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# SUMMARY ACCOUNT OF THE CRETACEOUS ALBERTA GROUP AND EQUIVALENT ROCKS, ROCKY MOUNTAIN FOOTHILLS, ALBERTA

(Report and 2 figures)

D. F. Stott

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CONTENTS



Illustration

# SUMMARY ACCOUNT OF THE CRETACEOUS ALBERTA GROUP AND EQUIVALENT ROCKS, ROCKY MOUNTAIN FOOTHILLS, ALBERTA

## INTRODUCTION

The Alberta group and equivalent rocks consist of a sequence of shales and sandstones that are predominantly of marine origin and mainly Late Cretaceous in age. They have been studied in the Foothills region from Carbondale River to Smoky River[1]. Studies of numerous sections in surface outcrop within this area were aimed at providing detailed lithologic correlations of the strata, indicating their lateral variations, adding to their palaeontology, determining their general environment of deposition, and outlining their potentialities as possible sources of oil and gas.

This summary account is intended to make available immediately some of the more important conclusions contained in a future report (GSC Mem. 317, in press). During the course of the study, the nomenclature was revised to eliminate overlapping terminology. Type sections are described for the Blackstone, Cardium, and Wapiabi formations. The members within the formations have been named, defined, and type sections established.

## FIELD WORK AND ACKNOWLEDGMENTS

This report is based on a Ph.D. thesis submitted at Princeton University. Research facilities and financial assistance were provided by that institution.

The field work was commenced in 1954 and continued during the field seasons of 1955 and 1956. During three weeks of 1957 some critical exposures were re-examined between MacLeod and Crowsnest Rivers.

Much of the biostratigraphical part of this study is based on the identification and age assignment of fossils by J.A. Jeletzky of the Geological Survey, who has commented in detail on the regional correlations. Jeletzky's zonal and stage assignments have served as the basis of correlation except where otherwise stated. Microfossil studies were made by R.T.D. Wickenden.

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[1] More recently this project has been extended northward to Pine River and a later report will describe the Smoky group of that region.

TABLE OF FORMATIONS

| Southern and Central Foothills | | | | Description | Northern Foothills | | | |
|---|---|---|---|---|---|---|---|---|
| Series | Group | Formation | Member | | Member | Formation | Group | Series |
| | (Thicknesses in feet) | | | | (Thicknesses in feet) | | | |
| Upper Cretaceous | Alberta (2,000-4,100) | Wapiabi (1,043-2,156) | Nomad (90-130) | Rusty-weathering rubbly shales, grading upwards into greenish grey shales and fine-grained, thinly bedded sandstones. Base is marked by band of pebbles. | Nomad (100±) | Wapiabi (1,550±) | Smoky (2,900) | Upper Cretaceous |
| | | | Chungo (135-416) | Fine-grained, thickly bedded, light-brown-weathering sandstones (lithick arenites to quartz wackes) and dark grey siltstone with reddish-brown-weathering concretions. | Chungo (205±) | | | |
| | | | Hanson (0-232) | Dark grey, rusty-weathering, blocky to rubbly shales with reddish-brown-weathering, sideritic concretions. | Hanson (?) | | | |
| | | | Thistle (384-778) | Dark grey to black, calcareous, platy to fissile shales, weathering grey to light grey, with thin, dense, bluish grey dolomitic beds. | Thistle (650±) | | | |
| | | | Dowling (101-351) | Dark grey, rubbly to platy shales, weathering rust, with reddish-brown-weathering sideritic concretions. | Dowling (250±) | | | |
| | | | Marshybank (41-104) | Dark grey, massive, argillaceous siltstone with large reddish brown concretions; siltstone grades into sandstone. | Marshybank (?) | | | |
| | | | Muskiki (144-325) | Dark grey, rubbly to platy shales, weathering rust and having banded or striped appearance; some reddish brown sideritic concretions. Bed of coarse-grained, pebbly sandstone or pebble-conglomerate at base. | Muskiki (250-275) | | | |
| | | | Sturrock (15-166) | Fine-grained, thickly to thinly bedded sandstone (lithic arenite to quartz wacke), weathering rusty brown. In some regions, includes brackish and nonmarine, greyish and greenish shales. | Sturrock (?) | | | |
| | | | Leyland (30-175) | Dark grey to black, rubbly to blocky shales with reddish brown sideritic concretions. | Leyland (?) | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Cardium (74-357) | Cardinal (0-35) | Dark grey, massive, argillaceous siltstone with large reddish brown concretions. | (Cardinal and Kiska members not recognized) | Cardium | | |
| | | | Kiska (0-37) | Dark grey to black, rubbly to blocky shales with reddish brown sideritic concretions. | | | | |
| | | | Moosehound (0-134) | Greyish green to brown, carbonaceous, rubbly shales; friable carbonaceous sandstones; thin coal beds; minor conglomerate. | Moosehound (50-134) | | | |
| | | | Ram (24-103) | Fine-grained, thickly bedded sandstone (lithic arenite), weathering rusty brown. | Ram (40-90) | | | |
| | | Blackstone (262-1,734) | Opabin (70-213) | Dark grey, rusty-weathering, blocky to rubbly shales with reddish-brown-weathering sideritic concretions. | Opabin (?) | Kaskapau (1,200-1,500) | | |
| | | | Haven (35-319) | Dark grey to black, rubbly to platy shales, weathering rust, with yellow sulphur-staining and fetid odor. | Haven (179) | | | |
| | | | Vimy (154-605) | Dark grey to black, calcareous, platy to fissile shales, weathering light grey to white (silver-grey), with dense, dolomitic limestone beds. | Vimy (500-600) | | | |
| | | | Sunkay (15-631) (Sunkay member of Central Foothills includes beds equivalent to Dunvegan formation and part of Fort St. John group) | Dark grey, rubbly to platy shales, weathering rust, with some argillaceous siltstone; few large kettle concretions; thin beds of coarse-grained sandstones; pebble bed at base. | Sunkay (125-175) | | | |
| | | | | Medium- to coarse-grained, carbonaceous, cross-bedded sandstone with greyish green, nonmarine, carbonaceous shales and dark grey marine shales and siltstones; few oyster beds. | | Dunvegan (210-281) | | |
| Lower Cretaceous | | | | Dark grey, rubbly to platy shales, weathering rust, with some argillaceous siltstone; few large kettle concretions; pebble bed at base. | | Shales of the Fort St. John group (325-400) | | Lower Cretaceous |

Competent assistance was given in the field in 1954 by R. Dawson, J. Hawryszko, and J.N. Arthur; in 1955 by J.W. Murray; in 1956 by M.N. Chernoff; and in 1957 by R.K. Broeder.

J.C. Sproule and C.R. Stelck kindly informed the writer of several well-exposed sections which proved useful in correlation. The writer also benefited from discussions with F.G. Fox. E. Dorf and F.B. Van Houten, professors of geology at Princeton, gave constructive criticism and advice during the course of the study.

For their assistance and many acts of kindness, the writer is indebted to L. Bello, J. Kostynuk, C. Luger, C. St. Denys, Mr. and Mrs. S. Nelson, Mr. and Mrs. S.L. Nelson, and the forest rangers of the Eastern Rockies Conservation Board.

## STRATIGRAPHY

In the Alberta group the Blackstone and the Wapiabi formations consist of shale. They are separated by arenaceous beds of the Cardium formation. The Smoky group, equivalent in part to the Alberta group (see Fig. 1), contains the Kaskapau, Cardium, and Wapiabi formations. The shale sequence of the Fort St. John group is separated from the Kaskapau by the arenaceous Dunvegan formation. The Fort St. John shales and the Dunvegan are considered equivalent to part of the Blackstone (see Fig. 1). The formations have been divided into members as shown in the Table of Formations.

The Alberta group lies on beds included in the Blairmore Mountain Park formations. The Fort St. John (Shaftesbury) shales are underlain by beds referred to the Luscar and Mountain Park formations. In southern Alberta, the Alberta group is overlain by the Belly River formation and by the Brazeau formation farther north; the latter is also found above the Smoky group. But beyond Smoky River, the equivalent beds are known as the Wapiti formation.

## FORT ST. JOHN SHALES

The term Fort St. John shales (originated by Dawson in 1881), was used by Wickenden and Shaw (1943)[1] as a group name for strata lying between the Bullhead group and the Dunvegan formation in the area southwest of Fort St. John. South of Smoky River, shales below the Dunvegan probably represent only part of the Shaftesbury formation, as it is known farther north in the region of Pine and Peace

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[1] Dates in parentheses are those of publications listed in the References.

Rivers. Until more precise relationships are established, the shales are referred to as 'Fort St. John group' without further subdivision.

The lower contact of the Fort St. John shale with the Luscar formation is distinct on Sulphur River. A basal bed of chert-pebble conglomerate is similar to that found at the base of the Blackstone formation throughout the southern Foothills. The upper contact of the Fort St. John group with the Dunvegan formation is gradational; fissile or rubbly shales grade upwards into siltstone and sandstone.

The upper shales of the Fort St. John group were measured in the Grande Cache area by Thorsteinsson(1952) who reported a thickness of 381 feet on Sulphur River. On Little Berland River the shales are 325 feet thick.

Interbedding of the silty shale and clay shales produces a striped appearance in the Fort St. John group similar to that found in the basal part of the Sunkay member of the Blackstone formation which is apparently equivalent.

Fossils reported by Thorsteinsson(1952) include specimens of Neogastroplites which Jeletzky dates as latest Albian.

## DUNVEGAN FORMATION

The Dunvegan formation, named by Dawson in 1881, comprises interbedded marine and nonmarine sandstone and shale lying between the Fort St. John group and the Smoky group. The base of the formation is drawn below the lowest siltstone unit. The upper contact is generally transitional and is drawn at the base of rusty shales that overlie massive siltstone or sandstone. The contacts are conformable.

The formation is well developed in the Fort St. John and Peace River areas. As it is traced southeastward in the Alberta Foothills, massive sandstone grades laterally into siltstone, and siltstone grades into shale. South of Athabasca River, these shales, equivalent to the Dunvegan formation, are included in the Blackstone formation (see Fig. 1).

The Dunvegan formation is well exposed in several sections near Smoky River. Thorsteinsson(1952) reported thicknesses of 281 feet on Syncline Hills and 279 feet on Sulphur River. A composite section on Susa Creek is approximately 250 feet thick. On Berland River at Adams Creek, 270 feet of Dunvegan strata were measured. On Little Berland River only 210 feet can be considered as Dunvegan.

The formation consists of flaggy, brownish grey to greenish grey sandstones interbedded with shales containing much carbonaceous material and thin coal beds. The sandstones contain considerable matrix. They consist mainly of quartz and chert, are generally dark grey or brown, and may be carbonaceous. Intrastratal flow structures, laminations, and channel-fills are found within the beds.

Fossil collections made by Thorsteinsson(1952) and Irish(1951) from the Dunvegan formation include:

Brachydontes multilinigera Meek
Inoceramus dunveganensis McLearn
Inoceramus rutherfordi Warren
Pleurobema dowlingi McLearn

These typical Dunvegan fossils are considered by Jeletzky to be of early late-Cenomanian age. Other fossils collected during the present study include:

Anomia anomoides Meek
Corbula nematophora Meek
Inoceramus sp. indet.
Melania sp.
Ostrea sp. indet.
Pleurobema dowlingi McLearn
Unio sp. indet.

## SMOKY GROUP

The Smoky group is nearly similar in lithology to the Alberta group. Many subdivisions of the Alberta group are recognized in the Smoky group, and therefore, in most instances, the same member names are used in both groups.

Rocks of the Smoky group are exposed on Little Berland River where their approximate thickness is 2,900 feet.

### Kaskapau Formation

The Kaskapau formation, as originally defined (McLearn, 1926, p. 119), included all the beds between the Dunvegan sandstone and the Bad Heart sandstone. In the vicinity of Smoky River, the name Kaskapau is given to those beds between the Cardium and Dunvegan formations. The Kaskapau formation of the Foothills is, therefore, stratigraphically equivalent to much of the Blackstone formation and the same members can be readily recognized (see Fig. 1).

The contact of the Kaskapau with the Cardium is drawn at the base of the lowest massive sandstone. The contact of the Kaskapau shale with the Dunvegan formation is drawn at the top of the first massive siltstone or sandstone. As the sand content of the Dunvegan increases towards the north and west, the boundary is drawn at different stratigraphic levels from one area to another.

The thickness of the Kaskapau on Little Berland River is in the order of 1,200 feet. Thorsteinsson(1952) estimated a thickness of about 1,500 feet in the Grande Cache area.

The shales of the Vimy, Haven, and Opabin members of the Kaskapau formation are discussed under the Blackstone formation. Rusty shales of the Sunkay member overlying the Dunvegan formation are stratigraphically equivalent to only the upper part of the Sunkay member of the Blackstone. The beds are approximately 150 feet thick on Little Berland River.

Fossils collected from the Kaskapau formation include:

Prionocyclus (Collignoniceras) cf. woollgari Mantell sensu Haas 1946
Scaphites cf. patulus Cobban
Inoceramus cf. lamarcki (Parkinson) Woods

The formation is dated as late Cenomanian to late Turonian.

## ALBERTA GROUP

The Alberta group, originally defined in the Highwood River area by Hume(1930), extends from the International Boundary in the south to the Athabasca River in the north. It comprises the Blackstone, Cardium, and Wapiabi formations.

The Alberta group thickens towards northwestern Alberta. A composite section on Highwood River indicates that about 2,000 feet are present. On Ghost River the thickness is at least 2,450 feet; on Burnt Timber Creek, approximately 3,200 feet; and composite sections on Bighorn River and on Thistle Creek give approximate thicknesses of 4,100 and 3,800 feet respectively.

## Blackstone Formation

The basal beds of the marine Cretaceous sequence in the Bighorn region were placed in the Blackstone formation by Malloch (1911). As the section he examined on Wapiabi Creek is badly faulted, one on Bighorn River has been selected as the type section of the formation and its members.

The formation is defined as those beds between the basal, thickly bedded sandstones of the Cardium formation and the underlying nonmarine beds of the Blairmore or Mountain Park formations.

The Blackstone overlies beds designated in different areas as the Blairmore formation, the Mountain Park formation, and the Luscar formation. These formations, of nonmarine origin, consist of greenish to brownish sandstones and shales that contain considerable carbonaceous material and coal beds. From Oldman River southward, the Blackstone shales lie on agglomerates and tuffs of the Crowsnest formation. In most sections the Blackstone has a well-defined contact with the underlying formation. A pebble layer, a few inches to a few feet thick, is generally present. The regional relationships, distinct contact, lack of interbedding with the underlying rocks, basal pebble beds, and local unconformities all indicate that the basal Blackstone contact is disconformable.

The thinnest observed section of the Blackstone formation is on Lynx Creek in the Carbondale map-area where a total of 262 feet was measured. The most northerly section examined is on Thistle Creek and has a composite thickness of 1,411 feet. On Sheep River, three sections within a distance of 15 miles indicate a decrease in thickness towards the east from 785 to 614 feet.

The Blackstone formation consists mainly of dark grey marine shales and siltstones with minor beds of argillaceous limestone, sandstone, bentonite, and some ironstone concretions. In general, the formation contains more silt in the westerly sections near the Rocky Mountains. Towards the east the silt content decreases, and the shales are rubbly, flaky, or fissile.

The Blackstone contains the zones of Dunveganoceras to Prionocyclus woollgari Mantell of Cenomanian to late Turonian age, and is also considered by the author, on lithological grounds, to include beds of late Albian age. The base of the formation is time-transgressive. In the Crowsnest area, its base lies high in the late

Summary of Type Section[1] of Blackstone Formation,
Bighorn River Below Junction of Littlehorn River,
Nordegg Map-area, Alberta

| | Thickness (feet) |
|---|---|
| **Cardium Formation** | |
| Sandstone, fine-grained, grey, laminated, rusty-brown-weathering; some interbedded platy shale and siltstone | |
| **Blackstone Formation** | |
| Opabin member: | |
| Shale, very silty; and siltstone, blocky, argillaceous, dark grey; reddish brown concretions; some thinly bedded sandstone towards top ..... | 179 |
| Haven member: | |
| Shale, silty, dark grey, rusty-weathering; much interbedded platy siltstone; few large dolomitic concretions; rare thin bentonitic layers ..... | 319 |
| Vimy member: | |
| Shale, fissile to platy, calcareous, dark grey to black, silver-grey-weathering; interbedded platy siltstone; small grey concretions; dolomitic beds, yellowish weathering ..... | 605 |
| Sunkay member: | |
| Shale, fissile to platy, dark grey, rusty-weathering; interbedded platy siltstone; reddish-brown-weathering sideritic concretions; thin beds of coarse-grained sandstone with fish scales near base ..... | 631 |
| Total thickness of Blackstone formation ..... | 1,734 |
| Fault contact; displacement small | |
| **Mountain Park Formation** | |
| Sandstone, medium-grained, greenish grey; siltstone, argillaceous, dark grey, greenish to brownish weathering | |

[1] This section was fully described in a previous paper (Stott, 1956, sec. 1) but new members were not designated at that time.

Cenomanian Dunveganoceras zone. In the type section, the basal beds may be as old as the younger part of the zone of Neogastroplites (late Albian).

Sunkay Member

This member includes the basal, rusty-weathering shales, siltstones, and coarse-grained sandstone of the Blackstone formation, and is equivalent to beds previously referred to as the Barren zone (Webb and Hertlein, 1934). North of Athabasca River, the Dunvegan formation is equivalent to part of the type Sunkay section, and therefore, the stratigraphic interval of the Sunkay member in the Kaskapau formation is less than that of the member in the central Foothills of Alberta (see Fig. 1).

The thickness of the Sunkay member decreases from 526 feet on Brazeau River in the north to 15 feet on Castle River. The maximum thickness of 631 feet, obtained in the type section, is almost the same as that obtained for the basal beds of the Kaskapau, the Dunvegan, and shales of the Fort St. John group which are considered to be equivalent on Little Berland River. On Sheep River the Sunkay member thins towards the east from 151 to 110 feet.

The member contains silty shales, platy siltstone, and some coarse-grained sandstone. These beds weather a characteristic rusty colour. The base of the member is generally marked by beds of chert pebbles. The lower part of the member is much siltier than the upper part, and generally contains large, reddish-brown-weathering concretions.

The Dunveganoceras zones of Cenomanian age are the only faunal zones definitely recognized in the Sunkay member. Warren and Stelck (1955, p. 64) reported several species of Dunveganoceras from the basal Blackstone shales. Fish scales in the Sunkay member may represent the "Fish-scale" sand marker-bed used by Stelck et al. (1958) as marking the Albian-Cenomanian boundary. The age of the Sunkay member may accordingly range from late Albian to late Cenomanian although no fossils of Albian age have so far been reported.

Fauna:

Dunveganoceras sp. indet.
Inoceramus corpulentus McLearn
Inoceramus fragilis Hall and Meek, s. lato
Inoceramus ex gr. lamarcki (Parkinson) Woods
Inoceramus ex gr. athabaskensis McLearn (?)
Fish scales

Vimy Member

This member includes those beds formerly placed in the Inoceramus labiatus zone (Webb and Hertlein, 1934). The member is named from a forestry cabin near Wapiabi Creek.

The Vimy member lies conformably on the Sunkay member. The contact between the underlying rusty-weathering shales and the silvery-grey-weathering shales is distinct in most sections. A persistent bed of bentonite near the base of the Vimy member may be used to establish the boundary if the contact between the members is not apparent. Relationships between the Vimy and Haven members are conformable. A bed of dark silty dolomite, 1 foot to 2 feet thick, commonly occurs at or near the upper contact of the Vimy member.

The thickness of the Vimy member varies from 605 feet on Bighorn River to 154 feet on Lynx Creek in the Carbondale map-area. A section on Ghost River is 287 feet thick. Three sections on Sheep River show a thinning of the member from 328 feet on the west to 254 feet on the east.

The member is characterized by its silver-grey-weathering calcareous shale and its yellow to buff-weathering beds of dense, argillaceous, dolomitic limestone. Pyrite and organic material are abundant. Towards the eastern edge of the Foothills the silt content of the shales decreases and thin dolomitic limestones become more numerous. A widespread bentonitic layer near the base of the member provides a useful stratigraphic marker and is an important time-horizon.

Most of the Vimy member lies within the Inoceramus labiatus zone of early Turonian age, although I. labiatus apparently does not extend to the top of the member.

Fauna:

Baculites sp. indet. ?
Metoicoceras sp. indet. ?
Prionocyclus (Collignoniceras) woollgari Mantell sensu Haas 1946
Prionocyclus s. lato
Scaphites larvaeformis Meek and Hayden
Scaphites larvaeformis var. obesa Cobban
Scaphites sp. indet. (S. delicatulus Warren ?)
Watinoceras reesidei Warren
Watinoceras sp. indet.
Inoceramus labiatus Schlotheim
Inoceramus ex gr. lamarcki Parkinson s. lato

Inoceramus sp. indet.
Ostrea congesta Meek and Hayden
Fish scales

Haven Member

The Haven member, named from a creek flowing from Bighorn Range, contains those rust-stained shales lying between the grey shales of the underlying Vimy member and the concretionary shales of the overlying Opabin member. The characteristic weathered surface of the Haven shales was responsible for the name 'Rusty shales' in previous reports. The upper boundary of the Haven member is generally drawn below the lowest shale unit containing numerous concretions. This commonly corresponds with the top of some hard, platy siltstones that generally form the upper part of the member.

On Little Berland River the member is 179 feet thick. The type section is 319 feet thick, and on Thistle Creek the member is 248 feet thick. On Wapiabi Creek east of Bighorn Range, a thickness of 137 feet was measured. The member's thickness is 240 feet on Burnt Timber Creek and 203 feet on Ghost River. In the area of Sheep and Highwood Rivers it is between 125 and 160 feet thick, decreasing towards the east. On Lynx Creek, the separation of the Haven and Opabin members is somewhat difficult, but about 35 feet of beds apparently belong in the Haven member.

The Haven member consists of platy to rubbly shales and thin siltstones which weather to a dark rust colour due to the presence of pyrite and siderite. Yellowish sulphur stains are commonly seen. Large buff to yellow-weathering concretions occur sporadically throughout the member. A few thin bentonitic layers are present within the member.

The Haven member lies within the zone of Prionocyclus woollgari Mantell which, according to Jeletzky, is of early late-Turonian age.

Fauna:

Prionocyclus (Collignoniceras) woollgari Mantell sensu Haas 1946
Prionocyclus (Collignoniceras) sp. indet.
Scaphites patulus Cobban
Scaphites sp. indet.
Inoceramus corpulentus McLearn
Inoceramus cf. I. fragilis Hall and Meek
Inoceramus cf. I. lamarcki (Parkinson) Woods
Inoceramus lamarcki (Parkinson) Woods s. lato
Inoceramus cf. I. lamarcki (Parkinson) Woods var. apicalis Woods

Inoceramus sp. indet.
Ostrea sp. indet.
Pteria sp. indet.
Gastropods
Fish scales

Opabin Member

Concretionary shales lying below the thickly bedded sandstones of the Cardium formation and overlying the rusty-weathering shales of the Haven member are designated as the Opabin member. The member contains the beds included in the 'Concretionary Shale' or 'Transition beds' of earlier writers.

The lower boundary of the member is drawn at the base of the concretionary shales or at the top of the hard platy siltstones of the underlying Haven member. The contact between the Haven and the Opabin is conformable and locally is gradational through 20 feet of strata. The upper beds of the Opabin member are gradational into the Cardium formation and the upper contact is drawn at the base of the lowest thickly bedded sandstone.

The thickness of the member ranges from a minimum of about 70 feet on Lynx Creek (Carbondale map-area) to 213 feet on Little Berland River.

As the Opabin member represents the transition from the shales of the Blackstone formation to the sandstones of the Cardium formation, the sediments range from sandstone through siltstone to blocky and rubbly shales. The member typically contains large, reddish-brown-weathering sideritic concretions. The basal part of the member generally consists of dark grey, blocky shale or mudstone rich in dark organic material. The upper part of the Opabin member contains considerable quantities of massive argillaceous siltstone and some sandstone.

No marked faunal change occurs between the Haven member and Opabin member according to the collections made during this study. Prionocyclus woollgari Mantell has been found within the Opabin member indicating that it is of early late-Turonian age.

Fauna:

Prionocyclus (Collignoniceras) cf. P. woollgari Mantell sensu Haas 1946
Prionocyclus (Collignoniceras) cf. P. woollgari Mantell var. typica Haas
Prionocyclus (Collignoniceras) sp. indet.

Scaphites arcadiensis Moreman
Scaphites cf. S. patulus Cobban
Anomia cf. A. subquadrata Stanton
Inoceramus cf. I. ex aff. cordiformis Sowerby
Inoceramus costellatus Woods
Inoceramus fragilis Hall and Meek
Inoceramus cf. I. fragilis Hall and Meek var. prairiensis McLearn
Inoceramus cf. I. lamarcki (Parkinson) Woods var. apicalis Woods
Inoceramus ex gr. lamarcki (Parkinson) Woods s. lato
Pholadomya coloradoensis Stanton (?)
Pteria sp. indet.
Gastropods

## Cardium Formation

The names 'Cardium' (Hector, in Whiteaves, 1895; Cairnes, 1907; Rutherford, 1927) and 'Bighorn' (Malloch, 1911) have been used for the same sandstone succession within the Alberta group. Although both names are invalid according to the approved rules of nomenclature, the introduction of a new name at this time would not be acceptable to most workers. To avoid further duplication, the more acceptable name—Cardium—is adopted.

No type section of the Cardium formation was specifically designated by Cairnes(1907) or by Rutherford(1927) who studied the formation in the vicinity of Bow River. Due to the lack of good exposures, resulting from the construction of power dams, the sections on Bow River are not suitable for a type section. Therefore, the one described by Malloch(1911, p. 23) is designated as the type section of the Cardium formation.

The upper contact of the formation has been defined by the present writer (Stott, 1956): "The upper contact of the Cardium (Bighorn) formation is drawn at the top of the uppermost fine-grained sandstone unit and below the pebble and grit beds, which are usually present within the basal shales of the Wapiabi formation..... The contact is sharp and well defined, although the upper surface of the Cardium (Bighorn) formation may be slightly uneven with pebbles embedded in reworked sand."

The lower contact of the Cardium formation is drawn at the base of the thickly bedded sandstone. The basal contact in the Highwood area is drawn below massive beds of sandy siltstone which are equivalent to the basal sandstones to the north.

Summary of Type Section of Cardium Formation, Headwaters of Wapiabi Creek, Southern Tributary Below Vimy Cabin, Nordegg Map-area, Alberta

| | Thickness (feet) |
|---|---|
| Upper contact is not exposed, although beds of Wapiabi formation outcrop less than 20 feet above sandstone | |
| **Cardium Formation** | |
| Sturrock member: | |
| Sandstone, fine- to medium-grained, grey, rusty-weathering; shale, dark grey; thin conglomerate of chert pebbles | 104 |
| Leyland member: | |
| Shales, rubbly, dark grey; grading upward into interbedded shale and argillaceous siltstone | 54 |
| Cardinal member: | |
| Siltstone, argillaceous, dark grey, rusty-weathering; massive; reddish-brown-weathering sideritic concretions | 21 |
| Kiska member: | |
| Shale, dark grey, rusty-weathering | 3 |
| Moosehound member: | |
| Sandstone, fine-grained, grey to brownish grey, carbonaceous; shale, brownish to greenish grey, carbonaceous, rubbly; some coal; brackish-water fossils | 41 |
| Ram member: | |
| Sandstone, fine-grained, laminated, grey, rusty-brown-weathering; massive to thickly bedded; mottled | 32 |
| Total thickness of Cardium formation | 255 |
| **Blackstone Formation** | |
| Opabin member: | |
| Shale, rusty-weathering; some thinly bedded sandstone; reddish-brown-weathering sideritic concretions | |

The Cardium formation extends along the Foothills from southwestern Alberta into the Foothills of northeastern British Columbia.

On the headwaters of Thistle Creek, Bighorn River, and Wapiabi Creek, the formation is about 300 feet thick. The maximum thickness is 357 feet on Ram River. Farther south, sections at Horseshoe Dam on Bow River, Kananaskis River, and Sheep River are slightly less, being about 300 feet. The minimum thickness, recorded on Drywood River, is 74 feet. In the northern part of the region, some thinning is evident in the section on Muskeg River (255 feet) and on Little Berland River (180 feet). The formation is 248 feet thick on Maskuta Creek and approximately the same in several sections north of Mount Solomon.

In the vicinity of Highwood River, several workers (Allan and Carr, 1947; Douglas, 1958, p. 85; Norris, 1958, p. 15) have reported more than 500 feet of Cardium formation. These sections are considered to contain sandstone equivalent to the basal members of the type Wapiabi formation.

The Cardium formation is characterized by fine-grained sandstone, but in many areas it contains a large percentage of shale. In the type section, marine (Kiska member) and nonmarine (Moosehound member) shales separate the basal and middle sandstone members, and marine shale (Leyland member) is present below the upper sandstone. As the formation is traced northward the marine shales and the middle silty member are replaced by beds of carbonaceous shale and sandstone (see Fig. 1). Southward from the type section the carbonaceous sediments are replaced by marine shales. Eastward from the type section and also from sections farther northwest, marine sandstones grade into siltstone and shale, and carbonaceous sediments grade into marine sandstones.

The Cardium formation, of late Turonian age, overlies beds with fossils of the zone of Prionocyclus woollgari Mantell. It contains fossils of late Turonian age and is overlain by beds lying within either the late Turonian zone of Scaphites preventricosus Cobban or the Coniacian zone of Scaphites ventricosus Meek and Hayden.

Ram Member

The massive sandstone at the base of the Cardium formation comprises the Ram member, typically developed on Ram River just east of Ram Falls. That exposure—103 feet thick—is designated as a standard section. At that locality, two massive sandstones are separated by 22 feet of argillaceous siltstone.

The basal contact with the Blackstone formation is gradational, but an arbitrary boundary is drawn at the base of the lowest massive sandstone unit. The upper contact of the Ram member is distinct in most sections. Where the overlying beds are the Moosehound member, the contrast between fine-grained sandstone of the Ram member and carbonaceous sandstones and shale of the Moosehound member is sufficient to establish a suitable boundary. Where the Ram member is overlain by the marine shales of the Kiska member, the contact is very distinct. The contact with the Moosehound member is probably conformable, as deposition was likely continuous. The contact with the Kiska member is considered to be disconformable although the hiatus probably was not great.

The Ram member is the most persistent of the Cardium members, and although detailed correlations are not made here, the Ram is apparently more-or-less equivalent to the producing sand of the Pembina oilfield.

In general, the member is thickest along Front Range and tends to thin towards the east. A maximum thickness of 103 feet was measured on South Ram River and a minimum thickness of 24 feet was found on Drywood River. The Ram member varies between 40 and 90 feet thick in the region between Muskeg and Athabasca Rivers. Along the edge of Front Range at the headwaters of Bighorn River, Wapiabi Creek, and Thistle Creek, the massive beds of the Ram sand are about 40 feet thick; a local thickening occurs here as the member is traced from west to east. Traced eastward from the headwaters of Wapiabi Creek, the Ram sandstone increases from 32 to a maximum of 79 feet thick. A similar thickening is found in the sections on Brazeau and Cardinal Rivers. This increase in thickness is due to a lateral facies change from carbonaceous nonmarine beds on the west to marine sandstones towards the east.

The Ram member is predominantly sandstone although a siltstone facies is recognized as part of the member in southern Alberta. The sandstone is fine grained, tan or buff weathering, thickly bedded, and consists mainly of chert and quartz grains.

Fauna:

Cardium pauperculum Meek
Inoceramus cf. I. fragilis Hall and Meek
Inoceramus cf. I. fragilis var. prairiensis McLearn
Inoceramus ex gr. lamarcki (Parkinson) Woods
Inoceramus sp. indet. (cf. I. dimidius White)
Modiolus sp. indet.

Moosehound Member

Nonmarine shales, siltstone, sandstone, and some coal, which lie above the Ram member, are included in the Moosehound member. The member is not overlain by the same member throughout the Foothills (see Fig. 1). In the type section the member contains all the beds between the overlying, dark grey concretionary shales of the Kiska member and the basal, thickly bedded sandstones of the Ram member. In areas where the Kiska member is replaced by nonmarine beds, the Moosehound member is overlain by the Cardinal member. North of MacLeod River the Cardinal member is not recognized, and the Moosehound member is overlain by marine shales of the Leyland member or by marine sandstones of the Sturrock member.

The Moosehound member is not recognized south of Ram River. It extends from Front Range to the eastern side of the Foothills and beyond.

The member is thickest in the north and along the western side of the Foothills. It ranges from about 134 feet on Muskeg River to 25 feet in sections on Cardinal River. Part of the decrease is caused by a facies change to sandstone of the underlying Ram member.

Adjacent to Front Range, the Moosehound member consists of green to brown, rubbly shale with thin beds of carbonaceous sandstone. The shale is generally soft and crumbly and contains a nonmarine invertebrate fauna. The sandstones vary from very fine grained to coarse grained, and are friable or massive and well indurated. Plant debris is abundant in some beds. In the Blackstone River region, coal beds as much as 6 inches thick are present.

Fauna:

Campeloma sp. indet.
Corbicula cf. C. occidentalis Meek and Hayden
Corbicula cf. C. obliqua Whiteaves
Corbula nematophora Meek and Hayden
Corbula subtrigonalis Meek and Hayden
Corbula cf. penundata Meek and Hayden
Modiolus (Brachidontes) cf. M. multilingera Meek

Melania sp. indet.
Ostrea sp. indet.
Gastropods, genus and species indet.
Angiosperm fragments

## Kiska Member

The marine shales lying on the Moosehound member in the type section, on the basal Ram member in some sections, and below the siltstone and sandstone of the Cardinal member—these comprise the Kiska member (see Fig. 1). The type section is on Wapiabi Creek, and a standard section is designated on Ram River. The member's name is derived from Kiska Creek north of the type section.

In the standard section and in more southerly sections, the basal contact is marked by a thin bed of chert pebbles or conglomerate. Where the Kiska member lies on the Moosehound member, the contact is generally distinct but pebbles are absent. The upper contact of the Kiska with the Cardinal member is gradational, and is drawn at the base of the siltstone.

The Kiska member increases in thickness eastward and southward, appearing as a tongue which pinches out toward the west and north.

At the headwaters of Wapiabi Creek, the member is represented by only 3 feet of shale. Farther east beyond Bighorn Range, its average thickness is about 20 feet. In the standard section on Ram River, 37 feet of shale is included in the member; it is 34 feet thick on McPhail Creek in the Highwood region.

The Kiska member is a fairly uniform sequence of dark grey marine shales with sideritic concretions.

## Cardinal Member

The Cardinal member—named from Cardinal River—is typically developed in the vicinity of Brazeau River, although the type locality forms part of the type section of the Cardium formation on Wapiabi Creek.

The Cardinal member includes those beds of massive, argillaceous siltstone and sandstone that occur about the middle of the formation. The upper boundary is well defined, with an abrupt change from the massive siltstone of the Cardinal member to the shales of the overlying Leyland member; in many places the upper boundary is marked by pebbles. The lower boundary is the base of the massive siltstone.

This member has been recognized from Thistle Creek to the Crowsnest Pass region. In the vicinity of MacLeod River the Cardinal member is replaced by nonmarine beds included in the Moosehound member.

The Cardinal has a relatively constant thickness throughout the area although it does thin towards the east. It has a maximum of 35 feet on Red Deer River and a minimum of 8 feet on Littlehorn River, and is between 15 and 20 feet thick in most areas.

In the central part of the Foothills, the Cardinal member is predominantly massive, argillaceous siltstone. However, from Burnt Timber Creek south to Dutch Creek, a thickly bedded, fine-grained sandstone is found in an equivalent position. North of Wapiabi Creek the member is replaced by nonmarine beds of the Moosehound member.

Leyland Member

A shale unit below the upper sandstone of the Cardium formation is named the Leyland member after the Canadian National railway station near Cadomin.

In most areas, the Leyland member lies between the Cardinal member and the overlying Sturrock member. However, north of MacLeod River, the Leyland shales lie on nonmarine beds included in the Moosehound member (see Fig. 1). The upper boundary of the Leyland member is arbitrarily drawn at the base of the thickly bedded sandstones of the Sturrock member. This boundary is gradational and does not occupy the same stratigraphic position throughout the region. The lower boundary is placed at the base of the marine shale, and may be marked by pebbles.

In general, the Leyland member increases in thickness southward and eastward across the Foothills. Most of the increase is produced by facies changes from sandstone to shale. The member is about 30 feet thick in the north, but on Sheep River, it is more than 175 feet thick. In the Bighorn region the member thickens from approximately 50 feet in the west to about 90 feet in the east.

The Leyland member consists of dark grey concretionary shales that commonly grade upward into silty shale and siltstone. Some sandstone is included in the member in those sections where thick shale units are separated by thin sandy units.

Fauna:

Baculites ovatus Say s. lato
Scaphites cf. S. impendicostatus Cobban

Scaphites cf. S. mariasensis Cobban
Scaphites preventricosus Cobban cf. typica
Scaphites preventricosus Cobban var. sweetgrassensis Cobban
Scaphites n. sp. aff. mariasensis Cobban
Anomia sp. indet.
Cardium pauperculum Meek and Hayden
Cardium sp. indet.
Inoceramus deformis Meek s. lato
Inoceramus cf. I. deformis Meek var. inconstans Woods
Inoceramus cf. I. dimidius White
Inoceramus fragilis Hayden and Meek (?)
Inoceramus lamarcki (Parkinson) Woods
Inoceramus cf. I. lamarcki (Parkinson) Woods var. cuvieri Sowerby
Inoceramus lamarcki (Parkinson) Woods s. lato
Inoceramus sp. indet.
Ostrea lugubris Conrad
Ostrea sp. indet.
Pteria sp. indet.
Gastropods, genus and species indet.
Macruran crustacean indet.

Sturrock Member

The uppermost sandstone of the Cardium formation is designated the Sturrock member—named from Sturrock Creek. The member is typically developed at the headwaters of Wapiabi Creek.

The Sturrock member includes all the fine-grained, thickly bedded sandstone at the top of the formation. The lower boundary, drawn at the base of thickly bedded sandstone, does not mark a persistent stratigraphic horizon. In some sections, thin units of concretionary shale and carbonaceous sediments have been included in the member.

The Sturrock is thickest along the western edge of the Foothills and thinnest on the eastern side. It ranges from 166 feet on Littlehorn River to 15 feet on Chungo Creek.

Fauna:

Actinocamax cf. A. aff. strehlensis Fritsch and Schloenbach
Cardium pauperculum Meek
Cardium sp. indet.
Inoceramus cf. I. fragilis Hall and Meek
Inoceramus cf. I. lamarcki (Parkinson) Woods var. cuvieri Sowerby

Inoceramus cf. I. lamarcki (Parkinson) var. apicalis Woods
Inoceramus lamarcki (Parkinson) Woods s. lato
Ostrea cf. O. lugubris Conrad
Ostrea sp. indet.
Pholodomya ex gr. coloradoensis Stanton
Pinna sp. indet.
Pteria sp. indet.
Tellina sp. indet.
Trigonoarca cf. T. obliqua Meek
Gastropods, genus and species indet.
Fish scales

## Wapiabi Formation

The Wapiabi formation was named by Malloch(1911) who examined exposures on Wapiabi Creek, however the section there is incomplete and a better-exposed one on Thistle Creek has been selected as the type section for the formation and its members.

The Wapiabi has different stratigraphic limits in the southern and central Foothills. In the type area it is defined as including all the beds between the coarse-grained, greenish grey sandstones of the Brazeau formation and the underlying Cardium formation. This takes in the fine-grained, light-brown-weathering sandstone near the top, and also the transition beds and thin beds of pebbles and coarse-grained sandstone at the base. In the southern Foothills around Sheep River, the Wapiabi formation occupies a smaller stratigraphic interval (see Fig. 1). Here it includes all the dark grey shales between the Cardium sandstones and the medium- to coarse-grained, carbonaceous sandstones of the Belly River formation. The two basal sandstones and overlying shale of the Belly River formation can be correlated with the upper three members of the Wapiabi formation where overlain by the Brazeau formation in the central Foothills.

The Wapiabi formation overlies the Cardium formation with possibly some slight disconformity. At the base of the Wapiabi is a bed of coarse material ranging in thickness from less than an inch (small pebbles) to several feet (large pebbles).

The total thickness of the type section is 2,100 feet, slightly less than the maximum of 2,156 feet measured a short distance upstream. A composite section, 1,950 feet thick, was measured on Bighorn River. On Little Berland River a partly covered section was found to be 1,550 feet thick. In the vicinity of Smoky River the formation is estimated to be about 1,600 feet thick. Complete sections of 1,820 and 1,299 feet were measured on Burnt

Timber Creek and Ghost River respectively. On the eastern side of the Foothills only 1,035 feet of Wapiabi strata was found on Chungo Creek, 1,043 feet on Wapiabi Creek, and 1,108 feet on Blackstone River. On Highwood River, east of the Highwood Range, the Wapiabi is 1,050 feet thick.

Summary of Type Section of Wapiabi Formation[1], West Flank of Syncline on Thistle Creek (Sec. 17, Tp. 44, Rge. 20 W 5), Grave Flats Map-area, Alberta

| | Thickness (feet) |
|---|---|
| **Brazeau Formation** | |
| Sandstone, medium-grained, grey, greenish-grey-weathering; massive; some greenish grey shale; conglomerate | |
| **Wapiabi Formation** | |
| Nomad member: | |
| Shale, greenish grey, rubbly; chert pebbles in shaly matrix at base overlain by a bed of dense dolomitic limestone; thinly interbedded sandstone, fine-grained, greenish grey, and siltstone in upper part ..... | 117 |
| Chungo member: | |
| Sandstone, fine-grained, brownish grey, laminated, massive; some coal and carbonaceous shale at top; siltstone, argillaceous, massive, with sideritic concretions at base ..... | 269 |
| Hanson member: | |
| Mudstone and shale, dark grey, blocky to fissile; reddish-brown-weathering sideritic concretions ..... | 214 |
| Thistle member: | |
| Shale, dark grey, slightly calcareous, grey-weathering; considerable interbedded platy siltstone; few dolomitic limestone beds and concretions ..... | 734 |

[1] This section is described in detail by the writer (Stott, 1956, sec. 9) but new members are not designated. The outcrop is located in section 17 and not section 13 as erroneously stated in the earlier paper.

| | Thickness (feet) |
|---|---|
| Dowling member: | |
| Shale, dark grey, platy to rubbly, rusty-weathering; some platy siltstone; reddish-brown-weathering sideritic concretions ..... | 351 |
| Marshybank member: | |
| Siltstone, argillaceous, dark grey, blocky to massive; sideritic concretions ..... | 90 |
| Muskiki member: | |
| Shale, dark grey, platy to rubbly, rusty-weathering; platy siltstone; sideritic concretions; pebbles in shaly matrix at base ..... | 325 |
| Total thickness of Wapiabi formation ..... | 2,100 |

Cardium Formation

Sandstone, medium- to fine-grained, light grey, massive

The shales of the Wapiabi formation vary from fissile to rubbly and platy. They are dark grey, weather rusty, and contain abundant dark organic material. Glauconite occurs in the concretionary shales. Reddish-brown-weathering, sideritic concretions are plentiful in the basal and upper thirds of the formation. Sandstone near the top is fine grained, thickly bedded, and weathers light brown. Thin bentonite layers occur throughout the formation but most are near the base.

The formation is characterized by the presence of several zones of Scaphites. Six zones, present in the lowest four members, range in age from latest Turonian to Santonian. The upper members of the formation contain fossils which are not readily placed in the standard section but may be as young as Campanian.

Muskiki Member

This member—the basal member of the Wapiabi formation—is named from Muskiki Creek, a small tributary of Brazeau River. The member contains all the beds from the top of the fine-grained sandstone of the Cardium formation to the base of a massive

siltstone of the Marshybank member. It consists predominantly of alternating beds of rubbly and flaky shale. The shale has a characteristic weathered surface that was responsible for the designation "Striped zone" by Hake et al. (1942). Locally, the shale is concretionary.

The Muskiki member thins towards the east and also towards the south. Sections on Thistle and Cripple Creeks are 325 and 312 feet respectively. On Little Berland River the member is 263 feet thick. In the south its thickness is between 150 and 175 feet. A minimum thickness of 145 feet was measured on Blackstone River.

Shales equivalent to the Muskiki member have been traced northward along the Foothills from Muskeg River almost to Pine River. In that region, they lie between the Cardium and Bad Heart formations but heretofore have received no formal designation (see Stott, 1960). As the shales retain the same characteristic features, occupy approximately the same stratigraphic interval, and are of approximately the same age, it is proposed that the Muskiki member be elevated to formational rank in that region.

In most sections, the basal beds of the Muskiki member lie within the zone of Scaphites preventricosus Cobban and Inoceramus deformis Meek which, according to Jeletzky, is of latest Turonian age. The main part of the member lies within the zone of Scaphites ventricosus Meek and Hayden and Inoceramus involutus (=I. umbonatus Meek and Hayden). This zone is considered by Jeletzky to be of Coniacian age in terms of the international standard. The Muskiki member is, therefore, of late Turonian to Coniacian age.

Diagnostic fossils have not been collected from the upper Cardium beds north of Bow River, but Scaphites mariasensis Cobban—the index fossil of the lower subzone of Scaphites preventricosus zone—occurs in the basal Wapiabi(Muskiki) shale in that part of the Foothills. In southern Alberta, however, Scaphites comparable with S. mariasensis Cobban and S. impendicostatus Cobban occur in the upper beds of the Cardium formation. Furthermore, in this part of the Foothills, S. cf. impendicostatus Cobban and Scaphites ventricosus Meek and Hayden s. str. occur in the basal Wapiabi shales in correct sequence, indicating the absence of any significant hiatus. These relationships indicate, according to Jeletzky, some diachronism of the Cardium-Wapiabi contact in the north-south direction. Only the earliest part of the Scaphites preventricosus zone could, under these circumstances, be present within the Cardium formation of the northern Foothills.

Fauna:

Baculites cf. B. asper Morton
Baculites ovatus Say s. lato

Baculites sp. indet.
Scaphites ex gr. corvensis-preventricosus Cobban
Scaphites impendicostatus Cobban
Scaphites mariasensis Cobban
Scaphites preventricosus Cobban
Scaphites cf. S. preventricosus Cobban var. sweetgrassensis Cobban
Scaphites ventricosus Meek and Hayden s. str.
Scaphites ex gr. ventricosus Meek and Hayden s. lato
Inoceramus cf. I. costellatus Woods
Inoceramus coulthardi McLearn (?)
Inoceramus deformis Meek
Inoceramus deformis Meek (giant variety)
Inoceramus cf. I. deformis Meek var. inconstans Wood
Inoceramus cf. I. fragilis Hall and Meek
Inoceramus ex gr. lamarcki (Parkinson) Woods s. lato
Inoceramus cf. I. lamarcki (Parkinson) Woods var. apicalis Woods
Inoceramus cf. I. lamarcki (Parkinson) Woods var. capulus Shumard
Inoceramus cf. I. subquadratus Schlüter s. lato
Inoceramus cf. I. leylandensis McLearn
Inoceramus involutus Sowerby var. exogyroides Meek and Hayden
Inoceramus cf. I. involutus Sowerby
Inoceramus ex gr. involutus Sowerby
Nucula sp. indet.
Ostrea sp. indet.
Tritonides cf. T. huerfranensis Stanton
Fish scales
Gastropods, genus and species indet.

Marshybank Member

A unit of massive siltstone or fine-grained sandstone approximately 200 to 250 feet above the base of the Wapiabi formation is given member status and named the Marshybank member. This particular subdivision was not recognized as a separate unit by previous workers. The name is taken from a creek that flows into Brazeau River.

The base of the member is drawn where the siltstone grades into shale or mudstone, and is arbitrary. The upper contact is commonly distinct and marked by a thin layer of pebbles.

The member thins towards the eastern side of the Foothills and also towards the south. An estimated thickness of 90 feet was obtained on Thistle Creek. A comparable section of 104 feet was measured on Bighorn River. The thickness to the east, on Blackstone

River, is 80 feet; on Highwood River, only 41 feet is included in the member.

The Marshybank member consists of massive argillaceous siltstone with large, reddish-brown-weathering, sideritic concretions. In the vicinity of Muskeg River a unit of fine-grained sandstone occupies an equivalent stratigraphic position. North of Smoky River, a sandstone occupying a similar stratigraphic interval is known as the Bad Heart sandstone.

The Marshybank member is characterized by Scaphites comparable with or referable to Scaphites depressus Reeside. Jeletzky considers this fauna to be of early Santonian age.

Fauna:

Baculites sp. indet.
Scaphites depressus Reeside s. stricto
Scaphites depressus Reeside var. stantoni Reeside
Scaphites ex gr. depressus Reeside
Scaphites ex gr. ventricosus Meek and Hayden s. lato
Anomia cf. A. subquadrata Stanton
Cardium cf. Cardium pauperculum Meek and Hayden
Inoceramus cf. I. lamarcki (Parkinson) Woods var. cuvieri Sowerby
Inoceramus cf. I. lamarcki (Parkinson) Woods var. apicalis Woods
Inoceramus sp. indet.
Pecten sp. indet.
Ostrea sp. indet.

Dowling Member

The Dowling member contains those beds of concretionary shale that are overlain by the calcareous shales of the central part of the Wapiabi formation and underlain by the Marshybank member. Dowling ford on Brazeau River provides the name for this member.

The type section of the Dowling member has a thickness of 351 feet. The minimum measurement was obtained on Blackstone River where 101 feet is present. On Bighorn River and Cripple Creek the member is about 270 feet thick; it has a similar thickness on Burnt Timber Creek and Highwood River.

Shales of the Dowling member are dark grey, weather rusty, and contain numerous sideritic concretions. Some thin platy siltstones are interbedded with the shale, but the member does not have the strongly banded appearance of the Muskiki member.

Two zones recognized in the Dowling member are those of Scaphites depressus and Scaphites vermiformis. Jeletzky, who recently recognized the latter between the underlying zone of S. depressus Reeside and the overlying zone of S. montanensis Cobban, dates the S. depressus and S. vermiformis zones as early Santonian.

Fauna:

Baculites cf. B. asper Morton
Baculites ovatus Say s. lato
Scaphites depressus Reeside s. stricto
Scaphites depressus Reeside var. stantoni Reeside
Scaphites ex gr. depressus Reeside
Scaphites (Clioscaphites) cf. S. platygastratus Cobban
Scaphites cf. S. saxitonianus McLearn
Scaphites (Clioscaphites) cf. S. vermiformis Meek and Hayden var. toolensis Cobban
Scaphites ex gr. ventricosus Meek and Hayden s. lato
Scaphites sp. indet.
Inoceramus cf. I. cardissoides Goldfuss
Inoceramus cordiformis Sowerby s. lato
Inoceramus cf. I. cordiformis Sowerby var. haenleini Müller
Inoceramus cf. I. coulthardi McLearn
Inoceramus cf. I. lobatus Goldfuss
Inoceramus sp. indet.
Ostrea sp. indet.
Fish scales
Gastropods, genus and species indet.

Thistle Member

The thick sequence of platy calcareous shales, known previously as the 'Platy shale zone' (Webb and Hertlein, 1934), is named the Thistle member after Thistle Creek where the type section of the Wapiabi formation is located.

The member consists of those beds between the overlying concretionary shales of the Hanson member and the underlying concretionary shales of the Dowling member. The lower contact, drawn at the base of the non-concretionary shales, is conformable. The upper contact is drawn at the top of the platy shales and/or siltstones that are overlain by blocky mudstone containing abundant sideritic concretions.

The type section on Thistle Creek is 734 feet thick and a maximum thickness of 778 feet was measured farther upstream. A minimum thickness of 384 feet was found on Highwood River. Farther

north, 650 feet was measured on Little Berland River but the lower contact of the member is not exposed there.

The shales of the Thistle member are fissile to platy, calcareous, dark grey to black, and weather grey to slightly rusty. In contrast to other members of the Wapiabi formation, the Thistle only rarely contains sideritic concretions. In many sections, large lens-like bodies are composed of argillaceous dolomitic limestone which weathers greyish yellow.

The fauna characterized by Scaphites montanensis Cobban occurs in the lower part of the Thistle member, and this fauna is considered by Jeletzky to be of middle to early late-Santonian age. The fauna in the upper beds of the member is probably only slightly younger. Therefore, a middle to early late-Santonian age is suggested for the Thistle member.

Fauna:

Baculites cf. B. ovatus Say var. haresi Reeside
Baculites ovatus Say s. lato
Baculites p. indet.
Scaphites (Clioscaphites) montanensis Cobban
Scaphites cf. S. (Clioscaphites) vermiformis Meek and Hayden
Scaphites ex gr. ventricosus Meek and Hayden s. lato
Scaphites sp. indet.
Anomia ? sp. indet.
Anomia cf. A. subquadrata Stanton
Inoceramus cf. I. lobatus Goldfuss
Inoceramus cf. I. stenstrupi de Loriol
Inoceramus cardissoides Goldfuss
Inoceramus cf. I. balticus Böhm
Inoceramus sp. indet.
Pteria nebrascana Evans and Shumard
Pteria sp. indet.
Ostrea sp. indet.
Ostrea congesta Conrad
Cardium sp. indet.
Gastropods, genus and species indet.
Shark teeth

Hanson Member

The concretionary shale that lies above the platy shales of the Thistle member and below massive siltstone or sandstone comprises the Hanson member. Hanson Creek, from which the member's name is taken, is north of Brazeau River.

The Hanson member thins from west to east although in the east it includes a greater stratigraphic interval as the siltstone of the overlying Chungo member grades into shale. The member ranges in thickness from 232 feet on Thistle Creek to 135 feet on Blackstone River.

In general, the shales are blocky to rubbly, and are not as platy as those of some other members. They are dark grey and weather rusty. Concretions occur throughout the member, and generally are larger than those in the Dowling member.

According to Jeletzky the fauna indicates deposition during some part of late Santonian time.

Fauna:

Baculites ovatus Say var. haresi Reeside
Baculites ovatus Say
Baculites ovatus Say s. lato
Scaphites (Clioscaphites) sp. indet. (? S. choteauensis Cobban)
Scaphites sp. indet.
Cardium cf. C. pauperculum Meek
Inoceramus lingua Goldfuss
Placenticeras planum Hyatt
Anomia subquadrata Stanton
Ostrea sp.
Lingula sp. indet.

Chungo Member

The Chungo member[1] of the Wapiabi formation is defined as those beds of siltstone and sandstone in the upper part of the formation which are overlain by a persistent conglomerate zone and are underlain by the concretionary shales of the Hanson member or, in the absence of Hanson beds, by calcareous shales of the Thistle member. The name of the member is taken from Chungo Creek northwest of Nordegg.

The lower boundary is arbitrarily drawn at the base of the lowest massive siltstone. In southern Alberta the member loses its typical marine character, and contains coarse-grained sandstone which is carbonaceous and greenish grey. Inasmuch as this sandstone is typical of the Belly River formation, beds equivalent to the Chungo member in this area are included with that formation.

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[1] The name 'Solomon', proposed by Lang(1946) for equivalent beds, is rejected because it has been pre-empted several times.

The Chungo member is 261 feet thick in the type section; farther west on Thistle Creek, it is 276 feet thick. The minimum thickness was measured on Chungo Creek where 135 feet was included in the member. The maximum thickness, 416 feet, is on Oldman River. In the north on Little Berland River, a thickness of 205 feet was measured. On Oldfort Creek the member is 171 feet thick. On the eastern side of the Foothills, its thickness is between 135 feet and 175 feet, but as the member grades into shale, its distinctive features disappear and it is no longer recognizable.

The Chungo member contains three sedimentary facies. In the western sections of the northern half of the area, sandstone predominates. In the eastern sections, and from the North Saskatchewan River to Bow River, siltstone is the dominant lithology. Greyish green shales with some thin coal beds occur near the top of the member in the area west of Bighorn Range and in the Highwood area.

The Chungo sandstone, composed mainly of chert and quartz grains, is very fine grained, grey to brownish grey, weathers dull buff to brown, and contains carbonate fragments as well as calcareous cement. Glauconite occurs in the sandstone but is more abundant in the silty facies.

In the vicinity of Highwood River the Highwood sandstone (Webb and Hertlein, 1934, p. 1402) forms part of the Chungo member. As the member is traced eastward, a tongue of shale appears in the middle, separating the member into the Highwood sandstone and an upper sandstone. The top of the upper sandstone is considered, on lithological evidence, to be equivalent to the top of the Milk River formation of southwestern Alberta.

The range of the youngest Wapiabi macrofauna, as developed in the Chungo and Nomad members may be from Santonian to early Campanian age. This macrofauna lacks, however, any diagnostic elements of the Eagle(Lower Campanian) time. According to Jeletzky, this suggests a late Santonian age for these members. Nevertheless, as the Chungo member is considered to be lithologically equivalent to the Campanian Milk River sandstones, the author suggests an early Campanian age for the Chungo member.

Fauna:

Baculites ovatus Say s. lato
Baculites ovatus Say (large variety)
Baculites ovatus Say var. haresi Reeside
Arctica sp. indet.
Cardium sp. indet.

Inoceramus lobatus Goldfuss cf. I. lobatus var. stenstrupi de Loriol
Leptosolen sp. indet.
Lingula sp. indet.
Liopista undata Meek and Hayden
Lucina sp. indet.
Lunatia ex gr. occidentalis Meek and Hayden
Modiolus sp. indet.
Nucula sp. indet.
Ostrea sp. indet.
Pteria (Oxytoma) nebrascana Evans and Shumard
Tancredia cf. Tancredia americana Meek and Hayden
Tancredia sp. indet.
Tellina sp. indet.

Nomad Member

Sediments between the coarse-grained sandstone of the Brazeau formation and the fine-grained sandstone or siltstone of the Chungo member of the Wapiabi formation are included in the Wapiabi formation and named the Nomad member. The name comes from a tributary of Cardinal River.

The lower contact of the Nomad member on the Chungo member is drawn below a pebble bed. The upper boundary is drawn at the base of coarse-grained sandstone in the Brazeau formation.

The Nomad varies in thickness from 90 to 130 feet throughout most of the Foothills but increases to as much as 170 feet in a few of the more easterly sections.

In general, the member consists of dark grey shales and some greenish grey siltstone and sandstone.

Microfauna obtained from the Nomad member on Highwood River included, according to Wickenden, several specimens of Verneuilina bearpawensis Wickenden. Wickenden commented that this diagnostic species occurs in the Pakowki equivalents above beds correlated with the Milk River sandstones. Although Jeletzky suggests a Santonian age for the macrofossils of the Nomad member, the author considers, on the basis of micropalaeontology and stratigraphic relationships, that the member is equivalent to the Pakowki formation, and therefore, of Campanian age.

Fauna:

Baculites ovatus Say (large variety)
Baculites ovatus Say var. haresi Reeside

Modiolus ? sp. indet.
Mya ? sp. indet.
Nucula cf. N. assiniboinensis Landes
Cardium sp.
Trochammina sp.
Haplophragmoides sp.
Verneuilina bearpawensis Wickenden

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