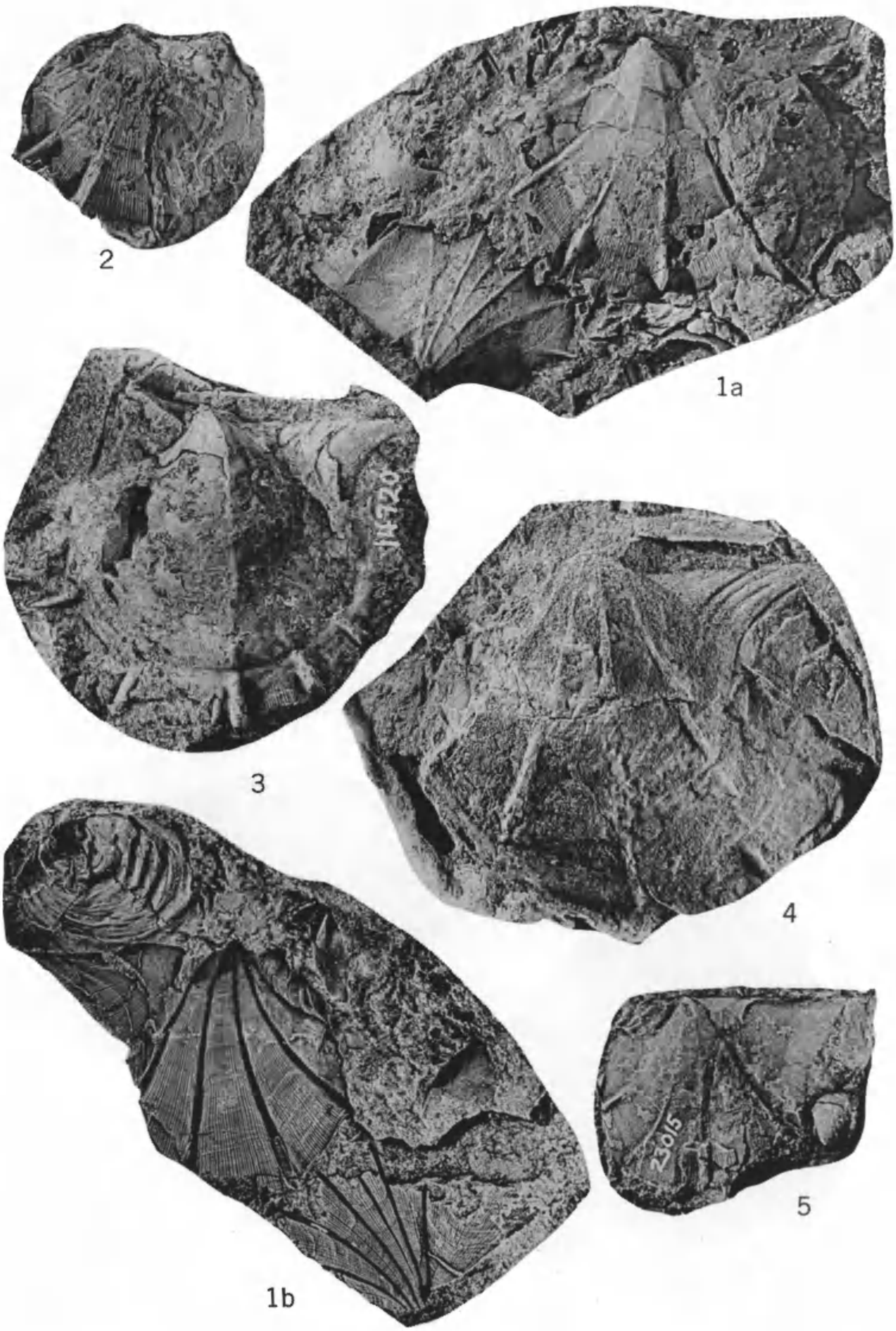


PLATE XVI

Figures 1-4. *Oxytoma cygnipes* Phillips. Left valves. 1b impression of the specimens figured in 1a. Top of mountain immediately south of Marble Mountain. Sinemurian. G.S.C. Nos. 12872-12875. (Page 67.)

Figure 5. *Oxytoma cygnipes* Phillips. Left valve. Forks of Ram River. Sinemurian. G.S.C. No. 12876. (Page 67.)

PLATE XVII

Harpoceras cf. *exaratum* Young and Bird. Lateral view. Canyon Creek, Moose Mountain area. Toarcian. G.S.C. No. 12877. (Page 47.)

1

PLATE XVIII

1

3

2

4

PLATE XVIII

Figure 1. *Peronoceras* cf. *subarmatum* Young and Bird Lateral view. Opposite George Creek Valley. Toarcian. G.S.C. No. 12878. (Page 46.)

Figures 2,3. *Harpoceras* cf. *exaratum* Young and Bird. Lateral views. Canyon Creek, Moose Mountain area. Toarcian. G.S.C. Nos. 12879, 12880. (Page 47.)

Figure 4. *Dactylioceras* aff. *commune* Sow. Lateral view. Canyon Creek, Moose Mountain area. Toarcian. G.S.C. No. 12881. (Page 46.)

PLATE XIX

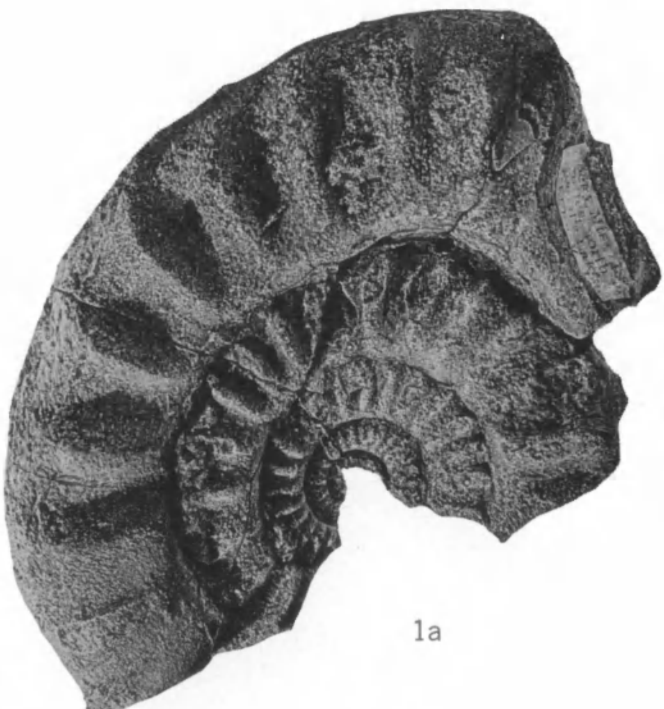
Figure 1. *Sonninia gracilis* Whiteaves. 1a, lateral view; 1b, whorl cross-section. 3 miles north of Devils Point, Lake Minnewanka. Middle Bajocian. Holotype of Whiteaves' *Schloenbachia gracilis*. G.S.C. No. 4809. (Page 48.)

Figure 2. *Sonninia* sp. indet. 2a, lateral view; 2b, whorl cross-section. Same locality as above. Middle Bajocian. G.S.C. No. 12882. (Page 49.)

PLATE XIX

2b

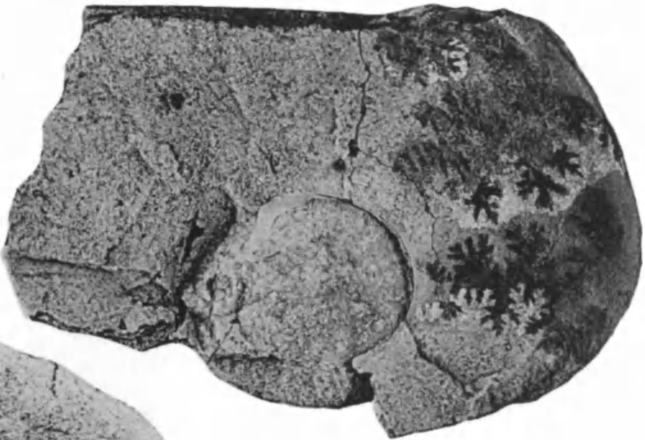
2a



1a

1b

PLATE XX



2

1

3

PLATE XX

Figure 1. *Sonninia* sp. indet. 1. Lateral view. 3 miles north of Devils Point, Lake Minnewanka. Middle Bajocian. G.S.C. No. 12883. (Page 48.)

Figures 2,3. *Sonninia* sp. indet. Lateral views. Same locality as above. Middle Bajocian. G.S.C. Nos. 12884, 12885. (Page 49.)

Plate XXI

Figure 1. *Stephanoceras* ex gr. *skidegatense* Whiteaves. Lateral view. Livingstone Gap. Middle Bajocian. Rock Creek member. G.S.C. No. 12886. (Page 49.)

Figure 2. *Stemmatoceras albertense* McLearn. 2a, ventral view and cross-section; 2b, lateral view. Same specimen as Plate XXIII. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12887. (Page 50.)

1

2a

2b

PLATE XXII

1a

1b

2

Plate XXII

Figure 1. *Stephanoceras* sp. indet. 1a, lateral view; 1b, venter. Snake Indian Valley. Middle Bajocian. Rock Creek member. G.S.C. No. 12888. (Page 50.)

Figure 2. *Stephanoceras* ex gr. *skidegatense* Whiteaves. Lateral view. Same specimen as Plate XXV, figure 2. Snake Indian Valley. Middle Bajocian. Rock Creek member. G.S.C. No. 12889. (Page 49.)

PLATE XXIII

Figure 1. *Stemmatoceras albertense* McLearn. 1a, lateral view; 1b, lateral view; 1c, venter and whorl cross-section of inner whorls of the same specimen as 1a. Same specimen as Plate XXI, figure 2. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12887. (Page 50.)

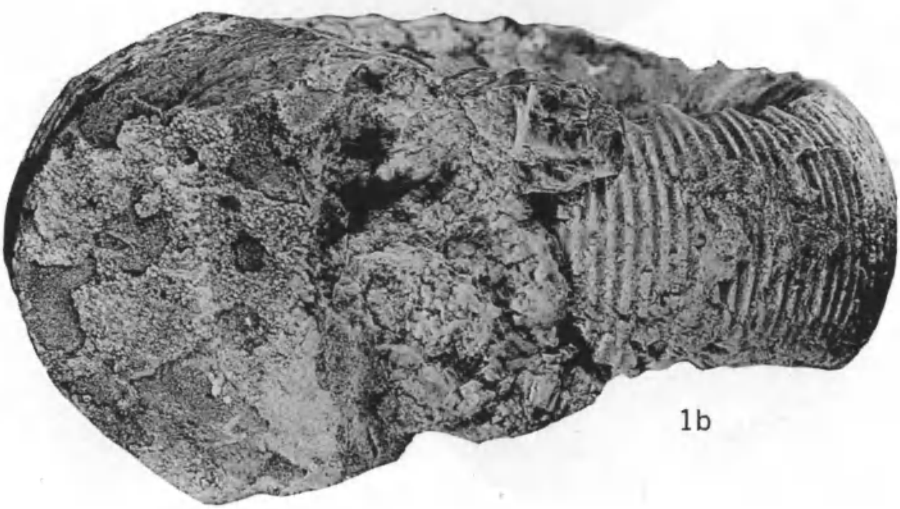
1a

1b

1c

Plate XXIV

1a



1b

PLATE XXIV

Figure 1. *Teloceras dowlingi* McLearn. 1a, lateral view; 1b, venter and whorl cross-section. Holotype (McLearn, 1932, Plate I, Plate V, figures 2, 3.) Probably from Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 9050. (Page 51.)

PLATE XXV

Figure 1. *Zemistephanus crickmayi* n.sp. Lateral view. Same specimen as Plate XXVI, figure 1 and Plate XXVII, figure 1. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12890. (Page 52.)

Figure 2. *Stephanoceras* ex gr. *skidegatense* McLearn. Venter. Same specimen as Plate XXII, figure 2. Snake Indian Valley. Middle Bajocian. Rock Creek member. G.S.C. No. 12889. (Page 49.)

Figure 3. *Chondroceras marshalli* McLearn, var. 3a, lateral view; 3b, venter and whorl cross-section. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12891. (Page 54.)

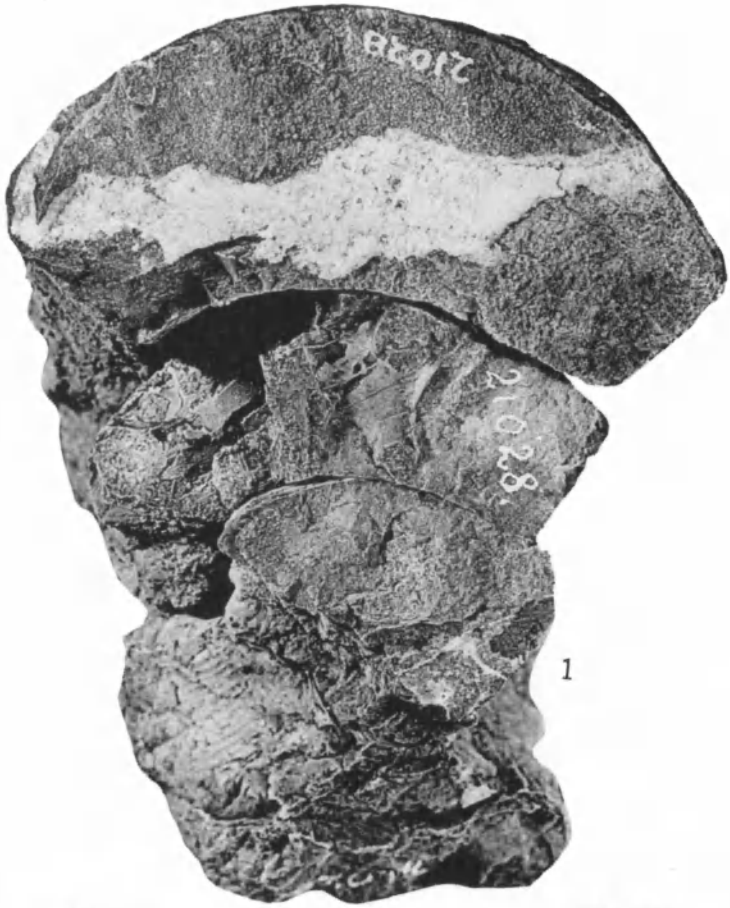
1

3a

2

3b

PLATE XXVI



1

2a

2b

PLATE XXVI

Figure 1. *Zemistephanus crickmayi* n.sp. Cross-section. Same specimen as Plate XXV, figure 1 and Plate XXVII, figure 1. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12890. (Page 52.)

Figure 2. *Chondroceras marshalli* McLearn var. 2a, venter and whorl cross-section; 2b, lateral view. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12892. (Page 54.)

Plate XXVII

Figure 1. *Zemistephanus crickmayi* n.sp. Venter. Same specimen as Plate XXV, figure 1 and Plate XXVI, figure 1. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12890. (Page 52.)

Figure 2. *Chondroceras allani* McLearn var. 2a, lateral view; 2b, venter and whorl cross-section. Ribbon Creek. Middle Bajocian. Rock Creek member. G.S.C. No. 12893. (Page 53.)

PLATE XXVII

1

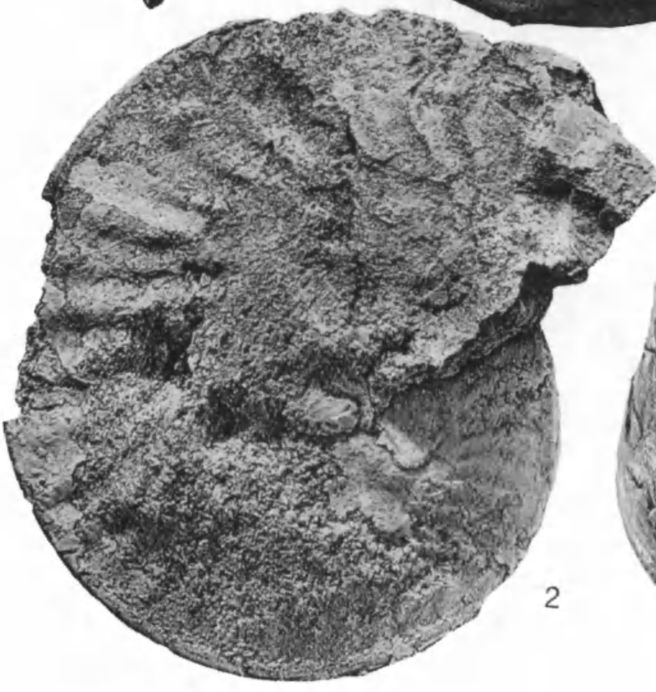
2a

2b

PLATE XXVIII

1b

1a



2

3

PLATE XXVIII

Figure 1. *Oppelia* (*Oxycerites*) ex gr. *fallax* Guéranger et *aspidoides* Oppel. 1a, lateral view; 1b, cross-section. Headwaters of Smoky River, on Sulphur River. Bathonian? Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 54.)

Figure 2. *Oppelia* (*Oxycerites*) ex gr. *fallax* Guéranger et *aspidoides* Oppel. Lateral view. Headwaters of Smoky River on Sheep River. Bathonian ? Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 54.)

Figure 3. *Gryphaea cadominensis* Warren. Left valve. Whitehorse River, about 4 miles north of Mountain Park. Middle Bajocian. Rock Creek member. G.S.C. No. 12894. (No new description.)

Plate XXIX

Figure 1. *Arcticoceras henryi* Meek and Hayden. Lateral view. Same specimen as Plate XXX, figure 1 and Plate XXXI, figure 1. Cascade River Canyon near Banff. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 59.)

Figure 2. *Xenocephalites bearpawensis* Imlay. 2a, cross-section; 2b, lateral view; 2c, venter. Pocaterra Creek, Elk River Basin, Highwood area. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 58.)

PLATE XXIX

1

2a 2b 2c

PLATE XXX

1c

2

3

1a

1b

Plate XXX

Figure 1. *Arcticoceras henryi* Meek and Hayden. Same specimen as Plate XXIX, figure 1, and Plate XXXI, figure 1. 1a, cross-section; 1b, lateral view of inner whorl; 1c, venter of inner whorl. Cascade River Canyon near Banff. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 59.)

Figure 2. *Xenocephalites bearpawensis* Imlay. Lateral view. Pocaterra Creek, Elk River Basin, Highwood area. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 58.)

Figure 3. "*Turbo*" *ferniensis* n.sp. Blairmore. Green beds. Oxfordian. Paratype, G.S.C. No. 12895. (Page 68.)

PLATE XXXI

Figure 1. *Arcticoceras henryi* Meek and Hayden. Venter. Same specimen as Plate XXIX, figure 1 and Plate XXX, figure 1. Cascade River Canyon near Banff. Lower Callovian. Palæontological collection Dept. of Geol., Univ. of Alberta. (Page 59.)

Figure 2. *Kepplerites* (*Seymourites*) sp. indet. 2. 2a, lateral view; 2b, venter. Cascade River Canyon near Banff. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 64.)

Figure 3. *Kepplerites* (*Seymourites*) sp. indet. Lateral view. Cascade River Canyon near Banff. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 65.)

Figure 4. "*Turbo*" *ferniensis* n.sp. Cascade River. Oxfordian. Holotype, G.S.C. No. 12895. (Page 68.)

PLATE XXXI

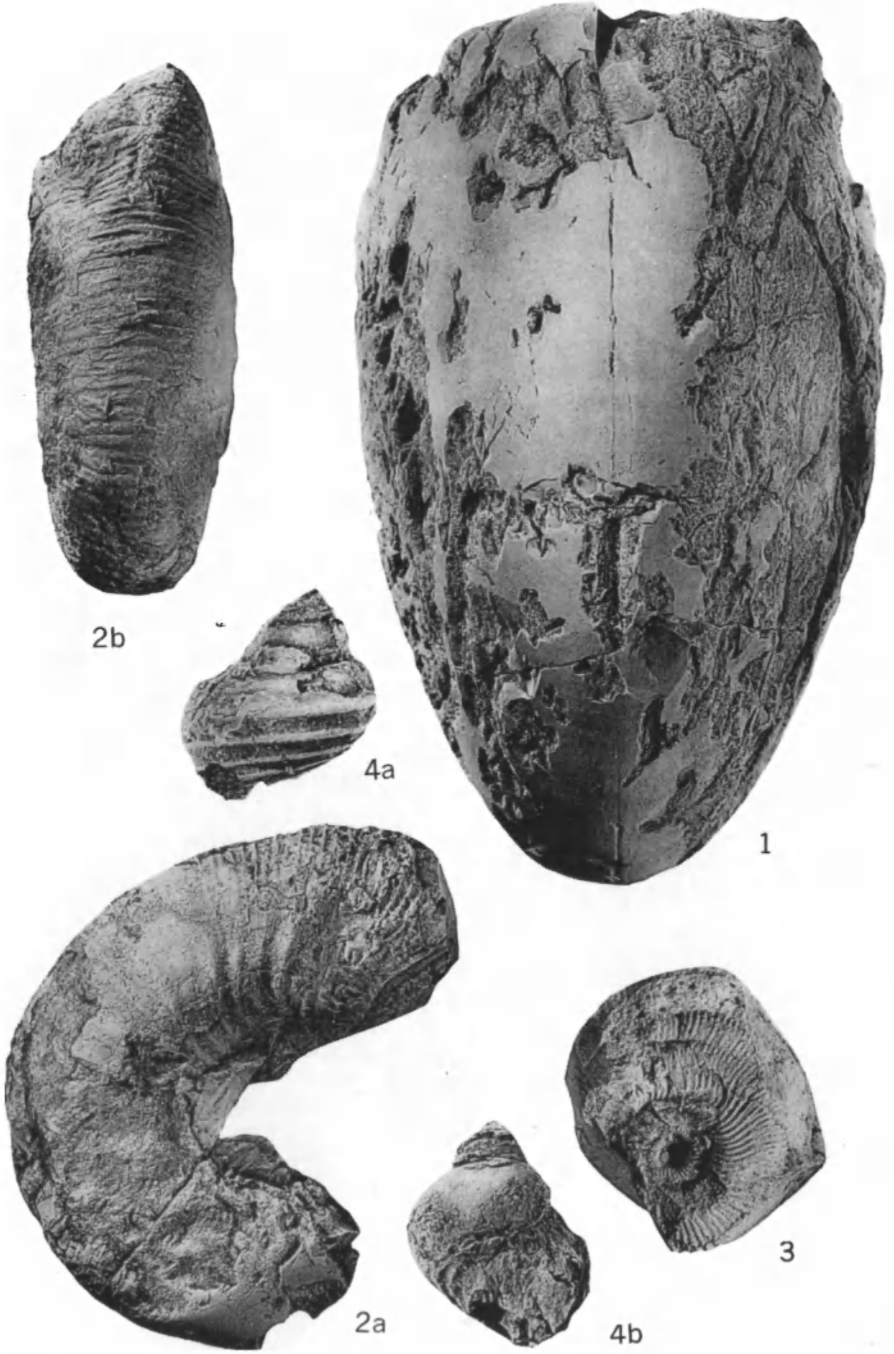


PLATE XXXII

1a

2b

2a

1b

Plate XXXII

Figure 1. *Lilloettia imlayi* n.sp. 1a, lateral view; 1b, venter. *Gryphaea* bed, west side of south slope of Grassy Mountain. Lower Callovian. Holotype, G.S.C. No. 12897. (Page 56.)

Figure 2. *Xenocephalites* cf. *bearpawensis* Imlay. 2a, lateral view; 2b venter. *Gryphaea* bed, Gold Creek road, south slope of Grassy Mountain. Lower Callovian. G.S.C. No. 12898. (Page 58.)

Plate XXXIII

Figure 1. *Lilloettia* ? sp. indet. Crushed specimen. Daisy Creek Summit, Livingstone range. *Gryphaea* bed. Lower Callovian. G.S.C. No. 12899. (Page 57.)

Figure 2. *Kepplerites* (*Seymourites*) sp. indet. 1. 2a, lateral view of whorl fragment; 2b, venter. *Gryphaea* bed, Gold Creek road, south slope of Grassy Mountain. Lower Callovian. G.S.C. No. 12900. (Page 64.)

Figure 3. *Lilloettia imlayi* n.sp. 3a, lateral view; 3b, cross-section. *Gryphaea* bed, Gold Creek road, south slope of Grassy Mountain. Lower Callovian. Paratype, G.S.C. No. 12901. (Page 56.)

2b

1

2a

3b

3a

PLATE XXXIV

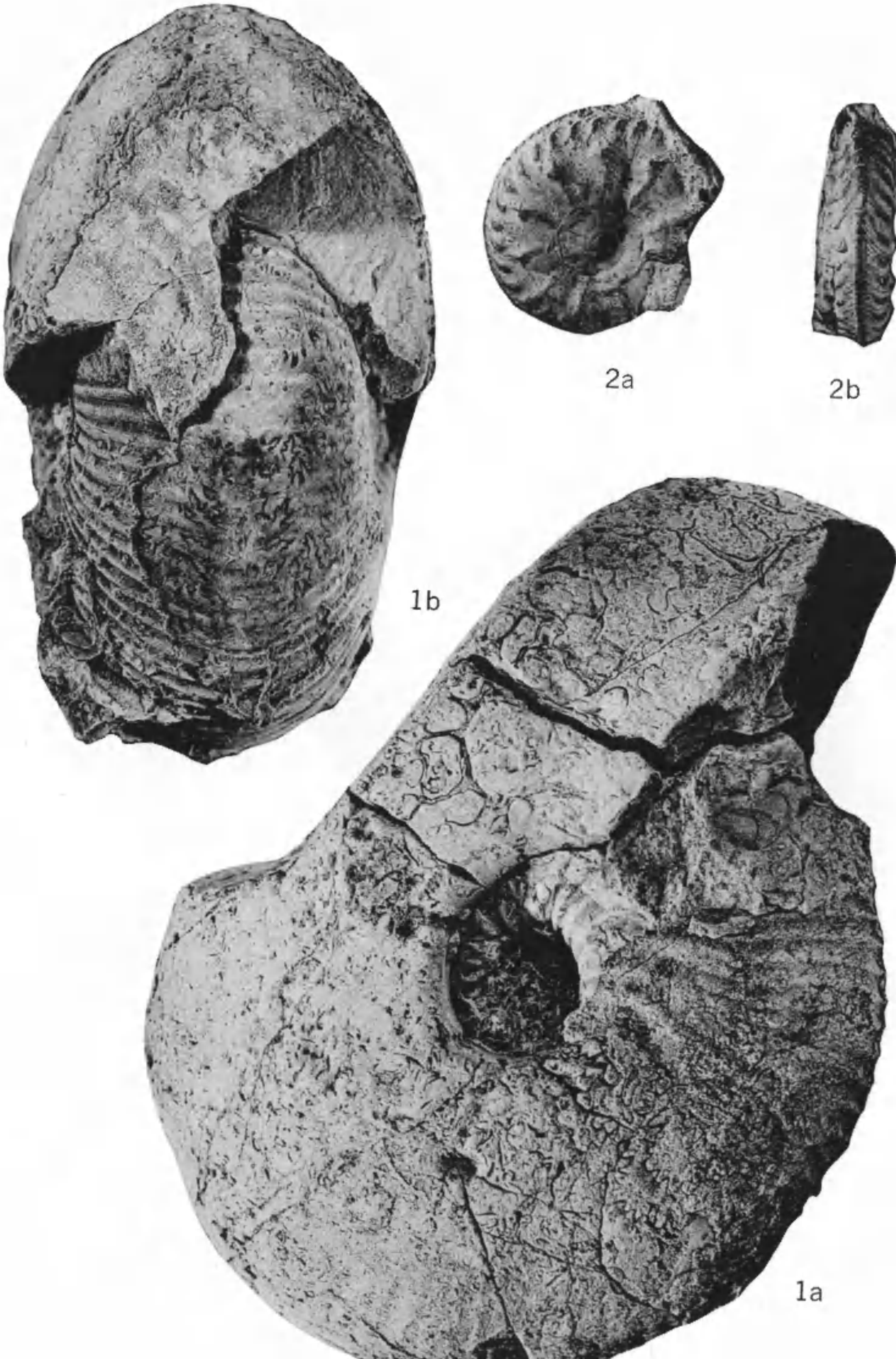


Plate XXXIV

Figure 1. *Cadoceras lillei* n.sp. 1a, lateral view; 1b, cross-section and venter of same specimen after removal of part of body chamber. Same specimen as Plate XXXV, figure 1. Upper part of *Corbula munda* beds, south slope of Grassy Mountain. Lower Callovian. Holotype, G.S.C. No. 12902. (Page 60.)

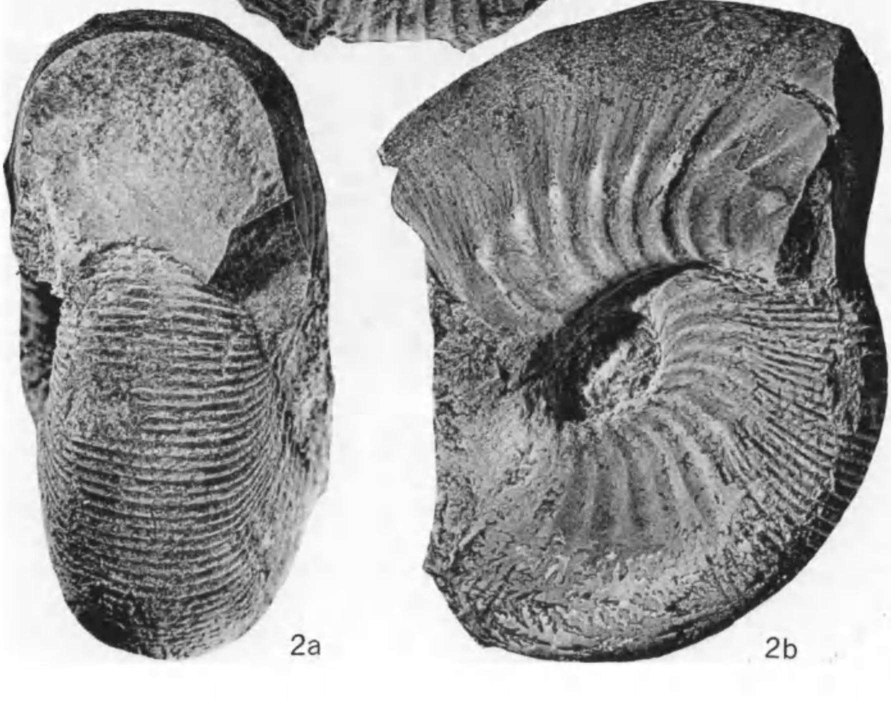
Figure 2. *Cardioceras canadense* Whiteaves. 2a, lateral view; 2b, venter. Exact locality unknown, ? Fernie, B.C. Oxfordian. Holotype of Whiteaves, (1903, pp. 65-67, figures 1, 1a). G.S.C. No. 7437. (Page 62.)

PLATE XXXV

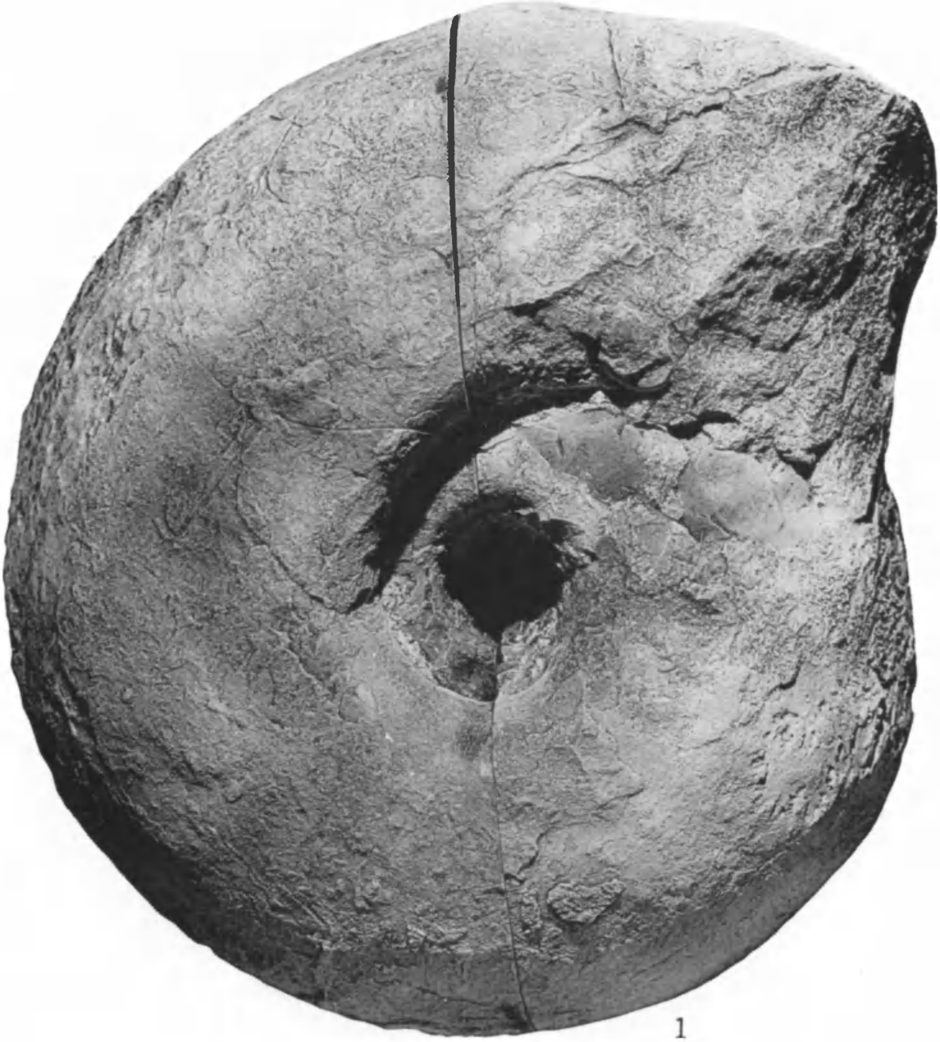
Figure 1. *Cadoceras lillei* n. sp. Lateral view. Same specimen as Plate XXXIV, figure 1 after removal of part of body chamber. Upper part of *Corbula munda* beds, south slope of Grassy Mountain. Lower Callovian. Holotype, G.S.C. No. 12902. (Page 60.)

Figure 2. *Kepplerites* (*Seymourites*) *mcevoyi* McLearn. 2a, venter and cross-section; 2b, lateral view. Ribbon Creek. Lower Callovian. Holotype of McLearn (1928, Plate IV, figures 1, 2). G.S.C. No. 5018. (Pages 63, 64.)

1



2a 2b



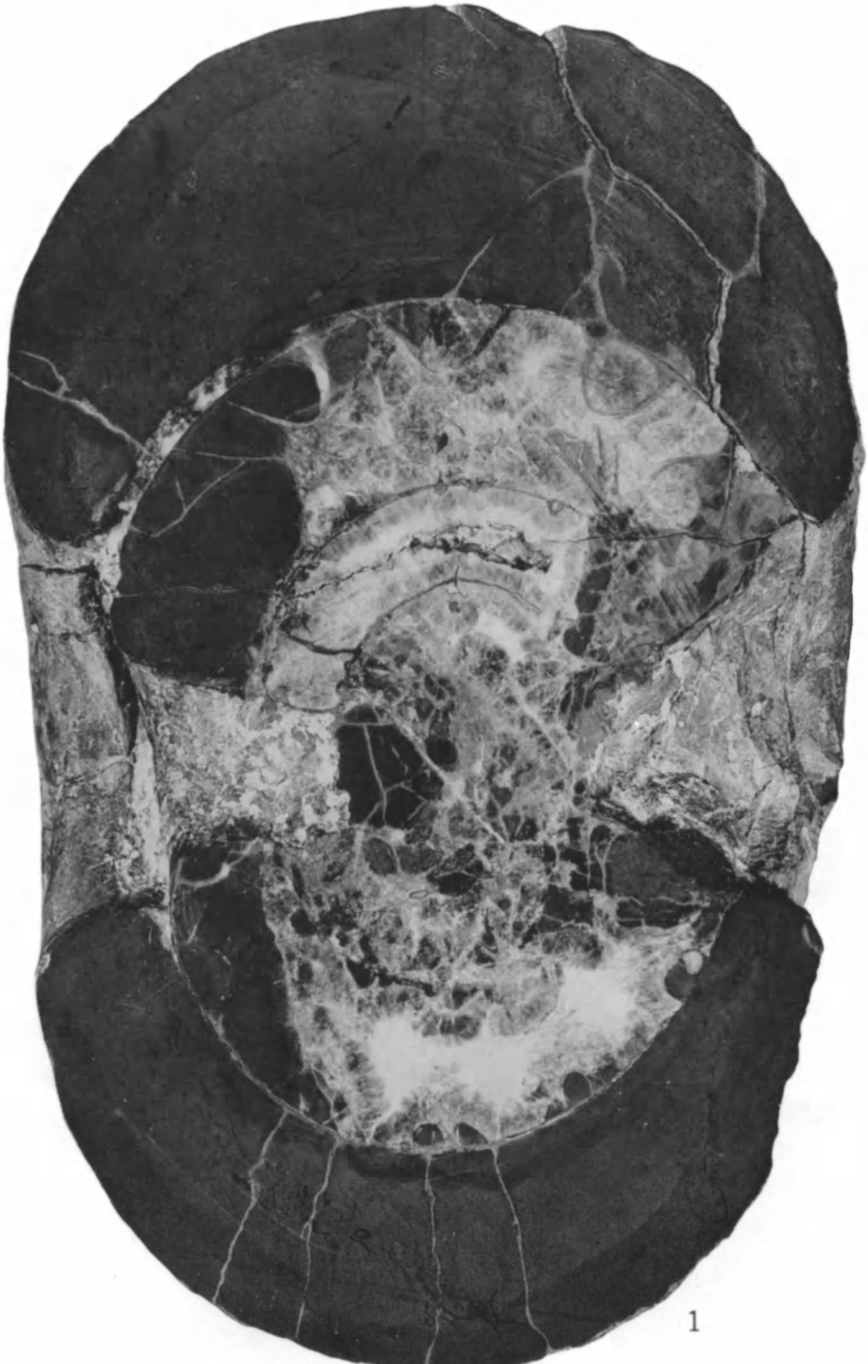
1

PLATE XXXVI

Cadoceras muelleri Imlay. Lateral view. Same specimen as Plate XXXVII. Upper part of *Corbula munda* beds, south slope of Grassy Mountain. Lower Callovian. G.S.C. No. 12903. (Page 60.) x about 0·7.

PLATE XXXVII

Cadoceras muelleri Imlay. Cross-section. Same specimen as Plate XXXVI. Upper part of *Corbula munda* beds, south slope of Grassy Mountain. Lower Callovian. G.S.C. No. 12903. (Page 60.) x about 0·9.



1

PLATE XXXVIII

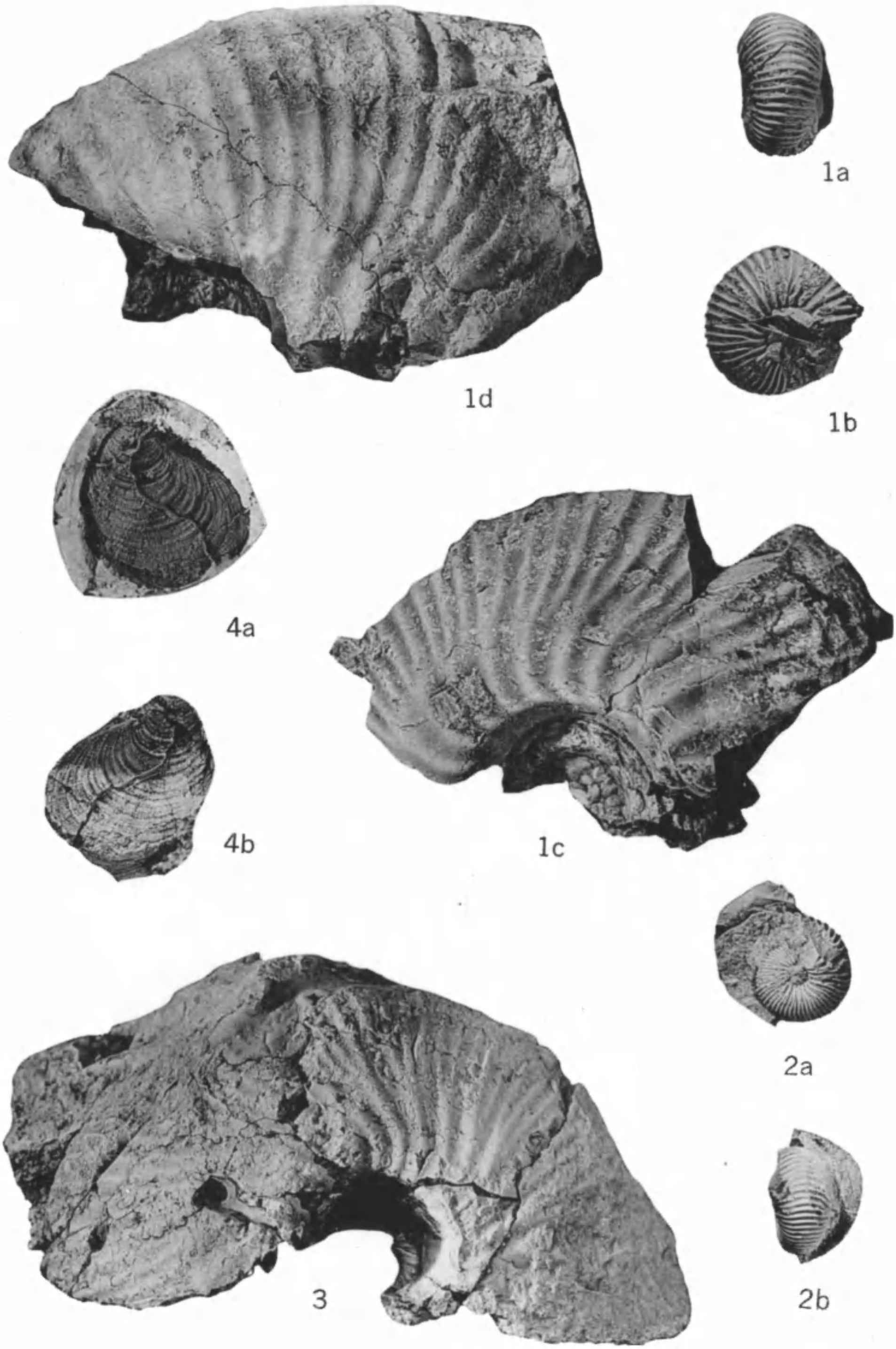


PLATE XXXVIII

Figure 1. *Cadoceras* ex gr. *victor* Spath. All fragments belong to the same specimen. 1a, venter; 1b, lateral view of young form; 1c, lateral view of the next preserved stage of growth; 1d, lateral view of whorl fragment of still older stage of growth. Probably just below *Gryphaea* bed, Adanac strip mine. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 61.)

Figure 2. *Cadoceras* ? sp. indet. 1. 2a, lateral view; 2b, venter. *Gryphaea* bed, Adanac strip mine. Lower Callovian. Palæontological collection, Dept. of Geol., Univ. of Alberta. (Page 62.)

Figure 3. *Cadoceras* sp. indet. 2. Lateral view of whorl fragment. *Corbula munda* beds, south slope of Grassy Mountain. Lower Callovian. G.S.C. No. 12904. (Page 62.)

Figure 4. *Aucella* ex gr. *bronni* Rouiller. Left valve. 4a, plaster cast made of impression; 4b, impression. Upper part of Green beds, 9 feet below lower boundary of Passage beds. Carbondale River. Oxfordian. G.S.C. No. 12905. (Page 68.)

PLATE XXXIX

Procerites engleri n.sp. Lateral view. *Gryphaea* bed, south slope of Grassy Mountain Lower Callovian. Holotype, G.S.C. No. 12906. (Page 65.) x about 0·66.

1

PLATE XL

1a

2a

2b

1b

3

Plate XL

Figure 1. *Procerites engleri* n.sp. 1a, lateral view; 1b, venter. *Gryphaea* bed, south slope of Grassy Mountain. Lower Callovian. Paratype, G.S.C. No. 12907. (Page 65.)

Figure 2. *Procerites* ? sp. indet. 2a, lateral view; 2b, venter. *Gryphaea* bed, south slope of Grassy Mountain. Lower Callovian. G.S.C. No. 12908. (Page 65.)

Figure 3. *Gryphaea impressimarginata* McLearn. Left valve. *Gryphaea* bed, near Adanac strip mine. Lower Callovian. G.S.C. No. 12909. (No new description.)

Plate XLI

Figures 1-6. *Procerites* ? sp. indet. 1-4 lateral views; 5 and 6 venters of other specimens. Southwest of Isola Peak. Lower Callovian. G.S.C. Nos. 12910-12915. (Page 66.)

Figures 7-9. *Procerites* ? sp. indet. 7, 8a, 9a, lateral views; 8b venter of 8a; 9b venter of 9a. *Gryphaea* bed, south slope of Grassy Mountain. Lower Callovian. G.S.C. Nos. 12916-12918. (Page 65.)

PLATE XLI

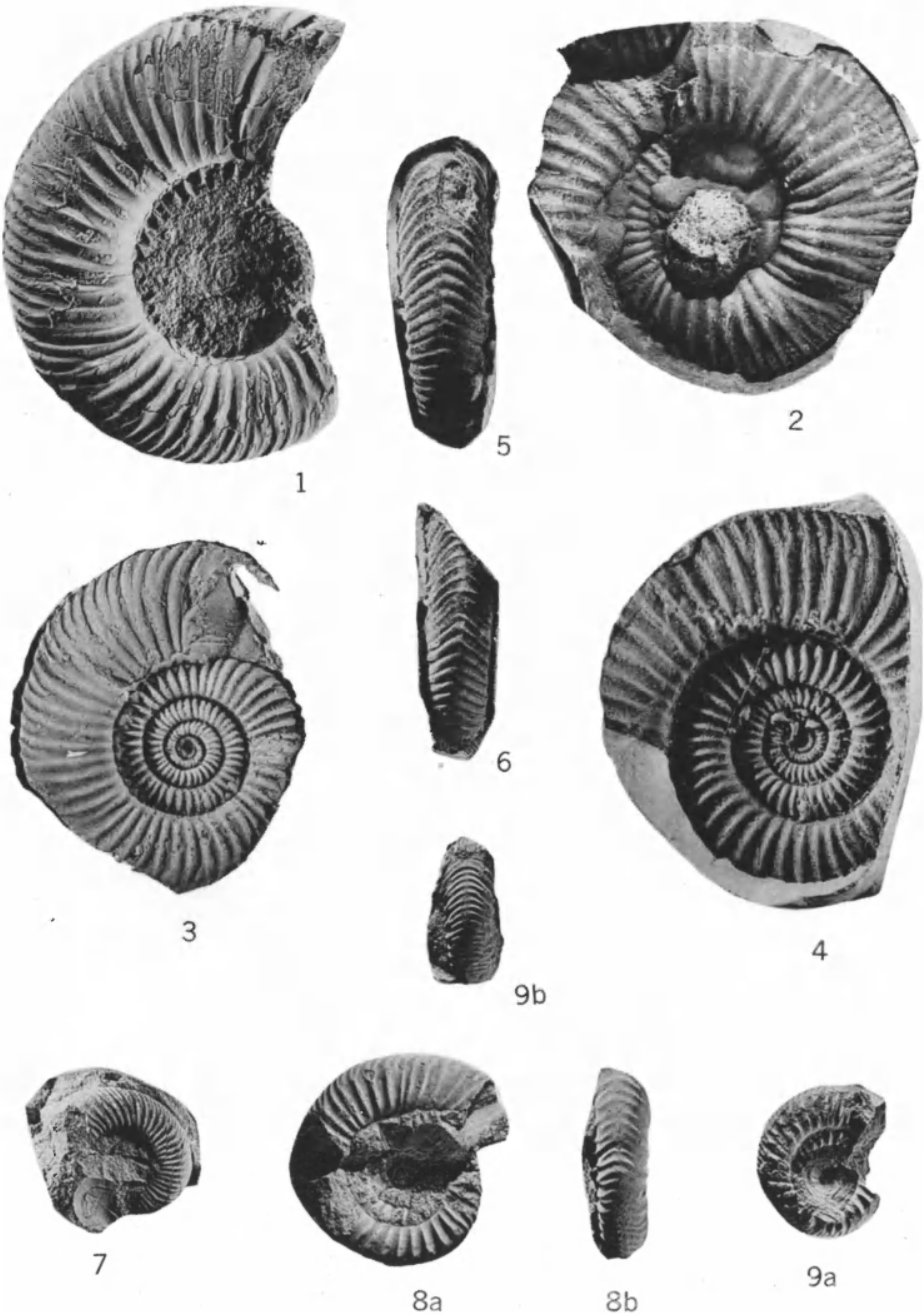


PLATE XLII

1

PLATE XLII

Titanites occidentalis n.sp. Same specimen as Plates XLIII, XLIV. Lower Kootenay sandstone. Upper Portlandian. Ammonite Gully. Coal Creek, east of Fernie, B.C. (Page 66.)

PLATE XLIII

Titanites occidentalis n.sp. Same specimen as Plates XLII, XLIV, Lower Kootenay sandstone. Upper Portlandian. Ammonite Gully, Coal Creek, east of Fernie, B.C. (Page 66.)

PLATE XLIII

1

PLATE XLIV

1

PLATE XLIV

Titanites occidentalis n.sp. Same specimen as Plates XLII, XLIII. Lower Kootenay sandstone. Upper Portlandian. Ammonite Gully, Coal Creek, east of Fernie, B.C. (Page 66.)

INDEX OF FOSSILS

*Numbers in **bold**-face type indicate pages where species are described.*

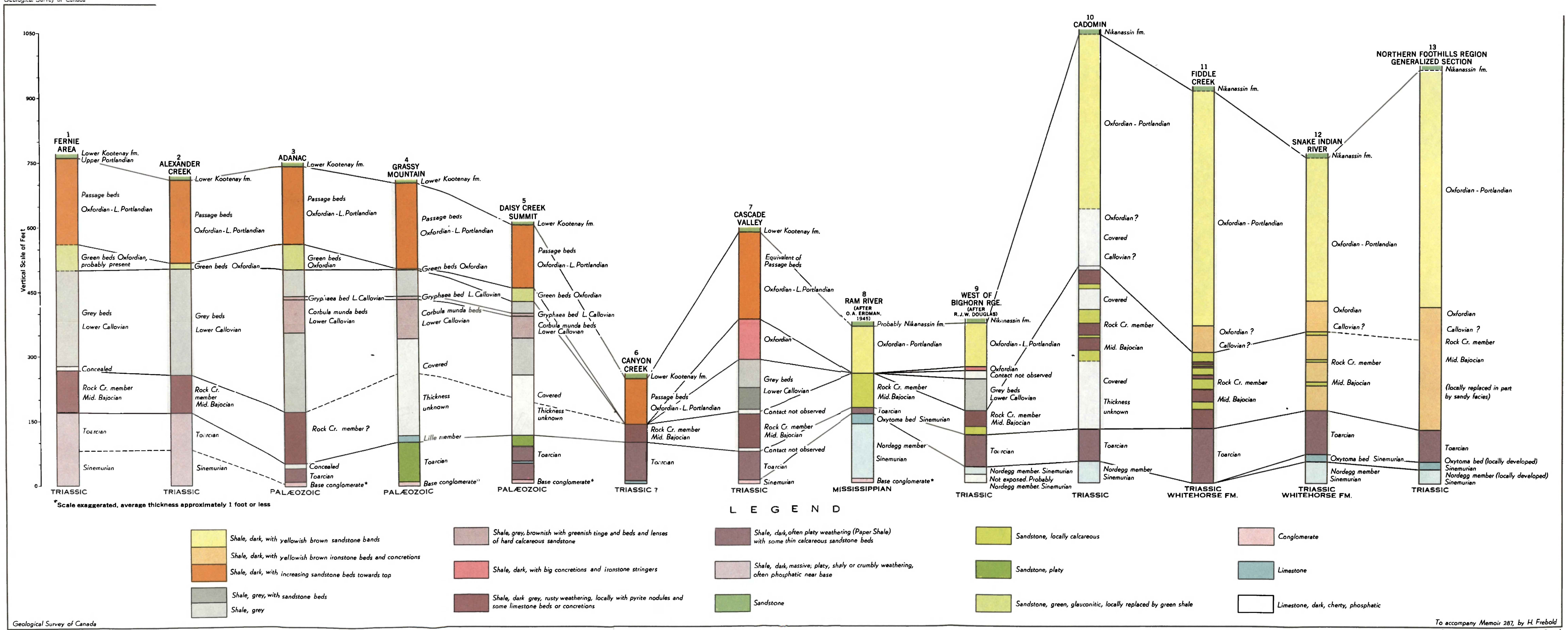


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Figure 3. Columnar sections showing subdivision and facies development of the Jurassic in the Canadian Rocky Mountains and Foothills

See Figure 2 for location of columnar sections 1-13

1 ENGLISH FORMATIONS (Arkell, 1933)	2 NORTHWEST EUROPE STANDARD ZONES (Arkell, 1946, 1951)	3 EUROPEAN STAGES (Arkell, 1946)	4	5 ROCKY MOUNTAINS AND ALBERTA FOOTHILLS	6 INDEX FOSSILS AND GAPS OF THE FERNIE GROUP	7 NAMES OF CERTAIN BEDS AND MEMBERS OF FERNIE GROUP	8 CENTRAL BRITISH COLUMBIA	9 WEST COAST VANCOUVER ISLAND	10 QUEEN CHARLOTTE ISLANDS	11 SOUTHERN YUKON	12 PRINCE PATRICK ISLAND	13 MONTANA	14 SOUTHERN PLAINS OF ALBERTA	15 SOUTHERN PLAINS OF SASKATCHEWAN
						LOWER CRETACEOUS	LOWER CRETACEOUS	MARINE VALANGINIAN	MARINE ALBIAN HAIDA FORMATION	CRETACEOUS	Aucella beds (L. part of Mould Bay fm.)	LOWER CRETACEOUS	LOWER CRETACEOUS	LOWER CRETACEOUS
Purbeck beds														
	Titanites giganteus			L. KOOTENAY FORMATION	Titanites occidentalis	Lower Kootenay sandstone		A. ex gr. rugosa, Phylloceras ex gr. subplicatum, A. ex gr. russiensis				Absent ?		
Portland beds	Glaucolithites gorei	Portlandian												
	Zaraiskites albani													
	Pavlovia pallasioides													
	Pavlovia rotunda													
	Pectinatites pectinatus													
	Subplanites wheatleyensis												Absent	Absent
	Subplanites spp.											Morrison formation		
Kimmeridge clay	Gravesia gigas	Kimmeridgian					Not identified							
	Gravesia gravesiana				Represented in part. No index fossils.	Passage beds								
	Aulacostephanus pseudomutabilis							Aucella ex gr. kirkhisensis, A. bronni, Phylloceras ex gr. glenense					?	?
	Rasenia mutabilis													
	Rasenia cymodoce		UPPER JURASSIC						Absent		Represented in part by non-marine sandstones		Morrison formation ?	Morrison formation ?
	Pictonia baylei			UPPER FERNIE										
	Ringsteadia pseudocordata										FORMATION			U. VANGUARD FM.
	Decipia decipiens												Upper part of Swift formation	
Corallian beds	Perisphinctes cautisnigrae											SWIFT FM.		
	Perisphinctes plicatilis	Oxfordian						Aucella bronni var. leguminosa, A. bronni, Cardioceras ex gr. lillooetense, A. ex gr. bronni		Not identified				
	Cardioceras cordatum				Aucella ex gr. bronni, Turbo ferniensis	Green beds	Aucella cf. bronni					C. cordiforme	Lower, glauconitic part of Swift fm.	Middle Vanguard formation
	Quenstedtoceras mariae											Qu. collieri		
	Quenstedtoceras lamberti													
Oxford clay	Peltoceras athleta				Possibly represented in part. No index fossils.		Not identified				POINT		Absent?	Absent?
	Erymnoceras coronatum											Absent		
	Kosmoceras jason	Callovian						C. ex gr. doroshini						
Kellaway beds	Sigaloceras calloviense				Lilloettia imlayi, Procerites engleri, Gryph. impressimarginata,	Gryphaea bed	Lilloettia,		Kepplerites (Seymourites) (Upper Yakoun fm.)					L. Vanguard fm.
	Proplanulites koenigi				Kepplerites (Seymourites), Xenocephalites bearpawensis.	} Grey beds	Gowericeras,					RIERDON FORMATION: K. mclearni, K. tychonis, G. subitum, G. costidensum, A. codyense	Rierdon formation	
	Macrocephalites macrocephalus				Cadoceras muelleri, C. lillei, C. aff. victor, Arcticoceras henryi.	Corbula munda beds	Cadoceras							U. Shaunavon fm.?
Cornbrash beds	Clydoniceras discus										WILKIE; Cranocephalites and Arkelloceras	Arctocephalites	?	L. Shaunavon fm.?
	Oppelia aspidoides													
	Tulites subcontractus													
Great oolite	Procerites progracilis	Bathonian			Possibly represented in part. No index fossils.				Agglomerates and tuff with rare belemnoids and brachiopods. Exact age unknown					
	Oppelia fallax						Not identified							
	Zigzagiceras zigzag											PIPER AND SAWTOOTH FMS.: No index-fossils	?	?
	Parkinsonia parkinsoni		MIDDLE JURASSIC					Sediments unknown Probably absent. Batholitic intrusions						
	Garantiana garantiana			MIDDLE FERNIE							Not indicated by guide fossils. Represented in part by sandstones			
	Strenoceras subfurcatum													
	Stephanoceras humphriesianum				Tel. dowlingi, T. warreni, Z. crickmayi, Stem. palliseri, St. albertense,	Rock Creek member	Stephanoceras		Stephanoceras, Chondroceras (L. Yakoun fm.)			Chondroceras	Sawtooth fm.	Gravelbourg fm.
Inferior oolite	Otoites sauzei	Bajocian			Steph. ex gr. skidegatense, Ch. allani, Ch. marshalli, Gryphaea cadominensis					Stephanoceras ?		Teloceras		
	Sonninia sowerbyi				Sonninia gracilis, S. sp.		Sonninia, Witchellia							Watrous fm. Age unknown. May include L. Jurassic and Triassic
	Ludwigia murchisonae						Not identified			Not identified				
	Tmetoceras scissum				Absent		Tmetoceras regleyi		Agglomerates and argillite with rare belemnoids, Exact age unknown					
	Leioceras opalinum									Pleydellia,	Leioceras opalinum			
	Lytoceras jurense				Hammatoceras ?		Not identified				Pseudolioceras			
Upper Lias	Hildoceras bifrons	Toarcian				"Paper shale" "Poker Chip shale"			Harpoceras, Fanninoceras, Dactylioceras, (Maude fm.)	Pseudogrammoceras,	Dactylioceras			?
	Harpoceras falcifer				Harpoceras cf exaratum, H. div. sp.,		Harpoceras	Harpoceras, Fanninoceras		SERIES				
	Dactylioceras tenuicostatum				Dactylioceras aff. commune, Peronoceras cf. subarmatum					Dumortieria				
	Paltopleuroceras spinatum													
Middle Lias	Amaltheus margaritatus									A. margaritatus, Prodactylioceras				
	Prodactylioceras davoei	Pliensbachian										Absent	Absent	Absent
	Tragophylloceras ibex						Not identified							
	Uptonia jamesoni		LOWER JURASSIC	LOWER FERNIE	Absent									
	Echioceras raricostatum							Volcanics and sediments. Exact age unknown		LABERGE; Not identified				
	Oxynoticeras oxynotum								Not identified		Absent			
Lower Lias	Asteroceras obtusum	Sinemurian					Asteroceras, Agassiceras							
	Euasteroceras turneri						Not identified							
	Arnioceras semicostatum				Arnioceras telferi, A. sp., Gryphaea rockymontana, Oxytoma cygnipes	Nordegg mem. incl. Oxytoma bed				Arnioceras				
	Arietites bucklandi						Coroniceras, Vermiceras	Arietitides						
	Schlotheimia angulata	Hettangian			Absent		Scamnoceras	Volcanics and sediments. Exact age unknown		Not identified				
	Psiloceras planorbe						Psiloceras canadense			"Psiloceras"				
					TRIASSIC OR UPPER PALÆOZOIC		TRIASSIC	UPPER TRIASSIC	UPPER TRIASSIC	TRIASSIC	DEVONIAN	TRIASSIC TO PERMIAN	MISSISSIPPIAN	MISSISSIPPIAN

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Figure 4. Age, subdivision and correlations of the Jurassic Fernie Group

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