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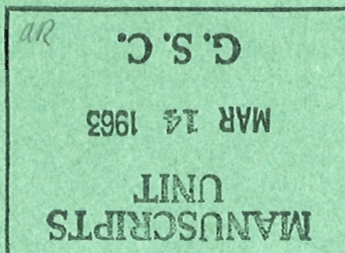
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BULLETIN 93

**AMMONITE FAUNAS OF THE
UPPER MIDDLE JURASSIC BEDS OF THE FERNIE GROUP
IN WESTERN CANADA**

Hans Frebold



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PREFACE

The Fernie Group comprises most of the Jurassic strata in the Rocky Mountains and Foothills. Although widespread and readily recognizable in both outcrop and subsurface, detailed correlation from place to place is difficult because of abrupt changes in facies of the rocks. Previous studies by the author have shown that internal age relationships can be established by means of index fossils common to the different facies. This report, based on additional fossil collections, adds refinement to some of the author's original conclusions and permits a more precise correlation of these rocks with similar Middle Jurassic rocks of the western United States and Arctic Canada.

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

OTTAWA, OCTOBER 30, 1962

Bulletin 93—Die Ammonitenfauna in den Schichten
des oberen Mitteljura der Fernie-Gruppe
in Westkanada von Hans Frebold

Es werden fünf Ammonitenzonen unterschieden, und zwar von unten nach oben: die *Paracephalites glabrescens*-Zone, die *Warrenoceras henryi*-Zone, die *Keplerites aff. tychonis*-Zone, die *Keplerites mclearni*-Zone und die *Imlayoceras mieltense*-Zone. Möglicherweise ist noch eine sechste Zone mit unbeschriebenen Perisphinctes vorhanden. Zwei neue Genera: *Warrenoceras*, dessen Spezies früher zu *Arcticoceras* Spath gestellt waren, und *Imlayoceras*, ein Macrocephalitid, werden beschrieben.

Бюллетень 93 — Аммонитовые фауны из верхнеюрских отложений группы Ферни западной Канады.
Автор: Ганс Фреболд.

Установлены пять аммонитовых зон, в восходящем порядке: зона *Paracephalites glabrescens*, зона *Warrenoceras henryi*, зона *Keplerites aff. tychonis*, зона *Keplerites mclearni* и зона *Imlayoceras mieltense*. При отсутствии шестой зоны с неописанными перисфинктидами считается возможным. Описаны два новых рода: *Warrenoceras* содержащих виды раньше относившиеся к *Arcticoceras* Spath, и *Imlayoceras* относящийся к макроцефалитидам.

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AMMONITE FAUNAS OF THE UPPER MIDDLE JURASSIC BEDS OF THE FERNIE GROUP IN WESTERN CANADA

Abstract

The upper part of the Middle Jurassic beds of the Fernie Group contains several ammonite faunas on which five to six ammonite zones are based. These are from the bottom to the top: the *Paracephalites glabrescens* zone, the *Warrenoceras henryi* zone, the *Kepplerites* aff. *K. tychonis* zone, the *Kepplerites mclearnii* zone, and the *Imlayoceras miettense* zone. A sixth zone, characterized by perisphinctids, yet undescribed, seems to be present in Jasper Park. The ammonite faunas contain two new genera, i.e., *Warrenoceras*, whose representatives had formerly been placed in the genus *Arcticoceras* Spath, and *Imlayoceras* that belongs to the Macrocephalitidae. Many of the ammonites are identical or similar to those of corresponding beds (Sawtooth and Rierdon Formations) of the western interior of the United States, but *Imlayoceras* seems to be restricted to more northerly parts of the Fernie. The Montana ammonites described as *Gowericeras* are absent or only poorly represented in Canada. The ammonite faunas of the Fernie Group and their equivalents in the western interior of the United States belong in the writer's opinion to a special faunal province that does not appear to have been connected with the Arctic Sea.

Résumé

La partie supérieure des couches du Jurassique moyen du groupe Fernie renferme plusieurs faunes d'ammonites sur lesquelles se fondent cinq à six zones à ammonites, qui sont, de bas en haut: la zone à *Paracephalites glabrescens*, la zone à *Warrenoceras henryi*, la zone à *Kepplerites* aff. *K. tychonis*, la zone à *Kepplerites mclearnii* et la zone à *Imlayoceras miettense*. Il semble exister dans le parc de Jasper une sixième zone qui se caractérise par la présence de périsphinctidés non encore décrites. Les faunes d'ammonites contiennent deux nouveaux genres, savoir le genre *Warrenoceras*, dont les représentants avaient antérieurement été classés avec le genre *Arcticoceras* Spath, et le genre *Imlayoceras*, qui fait partie des macrocéphalitidés. Plusieurs des ammonites sont identiques ou semblables à celles des couches correspondantes (formations Sawtooth et Rierdon) de la partie occidentale de l'intérieur des Etats-Unis, mais les *Imlayoceras* semblent se limiter aux parties plus septentrionales du groupe Fernie. Les ammonites du Montana connues sous le nom de *Gowericeras* sont absentes ou encore faiblement représentées au Canada. Les faunes d'ammonites du groupe Fernie et celles qui leur correspondent dans la partie occidentale de l'intérieur des Etats-Unis appartiennent, de l'avis de l'auteur, à un territoire faunique particulier qui ne semble pas avoir été rattaché à la mer Arctique.

INTRODUCTION

The term Middle Jurassic as commonly used in North America and Great Britain included only the Bajocian and Bathonian stages; on the other hand, in most of the European countries the Callovian stage was also included. In his book *Jurassic Geology of the World*, Arkell (1956)¹ placed the Callovian in the upper part of the Middle Jurassic, and in this he was soon followed by North American geologists, as for example by R. W. Imlay. Acknowledging some of the reasons given by Arkell for his assignment of the Callovian and realizing the advantage of uniformity in usage of this term, the writer now places the Canadian Callovian in the upper part of the Middle Jurassic.

In the Foothills and Rocky Mountains of southern Alberta the upper part of the Middle Jurassic beds of the Fernie Group includes the *Corbula munda* beds and the *Gryphaea* bed which were named by McLearn (1929). The author (1953, 1957) has used these names and considers these beds as a special facies of his Grey beds (1953), which have proven to be equivalent in age and which are found west and north of the *Corbula munda*-*Gryphaea* beds facies. The shales, which in southern Alberta occur between the *Gryphaea* bed and the Oxfordian Green beds, are also included in the upper part of the Middle Jurassic.

The first ammonites found in the *Corbula munda* beds of southern Alberta were described by Buckman (1929) and assigned to three new genera, i.e., *Para-cephalites*, *Metacephalites*, and *Miccocephalites*. Some of these ammonites have been repeatedly discussed (Spath, 1932; Imlay, 1948; Donovan, 1957; Frebold, 1957), but as they were poorly preserved or young specimens their precise systematic position could not be determined. During the last 12 years more ammonites were collected from the *Corbula munda* beds, the *Gryphaea* bed, and the Grey beds, and the succession of various ammonite faunas could be established; especially following publication of Imlay's fundamental studies in adjoining parts of the United States (Imlay, 1948, 1953a) where ammonites are much more common than in the Canadian Fernie Group.

The ammonites studied in this report were collected in various areas of the Rocky Mountains and Foothills. E. Mountjoy, Geological Survey of Canada, made valuable collections at a number of localities in Jasper Park including a new fauna near the top of the lower Callovian (*Imlayoceras* fauna). Other, in part well preserved, ammonites were collected by a Triad Oil Company field party in Cairn Pass, west side of Front Range, Jasper Park, whereas the specimens from southern Alberta (Grassy Mountain, Adanac mine) and easternmost parts of British Columbia (Fording River) were collected by the writer. In addition, Dr. P. S. Warren, University of Alberta, lent several specimens collected at various Fernie localities.

When describing the ammonites of the western interior of the United States, Imlay (1948, 1953a) assigned some of them to the Arctic genera *Arcticoceras* Spath and *Arctocephalites* Spath. The latter ones are now placed by him into

¹Names and/or dates in parentheses are those of References at end of this report.

Cranocephalites Spath (personal communication). The writer (1957) followed Imlay as far as *Arcticoceras* is concerned, but finding that the American ammonites concerned are distinguishable from the above Arctic forms, as already stated by Donovan (1957), they are now referred to other genera. The fact that the American ammonites cannot be identified with Arctic *Arcticoceras* and *Cranocephalites* has, of course, considerable bearing on the clarification of the zoogeographical position of the upper Middle Jurassic of the Fernie Group and equivalent beds of the western interior.

The assignment of some of the genera described in this paper to certain families is tentative, and may be subject to revision. Thus, for instance, the genera *Paracephalites* Buckman and *Warrenoceras* n. gen. could possibly belong to the Macrocephalitidae rather than the Cadoceratinae.

A *Kepplerites* fauna described in this report was obtained by L. L. Price, Geological Survey of Canada, from the subsurface at Esterhazy in Saskatchewan. This is the first ammonite fauna from the plains of Western Canada that could be reliably identified.

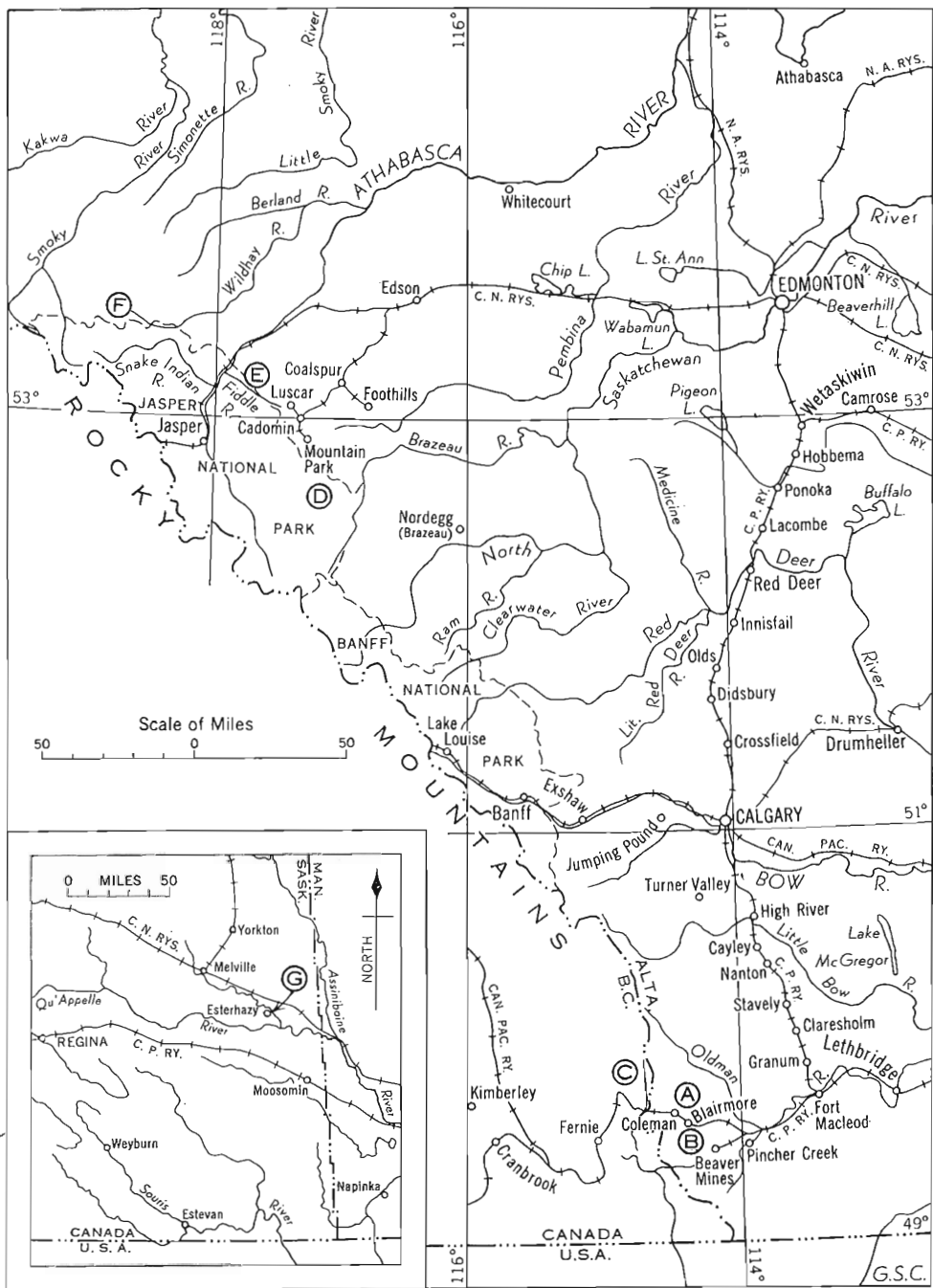


Figure 1. *Upper Middle Jurassic fossil localities in the Rocky Mountains and Alberta Foothills. A, Grassy Mountain; B, Adanac Mine area; C, Fording River area; D, Cairn Pass; E, Miette area; F, Rock Lake area. Inset map shows location of G, Esterhazy Shaft in eastern Saskatchewan.*

FOSSIL LOCALITIES

(The position of the described fossil localities is shown in Figure 1)

Southern Alberta

Grassy Mountain

The position of fossil localities on the south slope of Grassy Mountain, about 4½ miles north of Blairmore, is shown on Plate XIII.

In most of the Grassy Mountain outcrops both the *Corbula munda* beds with the *Paracephalites* zone in their upper 35 feet and the overlying *Gryphaea* bed with the *Warrenoceras* zone are exposed in continuous sections. In some of the sections the beds with *Keplerites* aff. *K. tychonis* Ravn (No. 5 in Pl. XIII), the Passage beds, and the lowermost Kootenay sandstone are exposed above the *Gryphaea* bed in normal succession. The Green beds, however, that are between beds 5 and 6 are, if at all, only very poorly represented in the form of stringers. They are faulted out.

A. Western part of south slope

The succession of the upper Middle and Upper Jurassic beds is best exposed on the western part of the south slope, i.e., in sections A, B, C, D, of Plate XIII, which are all on strike with one another, and of which D forms part of McLearn's classical railway section. A complete section (A in Pl. XIII) is described below and indicates also the stratigraphic position of fossil collections from sections B, C, and D (see also Frebold, 1957, p. 76).

	Thickness	
	Feet	Inches
7. Kootenay sandstone		
6. Passage beds		
Shale, sandy; three hard, 2-foot thick sandstone bands	17	6
Sandstone, hard, greyish brown, brown weathering. Fish remains	2	0
Shale, sandy, grey; sandstone bands. Fish remains	99	0
Shale, dark grey; thin sandstone bands (at Blairmore Shale quarry and other localities the lower part of the Passage beds contains <i>Buchia concentrica</i> Sowerby and belemnites)	98	0
Green beds, tectonically suppressed, indicated only by a few thin stringers.		
5. Shale		
Shale, dark grey, brownish weathering, with <i>Keplerites</i> aff. <i>K. tychonis</i> Ravn, ammonite gen. et sp. indet., and small pelecypods at about 20 feet above base of unit, GSC loc. 31412. <i>Warrenoceras imlayi</i> (Frebold), <i>Keplerites</i> sp. indet., <i>Cobbanites engleri</i> (Frebold), numerous belemnites in lower 4 feet of unit		approx. 60-70

4. *Gryphaea* bed

Coquina, many pelecypods, particularly <i>Gryphaea impressimarginata</i> , some gastropods, <i>Serpula</i> , belemnites, <i>Warrenoceras henryi</i> (Meek and Hayden), <i>W. rierdonense</i> (Imlay), <i>W. imlayi</i> (Frebold), <i>Keplerites</i> sp. indet., <i>Cobbanites engleri</i> (Frebold), (Section A, GSC loc. 21007; Section C, GSC loc. 19450)	1	6
Sandstone, hard, greyish blue, calcareous, fine-grained. Many pelecypods	2	0

3. *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. Pelecypods observed in the hard sandstone bands from about 70 feet below the <i>Gryphaea</i> bed upward; ammonoids in the upper 35 feet of these beds: <i>Paracephalites glabrescens</i> Buckman (Section A, GSC loc. 21383; Section C, GSC loc. 36249; Section D, GSC locs. 6591, 6593), <i>P. metastatus</i> (Buckman), <i>P. hashimotoi</i> Frebald (Section D, GSC loc. 18961)	99	0
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B. *Eastern part of south slope*

In the eastern part of the south slope of Grassy Mountain the Middle and Upper Jurassic sections are more disturbed than in the western part. The *Gryphaea* bed is exposed on the Gold Creek Road (E in Pl. XIII); three localities yielded *Warrenoceras imlayi* (Frebold), *W.* cf. *W. rierdonense* (Imlay) (GSC locs. 18965, 25606—both identical), *Cobbanites* sp. indet. and numerous pelecypods, particularly *Gryphaea impressimarginata* McLearn. No ammonites were found in the *Corbula munda* beds of this section.

In section F of Plate XIII at GSC locs. 31428 and 36252—both identical, *Keplerites* aff. *K. tychonis* Ravn, ammonite gen. et sp. indet. and small pelecypods occur in dark grey shales between the *Gryphaea* and Green beds. The stratigraphic relationships are, however, not very clear in this much disturbed section. The Green beds can only be seen in the form of stringers. Above the Green beds both Passage beds and Kootenay sandstone are exposed.

Adanac Strip Mine

Road to Adanac Strip mine (GSC loc. 25594), east limb of anticline. At this locality the upper part of the *Corbula munda* beds and the *Gryphaea* bed are exposed, but the section is somewhat disturbed. *Paracephalites* aff. *P. hashimotoi* Frebald, *Warrenoceras* sp. indet., *Keplerites* (*Gowericeras*?) sp. indet. a.

GSC loc. 46736, Adanac Strip mine. In the uppermost *Corbula munda* beds, *Paracephalites hashimotoi* Frebald occurs just below the well-developed *Gryphaea* bed.

Fording River Area

(eastern part of southern British Columbia)

GSC locs. 25596, 28289, 36248. The three numbers are for one and the same locality. Outcrop in cut of lumber road, 13 miles north of Natal, B.C., south of Fording River bridge. Grey beds. *Paracephalites glabrescens* Buckman, *P. hashimotoi* Frebold.

About 8 feet of Grey beds are exposed at this locality. The beds above and below are concealed.

GSC loc. 31433 is in Grey beds in a cliff on the west side of Fording River. At this locality about 130 to 140 feet of grey shales are exposed. There are several calcareous sandstone bands, about a foot thick, at almost regular intervals (about 24 feet). Poorly preserved ammonites: *Cobbanites* sp. indet., *Warrenoceras* sp. indet.

Jasper Park

Cairn Pass

(Stratigraphic information by A. Pedder, Triad Oil Company)

GSC loc. 27200. South side of Cairn Pass, west side of Front Range, Jasper Park. Between 590 and 750 feet above the base of the Fernie Group and 235 to 295 feet above the top of the Rock Creek Member. Grey beds. The ammonites were apparently collected from several different horizons of the Grey beds. *Paracephalites metastatus* (Buckman), *Warrenoceras henryi* (Meek and Hayden), *W. rierdonense* (Imlay), *W.? crassicostatum* (Imlay), *W.? loveanum* (Imlay), *Toricellites? spinosum* Frebold.

Miette Area

(Stratigraphic information by E. Mountjoy, Geol. Surv., Canada)

GSC loc. 31384. South boundary of Miette area, in a tributary joining Rocky River from the east. Latitude 53°00', longitude 117°39'. Grey beds. *Keplerites* spp. indet. b.

GSC locs. 31379, 36718. Rocky River. Latitude 53°01½', longitude 117°49'. Locality F in Figure 6, Bulletin 53 (Frebold, Mountjoy, and Reed, 1959). Probably from zone with large concretions. *Imlayoceras miettense* Frebold.

GSC loc. 36728. Rocky River, west of Makwa Ridge, Miette area, west half. Latitude 53°02½', longitude 117°50'. Grey beds, below bed with large concretions. *Keplerites* aff. *K. mclearni* Imlay.

GSC loc. 36725. Rocky River, west of Makwa Ridge, Miette area, west half. Latitude 53°02', longitude 117°50'. Grey beds. Approximately 30 feet below bed with large concretions. *Keplerites* sp. indet. c.

Rock Lake Area

(Stratigraphic information by E. Mountjoy, Geol. Surv., Canada)

GSC loc. 42076. Pass 2½ miles north of Mount Stornoway. Latitude 53°16½', longitude 118°24'. Between 30 and 50 feet below Green beds (see Mountjoy, 1962, Fig. 6). *Warrenoceras henryi* (Meek and Hayden).

GSC loc. 42080. Same locality as 42076. In talus *Warrenoceras imlayi* (Frebald).

GSC loc. 42083. North end of De Smet Range. Latitude 53°20½', longitude 118°24'. On the northeast side of a small creek Mountjoy measured the following section (personal communication):

	Thickness Feet	Height above base Feet
Overlying beds covered		
Shale, dark grey to black, with thin beds and concretionary layers of dark grey siltstone which weathers orange-red	300 to 400 estimated	
Shale, dark grey to black, a few small concretions	25	455
<i>Glauconite beds</i> (unit <i>a</i> of GSC Bulletin 53) 21 feet		
Glauconite, green, argillaceous	1	430
Shale, grey, slightly calcareous, traces of glauconite indurated and weathers resistant light orange-grey, abundant belemnites at base, <i>Gryphaea</i> sp.	19.5	429
Glauconite, green	0.5	409.5
Shale, indurated in part, light to medium grey, with concretions up to 4 feet in diameter, average 1 foot, largest at base. Fossils collected near base (GSC loc. 42083): <i>Imlayoceras miettense</i> Frebald	30	409
Shale, indurated, dark grey to black, gradually becomes lighter in colour—upwards; a few concretions, siltstone, dark grey, weathers dark grey, in beds 1/16 to 1 inch	75	379
Shale, silty, greenish grey with abundant belemnites	4	304
Underlying beds: <i>strata equivalent to Rock Creek Member</i> 170 feet		

GSC loc. 40229. Small tributary near the head of Rock Creek, latitude 53°29½', longitude 118°42'. About 30 feet below base of Green beds in zone with large concretions. *Imlayoceras miettense* Frebald.

GSC locs. 40224, 40240. Southwest side of Mowitch Creek, latitude 53°25', longitude 118°39'. Forty to sixty feet below Green beds in zone of concretions, section may be faulted. *Imlayoceras miettense* Frebald.

Saskatchewan

GSC locs. 42977-42984. Esterhazy Shaft, Saskatchewan (International Minerals and Chemical Corporation). At depth 1,310 to 1,315 feet. *Kepplerites* cf. *K. rockymontanus* Imlay, *Kosmoceras (Gulielmiceras) knechteli* Imlay.

PALÆONTOLOGY

Family CARDIOCERATIDAE Siemiradzki, 1891

Subfamily CADOCERATINAE Hyatt, 1900

Genus *Paracephalites* Buckman, 1929, emend. Frebold

Diagnosis. Outline more or less sphaerocone, fairly deep and moderately narrow umbilicus which opens up near the end of the body chamber. Most of the body chamber that is terminated by a fairly deep forwardly projected constriction is smooth. Transition from the steep umbilical wall to the flanks at right angles but rounded. Primary ribs are subdivided into two and occasionally more branches, intercalary ribs are present; secondaries cross the venter transversely. All ribs rounded and not of very strong relief. Effacement of ribs takes place from the umbilicus to the venter. Faint blunt ribbing on venter is still present at diameters of 110 mm.

Suture line fairly incised, ventral lobe slightly longer than first lateral. Both the first and second lateral lobes are trifold.

Type species. Buckman selected his immature and very poorly preserved *P. jucundus* as type species of the genus. The additional comments on this genus made in this report are based on new material of the other species, *P. glabrescens* Buckman, *P. metastatus* (Buckman), *P. sawtoothensis* (Imlay), and *P. hashimotoi* Frebold.

Occurrence. Upper part of *Corbula munda* beds, Grey beds; in Montana in the upper Sawtooth Formation.

Age. The exact age of the genus *Paracephalites* Buckman is unknown. On Grassy Mountain, southern Alberta, it occurs 35 feet below the base of the lower Callovian *Gryphaea* bed that contains various species of *Warrenoceras*, *Cobbanites engleri* (Frebold) and some *Keplerites*.

Discussion. As stated by Buckman (op. cit.), the inner whorls have some general similarities to Macrocephalitids but the adult stages which were unknown to Buckman have some cadoceratid aspects particularly in the shape of the umbilicus. Accordingly the writer (1957, p. 60) assigned an adult form to *Cadoceras* and named it *C. lillei* Frebold. After more material had been collected and the inner whorls of this species could be studied, this species proved to be identical with *Paracephalites glabrescens* Buckman. A very similar adult specimen from the Sawtooth Formation of Montana described by Imlay (1948, p. 19) as *Arctocephalites sawtoothensis* Imlay¹ is assigned by the writer to the genus *Paracephalites*.

Paracephalites Buckman is distinguished from both *Arctocephalites* Spath (Spath, 1928, 1932) and *Cranocephalites* Spath (Spath, 1932) by a wider umbilicus that opens up at a much later stage of growth and by the much later disappearance of the ribs. Donovan (1957, p. 134) also noted differences between the

¹Dr. Imlay (personal communication) has recently assigned this species to the subgenus *Cranocephalites* Spath.

North American forms, here described as *Paracephalites*, and *Arctocephalites*. "The inner whorls [of the North American forms] have coarse ribbing and do not greatly resemble those of *Arctocephalites*, while the ribs on the middle whorls are concave backwards, a feature unknown in the genus [*Arctocephalites*]."

The genus *Metastites* Buckman was based on an immature ammonite, *M. metastatus* Buckman, which is a young *Paracephalites*.

Paracephalites glabrescens Buckman

Plate I, figures 1a, 1b, 1c; Plate II, figures 1, 3a, 3b

Paracephalites glabrescens Buckman, 1929, p. 10, Pl. 1, figs. 1-3; Pl. 2, figs. 4-6.
Cadoceras lillei Frebold, 1957, p. 60, Pl. 34, figs. 1a,b; Pl. 35, fig. 1.

Holotype is *P. glabrescens* Buckman (loc. cit.), GSC No. 8601, from upper *Corbula munda* beds on Grassy Mountain, north of Blairmore (GSC loc. 6591).

Material. Two other specimens from the upper *Corbula munda* beds on Grassy Mountain, GSC No. 12902 (GSC loc. 21383) and GSC No. 14705 (GSC loc. 36249). GSC No. 14695 and 14719 are from the Grey beds near Fording River bridge, 13 miles north of Natal, British Columbia (GSC loc. 25596).

Description. Holotype is very poorly preserved, and has suffered considerable abrasion that has affected both the suture line and sculpture.

Other specimens from the upper part of the *Corbula munda* beds on Grassy Mountain and from the Grey beds in the Fording River area, collected during the last ten years, are larger and represent a more adult ontogenetic stage not preserved in the holotype. The identity of these specimens with Buckman's holotype became evident after removal of the more adult whorls. Thus, the penultimate whorl of the hypotype GSC 14705 (Pl. II, figs. 3a, b) has about the same dimensions as the holotype. Only one side of the penultimate whorl is preserved, as in the holotype. Suture line and sculpture are more clearly visible than in the holotype. At this stage of growth the flanks are gently convex, the venter is well rounded and the fairly high, steep umbilical wall is almost perpendicular. The transition from the umbilical wall to the flanks is abrupt but rounded, the transition from the flanks to the venter is gradual. In this general outline the specimen is very similar to the holotype.

Primary ribs begin at the umbilical margin where they are bent backward, on the inner part of the flanks they are bent forward. Somewhat below the middle of the flanks the primaries are divided into several branches which are bent forward but cross the venter transversely. There are also intercalated secondaries on the venter and in the outer part of the flank. On the holotype the ribs are considerably worn and no details can be seen. Anterior part of the last whorl of the holotype is almost smooth but this is caused by abrasion. As stated by Buckman (op. cit.), abrasion has affected length and elaboration of the second lateral lobe, which actually is much more incised and of about half the length of the first lateral (see Pl. II, figs. 3a, b).

The last whorl of hypotype GSC 14705 is poorly preserved and not figured. The posterior part is still septate and has fairly faint broad ribs on the outer part of the flanks and on the venter. Venter and outer parts of the flanks of the body chamber are not preserved, the inner part of the flanks is smooth. The umbilicus is much wider in this stage of growth than in the penultimate whorl.

Hypotype GSC 12902, previously described under the name of *Cadoceras lillei* Frebold (Frebold, 1957, p. 60, Pl. 34, figs. 1a, b; Pl. 35, fig. 1), represents the adult stage of the species with smooth body chamber and the umbilicus opening up towards the mouth. After removal of part of the body chamber the anterior part of the penultimate whorl is exposed with an outline and sculpture similar to the still smaller inner whorls of the specimens GSC 14705 and 14719.

The dimensions in millimetres of specimen GSC 14695 (Pl. II, fig. 1) from the Fording River area are:

<i>Diameter</i>	<i>Whorl height</i>	<i>Whorl thickness</i>	<i>Umbilical width</i>
155	66 (0.43)	61 (0.39)	24 (0.15)

The last whorl belongs to the body chamber; the septate part of the whorl is not preserved except for parts of the last suture line. The general shape is stout, the cross-section ovate, somewhat higher than wide; the umbilicus is enlarged at the anterior end of the whorl. The umbilical wall is steep, its transition to the slightly convex flanks is rounded. The flanks grade gently into the moderately broad venter. The aperture is inclined forward. A weak constriction at the end of the whorl is present in this and other specimens.

There are only a few broad ribs on the venter of the posterior part of the last whorl, the remaining part is entirely smooth.

This specimen is very similar to the adult stage of *P. glabrescens* Buckman represented by specimen GSC 12902, previously described as *Cadoceras lillei* Frebold, and to the specimen described by Imlay as *Arctocephalites sawtoothensis* Imlay.

The penultimate whorl of specimen GSC 14719 (Pl. I, figs. 1b, c) is very similar in outline and sculpture to the penultimate whorl of specimen GSC 14705 (Pl. II, figs. 3a, b), and the last preserved whorl of the holotype. The ribs are, however, somewhat finer. The complete specimen with body chamber corresponds to the adult ontogenetic stage of the species.

Comparisons. The specimen described by Imlay (1948, p. 19, Pl. 6, fig. 7) as *Arctocephalites sawtoothensis* Imlay is very similar to the corresponding adult stages of *Paracephalites glabrescens* Buckman.

Dr. Imlay compared plaster casts of the holotype of *P. glabrescens* and of hypotype GSC 12902 and states rightly (personal communication) that *sawtoothensis* has a coarser and sparser ribbing and consequently the writer does not unite *sawtoothensis* Imlay with *glabrescens* Buckman.

Paracephalites hashimotoi n. sp.

Plate III, figures 1a, b; Plate IV, figure 1

Cadoceras ex gr. *victor* Spath, Frebold, 1957, p. 61, Pl. 38, figs. 1a-d.*Cadoceras* sp. indet. 2, Frebold, 1957, p. 62, Pl. 38, fig. 3.*Cadoceras muelleri* Frebold (*non* Imlay), Frebold, 1957, p. 60, Pl. 36, fig. 1; Pl. 37, fig. 1.

Holotype is in the collection of the University of Alberta (also GSC No. 14374, plastotype) and is the specimen previously described as *C. ex gr. victor* Spath (Frebold, 1957, p. 61, Pl. 38, figs. 1a-d).

Paratype is specimen GSC No. 14697, from upper *Corbula munda* beds on Adanac Strip mine road (GSC loc. 45063).

Material. Other specimens are GSC No. 12904 from the *Corbula munda* beds on Grassy Mountain (GSC loc. 18961) previously described as *Cadoceras* sp. indet. 2 (Frebold, 1957, p. 62, Pl. 38, fig. 3); specimen GSC No. 12903 from upper *Corbula munda* beds on Grassy Mountain (GSC loc. 18961) previously described as *Cadoceras muelleri* (op. cit., p. 60, Pl. 36, fig. 1; Pl. 37, fig. 1); and GSC No. 14701 from Grey beds on lumber road, 13 miles north of Natal, British Columbia (GSC loc. 25596).

Description. The species comprises more globose forms with a depressed whorl section in adult stage. It is named for Dr. Stanley A. Hashimoto, who ably assisted the author in the field for several years.

Holotype consists of a number of fragments representing various stages of growth; it was described (Frebold, 1957, pp. 61, 62) as follows.

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 (Pl. 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 (Pl. 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 youngest preserved stage of this specimen is very similar in general outline and type of ribbing to *Paracephalites metastatus* (Buckman) (Buckman, 1929, p. 11, Pl. 3, figs. 1-4) which, however, is larger.

Paratype GSC No. 14697 is a large specimen with part of the body chamber preserved. The deep umbilicus has high and steep walls, it opens up at the end of the septate stage of the last whorl. No sculpture is visible on the body chamber, but there are moderately strong ribs of the same shape as in the holotype and in specimen GSC No. 14701. The venter of the penultimate whorl is broad and well rounded. The suture line is well incised, the ventral and first lateral lobes are of equal length but the second lateral is shorter than the first.

GSC No. 12903, formerly described by the author as *Cadoceras muelleri*, is very similar in general outline to the paratype and probably belongs to the same

species. Unfortunately, no sculpture and no suture line except for the last one is visible.

Specimen GSC No. 12904, previously described as *Cadoceras* sp. indet. 2, is very similar to the holotype and probably belongs to the same species.

Specimen GSC No. 14701 (Pl. III, figs. 1a, b) shows the development at medium stages of growth. Part of the body chamber (not illustrated) and part of the preceding whorl of the specimen are preserved. The cross-section of the last whorl is semicircular, much thicker than high. The umbilical wall of both whorls is high and steep, rounding abruptly into the flanks that grade into the broad venter. There are no ribs on the last whorl. In the posterior part of the preceding whorl fairly strong ribs are present. They are of the same shape as those in the corresponding part of the holotype. In the inner fourth of the flanks the fairly high primaries are bent backward, they are subdivided at about the top of the inner fourth of the flanks into two or three secondaries that are inclined forward in the outer parts of the flanks and are arched very gently forward on the venter. There are some intercalated ribs. The secondaries are fairly high and widely spaced.

Only parts of the simplified last suture line that is characterized by broad elements are visible.

Comparisons. *Paracephalites hashimotoi* n. sp. is similar to *P. glabrescens* Buckman. It has the same umbilicus and the same type of ribbing but it is distinguished by a more depressed whorl section and somewhat stronger ribs.

P. hashimotoi is also somewhat similar to some of Imlay's (1953a) *Cadoceras* from the Rierdon Formation in Montana, as for example *C. muelleri* Imlay and *C. tetonense* Imlay. These species are, however, distinguished from *P. hashimotoi* by details of the suture line and of the general shape. Furthermore they do not belong to the *Paracephalites* beds but to the *Gowericeras* beds, which are younger.

Paracephalites metastatus (Buckman)

Plate I, figure 2; Plate II, figure 2

Metacephalites metastatus Buckman, 1929, p. 11, Pl. 3, figs. 1-4.

Arctocephalites metastatus var. *sweetgrassensis* Imlay, 1948, p. 20, Pl. 6, figs. 1, 3.

Holotype is *M. metastatus* Buckman (loc. cit.), GSC No. 6098 from upper *Corbula munda* beds on Grassy Mountain, north of Blairmore (GSC loc. 6593).

Paratype is specimen GSC No. 14700 from Grey beds in Cairn Pass (GSC loc. 27200).

Material. The holotype and the paratype are the only specimens hitherto found in Canada.

Description. The holotype is a young specimen and is a little more than half the size of the paratype. However, it has the same general outline and the same kind of ribbing as the paratype that represents a medium-sized specimen. The holotype is described by Buckman (loc. cit.).

The paratype has a maximum diameter of 79 mm. The whorl thickness is

42 mm (0.53). As the umbilical region is badly damaged, the whorl height and the width of the umbilicus cannot be determined accurately. The cross-section is ovate, slightly higher than wide. The flanks are gently convex and converge gradually to the rounded venter. Their transition to the umbilical wall is not preserved. The ribs are fairly thick in the posterior part of the last whorl and are strongest on the venter. Towards the end of the whorl they disappear on the inner half of the flank and become weaker on their outer part and on the venter. Primaries are subdivided in the inner third of the flanks, the point of division is marked by a slight swelling. Most primaries bifurcate and between two pairs of secondaries an intercalary rib is commonly present, and there may be occasional bifurcation of a secondary rib on the outer part of the flank. Ribs are bent forward on the inner part of the flanks, curve slightly backward above the point of bifurcation and cross the venter transversely. The specimen is septate to its end but the suture lines are poorly preserved and do not warrant detailed study.

Comparisons. The paratype has essentially the same kind of ribbing and apparently a very similar general outline as the specimen described by Imlay (1948) as *Arctocephalites metastatus* var. *sweetgrassensis* Imlay. As Imlay's specimen may be somewhat deformed (*see* Imlay, *op. cit.*, p. 20) and the umbilical area of the paratype is destroyed no accurate comparisons of measurements can be made.

Imlay (*op. cit.*) has already demonstrated the close relationship of his specimen with Buckman's *Metacephalites metastatus*. This is confirmed by the writer who considers Buckman's specimen as a young form. Imlay (1949) assigned his specimen and the holotype to the genus *Arctocephalites* Spath and now places it (personal communication) into the subgenus *Cranocephalites* Spath. The writer places the species into *Paracephalites* Buckman which is distinguished from both *Arctocephalites* and *Cranocephalites* by the umbilicus, which in these genera is much smaller in young forms and opens up at a much earlier stage of growth. Furthermore, *Arctocephalites* and *Cranocephalites* lose their ribbing much earlier than *Paracephalites*.

Genus *Warrenoceras* n. gen.

Diagnosis. Involute, umbilicus very narrow to occluded in young to adult stages of growth. Enlargement of umbilicus may take place in very large specimens. Fine subdivided ribs in young to medium-sized specimens, commonly becoming smooth early. Effacement of ribs takes place from umbilicus to venter. Cross-section of whorl ovate to trigonal, venter becoming rounded in larger specimens. No constrictions. Suture lines with rather broad saddles and lobes, second lateral lobe of some species occasionally bifid.

Type species is *Ammonites henryi* Meek and Hayden. Other species are *W. codyense* (Imlay), *W. rierdonense* (Imlay), *W. imlayi* (Friebold).

The genus is named in honour of Dr. P. S. Warren, University of Alberta.

Occurrence: Fernie group, *Gryphaea* bed, associated with *Keplerites*, *Cobbanites*; above upper *Corbula munda* beds with *Paracephalites*. Grey beds, associated with *Keplerites*.

Age: Early Callovian.

Discussion. Imlay (1948, 1953a) assigned the species *henryi*, *codyense*, and *rierdonense* to the genus *Arcticoceras* Spath (1932). The writer (1957) followed Imlay placing a Canadian specimen of *henryi* into *Arcticoceras*. Donovan (1957, p. 137) stated that most of Imlay's western interior *Arcticoceras*, i.e., the group of *codyense*, do not belong to *Arcticoceras* Spath. They should, in his opinion "if anything be called *Arctiocephalites*, but the inner whorls and suture lines are so dissimilar from typical species that it seems doubtful whether they belong to this genus."

Despite certain similarities of the group of *henryi*, *codyense*, *rierdonense*, and *imlayi* to species of *Arcticoceras* Spath the writer agrees with Donovan that they do not belong to this genus. These species, now assigned to the new genus *Warrenoceras*, are clearly distinguished from *Arcticoceras* by the much narrower umbilicus, less sharp ribs, absence of constrictions and broader elements of the suture line. *Warrenoceras* is clearly distinguished from *Arctiocephalites* Spath in which the umbilicus is wider in young specimens and opens up at a much earlier stage of growth.

Two other species, described by Imlay (1953a) as *Arcticoceras loveanum* Imlay and *A. crassicostatum* Imlay are only tentatively included in the genus *Warrenoceras*. They are distinguished from the other species by their much coarser ribs and a wider umbilicus at medium sizes of growth.

According to Donovan (1957, p. 134) *loveanum* and *crassicostatum* "seem more closely related to '*Cadoceras*' *shoshonense*" Imlay than to *Arcticoceras*.

As all specimens of these two species are more or less fragmentary or crushed and as the suture lines are unknown no reliable assignment of genus is possible at present.

Warrenoceras henryi (Meek and Hayden)

Plate V, figures 1, 2a, b; Plate VI, figure 1; Plate VII, figures 1-3

Ammonites henryi Meek and Hayden, 1865, p. 123, Pl. 5, figs. 9a-c.

Arcticoceras henryi (Meek and Hayden), Imlay, 1948, p. 21.

Arcticoceras henryi (Meek and Hayden), Imlay, 1953a, p. 22, Pl. 5, figs. 6-15.

Arcticoceras henryi (Meek and Hayden), Frebold, 1957, p. 59, Pl. 29, fig. 1; Pl. 30, figs. 1a-c; Pl. 31, fig. 1.

Holotype is *A. henryi* Meek and Hayden (loc. cit.).

Material. Specimen GSC No. 14690 is from the *Gryphaea* bed on Grassy Mountain (GSC loc. 45067), specimens GSC Nos. 14689, 14691, 14692 are from the Grey beds in Cairn Pass (GSC loc. 27200), specimen GSC No. 14688 is from Grey beds at GSC loc. 42080 in Ram Pass, Rock Lake area.

Description. Small (diameters about 40 mm), medium and large (diameters up to 175 mm) specimens are known.

The small specimens (GSC Nos. 14689, 14691, Pl. VII, figs. 2, 3) are semi-globose and have a well-rounded venter that grades into the convex flanks. The umbilicus is very narrow, has steep walls, and a fairly sharp umbilical edge. Fairly strong ribs are present on the venter and in the upper two thirds of the flanks, the

lower third of which appears to be smooth. Very faint ribs are still present at a diameter of about 75 mm. The effacement of the ribs takes place from the umbilicus to the venter.

The dimensions of the medium-sized specimen GSC 14692 (Pl. V, figs. 2a, b) are:

<u>Diameter</u>	<u>Whorl height</u>	<u>Whorl thickness</u>	<u>Umbilical width</u>
80	50 (0.63)	46 (0.58)	—

As the specimen is compressed to a certain extent the measurements are approximate. The umbilicus is very narrow. The shell is fairly stout, has a trigonal to ovate, higher than wide cross-section, gently convex flanks and rounded venter. Some fine striae are present on the flanks, they become thicker near the end of the last whorl where they form faint undulations on the venter, there are no ribs. Poorly preserved remnants of suture lines are present on the posterior part of the last whorl. This specimen is very similar to the inner whorls of a specimen previously described from Cascade Valley (*see* Frebold, 1957, Pl. 30, figs. 1b-c).

Dimensions of the two figured large specimens GSC 14688 (Pl. VII, fig. 1) and GSC 14690 (Pl. V, fig. 1; Pl. VI, fig. 1) are:

	<u>Diameter</u>	<u>Whorl height</u>	<u>Whorl thickness</u>	<u>Umbilical width</u>
GSC 14688	155	80 (0.51)	87 (0.56)	18 (0.12)
GSC 14690	155	90 (0.58)	83 (0.54)	9 (0.06)

The umbilicus of specimen GSC No. 14688 is still narrow but opens up slightly near the end of the last whorl, where the umbilical wall is gently sloping. In the posterior part of the whorl it is steeper. Umbilical edge is rounded, the flanks are moderately convex and grade into the rounded venter. Towards the end of the last whorl the venter is much broader and the cross-section much more depressed than in younger specimens. About three quarters of this specimen belong to the body chamber. The suture lines in the posterior part of the last whorl have fairly broad saddles and trifid lateral lobes. The first lateral is equal in length to the ventral lobe.

Specimen GSC No. 14690 has a sharper and a higher cross-section than that of specimen GSC No. 14688. Umbilicus has not opened up at this stage of growth. Differences between the two large specimens may be explained by the fact that most of the last whorl of specimen GSC No. 14688 belongs to the body chamber, whereas specimen GSC No. 14690 is septate to the end of the last whorl.

Neither of the two large specimens shows any sculpture, both appear to be entirely smooth.

Comparisons. Identification of the described specimens with *Warrenoceras henryi* (Meek and Hayden) is somewhat difficult because the holotype of the species is laterally compressed and does not show the round whorl section described by Imlay (1953a, p. 22). The venters of the Canadian specimens are less rounded than one of the specimens illustrated by Imlay (*op. cit.*, Pl. 5, figs. 13, 15) but these differences may have been caused by secondary deformation or variation.

W. codyense (Imlay) is a very closely related species but according to Imlay (op. cit.) has a thinner and less-rounded whorl section. Some of the Canadian specimens take an intermediate position between *henryi* and *codyense*. The differences in whorl shape between these two species may be of secondary nature and the slight differences in the thickness and number of ribs between *henryi* and *codyense* mentioned by Imlay (op. cit., p. 22) may be due to variation.

Occurrence. The species occurs in the *Gryphaea* bed on Grassy Mountain, north of Blairmore, associated with *W. imlayi* (Frebold), *W. cf. W. rierdonense* (Imlay), *Cobbanites engleri* (Frebold), *Kepplerites* sp. and many pelecypods. In the Grey beds in Cairn Pass it was found between 590 and 750 feet above the base of the Fernie Group and 235 and 295 feet above the top of the Rock Creek Member. At this locality it is associated with *W. rierdonense* (Imlay), *Warrenoceras? crassico-statum* (Imlay) and *W.? loveanum* (Imlay). In the Rock Lake area the species occurs in the Grey beds associated with *W. imlayi* (Frebold).

Warrenoceras imlayi (Frebold)

Plate VI, figure 3

Lilloettia imlayi Frebold, 1957, p. 56, Pl. 32, figs. 1a, b; Pl. 33, figs. 3a, b.

Material. Three specimens (GSC Nos. 12897, 12901, 14687) from the *Gryphaea* bed, Grassy Mountain near Blairmore (GSC locs. 21007, 18965, 25606), and one specimen (GSC No. 14720) from the Grey beds, Rock Lake area (GSC loc. 42080). Specimen GSC 14687 is not figured.

Description. Dimensions of the holotype, in millimetres, are:

<i>Diameter</i>	<i>Whorl height</i>	<i>Whorl thickness</i>	<i>Width of umbilicus</i>
88	49 (0.56)	55 (0.62)	5 (0.06)

The umbilicus of all the specimens is very narrow and has steep walls, the whorls have convex flanks that grade into the rounded venter. Their transition to the umbilicus is abrupt, the margin between umbilicus and flanks is rounded. The cross-section of the holotype at 90 mm diameter is elliptic, the greatest width below the middle of the flanks. The ribs are almost straight, slightly inclined forward. The primaries are divided into two, three, or four branches that cross the venter almost transversely. The effacement of the ribs takes place from the umbilicus to the venter. On the holotype the primaries disappear in the posterior part of the last whorl, secondaries are still present on the larger specimen GSC 14720 (Pl. VI, fig. 3) at a diameter of 112 mm. The suture line of the holotype has a trifold first lateral lobe that is slightly deeper than the ventral lobe, the second lateral is about half as deep as the first.

Comparisons. The species formerly assigned tentatively to the genus *Lilloettia* Crickmay (Frebold, 1957, p. 56) is very similar to certain species described by Imlay (1948, 1953) from the western interior of the United States. In its ribbing the species resembles *W. rierdonense* (Imlay), from which it is distinguished by its more globose shape. In its general outline it is closer to *W. codyense* (Imlay)

and *W. henryi* (Meek and Hayden) which, however, lose their ribs at a much earlier stage of growth. The suture line of *W. rierdonense* Imlay (see Imlay, 1953a, Pl. 3, fig. 16) is similar to that of *W. imlayi*.

Occurrence. *W. imlayi* was found in the *Gryphaea* bed on Grassy Mountain associated with *W. cf. W. rierdonense*, *W. henryi*, *Cobbanites engleri*, *Kepplerites* sp. and many pelecypods. In the Rock Lake area the species occurs in the Grey beds, where it is associated with *W. henryi*.

Warrenoceras rierdonense (Imlay)

Plate VI, figure 2

Arcticoceras rierdonense Imlay, 1953a, p. 19, Pl. 2, figs. 1, 2; Pl. 3, figs. 16, 18, 21, 22.

Holotype is *A. rierdonense* Imlay, op. cit., Pl. 2, figs. 1, 2.

Material. One specimen (GSC No. 14693) from Cairn Pass, Jasper Park (GSC loc. 27200), several poorly preserved specimens from *Gryphaea* bed on Grassy Mountain (GSC loc. 45067).

Description. The dimensions in millimetres of specimen GSC No. 14693 are:

<u>Diameter</u>	<u>Whorl height</u>	<u>Whorl thickness</u>	<u>Umbilical width</u>
68	41 (0.60)	38 (0.56)	4 (0.06)

Up to the diameter of 66 mm the specimen is septate. The remaining small part of the ammonite which is somewhat compressed belongs to the body chamber.

The well-preserved specimen has a very narrow umbilicus, with steep wall, elliptical whorls that are slightly higher than wide and thickest near the umbilicus. The flanks are very slightly convex and grade into the narrow venter. At the posterior end of the last whorl very fine primary ribs are faintly visible in the inner, almost entirely smooth part of the whorl. The secondaries are clearly developed in the outer part of the flanks and on the venter. In the anterior part of the whorl the secondaries become more widely spaced and are shorter on the flanks and weaker on the venter. No ribbing is visible on the part of the body chamber that is preserved.

The suture line has trifold lateral lobes, the first lateral has about the same length as the ventral lobe.

Comparisons. The specimen agrees well with Imlay's (1953a) description of the general shape and ribbing of the species. The holotype is much larger than the Canadian specimen and its last suture line has the wide elements described by Imlay as characteristic of this stage of growth. The suture line of one of the paratypes (op. cit., Pl. 3, fig. 16) taken at a whorl height of 96 mm differs from the suture of the Canadian specimen taken at whorl height of 39 mm, mainly by its less slender lobes and saddles. Apparently the suture line of this species is subject to changes in the course of the ontogenetic development.

According to Imlay, *Warrenoceras codyense* is distinguished by a more trigonal-shaped whorl section, finer ribbing that disappears at an earlier stage of growth, and a bifid second lateral lobe.

Warrenoceras cf. *W. rierdonense* (Imlay)

Material. One specimen, GSC No. 14702 from *Gryphaea* bed on Gold Creek road, south slope of Grassy Mountain (GSC loc. 25606).

Description. The specimen has a diameter of about 170 mm. About half of the last whorl belongs to the body chamber. Secondary compression of the specimen has apparently affected part of the last whorl resulting in a sharper venter. The whorls are much higher than wide, the cross-section at the end of the last whorl is ovate to triangular, the very narrow umbilicus has a high, apparently somewhat overhanging wall. Some blunt undulations are present in the outer part of the flanks and on the venter of the posterior part of the last whorl, but no ribs are present on the inner part of the flanks. Parts of the suture line are visible, the ventral and the fairly broad trifid first lateral lobe are of about equal length, the second lateral, which is much shorter than the first, is trifid on one side, on the other side on which only parts of it are visible it may be bifid.

Comparisons. The state of preservation does not permit accurate identification of this specimen, particularly as its inner whorls cannot be studied. Although smaller it is very similar to the holotype of *Warrenoceras rierdonense*.

Warrenoceras? *crassicoatum* (Imlay)

Plate III, figures 2, 3

Arcticoceras crassicoatum Imlay, 1953, p. 20, Pl. 3, figs. 1-6.

Holotype is *A. crassicoatum* Imlay, op. cit., Pl. 3, figs. 1, 2.

Material. Two specimens (GSC Nos. 14698, 14704), both from Grey beds in Cairn Pass, Jasper Park (GSC loc. 27200).

Description. The dimensions in millimetres of specimen GSC No. 14698, Plate III, figure 2, are:

<u>Diameter</u>	<u>Whorl height</u>	<u>Whorl thickness</u>	<u>Umbilical width</u>
71	36 (0.49)	40 (0.56)	9 (0.13)

Because of some secondary deformation these measurements are approximate. The whorls reach their greatest thickness below the middle of the flanks, they are slightly convex and grade into the rounded venter. The transition to the steep umbilical wall is more abrupt, the umbilical edge is rounded. The ribs are very strong in the anterior part of the whorl, thinner in the posterior part. They are widely spaced, forward inclined, and most of them are bifurcated. Some ribs bifurcate only on one flank. The points of bifurcation are indistinct. On the venter the ribs are slightly bent forward, particularly in the anterior part of the whorl. Fine lines of growth are visible on the ribs and in the intervals between them, particularly on the venter. No suture line is observable and the entire whorl may belong to the body chamber.

The fragment GSC No. 14704 (Pl. III, fig. 3) has part of the preceding whorl preserved which has much finer and more numerous ribs than the last whorl. No suture line is visible.

Comparisons. The ribs of the outer whorls of the described specimens and the general outline of the specimen illustrated (Pl. III, fig. 2) are very similar to *Warrenoceras? crassicosatum* (Imlay). There is, however, a difference in the measurements of Imlay's specimens which have a cross-section higher than wide unlike the specimen illustrated (Pl. III, fig. 2). These differences may have been caused by secondary deformation of the specimens concerned. As Imlay's specimens did not show the internal whorls the fragment illustrated is particularly interesting, as it demonstrates the fine ribs on young specimens. As stated by Imlay, *crassicosatum* is closely related to *loveanum* Imlay from which it is distinguished mainly by stronger ribbing.

Warrenoceras? loveanum (Imlay)

Plate III, figure 4; Plate X, figure 5

Arcticoceras loveanum Imlay, 1953a, p. 21, Pl. 3, figs. 7-12, 14.

Holotype is *A. loveanum* Imlay, op. cit., Pl. 3, figs. 7-8.

Material. One specimen (GSC No. 14699) from Grey beds, Cairn Pass, Jasper Park (GSC loc. 27200).

Description. On one side of the specimen part of the last whorl is broken off and the preceding whorl shows a hitherto undescribed ontogenetic stage of this species (see Pl. III, fig. 4). The dimensions of the specimen in millimetres are:

<u>Diameter</u>	<u>Whorl height</u>	<u>Whorl thickness</u>	<u>Width of umbilicus</u>
32	18 (0.87)	18 (0.56)	3 (0.094)
58	31 (0.53)	28 (0.48)	5 (0.086)

At diameters of 32 and 55 millimetres the specimen has a very narrow umbilicus, the whorl height is slightly greater than the whorl thickness, the greatest thickness is below the middle of the flanks, which are moderately convex and grade into the rounded venter. The umbilical wall is steep and its transition to the flanks is rather abrupt but rounded. The youngest visible whorl has in its posterior part very fine equally spaced ribs that become gradually thicker towards its end and still thicker on the succeeding whorl. On the umbilical wall the primaries are slightly inclined backward, on the inner part of the flanks they are inclined forward. On the young whorl they are subdivided below the middle of the flanks into two or three secondaries. The connection of the third branch with the primaries is sometimes so indistinct that it may appear to be an intercalated rib. On the last whorl (up to a diameter of 55 mm) the primaries are bifurcated, and between some of the pairs of secondaries intercalary ribs are present. The secondaries and intercalaries are slightly bent forward on the venter. All ribs are sharp, and thickest in the outer part of the flanks and on the venter. The space between the ribs increases towards the end of the whorl.

Comparisons. The specimen agrees well with the description and figures of *Warrenoceras? loveanum* given by Imlay (op. cit.). The Canadian specimen is, however, much better preserved and shows also the development at a younger stage

of the ontogeny. As stated by Imlay (1953a, p. 21), *Warrenoceras? loveanum* is distinguished from the closely related *W.? crassicosatum* by its considerably finer ornamentation. Imlay mentions also that *W.? loveanum* has a more inflated shape. As Imlay's specimens of both species are more or less secondarily deformed this observation may not be reliable, but the specimens of *W.? loveanum* and *W.? crassicosatum* described here do seem to suggest these differences. Donovan (1957, p. 134) has already stated that both species seem to be closely related to '*Cadoceras? shoshonense* Imlay.

Family MACROCEPHALITIDAE Buckman, 1922

Genus *Imlayoceras* n. gen.

Diagnosis. Involute, strongly inflated, ball-like with depressed cross-section. Umbilicus narrow and deep with rounded edge. Primary ribs slightly bent forward, subdivided below the middle of the flanks commonly into two equally spaced, comparatively sharp secondaries that cross the venter transversely. On living chamber ribs disappear, first the primaries and then the secondaries. Suture line deeply incised, the ventral and the two lateral lobes rather slender and deep, ventral and first lateral lobes of equal length, the two laterals trifid. Three or more auxiliary lobes; first and second lateral saddles of about equal height.

The genus *Platystomaceras* Corroy (1932) (*Pleurocephalites* Buckman according to Arkell, 1957, p. L294) includes forms with similar shape but entirely different suture line and an umbilicus that mostly opens up. *Pleurocephalites* Buckman is less globose and has a wider umbilicus. *Type species* is *Imlayoceras miettense* n. sp.

Occurrence. Upper part of Grey beds (zone with large concretions) Jasper Park, Canadian Rocky Mountains.

Age. Callovian, younger than beds with *Warrenoceras*.

The genus is named in honour of Dr. R. W. Imlay, United States Geological Survey.

Imlayoceras miettense n. sp.

Plate VIII, figures 1a-c, 2; Plate IX, figure 1; Plate X, figure 1;
Plate XI, figure 1

Holotype is specimen GSC No. 14707 (Pl. VIII, figs. 1a-c; Pl. XI, fig. 1) from upper Grey beds at Rocky River (GSC loc. 36718).

Material. Paratype GSC No. 14708 is from the zone with large concretions in the upper Grey beds on Rocky River (GSC loc. 31379), paratype GSC No. 14694 is from the same bed at the north end of De Smet Range (GSC loc. 42083).

Description. The holotype has at a diameter of 70 mm, a whorl height of about 46 mm (0.66), a whorl thickness of 73 mm (0.104), and an umbilical width of about 6 mm (0.086). Suture lines are present to the end of the whorl at a diameter of 70 mm. About half a whorl of the living chamber is preserved, another half

whorl that had joined the septate part of the ammonite is missing. The preserved part of the living chamber has a very depressed cross-section similar to that of some species of *Cadoceras*. Part of the high perpendicular umbilical wall is preserved, the umbilical edge is rounded. There are no primary ribs on the living chamber and the secondaries are low and blunt.

The inner, septate whorl that has a more arched cross-section has rounded straight primaries, some of them very slightly inclined forward. They are subdivided below the middle of the flanks into two secondaries. Other secondaries are intercalated between some of the pairs of secondaries. The secondaries are rather sharp and strongest on the venter.

The suture line is characterized by long slender lobes and saddles. The first lateral and the ventral lobes are of equal length, both lateral lobes are trifold. The suture line is also well exposed on paratype GSC No. 14708 that is septate to the end of the last whorl.

Paratype GSC No. 14708 (Pl. VIII, fig. 2) has a diameter of 85 mm, the whorl height is 60 mm (0.71), and the whorl thickness 77 mm (0.91). The ribs of the last whorl become gradually weaker and more blunt towards the end of the whorl. The ribs of the preceding whorls are much sharper. The specimen is septate to the end of the whorl.

Paratype GSC No. 14694 (Pl. IX, fig. 1; Pl. X, fig. 1) is a large specimen consisting of two more or less fragmentary whorls with depressed cross-sections. The outer whorl belongs entirely to the body chamber. The penultimate whorl (not figured) shows traces of suture lines and blunt ribbing on the venter. The umbilicus is still very narrow.

The measurements in millimetres at the maximum diameter are:

<i>Diameter</i>	<i>Whorl height</i>	<i>Whorl thickness</i>	<i>Width of umbilicus</i>
160	about 80 (0.50)	120 (0.75)	—

Comparisons. In its general shape this species is similar to some of Quenstedt's specimens described as *Ammonites platystomus*. For example *Ammonites platystomus globulatus* Quenstedt (Quenstedt, 1887, Pl. 78, fig. 2) has the same aspect as paratype GSC No. 14708 of *Imlayoceras mieltense* and Quenstedt's *A. platystomus* (op. cit., Pl. 78, fig. 28) is similar to the holotype.

However, Quenstedt's specimens are clearly distinguished from *Imlayoceras* by the suture line, particularly the shape of the second lateral that is trifold in *I. mieltense* and bifid in Quenstedt's specimens. Corroy (1932, p. 102) who included Quenstedt's *platystomus* in his genus *Platystomaceras* stated already that the suture line of species of this "genus" was analogous to that of *Sphaeroceras*.

In its depressed whorl section, *I. mieltense* is also similar to specimens of *Macrocephalites rotundus* figured by Quenstedt (1887, p. 648, Pl. 76, figs. 5, 11, 12, 13, 16, 18), but the Canadian specimens are more globular and have still more depressed whorls. Furthermore, the original specimen of *Macrocephalites rotundus*

Quenstedt (Quenstedt, 1849, p. 184, Pl. 15, figs. 2a-c) seems to have a bifid second lateral lobe and a wider umbilicus. Perhaps Quenstedt's figure of the suture line is incorrect, Jeannet's (1951, p. 239, fig. 14) drawing of the suture line of a form determined as *Macrocephalites (Indocephalites)*¹ *rotundus* Quenstedt sp. var. shows a trifid second lateral lobe and is largely well in agreement with the suture line of the Canadian specimens.

I. miettense shows some resemblance to *Lilloettia milleri* Imlay (Imlay, 1953b, p. 75, Pl. 28, figs. 11, 13, 14, 15; Pl. 29, figs. 14, 15) but in this species the whorl height increases during growth unlike *Imlayoceras* which, furthermore, has a different suture line from *Lilloettia*.

Family KOSMOCERATIDAE Haug, 1887

Genus *Toricellites* Buckman, 1922

Toricellites? *spinosum* n. sp.

Plate X, figure 2; Plate XI, figures 2a-c

Holotype is specimen GSC No. 14709 (Pl. XI, figs. 2a-c); *paratype* GSC No. 14710 (Pl. X, fig. 2). Both specimens are from Grey beds, Cairn Pass (GSC loc. 27200).

Description. Both specimens are incompletely preserved; the holotype is the larger one, and has a maximum diameter of about 46 mm. No accurate measurements could be made.

The larger specimen was taken apart to disclose the inner whorls. Diameter of the youngest preserved stage is about 13 mm. Flanks are not preserved except for their outermost part, venter is almost flat and has a fairly broad and deep furrow. There are small tubercles on the ribs on both sides of the furrow. The next older preserved stage has a diameter of about 30 mm. Umbilical area and inner part of the whorl are concealed by rock material. Flanks are gently convex, the almost flat venter has a deep furrow with fairly strong ribs on both sides and on the outer parts of the flanks. The ribs end at the furrow in small tubercles. The next older preserved part of the ammonite has a diameter of about 46 mm, which is the maximum diameter. In the posterior part of this last whorl the ribs, tubercles and venter are still similar to the preceding ontogenetic stage but towards the anterior whorl part of the ventral furrow becomes gradually shallower and the ribs begin to cross the venter. Towards the end of the last whorl the furrow and the ventral tubercles have disappeared entirely but the venter is still fairly flat. On one side of the flank of the last whorl the ribs are preserved. They begin at the umbilical edge where they are bent slightly backward, on the inner part of the flank they swing forward. Some of the ribs bifurcate at about the middle of the

¹Jeannet (op. cit.) has placed *rotundus* Quenstedt and other related forms into *Indocephalites* Spath. This subgenus has, however, laterally compressed whorls when adult, whereas *rotundus* retains its depressed whorls during the various stages of its ontogeny. Furthermore, the wide umbilicus of *rotundus* is not characteristic of *Indocephalites* but of *Pleurocephalites* Buckman (1922) to which subgenus *rotundus* was referred by Callomon (1953, p. 240).

flank, others remain undivided. On some ribs a tubercle is present at the middle of the flank. The secondaries and the undivided primaries are slightly rectiradial in the outer part of the flanks and cross the venter transversely.

The ventral lobe and part of the first lateral are visible in the second described stage of growth and remnants of apparently the last suture line are present in the posterior part of the last whorl.

The paratype is poorly preserved. It is fairly wide umbilicate. The impression of the anterior part of the last whorl shows the same type of ribs and a similar venter as the last whorl of the larger specimen. The posterior part of the last whorl has high, sharp regularly spaced primaries some with long spines on the line of involution. Some spines are also present on the partly preserved preceding whorl. On the larger specimen no spines are present. It is assumed they are not preserved.

Comparisons. The larger specimen is similar in general shape to the type species *T. approximatus* Buckman (1922, Pl. 336, figs. 1-3), which, however, has a more rounded venter and some secondary ribs that do not reach beyond the middle of the flanks. Furthermore, no spines like those on the smaller Canadian specimen are present in *T. approximatus*. As they are also absent in the larger Canadian specimen they may have broken off. The two Canadian specimens are tentatively assigned to the genus *Toricellites*.

Genus *Kosmoceras* Waagen, 1869

Subgenus *Gulielmiceras* Buckman, 1920

Kosmoceras (Gulielmiceras) knechteli Imlay

Plate X, figure 3

Kosmoceras (Gulielmiceras) knechteli Imlay, 1953a, p. 31, Pl. 5, figs. 1-5.

Material. One specimen (GSC No. 14696) from Esterhazy Shaft, Saskatchewan (GSC loc. 42980), between 1,310 and 1,315 feet depth.

Description. The specimen has a diameter of 41 mm. As it is secondarily flattened, no other reliable measurements can be taken. The umbilicus is fairly narrow and shallow, the umbilical wall is low. Only part of the venter can be seen, it is apparently narrow. The last whorl embraces about two thirds of the preceding one.

Ribs are very fine and dense. On the umbilical wall the primaries are apparently bent backward, they swing forward on the inner part of the flanks. They are subdivided into pairs of secondaries somewhat below the middle of the flanks. Other secondaries are intercalated, they do not go beyond the line of furcation. The secondaries are bent forward on the middle part of the flanks and swing backward in their outer part. As far as can be seen they cross the venter transversely. No suture lines could be seen.

Comparisons. The specimen has been compared with casts of Imlay's types of *Kosmoceras (Gulielmiceras) knechteli* Imlay with which it agrees very well. *K. (Gulielmiceras) zartmanense* Imlay (Imlay, 1953a, p. 32, Pl. 14, figs. 1-6, 8) is a closely related species that is distinguished mainly by a sparser and coarser ribbing.

Genus *Keplerites* Neumayr and Uhlig, 1892

All the material described under the genus *Keplerites* in this report is more or less poorly preserved or fragmentary. The best preserved *Keplerites* from the Rocky Mountains region is the specimen of *K. mcevoyi* described by McLearn (McLearn, 1928, p. 20, Pl. 4, figs. 1, 2) and refigured in a more recent report (Friebold, 1957, p. 64, Pl. 35, figs. 2a, b).

Keplerites sp. indet. a

Plate IX, figure 2

Material. One whorl fragment (GSC No. 14706) from *Gryphaea* bed on Adanac Strip mine road (GSC loc. 25594).

Description. The fragment illustrated is slightly deformed and is an apparently fairly evolute ammonite with moderately convex flanks and rounded, apparently slightly flattened venter. Height and thickness of the whorl were about equal. There are ten fairly high and sharp primary ribs that are slightly bent forward. In the middle of the flanks they terminate in a fairly strong node and are subdivided into a number of secondaries that are also bent forward. There are also some intercalated secondaries. The secondaries cross the venter almost transversely except for the deformed parts of the shell. There are about five secondaries to one primary. No suture line is visible.

Comparisons. This fragment cannot be identified specifically. The holotype of a form described by Imlay (1953a, p. 30, Pl. 23, figs. 14-16) as *Gowericeras costimedium* Imlay is similar but smaller than the Canadian fragment. At this stage of growth *costimedium* has no strong lateral nodes and less secondaries than the Canadian form whereas *G. costidensum* Imlay (op. cit., p. 31, Pl. 22, figs. 10-13) has more numerous, denser, and finer secondaries.

Keplerites sp. indet. b

Plate XI, figure 3

Material. One whorl fragment (GSC No. 14711) from Grey beds in an east tributary to Rocky River just south of Miette map-area.

Description. The fragment is somewhat laterally contorted. The flanks are moderately convex and the venter is slightly rounded. The primary ribs are widely spaced, slightly bent forward, and end in a tubercle somewhat below the middle of the flanks where they are subdivided into several, mostly three, secondaries. Some secondaries are intercalated. The secondaries cross the venter transversely.

Keplerites sp. indet. c

Plate X, figure 4

Material. One whorl fragment (GSC No. 14716) from Grey beds on Rocky River, west of Makwa Ridge, Miette area, west half (GSC loc. 36725).

Description. The specimen is secondarily flattened and shows a small part of the preceding whorl. The venter is not preserved and suture lines are not visible. Ribs slightly flexuous, primaries bifurcate at about the middle of the flanks, and between two pairs of secondaries one or sometimes two intercalated ribs are present. There are no tubercles.

Keplerites aff. *K. tychonis* Ravn

Plate IX, figure 3

Material. One secondarily compressed fragmentary specimen (GSC No. 14715) and several small specimens from a zone about 20 feet above *Gryphaea* bed on Grassy Mountain, north of Blairmore (GSC loc. 31428).

Description. Specimen GSC 14715 shows a fairly wide umbilicus and has numerous very fine ribs that are bent forward. No measurements could be taken. The smaller specimens are very poorly preserved.

Comparisons. In its very fine ribbing the specimen is similar to fragments described by Imlay (1953a, p. 27, Pl. 20, figs. 1-3) as *Keplerites tychonis* Ravn. Precise identification of Imlay's fragments from the Rierdon Formation in Montana with Ravn's species is perhaps open to question, but they belong probably to the same group.

Keplerites aff. *K. mclearnii* Imlay

Material. One specimen (GSC No. 14703) from Grey beds on Rocky River, west of Makwa Ridge, Miette area, west half (GSC loc. 36728). Below bed with large concretions.

Description. The specimen is secondarily compressed and distorted and no measurements could be taken. It is apparently moderately evolute. Primary ribs are slightly bent forward and subdivided into two to four almost straight forwardly inclined secondaries, the point of division is marked by high conical tubercles that persist to the end of the last preserved whorl, one or more intercalated ribs are present between the bundles of secondaries. No suture line is visible.

Comparisons. The specimen has the same high conical tubercles as *Keplerites mclearnii* Imlay and *K. cf. K. rosenkrantzi* Spath described by Imlay (1953a, p. 27, Pl. 14, fig. 9).

Keplerites cf. *K. rockymontanus* Imlay

Plate XII, figure 1

Keplerites (Seymourites) rockymontanus Imlay, 1953a, p. 26, Pl. 18; Pl. 19, figs. 1, 2.

Material. Several fragmentary specimens from Esterhazy Shaft, Saskatchewan, GSC locs. 42977, 42979-42984, at depths 1,310 to 1,315 feet.

Description. The best preserved fragment is specimen GSC No. 14713. It is almost entirely laterally compressed so that the height of the whorls has become exaggerated and the venter sharp.

This specimen has parts of three whorls preserved, the innermost one very fragmentary. The anterior part of the last preserved whorl belongs to the body chamber, the posterior part (the middle part is broken off) is septate. At this stage of growth the umbilicus is very wide, the umbilical wall is almost vertical but very low. The umbilicus is much narrower on the innermost visible wall.

The ribs begin on the umbilical wall where they are bent backward. They curve forward on the inner part of the flank. The primaries are commonly subdivided on the inner third of the flank into three secondaries which are gently inclined forward and cross the venter transversely. The point of division is marked by tubercles. Other secondaries are intercalated between the trifurcated ribs. They begin commonly slightly above the points of division. In the anterior part of the body chamber the ribs become less sharp and the subdivision more irregular. At this stage of growth the ribs are strongest on the umbilical wall and the innermost part of the flanks. Towards the end the last whorl is almost smooth except for the umbilical region where the primaries are still strong.

Comparisons. As far as the state of preservation permits a comparison the specimen agrees very well with *K. rockymontanus* Imlay.

Ammonites gen. et sp. indet.

Plate VIII, figures 3-5

Material. Several specimens from a zone about 20 feet above *Gryphaea* bed on Grassy Mountain, north of Blairmore (GSC locs. 31428, 36252, 31412) and from Rock Creek near Burmis.

Description. The ammonites are preserved as flattened specimens or imprints. The diameter of the largest specimen is about 15 mm. The shell is involute, the umbilicus small. Thickness of whorl relative to its height is unknown, no complete venter and no suture lines are visible. Primaries are slightly bent forward and most of them bifurcate at about the middle of the flank, only a few on the inner part. Secondaries are straight and slightly inclined backward. They seem to cross the venter transversely. Specimens GSC No. 14714 and 14717 (Pl. VIII, figs. 3, 4) have more numerous and finer ribs than specimen GSC No. 14718 (Pl. VIII, fig. 5). All ribs are fairly sharp.

Comparisons. Differences in number and strength of ribs seem to indicate presence of two species of uncertain generic position. In general appearance the ammonites have a macrocephalitid aspect.

Table I
Correlation of the Upper Middle Jurassic Beds of the Fernie Group with those of Montana

FORMATIONS IN MONTANA	STRATIGRAPHIC UNITS		STAGE	ZONES OR FAUNAS	MONTANA, MAINLY AFTER IMLAY (1953a)
	JASPER PARK	SOUTHERN ALBERTA			
Lower Swift	Green beds	Green beds	Lower Oxfordian	Cardioceras fauna	Cardioceras fauna
Hiatus	Hiatus	Hiatus	Upper and Middle Callovian	Hiatus	Hiatus
	Bed with large concretions	Bed with large concretions locally developed		Lower	<i>Imlyoceras miffense</i> zone <i>Persphinctids</i> (undescribed)
Rierdon	Shale	Shale	Callovian	<i>Keplerites mclearnii</i> zone <i>Keplerites aff. K. tychonis</i> zone	<i>Keplerites mclearnii</i> zone <i>Keplerites tychonis</i> zone
		Grey beds		not identified	<i>Gowericeras subitum</i> zone
	Gryphaea bed		<i>Warrenoceras henryi</i> zone	<i>Gowericeras costidensum</i> zone <i>Arcticoceras</i> zone	
Sawtooth	Rock Creek Member	Corbula munda beds	Lower Callovian or Upper Bathonian	<i>Paracephalites glabrescens</i> zone	<i>Cranocephalites</i> zone
			?	?	
	Rock Creek Member	Rock Creek Member	Middle Bajocian	<i>Stephanoceras,</i> <i>Stemmatoceras,</i> <i>Teloceras,</i> <i>Chondroceras,</i> etc. } in one and the same zone	<i>Stemmatoceras, Chondroceras</i>

AGE AND FAUNAL AFFINITIES

Hitherto five ammonite zones have been recognized in the upper part of the Middle Jurassic beds of the Fernie Group. In ascending order these are the zones of *Paracephalites glabrescens*, *Warrenoceras henryi*, *Keplerites* aff. *K. tychonis*, *Keplerites mclearni*, and *Imlayoceras miettense*. A sixth zone, characterized by perisphinctids, yet undescribed, seems to be present locally (Jasper Park) between the *Imlayoceras miettense* and *Keplerites mclearni* zones.

Not all these zones are known in each of the areas studied, for example, the *Imlayoceras* fauna has only been found in parts of the Jasper Park area and the *Paracephalites* fauna only in the Blairmore, Fording River, and Cairn Pass areas. The *Keplerites mclearni* fauna is well represented in Saskatchewan.

Stratigraphically, the uppermost lower Callovian *Imlayoceras miettense* zone is 15 to 60 feet below the Oxfordian Green beds with *Cardioceras*, from which it is separated by a hiatus that corresponds to the upper and middle Callovian. The lowermost Callovian or uppermost Bathonian zone of *Paracephalites glabrescens* occurs above the middle Bajocian Rock Creek member, from which it is separated by shales whose thickness changes apparently from place to place.

The relationships of the various faunas are summarized on Table I.

The *Paracephalites glabrescens* Zone

The *Paracephalites glabrescens* zone was found on Grassy Mountain north of Blairmore, at Adanac mine, on Fording River, and in Cairn Pass, and is probably present at many other localities. On Grassy Mountain it occurs in the upper part of the *Corbula munda* beds below the *Gryphaea* bed that contains the *Warrenoceras* fauna. The lowermost known occurrence of *Paracephalites* is 35 feet below the *Gryphaea* bed. The species hitherto found at this locality are *Paracephalites glabrescens* Buckman, *P. metastatus* (Buckman), *P. hashimotoi* Frebold; *P. glabrescens* and *P. hashimotoi* were also found in the Fording River area, *P. hashimotoi* at Adanac mine and *P. metastatus* in Cairn Pass.

These ammonites are very similar to the ammonites from the upper Sawtooth Formation in Montana described by Imlay (1948) as *Arctocephalites* Spath and which he now assigns to *Cranocephalites* Spath (personal communication). At least one of the Fernie and Montana species is identical (*P. metastatus*) and shows the equivalence in age of these Fernie and Montana ammonite faunas. As the lithology of the upper part of the *Corbula munda* beds in the Blairmore and Adanac areas is similar to that of the upper Sawtooth Formation in Montana, this formal name may be applied to the upper *Corbula munda* beds in Alberta.

It has already been shown in this report that the *Paracephalites* fauna is clearly distinguishable from the Arctic genera *Arctocephalites* Spath and *Cranocephalites* Spath. Even if these genera were used in a wider sense to include the Canadian and western interior forms the difference in species between the Arctic region and the Canadian and United States' western interior areas would remain.

This has some bearing on the determination of the age and zoogeographical position of the fauna. None of the species concerned is known from other regions, and certain similarities of the *Paracephalites* fauna with Arctic *Cranocephalites* faunas do not necessarily prove that it is of the same age as these, i.e., Bathonian. However, as the overlying lower Callovian *Warrenoceras* fauna of the *Gryphaea* bed is separated by only 35 feet of beds and as no hiatus is indicated to be present the *Paracephalites* fauna is considered to be of early Callovian or very late Bathonian age.

Zoogeographically the *Paracephalites* fauna of Western Canada and the United States western interior can be regarded as a special faunal province.

The *Warrenoceras henryi* Zone

In the Grassy Mountain, Blairmore, and Adanac areas the *Warrenoceras henryi* zone occurs in the *Gryphaea* bed that is 35 feet above the lowermost known occurrence of *Paracephalites*. The *Gryphaea* bed is a fossil concentration, about 3 feet 6 inches thick, which in addition to numerous pelecypods—the guide pelecypod is *Gryphaea impressimarginata* McLearn—contains belemnites, gastropods, and ammonites. The ammonites are *Warrenoceras henryi* (Meek and Hayden), *W. imlayi* (Frebold), *W. rierdonense* (Imlay), *Kepplerites* (*Gowericeras?*) spp., *Cobbanites engleri* (Frebold). The species of *Warrenoceras* are the same as some of those described by Imlay as *Arcticoceras* (1948, 1953a) from his *Arcticoceras codyense* beds of the lower Rierdon Formation of Montana and the lower Sundance Formation of Wyoming and South Dakota respectively. *Cobbanites* (previously described by Imlay, 1948, 1953a, and Frebold, 1957 as *Procerites*) occurs in both regions in the same beds, but *Kepplerites* (*Gowericeras?*) aff. *costimedium* Imlay that is found in fragments in the Canadian *Gryphaea* bed belongs in Montana to the *Gowericeras costidensum* and *G. subitum* beds (Imlay, 1948, 1953a), which are younger than the *codyense* beds. Accordingly, the *Gryphaea* bed may include both the *codyense* and *Gowericeras costidensum* zones of Montana.

In Montana the *codyense*, *costidensum*, and the younger *subitum* zones contain other ammonites such as *Cadoceras piperense* Imlay, *C. muelleri* Imlay, *C. tetonense* Imlay, and other Cadoceratids (Imlay, 1953a). As most of these Cadoceratids belong to the *costidensum* and *subitum* zones and as these zones are missing or poorly represented in Alberta the absence of these Cadoceratids in the Fernie Group is understandable.¹

The *Warrenoceras henryi* zone is also well represented at other Fernie localities. In Cairn Pass, Jasper Park, *W. henryi* (Meek and Hayden) and *W. rierdonense* (Imlay) were found. They indicate the presence of beds equivalent in time to the Canadian *Gryphaea* bed and the *codyense* beds in Montana. *Warrenoceras? crassicostatium* (Imlay), *W.? loveanum* (Imlay), and *Toricellites? spinosum* n. sp.

¹One specimen from the upper *Corbula munda* beds on Grassy Mountain that was previously described as *Cadoceras muelleri* (Frebold, 1957, p. 60, Pl. 36, fig 1; Pl. 37, fig. 1) is *Paracephalites hashimotoi* Frebold (see p. 11).

were collected at the same locality but their association with *Warrenoceras henryi* and *W. rierdonense* in the same bed is not certain.

In the Rock Lake area, Jasper Park, *W. henryi* and *W. imlayi* occur in grey shales between 30 and 50 feet below the Oxfordian Green beds. In Cascade Valley near Banff, *W. henryi* is present. At the same locality poorly preserved specimens of *Kepplerites* similar to *K. mcevoyi* McLearn occur. It is still doubtful whether *Warrenoceras* and *Kepplerites* are associated with each other in the same bed at this locality.

Zoogeographically the *Warrenoceras* fauna is, as is the older *Paracephalites* fauna, restricted to the Fernie Group in Canada and to the Rierdon and equivalent formations in the western interior of the United States. The genus *Warrenoceras* has some similarities with the Arctic genus *Arcticoceras* Spath to which genus Imlay has assigned the North American forms but the two genera can be easily distinguished (*see section on Palæontology*, p. 14). The genera *Cadoceras* and *Kepplerites* (*Gowericeras?*) which are associated with *Warrenoceras* in the western interior are also represented by species that are unknown in other regions (*see also* Donovan, 1957, p. 135). This fact supports the view that at that time a restricted faunal province existed in parts of Western Canada and the western interior of the United States.

No reliable age determination can be based on the genus *Warrenoceras* as it is unknown from other regions. Its association in the United States western interior with *Cadoceras* or *Kepplerites* (*Gowericeras?*), however, indicates an early Callovian age.

Gowericeras subitum Imlay the index fossil of Imlay's *Gowericeras subitum* zone in Montana, has hitherto not been found in Canada. In southern Alberta it could be expected above the *Gryphaea* bed that contains the equivalents of the Montana *codyense* and possibly the *costidensum* zones.

The *Kepplerites* aff. *K. tychonis* and *K. mclearni* Zones

In Montana, Imlay (1953) established the presence of two *Kepplerites* zones, i.e., a lower one with *K. tychonis* Ravn and an upper one with *K. mclearni* Imlay.

In the Grassy Mountain, Blairmore, and Adanac areas of southern Alberta, the beds between the *Gryphaea* bed and the Oxfordian Green beds are very poor in fossils but about 20 feet above the *Gryphaea* bed an ammonite fauna occurs in a bed a few inches thick. This ammonite fauna is very unsatisfactorily preserved and consists of two species. The more common one includes forms described in the palæontological part of this report as Ammonite gen. et sp. indet., the other species, which is characterized by very fine ribs, is similar to Imlay's *K. tychonis* from Montana and Alaska. This southern Alberta fauna is tentatively correlated with Imlay's *tychonis* zone. The younger Montana zone of *K. mclearni* has hitherto not been identified in southern Alberta but is represented in Saskatchewan in the Esterhazy well (*see p. 25*) where it also contains *Kosmoceras* (*Guliel-*

miceras) knechteli Imlay and at several localities in Jasper Park, where several *Kepplerites* belonging to this zone were found.

Owing to its uncertain stratigraphic position, *K. mcevoyi* unfortunately does not afford any additional evidence of age for the *Kepplerites* zones. It may well be associated with *Warrenoceras* in slightly older beds.

According to Donovan (1957, pp. 133, 135), most of the species of *Kepplerites* and *Gulielmiceras* described by Imlay (1953a) are different from species in East Greenland and Europe respectively. Only Imlay's western interior *K. tychonis* seems to be closely related to Ravn's species from East Greenland.

The *Imlayoceras miettense* Zone

The *Imlayoceras miettense* zone has hitherto been found only in the Rocky River, Blue Creek, and Rock Lake areas (Jasper Park). In southern parts of Alberta, southern parts of eastern British Columbia, and in the western interior of the United States this very characteristic genus is unknown.

The stratigraphic position of the zone is in the upper Grey beds, in the bed with large concretions, approximately 15 to 60 feet below the base of the Oxfordian Green beds. At no locality was *Imlayoceras* found associated with other ammonites but as it occurs at certain localities above beds with *Kepplerites* species of the *K. mclearni* zone it is believed that it characterizes the uppermost known early Callovian beds of parts of the Canadian Rocky Mountains. As the genus is unknown in other areas no further correlation is attempted.

Summarizing all the available evidence on the upper Middle Jurassic ammonite faunas of the Canadian Fernie Group and the western interior of the United States it is apparent that the ammonites of these beds are local faunas, as was already stated by Donovan (Donovan, 1957, pp. 132-135) for most of the ammonites concerned. The new genus *Imlayoceras* described in this report but unknown in other regions confirms this. It is interesting to note that the genera *Paracephalites*, *Warrenoceras*, and *Imlayoceras* seem to be absent even in the adjoining parts of central British Columbia to the west. These differences are, however, in part caused by slight age differences. Absence of the typical Middle Jurassic Arctic ammonites in the Canadian Fernie Group and the western interior of the United States is explained by the absence of any direct connection of these regions with the Arctic sea (see Frebold, 1957, p. 38, fig. 5; p. 44).

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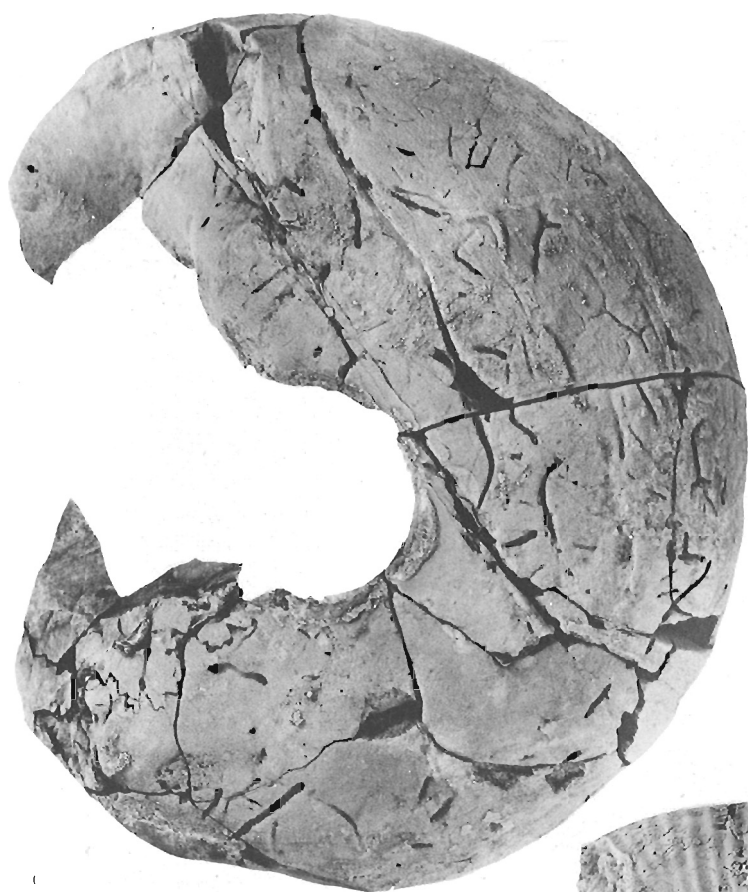
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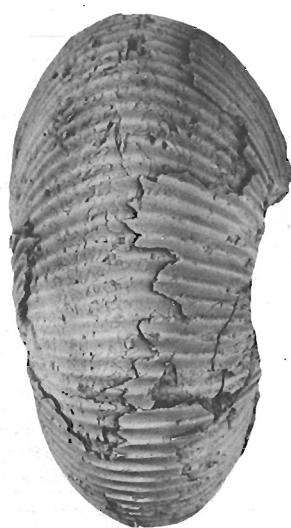
PLATES I TO XIV

PLATE I

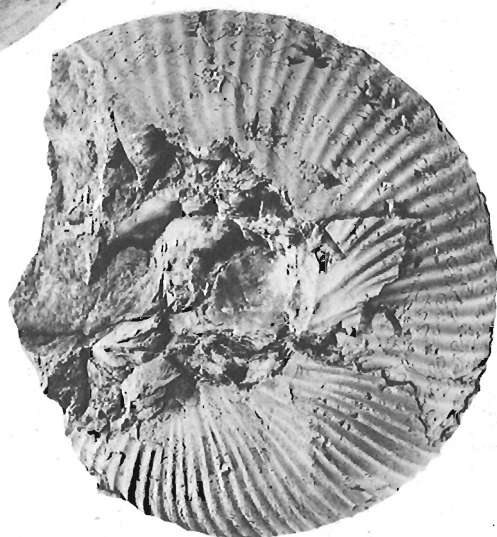
- Figures 1a-c. *Paracephalites glabrescens* Buckman (Page 9)
GSC No. 14719; Grey beds near Fording River bridge, GSC loc. 25596. Fig. 1a, living chamber; 1b, lateral view of penultimate whorl; 1c, venter of penultimate whorl. Natural size.
- Figure 2. *Paracephalites metastatus* (Buckman) (Page 12)
GSC No. 14700; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view. Same specimen as Plate II, figure 2. Natural size.



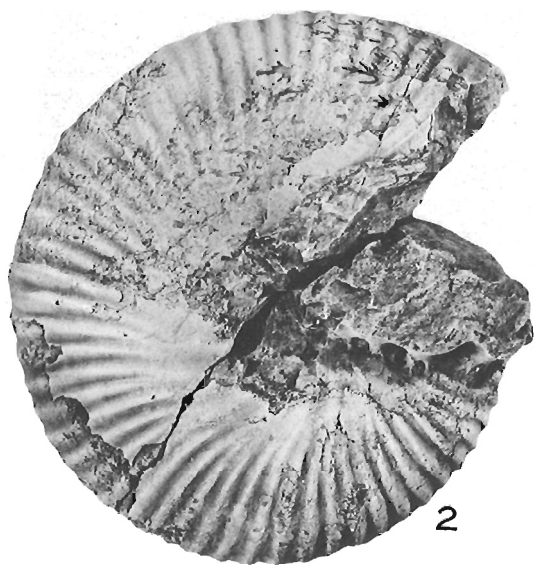
1a



1c



1b



2

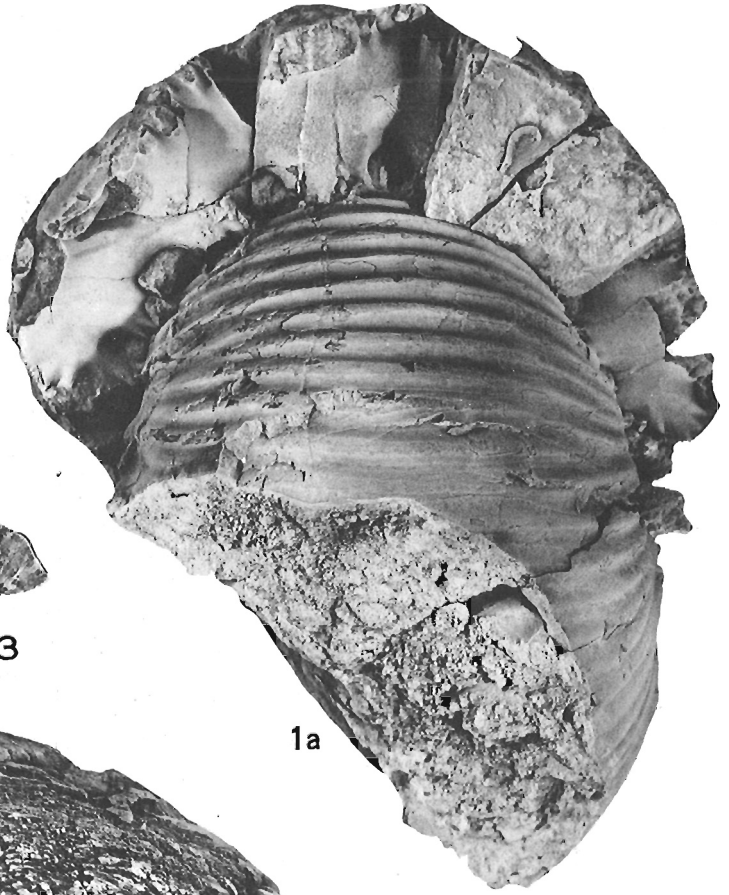


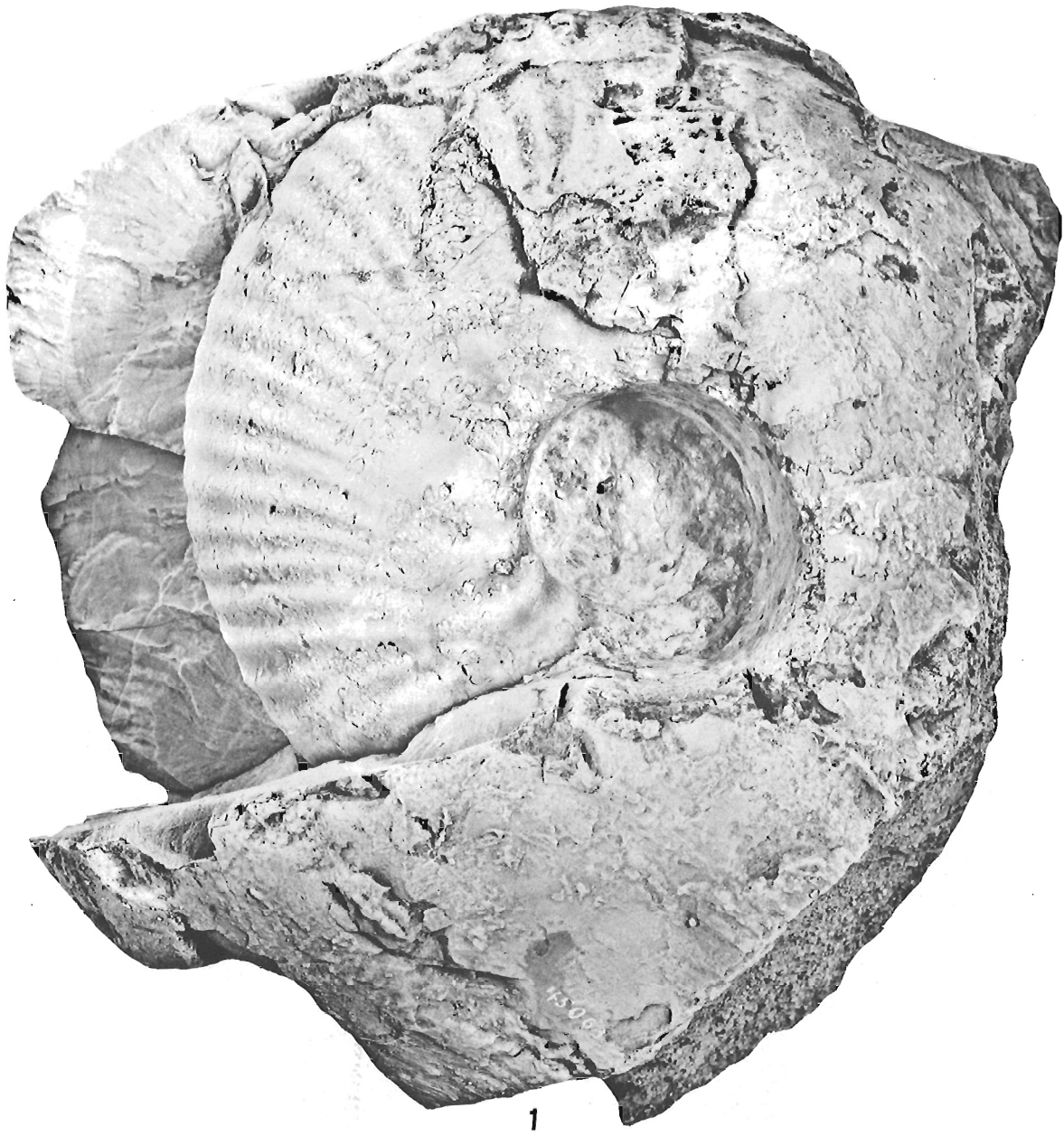
PLATE II

- Figure 1. *Paracephalites glabrescens* Buckman (Page 9)
GSC No. 14695; Grey beds near Fording River bridge, GSC loc. 25596. Lateral view. (Note: The specimen is somewhat larger than the figure; actual diameter is 155 mm.)
- Figure 2. *Paracephalites metastatus* (Buckman) (Page 12)
GSC No. 14700; Grey beds in Cairn Pass, GSC loc. 27200. Venter. Same specimen as Plate I, figure 2. Natural size.
- Figures 3a, b. *Paracephalites glabrescens* Buckman (Page 9)
GSC No. 14705; upper *Corbula munda* beds on Grassy Mountain, GSC loc. 36249. Lateral views and suture line. Natural size.

PLATE III

- Figures 1a, b. *Paracephalites hashimotoi* Frebold (Page 11)
GSC No. 14701; Grey beds near Fording River bridge, GSC loc. 25596. Figure 1a, cross-section and venter; 1b, lateral view. Slightly smaller than the specimen.
- Figure 2. *Warrenoceras? crassicostatum* (Imlay) (Page 18)
GSC No. 14698; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view. Natural size.
- Figure 3. *Warrenoceras? crassicostatum* (Imlay) (Page 18)
GSC No. 14704; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view of fragmentary last and penultimate whorls. Natural size.
- Figure 4. *Warrenoceras? loveanum* (Imlay) (Page 19)
GSC No. 14699; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view of last and inner whorls. Same specimen as Plate X, figure 5. Natural size.





1

PLATE IV

Figure 1. *Paracephalites hashimotoi* Frebold (Page 11)
GSC No. 14697; paratype. Upper *Corbula munda* beds on Adanac Strip mine road, GSC loc. 45063. Lateral view and suture lines. Part of living chamber removed. Natural size.

PLATE V

- Figure 1. *Warrenoceras henryi* (Meek and Hayden) (Page 14)
GSC No. 14690; *Gryphaea* bed on Grassy Mountain, GSC loc. 45067. Lateral view. Same specimen as Plate VI, figure 1. (Note: The specimen is somewhat larger than the figure. Actual diameter is 155 mm.)
- Figures 2a, b. *Warrenoceras henryi* (Meek and Hayden) (Page 14)
GSC No. 14692; Grey beds in Cairn Pass, GSC loc. 27200. Figure 2a, lateral view; fig. 2b, venter. Natural size.



1



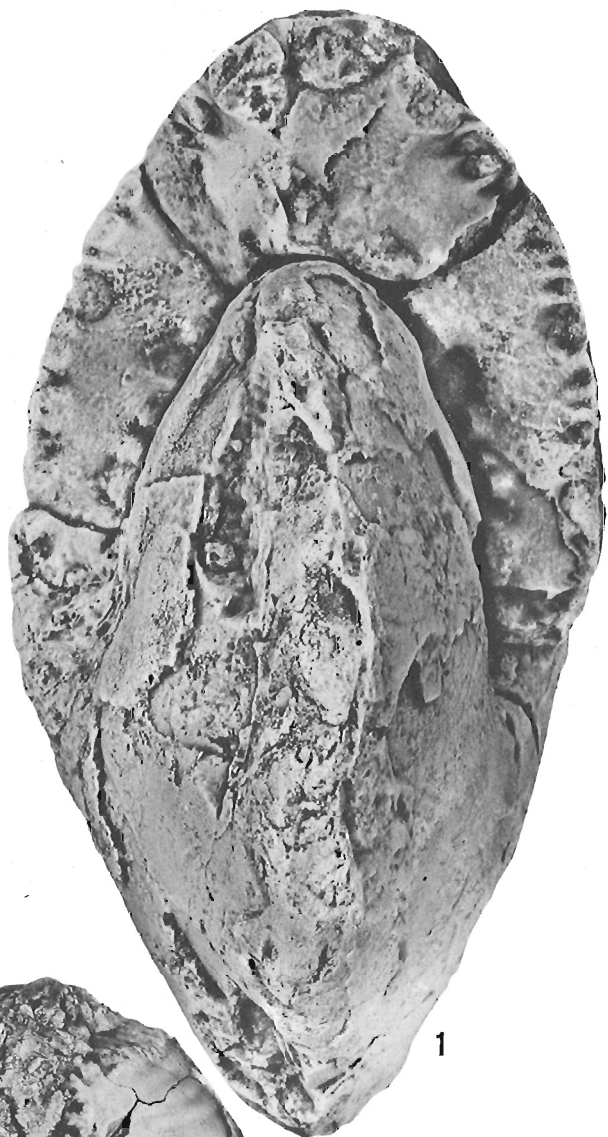
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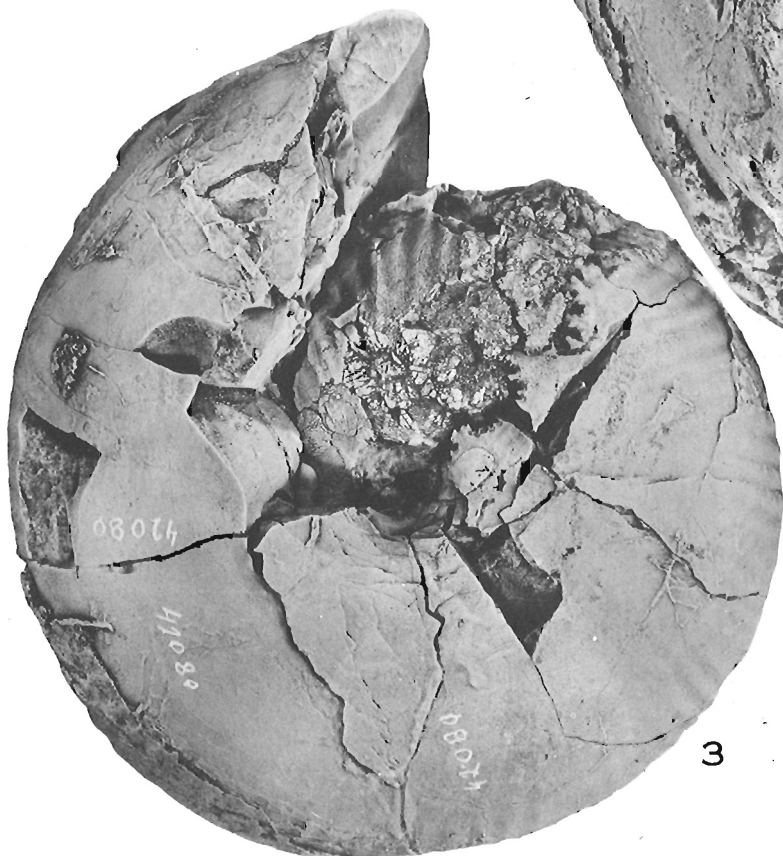
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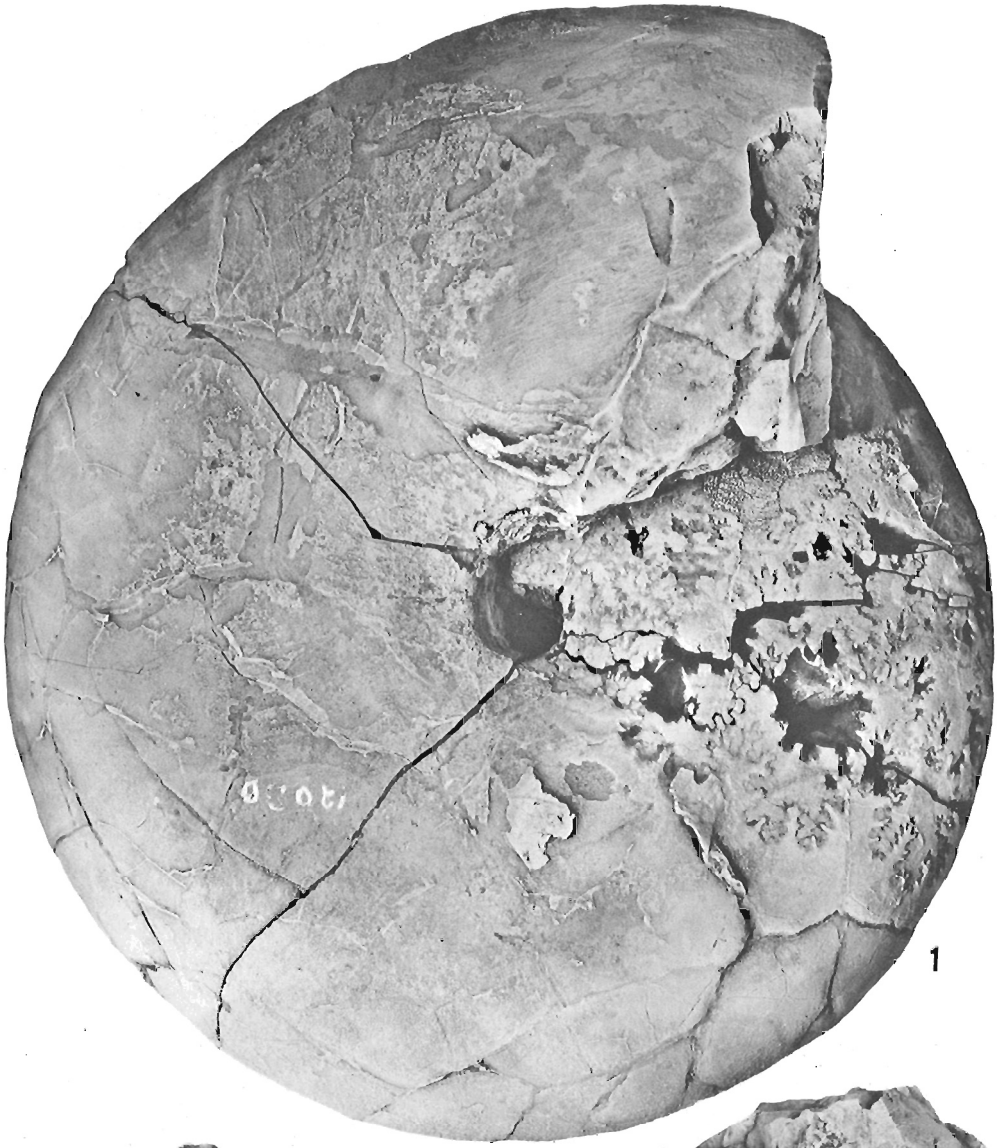
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PLATE VI

- Figure 1. *Warrenoceras henryi* (Meek and Hayden) (Page 14)
GSC No. 14690; *Gryphaea* bed on Grassy Mountain, GSC loc. 45067. Cross-section and venter. Same specimen as Plate V, figure 1. (Note: The specimen is somewhat larger than the figure; actual diameter is 155 mm.)
- Figure 2. *Warrenoceras rierdonense* (Imlay) (Page 17)
GSC No. 14693; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view and suture line. Natural size.
- Figure 3. *Warrenoceras imlayi* (Frebald) (Page 16)
GSC No. 14720; Grey beds in Rock Lake area, GSC loc. 42080. Lateral view. Natural size.

PLATE VII

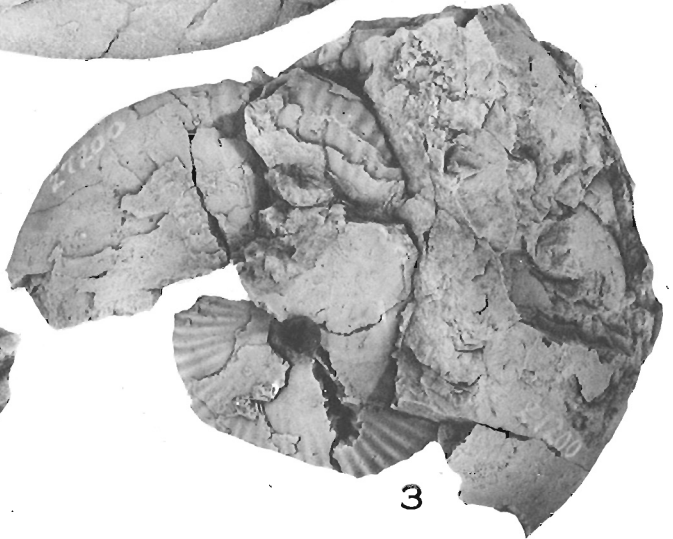
- Figure 1. *Warrenoceras henryi* (Meek and Hayden) (Page 14)
GSC No. 14688; Grey beds in Ram Pass, Rock Lake area, GSC loc. 42080.
Lateral view and suture line. Natural size.
- Figure 2. *Warrenoceras henryi* (Meek and Hayden) (Page 14)
GSC No. 14689; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view showing costation of inner whorls. Natural size.
- Figure 3. *Warrenoceras henryi* (Meek and Hayden) (Page 14)
GSC No. 14691; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view showing costation of inner whorls. Natural size.



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2



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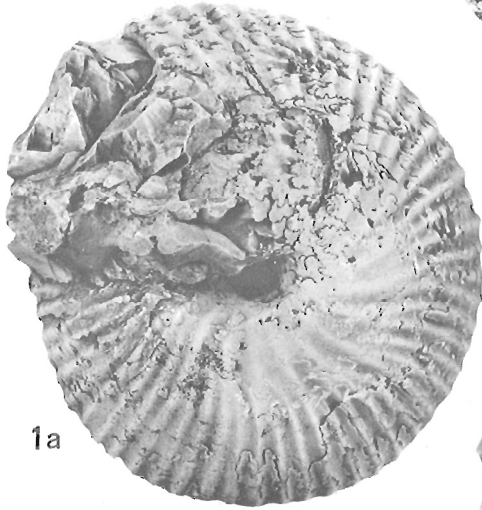
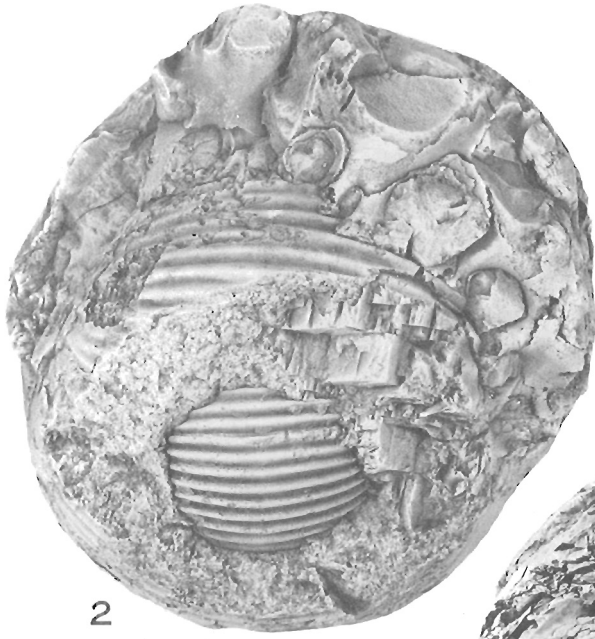
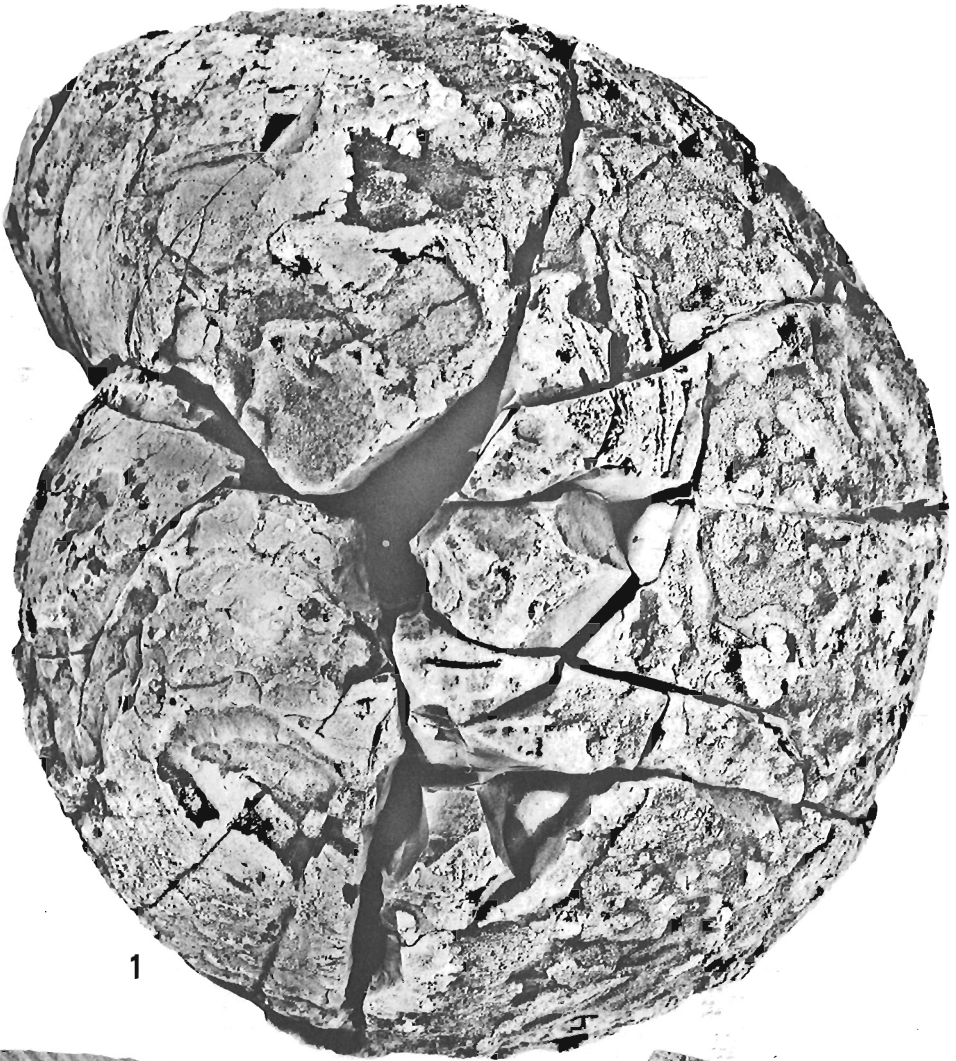


PLATE VIII

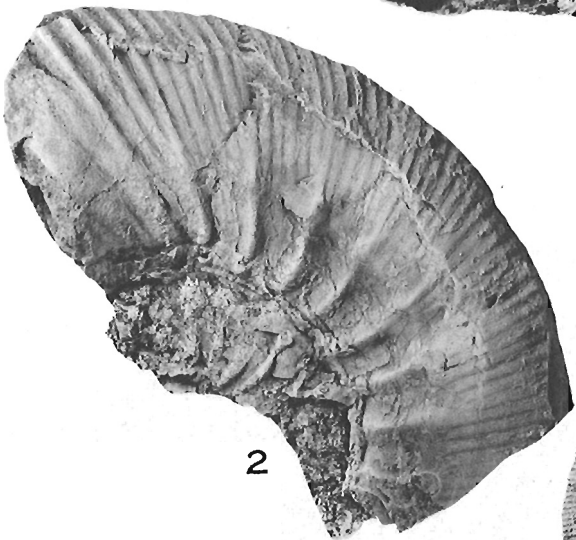
- Figures 1a-c. *Imlayoceras miettense* n. sp. (Page 20)
GSC No. 14707; zone with large concretions in upper Grey beds at Rocky River, GSC loc. 36718. Fig. 1a, lateral view; fig. 1b, cross-section and venter; fig. 1c, venter and suture line. Same specimen as Pl. XI, fig. 1. Figures are slightly smaller than specimen. Holotype.
- Figure 2. *Imlayoceras miettense* n. sp. (Page 20)
GSC No. 14708; zone with large concretions in upper Grey beds at Rocky River, GSC loc. 31379. Cross-section and venter. Slightly smaller than specimen. Paratype.
- Figure 3. Ammonite gen. et sp. indet. (Page 26)
GSC No. 14714; about 20 feet above *Gryphaea* bed on Grassy Mountain. GSC loc. 36252. Lateral view. Natural size.
- Figure 4. Ammonite gen. et sp. indet. (Page 26)
GSC No. 14717; about 20 feet above *Gryphaea* bed on Grassy Mountain, GSC loc. 31428. Lateral view. Natural size.
- Figure 5. Ammonite gen. et sp. indet. (Page 26)
GSC No. 14718; about 20 feet above *Gryphaea* bed on Grassy Mountain, GSC loc. 31428. Lateral view. Natural size.

PLATE IX

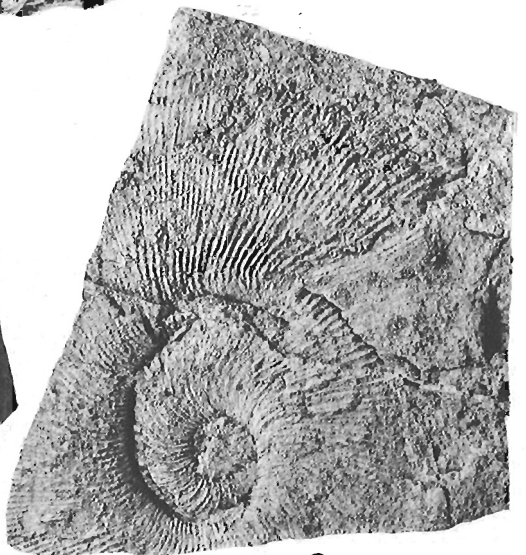
- Figure 1. *Imlayoceras mieltense* n. sp. (Page 20)
GSC No. 14694; zone with large concretions in upper Grey beds at the north end of De Smet Range, GSC loc. 42083. Lateral view. Paratype. Same specimen as Pl. X, fig. 1. (Note: The specimen is larger than the figure; actual diameter is 160 mm.)
- Figure 2. *Keplerites* sp. indet. a (Page 24)
GSC No. 14706; *Gryphaea* bed on Adanac Strip mine road, GSC loc. 25594. Lateral view. Natural size.
- Figure 3. *Keplerites* aff. *K. tychonis* Ravn (Page 25)
GSC No. 14715; 20 feet above *Gryphaea* bed on Grassy Mountain. GSC loc. 31428. Lateral view. Natural size.



1



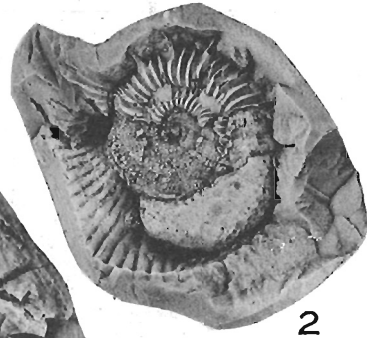
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5



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PLATE X

- Figure 1. *Imlayoceras miettense* n. sp. (Page 20)
GSC No. 14694; zone with large concretions in upper Grey beds at north end of De Smet Range, GSC loc. 42083. Cross-section and venter. Same specimen as Pl. IX, fig. 1. (Note: The specimen is larger than the figure; actual diameter is 160 mm.) Paratype.
- Figure 2. *Toricellites? spinosum* n. sp. (Page 22)
GSC No. 14710; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view. Natural size. Paratype.
- Figure 3. *Kosmoceras (Gulielmiceras) knechteli* Imlay (Page 23)
GSC No. 14696; Esterhazy Shaft, eastern Saskatchewan, between 1,310 and 1,315 feet depth, GSC loc. 42980. Lateral view. Natural size.
- Figure 4. *Keplerites* sp. indet. c (Page 24)
GSC No. 14716; Grey beds on Rocky River, GSC loc. 36725. Lateral view. Natural size.
- Figure 5. *Warrenoceras? loveanum* (Imlay) (Page 19)
GSC No. 14699; Grey beds in Cairn Pass, GSC loc. 27200. Lateral view. Same specimen as Pl. III, fig. 4. Natural size.

PLATE XI

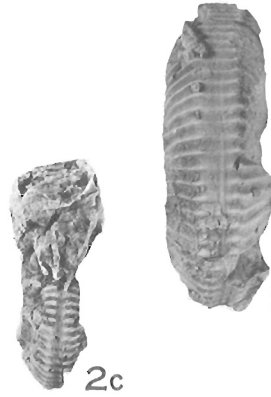
- Figure 1. *Imlayoceras mieltense* n. sp. (Page 20)
GSC No. 14707; zone with large concretions in upper Grey beds on Rocky River, GSC loc. 36718. Same specimen as Pl. VIII, figs. 1a-c. Venter of living chamber. (The specimen is larger than the figure.) Holotype.
- Figures 2a-c. *Toricellites? spinosum* n. sp. (Page 22)
GSC No. 14709; Grey beds in Cairn Pass, GSC loc. 27200. Fig. 2a, lateral view; fig. 2b, venters at various stages of growth. Natural size. Holotype.
- Figure 3. *Kepplerites* sp. indet. b (Page 24)
GSC No. 14711; Grey beds, east tributary to Rocky River, GSC loc. 31384. Lateral view. Natural size.
- Figure 4. *Kepplerites* aff. *K. mclearnii* Imlay (Page 25)
GSC No. 14703; Grey beds on Rocky River, GSC loc. 36728. Lateral view. Natural size.



1



2a

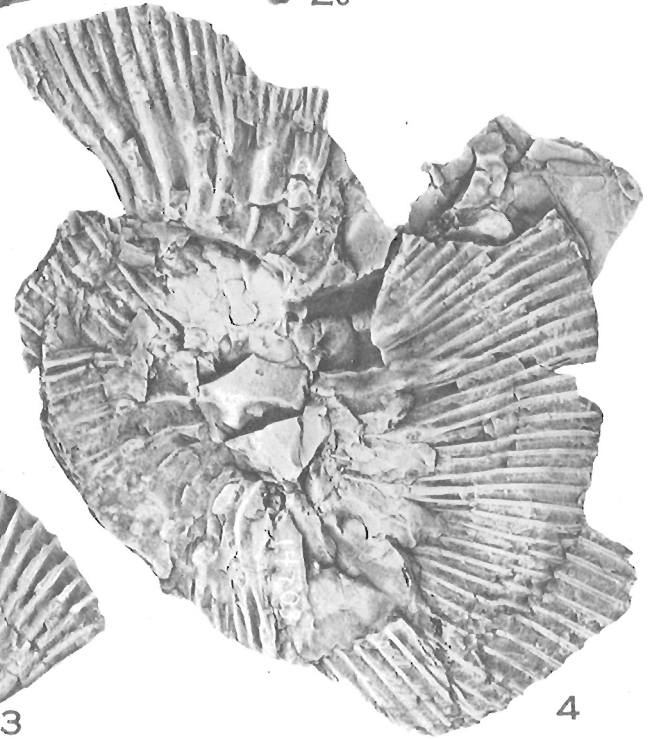


2b

2c



3



4



1

PLATE XII

- Figure 1. *Keplerites* cf. *K. rockymontanus* Imlay (Page 25)
GSC No. 14713; Esterhazy Shaft, eastern Saskatchewan, between 1,310 and
1,315 feet depth, GSC loc. 42983. Lateral view. Natural size.

PLATES XIII & XIV

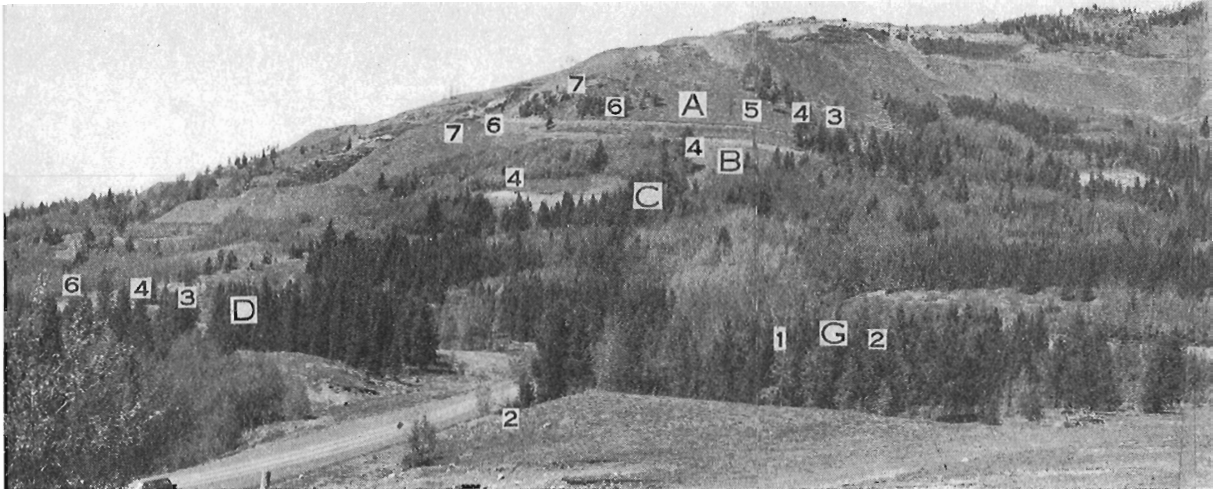


PLATE XIII Jurassic sections on south slope of Grassy Mountain, north of Blairmore.

A, B, C—sections on western side of south slope; D—part of old railway section; E—Gold Creek road section; F—section on eastern side of south slope; G—part of old railway section. 1—Lower Jurassic sandstones, 2—Lille Member, 3—*Corbula munda* beds, 4—*Gryphaea* bed, 5—shale between *Gryphaea* bed and Green beds (the latter only very poorly exposed), 6—Passage beds, 7—lower Kootenay sandstone.

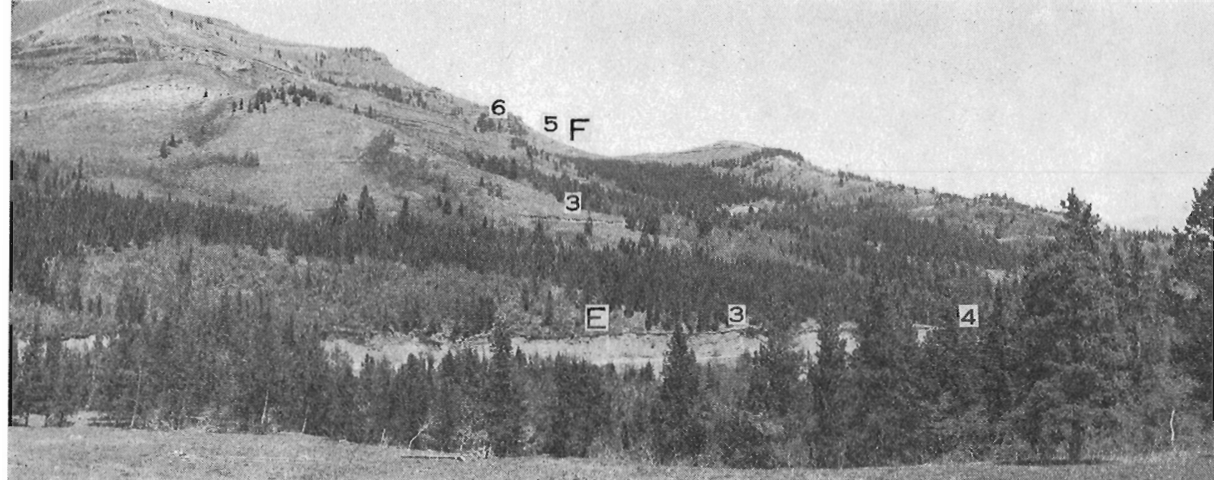
PLATE XIV

Section C in western part of south slope of Grassy Mountain, north of Blairmore (see position in fig. 1, Pl. XIII).

1—*Corbula munda* beds, upper part.

1a—*Paracephalites glabrescens* zone in upper 35 feet of *Corbula munda* beds.

2—*Gryphaea* bed with *Warrenoceras henryi* zone.



H.F., 1961

H.F., 1961



