SMITHSONIAN MISCELLANEOUS COLLECTIONS
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Charles D. and Mary Vaux Walcott
Research Fund

MIDDLE CAMBRIAN STRATIGRAPHY AND FAUNAS OF THE CANADIAN ROCKY MOUNTAINS

(With 34 Plates)

BY
FRANCO RASETTI
The Johns Hopkins University
Baltimore, Maryland

(Publication 4046)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
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PART I. STRATIGRAPHY

INTRODUCTION

THE PROBLEM

The area described in this work is situated on or near the Continental Divide in the southern Canadian Rocky Mountains. The portion of the Divide investigated centers around Kicking Horse Pass and extends northwest to Bow Pass and south to Wenkchemna Pass. The mountains forming the Divide are known as the Waputik and Bow Ranges, respectively north and south of Kicking Horse Pass. All the localities discussed are either in Banff National Park, Alberta, or in Yoho National Park, British Columbia.

Stratigraphically this study covers the lower portion of the Middle Cambrian, i.e., the Mount Whyte, Cathedral, and Stephen formations. These strata average, in the area investigated, a thickness of somewhat over 2,000 feet and represent about one-half of the total thickness of the Middle Cambrian series. Immediately underlying and overlying formations are occasionally discussed.

The area is famous for the great development, high fossil content, and splendid exposures of the entire Cambrian system. The simple fault-block structure of these mountains facilitates the study of the stratigraphy. Hence the Canadian Rocky Mountains attracted the attention of the foremost student of the Cambrian in North America, Charles D. Walcott, who devoted more time and work to the Cambrian in this area than in any other portion of North America. He established the general Cambrian section of the region, named the formations, described a number of sections in detail, and made an extensive study of the fossils. His discovery and study of a large fauna of invertebrates preserved in exceptional manner in the Burgess shale represents one of the greatest paleontologic contributions of all time.

Walcott fully realized the provisional character of some of his work, a consequence of the enormous geographic and stratigraphic range of his studies, the rugged topography, and difficult communications. He often pointed out the necessity for more detailed investigation and especially more intensive fossil collecting by future students.

The choice of the particular problem discussed in this paper was determined by the following considerations: The area was chosen for reasons of accessibility and because it includes the type sections of the formations that it appeared desirable to revise. The portion of the stratigraphic column investigated, the lower half of the Middle Cambrian, was chosen because of the poor knowledge of the faunas of this age, and because the southern Canadian Rockies probably contain one of the thickest, most fossiliferous, and better-exposed sections of this stratigraphic interval. Hence a study of the faunal succession in this area was expected to present much more than local interest leading to the establishment of a standard sequence for the entire Cordilleran province. The results rewarded these expectations, as the writer believes that the fossils here described give for the first time a clear idea of the succession of trilobite faunas that followed the *Olenellus* fauna and preceded the *Albertella* fauna.

The Cambrian beds underlying those investigated (the Lower Cambrian sandstones) and those immediately overlying (the Eldon dolomite) are but sparsely fossiliferous and are represented by more fossiliferous equivalents in other areas of the Cordilleran province; hence they presented less interest than the strata studied in this work.

ACKNOWLEDGMENTS

The present work was made possible by grant No. 509-47/48 from the Penrose Bequest of the Geological Society of America. The grant defrayed the writer's and an assistant's expenses for two field seasons. The writer is glad to acknowledge his deep gratitude to the Society.

Thanks are also due to the Department of Mines and Resources, Ottawa, for permitting the collection of fossils in the Canadian National Parks; and to the officials of Banff and Yoho Parks for their helpful cooperation.

The writer is also greatly indebted to Dr. G. Arthur Cooper for making available the collections and facilities of the United States National Museum, for the identification of the brachiopods, and for taking some of the photographs of specimens in the National Museum collections.

Thanks are also due to Prof. Christian Poulsen, of the University of Copenhagen, for information concerning the Cambrian faunas of Greenland.

Finally, the writer wishes to thank F. Bonenfant and C. T. Moore who assisted him in the field in 1947 and 1948, respectively.

SUMMARY OF PREVIOUS WORK

The work done on the Cambrian of the area prior to 1939 is summarized very briefly, as excellent reports have been published by Deiss (1939; 1940). Only the essential results of Walcott and Burling are mentioned.

Walcott, in a series of papers (Walcott, 1908a; 1908c; 1917a; 1927; 1928) laid the foundation of the Cambrian stratigraphy of the region. In several other publications he described many of the fossils. The Cambrian formations established by Walcott are the following.

Lower Cambrian.—Coarse Lower Cambrian clastics were found by Walcott to overlie unconformably late Proterozoic (Beltian) shale. Walcott divided the Lower Cambrian into four formations. The first three, in ascending order, are the Fort Mountain formation (formerly known as Fairview formation), the Lake Louise shale, and the St. Piran formation. The Fort Mountain formation consists of sandstone and quartzite and was reported to be 940+ feet thick. The Lake Louise shale is a siliceous shale 105 feet thick at the type locality. The St. Piran formation consists mostly of sandstone and quartzite with some siliceous shale and was reported to be 2,632 feet thick at the type locality. Fossils, chiefly olenellid trilobites, are known from several horizons through the St. Piran formation and indicate an Early Cambrian age.

The uppermost Lower Cambrian unit was named the Mount Whyte formation from Mount Whyte west of Lake Louise. The formation consists of interstratified siliceous shale and crystalline or oolitic limestone. Its thickness on Mount Whyte was given as 386 feet.

The fauna of the Mount Whyte formation was described by Walcott (1917c). However, owing partly to the meager and rather poorly preserved material available at the time, partly to the difficulty of correlating different horizons among the various measured sections of the formation, the character of the fauna of the Mount Whyte formation has remained uncertain until the present time. The presence of Olenellidae in the basal beds of the formation induced Walcott to consider the entire unit of Early Cambrian age.

Middle Cambrian.—Walcott's original lowermost Middle Cambrian unit was named the Cathedral formation (Walcott, 1908a) from the intended type locality on Cathedral Mountain, and described as "massive, arenaceous and dolomitic limestones." Later (Walcott, 1928) he changed the type locality to Mount Bosworth, where he gave a thickness of 1,212 feet. No fossils were reported from the Cathedral formation.

In 1917 Walcott (1917a) added a new formation, the Ptarmigan, chiefly in order to provide a name for the shale bearing the *Albertella* fauna (the Ross Lake shale), which Walcott had discovered and which for many years had been known only from drift blocks collected at the base of Mount Bosworth. However, in defining the Ptarmigan formation, he designated as typical a series of limestones on Ptarmigan Peak where the *Albertella*-bearing shale does not occur. Furthermore, Burling (1916) had already found the *Albertella*-bearing shale in place on Mount Bosworth and proved that its position is within the Cathedral formation, 375 feet above the base. Hence the Ptarmigan was essentially a name for the lower portion of the beds previously included in the Cathedral formation.

The next Middle Cambrian unit was named (Walcott, 1908a; 1908c) the Stephen formation from the type locality on Mount Stephen. The Stephen formation was reported to consist of 712 feet of siliceous and calcareous shales and dark-gray, thin-bedded limestones, and was stated to include at the top the extremely fossiliferous shale bearing the *Ogygopsis* fauna. The Burgess shale, discovered on Mount Field opposite Mount Stephen, was also considered as a local development within the Stephen formation.

The uppermost Middle Cambrian unit was named the Eldon formation and the type section defined on Castle Mountain (now Mount Eisenhower). The formation was described as 2,195 feet of "massive, arenaceous, dolomitic limestones, with a few bands of purer bluish gray limestones." A few fossils collected at various horizons indicated a Medial Cambrian age.

Upper Cambrian.—Walcott tentatively placed the Middle-Upper Cambrian boundary at the top of the Eldon formation, although the next overlying units, the Arctomys and Bosworth formations, are unfossiliferous and hence of uncertain age. These are succeeded by the Paget and Sherbrooke formations. Fossils collected from both indicate an early Late Cambrian (Dresbachian) age. Walcott reported a total thickness of 3,590 feet for the Upper Cambrian series on Mount Bosworth. Upper Cambrian deposits are not known to be present south of Kicking Horse Pass, the summits of the Bow Range being usually formed by Middle Cambrian rocks.

A paper was especially devoted by Walcott (1927) to a discussion of the early Paleozoic sedimentary basins in the Canadian Rockies. He distinguished the Beaverfoot, Goodsir, Bow, Glacier Lake, and Sawback troughs. He observed that deposits of particular ages were represented in some of these troughs but were absent from others. The area studied in the present work is almost entirely located within the Bow trough, involving only the northeastern marginal area of the Goodsir trough. Walcott distinguished the Bow and Goodsir troughs from the facies of the Upper Cambrian sediments, since Lower and Middle Cambrian formations are not exposed in the area of the Goodsir trough. It will be shown in this paper that the Middle Cambrian formations along the line that Walcott considered as the border between the Bow and Goodsir troughs already show remarkable changes of facies from the normal sediments of the Bow trough.

No field work was done on the Cambrian of the area between 1917 and 1938. Discussion of Walcott's stratigraphic and paleontologic data by various authors (cited in Deiss, 1939) added little to what had already been published by Walcott concerning the faunal succession in the Mount Whyte, "Ptarmigan," and Stephen formations.

Deiss undertook an accurate revision of several of Walcott's sections. Unfortunately he did not supplement his two stratigraphic papers (Deiss, 1939; 1940) with descriptions of the fossils. Deiss restudied the Castle Mountain, Ptarmigan Peak, Ross Lake, Mount Bosworth, and Mount Assiniboine sections (the last outside the area considered in this paper). His conclusions are briefly summarized in the following paragraphs.

(1) The Lower Cambrian clastic formations were accurately and completely measured by Deiss (in the Ptarmigan Peak area). He reported a thickness of 865 feet for the Fort Mountain sandstone (including 60 feet of Lake Louise shale member at the top) and 815 feet for the St. Piran sandstone, a total of 1,680 feet. According to Walcott, the aggregate thickness of these formations in the Bow Range is 3,677+ feet; hence, even allowing for inaccuracies in the measurements, it is clear that there is considerable lateral variation in the thickness of the Lower Cambrian within short distances.

In the Mount Assiniboine area, Deiss united all these Lower Cambrian clastics under one name, the Gog formation, reported to be 1,235 feet thick in that area. Deiss expressed the doubt, shared by the writer, that the Lake Louise shale is more than a localized deposit; in the absence of this shale, there is nothing to distinguish the Fort Mountain from the St. Piran sandstone. In this case the name Gog formation could be applied everywhere to the entire series of Lower Cambrian clastics. However, Walcott's original names are still used in this paper as the problem has not been sufficiently investigated.

(2) Four sections of the Mount Whyte formation were measured by Deiss, at Castle Mountain, Ptarmigan Peak, Ross Lake, and Mount Bosworth, yielding thicknesses of 145, 275, 315, and 285 feet, respectively. Although he did not measure the Mount Whyte section, he transferred the type section of the Mount Whyte formation to Ptarmigan Peak (an action that the writer considers unwarranted). Deiss found that olenellid trilobites are confined to a few basal feet of the formation instead of ranging through the entire unit as had been reported by Walcott. The rest of the formation yields faunules assigned by Deiss to a "*Plagiura* zone," which, for no clearly stated reasons, Deiss still included in the Lower Cambrian.

In the Mount Assiniboine area, Deiss applied a new name, Naiset formation, to 475 feet of shale and limestone between the Gog formation and the Cathedral dolomite.

(3) Deiss recognized the Ptarmigan limestone, in which he included 460 feet of strata on Ptarmigan Peak, 105 feet on Castle Mountain, and tentatively 195 feet on Mount Bosworth. He could not find any strata assignable to the Ptarmigan in the Ross Lake section. The Ptarmigan limestone was considered to be a basal Middle Cambrian deposit chiefly localized in the Slate Mountains area. In his later paper, Deiss (1940, p. 777) expressed doubts as to the validity of the Ptarmigan as an independent formation and suggested that it might be included in the Cathedral. Deiss saw evidence for the Medial Cambrian age of the Ptarmigan in the presence of a *Kochaspis cecinna* fauna, which he considers sharply distinct from the underlying *Plagiura* fauna.

(4) The Cathedral formation (styled by Deiss the Cathedral dolomite) was measured in three sections, yielding thicknesses of 670 feet on Castle Mountain, 620 feet on Ptarmigan Peak, and 1,085+ feet in the type section on Mount Bosworth. Deiss confirmed Burling's finding that the Ross Lake shale member, containing the *Albertella* fauna, occurs within the formation, but did not find this shale in the Ptarmigan Peak section.

(5) The Stephen formation was measured by Deiss on Castle Mountain, Ptarmigan Peak, and Mount Bosworth, yielding thicknesses of 285, 315, and 470 feet, respectively. In all these sections the Stephen formation yielded a *Glossopleura* faunule from the basal beds, and several distinct faunules in the upper portion. However, nowhere did Deiss find any strata analogous lithologically and faunally to the *Ogygopsis* and Burgess shales. No redefinition of the Stephen formation was attempted because Walcott's type section on Mount Stephen was not remeasured.

(6) The Eldon formation (styled by Deiss the Eldon dolomite) was measured on Castle Mountain, Ptarmigan Peak, and Mount Bosworth, the reported thicknesses being 1,015, 1,230, and 1,110 feet, respectively. Part of the decrease in thickness as compared with Walcott's data is due to Deiss' setting off the upper part of Walcott's Eldon formation as a separate unit, the Pika limestone.

(7) The Pika limestone was defined on Ptarmigan Peak and stated to be 460 feet thick on Ptarmigan Peak, 550 feet on Castle Mountain, and 845 feet on Mount Bosworth. The formation yielded "a new basal Upper Cambrian fauna" and was therefore considered Upper Cambrian.

(8) Deiss also discussed the Upper Cambrian Arctomys and Bosworth formations in some of his sections. He affirmed that Walcott had greatly overestimated the total thickness of the Upper Cambrian series in the Mount Bosworth section.

METHOD OF WORK

The area investigated is the most easily accessible in the Canadian Rocky Mountains. The highway Banff–Lake Louise–Kicking Horse Pass–Field, the Banff–Jasper highway, and the side roads to Mount Temple Lodge, Moraine Lake, and Yoho Valley allow one to drive within easy reach of many of the sections. Many other localities are accessible by trail from points not situated on the roads, but where accommodation is available, such as Skoki Lodge in the Slate Mountains and Lake O'Hara Lodge in the valley of Cataract Brook. These facilities enable one to reach within a day's walk or climb most of the important sections in the area. Even when the day's work involved a climb of 5,000 feet and a walk of 10 or 15 miles it was found practical and time-saving to do this from a convenient base where accommodation was available instead of camping near the place to be studied. Owing to the unstable mountain weather, it was found that expeditions of the type that had to be planned in advance were usually doomed to failure, whereas great mobility and the freedom to decide instantly the location of the day's work according to weather conditions, made for good utilization of the available time. The writer's long experience of mountain climbing in the Alps proved a valuable asset. Four months were spent in the field.

The mountains are of the fault-block type, dips seldom exceeding 15°. Often each mountain forms a single block separated from neighboring mountains by normal faults, as valleys and gullies were prevalently eroded along fault lines. This structure makes it possible to find localities where the strata to be investigated are exposed at the most favorable altitudes, between 7,000 and 10,000 feet. Most of Walcott's work was done near the valley bottoms, where the strata are partially covered by glacial drift, talus, soil, and vegetation. The writer's sections were measured mostly above timber line. The section traverse usually followed either a ridge, generally free from talus cover even on moderately steep slopes, or a gully bottom, which can be climbed more easily than an equally steep open slope, and where the strata often offer fine exposures in the cliffs on either side of the gully.

Most of the sections were measured on slopes between 30° and 45° with respect to the horizontal, the dip of the beds not exceeding 20°. Under these circumstances the following method allowed a fast, if not extremely accurate, measurement of the thickness. Once the direction of the traverse on the mountain slope or ridge had been selected, the level of a Brunton compass was adjusted to the inclination of the strata in that direction. The angle of inclination could be anywhere between zero (when the traverse followed the strike) and the angle of dip. A point sighted on the slope is then known to be approximately higher stratigraphically than the point where the observer is standing by a constant distance (in the writer's case 5′3″). The observer then moves to the sighted point and repeats the operation. If the inclination of the beds is appreciable, the value found must be corrected by multiplying by the cosine of the angle that the line of sight forms with the horizontal. This correction never exceeded 10 percent. The writer was able to measure almost 1,000 feet of horizontal strata in one hour on a conveniently steep slope. The measurement obviously must be effected when climbing the mountain. Reference marks were written on the rocks, permitting a ready placement in the section of the fossils that were searched for and collected in the descent. In certain cases thin units were measured directly with a tape.

Sections are not described in excessive detail, although sometimes finer subdivisions were distinguished when measuring the section than are reported here. Observation shows that great detail is of little or no significance. Minor units in a given section traverse that can be distinguished by slight differences in thickness of the beds or other lithologic characters are often lenticular, or no longer recognizable whenever change in slope or other conditions of exposure alter the appearance of the weathered rock.

Topographic maps of the region are issued by the Surveys and Engineering Branch of the Department of Mines and Resources, and the following sheets are available: Lake Louise and Yoho Park sheets, scale 1 inch to 1 mile; Kootenay Park sheet, scale 1 inch to 2 miles; Banff Park sheet, scale 1 inch to 3 miles. The last, not very accurate map is the only one that covers the localities investigated in the upper Bow Valley.

DESCRIPTION OF LOCALITIES AND SECTIONS

TERMINOLOGY

Each section was assigned a number. The fossiliferous horizons in each section are designated by a capital letter indicating the formation (P=St. Piran, W=Mount Whyte, C=Cathedral, S=Stephen, E=Eldon) followed by the number of the section. The last symbol is a lower-case letter indicating a particular horizon within the formation. Successive letters indicate progressively higher horizons in the same section, and as far as possible the same letter was used to designate equivalent horizons in the different sections. For example, the letters Cm designate the Ross Lake shale member of the Cathedral formation, bearing the *Albertella bosworthi* faunule. The symbol C3m indicates this horizon on Mount Whyte, C4m at Ross Lake, C5m on Mount Bosworth, etc. An exception in the order of the letters is represented by the horizons designated as Wh, Wi, Wj, and Wk in the Fossil Gully section on Mount Stephen. When these beds were first discovered in 1947, their position in the general section was unknown and they were given these symbols. In 1948 it was found that the highest of these horizons, Wk, is approximately equivalent to the horizon designated as Wb in the Mount Whyte and other sections, but too many fossils had been labeled by that time to make a change to a more rational terminology worth while. It must also be noted that the horizons designated as Ch, Cj, and Cj′, and Ck in the equivalent of a portion of the Cathedral formation on Mount Stephen may be younger and not older than the Ross Lake shale as the sym-

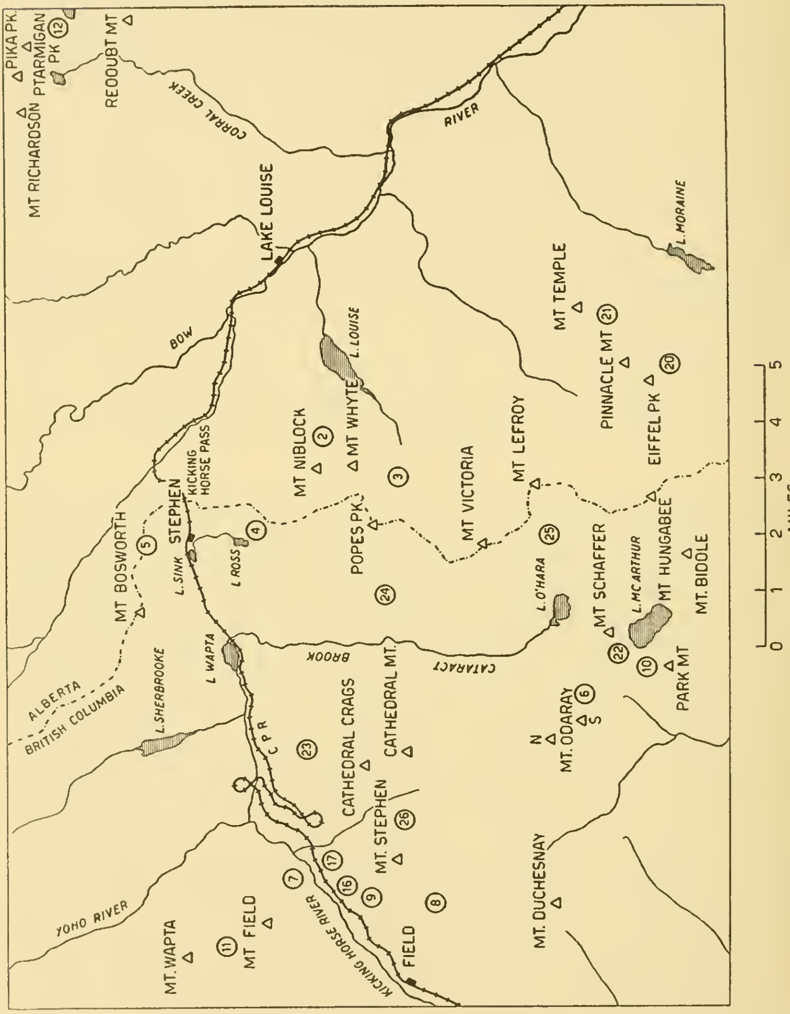

Fig. 1.—Map of the area indicating location of sections.

bols would imply. Finally, the fossil horizons in the *Ogygopsis* and Burgess shales were given the symbols Sd, Se, Sf, Sg, indicating their probable relative positions with respect to each other and to the other fossiliferous horizons in the Stephen formation, but this order is inferred from paleontologic evidence and is not absolutely certain.

All the fossils collected and prepared, over 4,000 specimens, were labeled according to these locality and horizon symbols. A list of all the fossil localities, including topographic and stratigraphic position and lithology, is given at the end of the stratigraphic part of this paper.

Figure 1 represents a diagrammatic map of the area, with the localities indicated by numbers in circles. The localities at Bow Lake, Hector Creek, and in the Skoki Valley are not comprised in the map, lying north of the area represented. Mount Stephen is illustrated by a special large-scale contour map (fig. 3).

In the fossil lists included with the descriptions of the sections, the relative abundance of the species is indicated by the abbreviations cc=very common, c=common, r=rare, rr=very rare. An asterisk preceding the specific name indicates that the locality is typical for the species.

BOW LAKE

The Cambrian formations are excellently exposed in the eastern slopes of the Waputik Range on the west side of the Bow Valley, from Mount Bosworth to Bow Pass. The slopes of the northeastern spur of Mount Thompson, between Bow Lake and Bow Pass, offer the most accessible of these sections. Because of the gentle southward dip of the beds, a very thick section is available, extending from the base of the Cambrian in the cliffs overlooking Peyto Lake through the entire Lower and Middle Cambrian and well into the Upper Cambrian.

A section including the upper portion of the St. Piran sandstone and the entire Mount Whyte and Cathedral formations was measured in the slope and ridge just south of a glacial cirque facing the Bow Valley, 1.0 mile northwest of Num-Ti-Jah Lodge on the north shore of Bow Lake. Walcott (1928) had measured a portion of this section.

BOW LAKE SECTION (NO. 15)

MIDDLE CAMBRIAN

Stephen formation

Note.—The formation is incompletely represented in the fault block where the section was measured. The lower portion of the

Stephen is an argillaceous, dark-gray, thin-bedded limestone, with *Glossopleura* pygidia near the base, and forms a sharp contact with the underlying dolomite of the Cathedral formation.

Cathedral formation

	Feet
9. Dolomite: crystalline, light gray, tan weathering, in irregular thick beds	355
8. Limestone: black-gray, subcrystalline, in irregular beds 1-4 inches thick	65
7. Dolomite: as unit 9	210
6. Limestone: subcrystalline, black-gray, with tan clay partings and flakes, in irregular beds 1-3 inches thick. Fossils well preserved and fairly common in the thicker beds (locality C15n).	16

FOSSILS:

**Albertella limbata* Rasetti	c
* *stenorhachis* Rasetti	r
**Kochina macrops* Rasetti	r
**Ptarmiganoides bowensis* Rasetti	c

Cathedral formation (*Ross Lake shale member*)

5. Shale: siliceous, fine-grained, blue-gray, fissile, with one or two beds of gray, crystalline limestone 1-2 inches thick at the top. Fossils abundant both in shale and limestone (locality C15m).	6

FOSSILS (in shale):

Albertella bosworthi Walcott	c
microps Rasetti	r
nitida Resser	r
Kochina americana (Walcott)	rr
Mexicella stator (Walcott)	c
Ptarmigania rossensis (Walcott)	rr
Vanuxemella nortia Walcott	cc

FOSSILS (in limestone):

**Albertella declivis* Rasetti	r
microps Rasetti	r
nitida Resser	r
Mexicella stator (Walcott)	c
Vanuxemella nortia Walcott	cc

Cathedral formation (continued)

4. Limestone: subcrystalline, dark gray, in irregular beds 1-4 inches thick	40
3. Limestone: finely crystalline, dark or medium gray, mostly thick-bedded, weathering to rough surfaces; partly grading laterally to crystalline, light-gray dolomite	155
2. Limestone: subcrystalline, dark gray, in irregular beds 1-4 inches thick	135
1. Limestone: subcrystalline, medium gray, weathering light gray, in irregular, mostly thick beds, up to several feet in thickness	260
Total thickness of Cathedral formation	1,242

Mount Whyte formation

	Feet
3. Limestone: subcrystalline, dark gray, with tan clay partings and flakes, in irregular beds mostly 1-2 inches thick..............	78
2. Shale and limestone: alternating layers of siliceous, gray shale and subcrystalline, gray limestone..............................	285
1. Shale and sandstone: gray and greenish siliceous shale alternating with thin and thick, greenish sandstone beds in lower third....	140
Total thickness of Mount Whyte formation................	503

Lower Cambrian

St. Piran sandstone (*Peyto limestone member: type locality*)

4. Limestone: crystalline or oolitic, partly sandy, gray, in thick, irregular beds. Partings poorly developed, giving the limestone a massive aspect in cliff exposures. Olenellid fragments and *Bonnia* common 130 feet above base. A fault cutting this unit may cause a small error in the measurement of the thickness..	180
3. Shale and limestone: siliceous, fine-grained, blue-gray shale alternating with thick-bedded, gray, sandy limestone..............	28
2. Limestone: crystalline or oolitic, gray, partly sandy, in thick, irregular beds	30
1. Sandstone: gray, more or less calcareous especially in upper part..	40
Total thickness of Peyto limestone member................	278

St. Piran sandstone

1. Sandstone: purple, very thick-bedded......................Not measured

Note.—Below about 100 feet of this purple sandstone is a siliceous shale yielding rare olenellid shields.

HECTOR CREEK

A section of the Mount Whyte formation was measured on the northeast spur of Mount Hector, in cliffs facing the Bow Valley just south of Hector Creek. The section traverse is approximately located 0.8 mile northeast of the lower end of Hector Lake. The cliffs were climbed following the bottom of a gully offering excellent exposures. The summit of the ridge is formed by the top unit of the Mount Whyte formation. The strata dip 23° northeast.

The Peyto limestone member of the St. Piran sandstone attains here almost as great a thickness as at Bow Lake.

HECTOR CREEK SECTION (NO. 19)

Middle Cambrian

Note.—The Cathedral formation consists as elsewhere of alternating and often interfingering limestone and dolomite. The lowermost portion is a gray, very thick-bedded limestone.

Mount Whyte formation

	Feet
4. Limestone: finely crystalline, dark gray, in irregular beds 1-4 inches thick, weathering to rough surfaces. Thickness approximate because dip slope makes measurement difficult.....	30
3. Limestone: crystalline, dark gray, with tan clay partings and flakes, in irregular beds 1-6 inches thick.....................	125
2. Shale and limestone: mostly alternating thin layers of siliceous shale and limestone, but with intervals of almost pure, gray siliceous shale and others of crystalline or oolitic, dark-gray limestone in beds 1-6 inches thick. Trilobite fragments common in limestone in middle of unit (locality W19c)..........	175
Fossils: *Amecephalus* sp. *Plagiura cercops* (Walcott)	
1. Shale and sandstone: siliceous, gray and greenish shale alternating with beds of greenish sandstone, more abundant in lower part.	150
Total thickness of Mount Whyte formation................	480

Lower Cambrian

St. Piran sandstone (*Peyto limestone member*)

1. Limestone: crystalline or oolitic, partly sandy, gray, in thick, irregular beds; interstratified with a little green-gray siliceous shale. Olenellid fragments abundant through most of the limestone, forming a coquina in certain layers. Thickness estimated	200

Note.—The Peyto limestone is underlain by purple and gray, thick-bedded sandstone.

SLATE MOUNTAINS

The Slate Mountains include the classic Ptarmigan Peak section first measured by Walcott and later revised by Deiss (1939). The lower portion of this section (including the Mount Whyte and "Ptarmigan" formations) was examined by the writer but no new measurements were effected and the fossil collecting yielded poor results. The conclusions reached by the writer are discussed in the descriptions of the Mount Whyte and Cathedral formations and need not be mentioned here.

The study of the lower Middle Cambrian formations was extended to the northern part of the Slate Mountains, north of Mount Richardson and Pika Peak. The Skoki Valley descends from the northern slopes of these mountains, and its upper cirque is occupied by a lake lying about 1 mile north of the summit of Pika Peak. The only available map of this area is so inaccurate that the writer was unable to decide whether the lake designated as Merlin Lake is this lake, or another lake farther up in the valley. Below the lake, steep cliffs are formed by the massive limestones of the lower Cathedral formation, and below these the Mount Whyte formation is excellently exposed. All these strata present much the same thickness and lithology as in the Ptarmigan Peak section measured by Deiss.

The lower, calcareous portion of the Cathedral formation was not measured, but a rough estimate indicates a thickness of the order of 400 feet. This is succeeded by dolomite, and a portion of the dolomitic Cathedral formation was measured in order to locate the position of a fossiliferous horizon. The section was measured in the slope and cliffs southeast of the above-mentioned lake, approximately 1.0 mile N. 15° W. of the summit of Pika Peak. The beds dip about 15° south.

SKOKI VALLEY SECTION (NO. 13)

MIDDLE CAMBRIAN

Cathedral formation

	Feet
5. Dolomite: crystalline, light gray, tan weathering, thick-bedded. Forms cliffs and extends for several hundred feet to base of Stephen formation	Not measured
4. Limestone: fine-grained, black-gray, in beds 2-4 inches thick. Grades laterally into dolomite. Fossil locality C13r	5
FOSSILS:	
*Glossopleura merlinensis Rasetti c	
sp. ..... r	
* skokiensis Rasetti c	
3. Dolomite: as unit 5	13
2. Limestone: crystalline or fine-grained, black-gray, in beds 1-5 inches thick	32
1. Dolomite: as unit 5	225
Total measured thickness of Cathedral formation	275

MOUNT NIBLOCK

The Mount Whyte formation is well exposed in the cirque between Mount Niblock and Mount Whyte, above Lake Agnes. This is obviously the locality where Walcott measured the upper part of his "Lakes Louise and Agnes section" (Walcott, 1928, p. 302).

The best and most accessible exposure of the Mount Whyte formation was found to occur on the south slope of the east ridge of Mount Niblock, and the section measured here is referred to as the Mount Niblock section. The beds have a slight westward dip. The top of the Mount Whyte formation is exposed at the approximate altitude of 8,250 feet.

The lower portion of the Cathedral formation was examined and found to consist of the usual alternating dolomite and dark-gray limestone. The Ross Lake shale occurs approximately 400 feet above the base of the formation, but appears thinner than in the neighboring sections and no fossils were observed.

The Cathedral–Mount Whyte contact is better defined than in most of the other sections, as an increase in thickness of the beds coincides with the transition from limestone to dolomite.

MOUNT NIBLOCK SECTION (NO. 2)

Middle Cambrian

Mount Whyte formation

	Feet
9. Limestone: crystalline or oolitic, dark gray, in thin, irregular beds, with some thicker beds in middle of unit....................	56
8. Shale and limestone: alternating layers of siliceous, gray, tan-weathering shale and fine-grained, oolitic, or crystalline gray limestone...	45
7. Limestone: crystalline or oolitic, dark gray, in thin, irregular beds with tan clay partings and flakes...........................	13
6. Shale and limestone: as unit 8, with shale predominating.........	22
5. Shale and sandstone: siliceous, gray shale with thin layers of greenish sandstone, all weathering tan....................	29
4. Shale and dolomite: alternating thin layers of fine-grained, greenish dolomite and siliceous, gray, tan-weathering shale..........	44
3. Shale: siliceous, fissile, slightly micaceous, greenish or tan, mostly tan weathering. Lower part of interval forms bench and is usually covered..	52

Mount Whyte formation (Lake Agnes shale lentil)

2. Shale: siliceous, fissile, very fine-grained, blue-green-gray (locality W2b)	5

Fossils:

- *Amecephalus agnesensis* (Walcott)................ .. c
- *Poliella prima* (Walcott)........................... r
- *Syspacephalus perola* (Walcott)..................... c
- *Wenkchemnia walcotti* Rasetti...................... r

Mount Whyte formation (continued)

1. Shale and limestone: siliceous, gray shale with interstratified nodular beds of gray limestone; weathers to pitted surfaces after solution of the limestone.............................	15
Total thickness of Mount Whyte formation..............	281

Lower Cambrian

St. Piran sandstone (Peyto limestone member)

5. Limestone: crystalline, sandy, medium gray, limonitic, in thick, irregular beds; including some calcareous sandstone in lower part. Olenellid fragments common throughout.............	28

St. Piran sandstone

	Feet
4. Shale: siliceous, fissile, green-gray	2
3. Sandstone: calcareous, light gray, tan weathering	1
2. Shale and sandstone: micaceous, green-gray shale with thin interstratified sandstone beds	10
1. Sandstone: thick-bedded, gray and purple	Not measured
Total measured thickness of St. Piran sandstone	41

MOUNT WHYTE—PLAIN OF SIX GLACIERS

An excellent section ranging from the uppermost Lower Cambrian to the lower portion of the Eldon dolomite is exposed and entirely

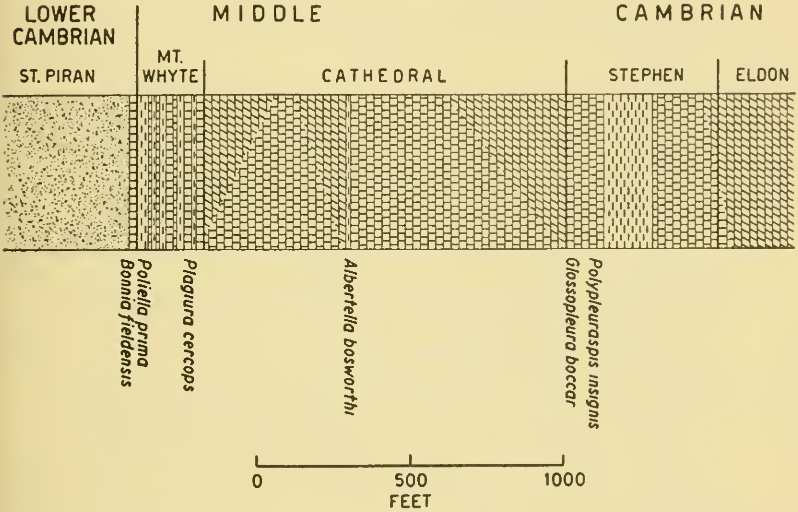

FIG. 2.—The Mount Whyte section. This section is typical for the Bow Range. The position of the faunules is indicated.

accessible on the south ridge of Mount Whyte, from Plain of Six Glaciers to near the summit of the mountain. The Stephen and Cathedral formations were measured following the crest of this ridge. The Mount Whyte formation, because of better exposure, was measured on the southeast slope of Popes Peak, a few hundred feet west of the lowermost measured exposure of the Cathedral formation, in a small gully 0.2 mile west of Plain of Six Glaciers Chalet. The two exposures are separated by a normal fault, along which the deep valley separating the slopes of Popes Peak from those of Mount Whyte was eroded. The strata on the side of Popes Peak (west side) are downthrown about 250 feet. This discontinuity in the measured section does not introduce confusion because the Cathedral–Mount Whyte contact is clearly defined. The entire section is referred to as the Mount Whyte section. All these strata are approximately horizontal. The Eldon–Stephen contact is exposed at an approximate altitude of 9,300 feet on the south ridge of Mount Whyte. The base of the Mount Whyte formation, in the fault block where it was measured, is exposed at an approximate altitude of 6,800 feet.

The Eldon dolomite becomes gradually thinner-bedded near the base and interfingers with limestone, thus making the Eldon–Stephen contact arbitrary within 50-100 feet (see discussion of Stephen–Eldon contact).

MOUNT WHYTE SECTION (NO. 3)

MIDDLE CAMBRIAN

Stephen formation

	Feet
4. Limestone: subcrystalline, dark gray, in beds 2-4 inches thick; in upper portion interfingering with dolomite, thus making the boundary with the overlying Eldon dolomite highly arbitrary.	80
3. Limestone: subcrystalline, black-gray, in beds 1-3 inches thick; in lower third thinner-bedded, with tan clay partings and flakes	130
2. Shale: mostly argillaceous, green-gray, with some interstratified fine-grained, argillaceous, gray, thin-bedded limestone. Near base darker, harder siliceous shale	160
1. Limestone: near top fine-grained, banded; underlying beds finely crystalline, dark gray, 2-4 inches thick; lower third argillaceous, fine-grained, in beds 1-3 inches thick. Fossils abundant in finely crystalline and fine-grained argillaceous beds 50-60 feet above base (locality S3b)	125
FOSSILS:	
Glossopleura mckeei Resser ... c	
* *stenorhachis* Rasetti ... r	
Polypleuraspis insignis Rasetti ... c	
Total thickness of Stephen formation	495

Cathedral formation

8. Dolomite: crystalline, light gray, weathering pale tan, thick-bedded; in upper part interfingering with limestone	385
7. Limestone: finely crystalline, dark gray, in irregular thin and thick beds. *Girvanella* in some of the beds	145
6. Limestone: subcrystalline, gray, very thick-bedded	63
5. Limestone: subcrystalline, dark gray, thick-bedded except near top; weathering to coarse surfaces because of less soluble inclusions	108

Cathedral formation (*Ross Lake shale member*)

	Feet
4. Shale: siliceous, hard, fissile, fine-grained, dark blue-gray, highly fossiliferous (locality C3m)	5

FOSSILS:

Albertella bosworthi Walcott	cc
microps Rasetti	r
nitida Resser	c
Kochina americana (Walcott)	r
Mexicella stator (Walcott)	cc
Vanuxemella nortia Walcott	cc

Cathedral formation (continued)

3. Dolomite: crystalline, light gray, tan weathering, thick-bedded; interfingering with subcrystalline, dark-gray limestone	120
2. Limestone: subcrystalline, medium gray, very massive; with less soluble inclusions weathering in relief	48
1. Dolomite: crystalline, light gray, tan weathering, thick-bedded; with lenses of undolomitized dark-gray limestone	295
Total thickness of Cathedral formation	1,169

Mount Whyte formation (*type section*)

9. Limestone: finely crystalline or oolitic, dark gray, with tan clay partings and flakes; in irregular beds 1-6 inches thick. Contact with overlying Cathedral formation well marked	45
8. Shale and limestone: thin alternating layers of gray, subcrystalline limestone and gray, siliceous shale	20
7. Limestone: as unit 9	10
6. Shale and limestone: as unit 8	24
5. Limestone: as unit 9. Contains fragments of trilobites (locality W3c)	12

FOSSILS:

Amecephalus cleora (Walcott)

Plagiura cercops (Walcott)

4. Shale and limestone: as unit 8, mostly shale in lower third	73

Mount Whyte formation (*Lake Agnes shale lentil: type locality*)

3. Shale: siliceous, very fine-grained, fissile, green-blue-gray, highly fossiliferous (locality W3b)	5

FOSSILS:

Acrotreta sp.	c
Amecephalus agnesensis (Walcott)	c
Poliella prima (Walcott)	r
Syspacephalus perola (Walcott)	c
**Wenkchemnia walcotti* Rasetti	c

Mount Whyte formation (continued)

	Feet
2. Shale and limestone: siliceous, gray shale with thin, nodular beds of fine-grained, gray limestone. A limestone nodule yielded fragments of *Amecephalus*	6
1. Shale: siliceous, fine-grained near base, coarser in upper part, green-gray	16
Total thickness of Mount Whyte formation	211

Lower Cambrian

St. Piran sandstone (*Peyto limestone member*)

	Feet
1. Calcareous, limonitic sandstone, grading into sandy limestone near the top; the more calcareous layers filled with *Bonnia* and olenellid fragments. Underlain by brown and purple, thick-bedded sandstone	20

ROSS LAKE

A section of the Mount Whyte and lower Cathedral formations in the cliffs southeast of Ross Lake was measured and reported by Deiss (1939, pp. 988-993). The section was not measured by the writer, but at least the major units of Deiss' section could be easily identified in the field. A summary of Deiss' section is reported in order to establish the stratigraphic position of several beds from which fossils were collected by the writer. The lowermost portion of Deiss' Mount Whyte formation, containing olenellid trilobites and hence Lower Cambrian, was reassigned to the Peyto limestone member of the St. Piran sandstone.

ROSS LAKE SECTION (NO. 4)

(After Deiss, 1939. Fossil localities and lists according to the writer.)

Middle Cambrian

Mount Whyte Formation

		Feet
6. Limestone: finely to medium crystalline, partly oolitic, dark gray, with partings and flakes of tan clay, mostly thin-bedded		26
5. Limestone: finely crystalline, dark gray, thin- and thick-bedded. Fossil locality W4e near top of unit, locality W4d 5 feet above base		56
Fossils (loc. W4e):		
Amecephalus cleora (Walcott)	c	
Plagiura cercops (Walcott)	r	
Fossils (loc. W4d):		
Amecephalus cleora (Walcott)	cc	
Caborcella skapta (Walcott)	c	
Plagiura cercops (Walcott)	c	
Schistometopus convexus Rasetti	r	

		Feet
4. Limestone: oolitic, dark gray, in beds 1-6 inches thick. Fossil locality W4c 3-5 feet above base of unit		22
Fossils:		
Amecephalus cleora (Walcott)	cc	
Caborcella skapta (Walcott)	r	
Plagiura cercops (Walcott)	c	
Schistometopus convexus Rasetti	r	
3. Shale, sandstone, and limestone		62
2. Shale and limestone		45
1. Shale and limestone		53
Total thickness of Mount Whyte formation		264

MOUNT BOSWORTH

A section of the Cathedral and Mount Whyte formations was measured by Walcott and more recently by Deiss (1940, pp. 739-751) on the east ridge of Mount Bosworth, on the Continental Divide above the Stephen station on the Canadian Pacific Railway. Both formations were remeasured by the writer. The results concerning the Cathedral formation entirely agree with Deiss', hence the writer's data are not reported. However, the writer found it difficult to recognize in the field several of the units into which Deiss subdivided the Mount Whyte formation. This is entirely attributable to the different aspect that strata may assume depending on weathering conditions. In the present instance, certain portions of the section can be measured either in vertical cliffs or on gentle slopes, and lithologic units that may be separated in one type of exposure become indistinguishable elsewhere. The total thickness measured by the writer closely agrees with Deiss' data, but the subdivision into units is somewhat different. Hence the writer's measured section is reported, chiefly in order to define the position of a fossiliferous horizon. It should be noted that, according to the writer's interpretation, the Mount Whyte formation includes at the top 105 feet of dark-gray limestone that Deiss tentatively assigned to the Ptarmigan formation (Deiss gave a thickness of 195 feet for these strata), whereas the lowermost 49 feet of Deiss' section, containing *Bonnia* and *Olenellus*, are reassigned to the Peyto limestone member of the St. Piran sandstone. With these reassignments, the thickness of the Mount Whyte formation as measured by Deiss would be 381 feet, in good agreement with the writer's value of 389 feet.

On the east ridge of Mount Bosworth, the Mount Whyte–Cathedral contact is better defined than usual, a thick-bedded dolomite of the Cathedral formation overlying the thin-bedded, dark-gray limestone that Deiss assigned to the Ptarmigan formation.

MOUNT BOSWORTH SECTION (NO. 5)

Middle Cambrian

Mount Whyte formation

	Feet
6. Limestone: fine-grained or finely crystalline, dark gray, with tan clay partings and flakes particularly in the lower part; in irregular beds 1-3 inches thick. Some oolitic beds near the base.	105
5. Limestone: oolitic, dark gray, in irregular beds 1-5 inches thick, with occasional shaly intervals. Fossil locality W5c 50 feet above base	80
Fossils:	
Amecephalus cleora (Walcott) c	
Caborcella skapta (Walcott) c	
Plagiura cercops (Walcott) c	
Schistometopus convexus Rasetti c	
4. Shale and limestone: massive beds composed of thin alternating layers of siliceous, gray, tan-weathering shale and fine-grained, gray limestone	92
3. Shale and limestone: as unit 4, but with lesser percentage of limestone	52
2. Shale and limestone: massive beds of siliceous, gray, tan-weathering shale with interstratified thin nodular layers of fine-grained, gray limestone. Upon solution of the limestone the beds weather to pitted surfaces	36
1. Shale and sandstone: micaceous, green shale with interstratified sandstone beds	24
Total thickness of Mount Whyte formation	389

Lower Cambrian

St. Piran sandstone (Peyto limestone member)

1. Limestone: crystalline, more or less sandy, limonitic, in thick, irregular beds, with a little interstratified shale. Olenellid fragments extremely abundant in the purer calcareous portions	24

MOUNT VICTORIA

A section of the Mount Whyte formation was measured on the south face of Mount Victoria directly above Lake Oesa. The Mount Whyte formation is here exposed at an approximate altitude of 9,350 feet. The beds dip 10° east.

MOUNT VICTORIA SECTION (NO. 25)

Middle Cambrian

Mount Whyte formation

	Feet
3. Limestone: crystalline or oolitic, dark gray, in beds 1-3 inches thick. The upper portion interfingers with dolomite, making the Cathedral-Mount Whyte contact more or less arbitrary..	25

	Feet
2. Shale and limestone: siliceous, gray, tan-weathering shale alternating with layers of fine-grained or crystalline, mostly thin-bedded limestone. A crystalline limestone layer near top of unit yielded *Amecephalus* sp.	32
1. Limestone: finely crystalline, dark gray, weathering to mottled surfaces owing to dolomite inclusions; in irregular beds up to 3 inches thick	6
Total thickness of Mount Whyte formation	63

LOWER CAMBRIAN

St. Piran sandstone (Peyto limestone member)

1. Dolomite: crystalline, sandy, gray, weathering dark tan, with concretions of fine-grained dolomite resembling algal growths. Lenticular beds of sandy limestone in top 3 feet yielded olenellid fragments	17

CATHEDRAL MOUNTAIN

A section of the Mount Whyte formation was measured on the northernmost spur of Cathedral Mountain. Here the Cathedral formation forms inaccessible cliffs, but the Mount Whyte formation is entirely accessible and well exposed. The strata are approximately horizontal.

CATHEDRAL MOUNTAIN SECTION (NO. 23)

MIDDLE CAMBRIAN

Cathedral formation

	Feet
1. Dolomite: crystalline, gray, tan weathering, massive excepting the lowermost 5 feet which are thin-bedded. Possibly these lowermost beds should be included in the Mount Whyte formation	Not measured

Mount Whyte formation

2. Limestone: finely crystalline, dark gray, with tan clay partings and flakes especially in upper part. The lower beds yielded poorly preserved gastropods and trilobite fragments	75
1. Shale and limestone: alternating thin layers of siliceous gray, tan-weathering shale and finely crystalline limestone. Limestone prevails in the upper portion, forming a gradual transition to overlying unit	80
Total thickness of Mt. Whyte formation	155

Lower Cambrian

St. Piran sandstone (Peyto limestone member)

	Feet
1. Sandstone and limestone: more or less calcareous, limonitic sandstone alternating with sandy, crystalline, gray limestone. Olenellid fragments and *Bonnia* abundant in the more calcareous layers	30

POPES PEAK

A section of the Mount Whyte formation was measured in the valley of a creek, tributary of Cataract Brook, that originates in a glacier occupying a cirque between Popes Peak and Mount Victoria. It is difficult to describe accurately the location of this section, but the position is clearly indicated on the map (fig. 1).

The Mount Whyte formation is exposed and was measured at an approximate altitude of 8,000 feet on the north side of a waterfall formed by the brook a little below the tongue of the glacier. The beds dip 22° north.

POPES PEAK SECTION (NO. 24)

Middle Cambrian

Cathedral formation

	Feet
1. Dolomite: crystalline, light gray, tan weathering, thick-bedded. Lowermost 15 feet darker, still thick-bedded, forming a relatively sharp contact with the underlying limestone of the Mount Whyte formation	Not measured

Mount Whyte formation

5. Limestone: subcrystalline, dark gray, in beds 1-3 inches thick, with tan clay partings and flakes; lower part shaly	50
4. Limestone: oolitic, dark gray, thick-bedded	27
3. Limestone: finely crystalline or oolitic, dark gray, in irregular beds 1-2 inches thick, alternating with some shale. Trilobite fragments (*Amecephalus* sp.)	52
2. Shale: siliceous, gray, tan weathering, with some thin limestone layers	50
1. Shale, sandstone and limestone: alternating thin layers of siliceous, green-gray shale and green sandstone, with some thin, lenticular limestone beds. No fossils were found in this interval, hence it is uncertain whether it should be placed in the Mount Whyte formation or in the underlying St. Piran sandstone	47
Total thickness of Mount Whyte formation	226

Lower Cambrian

St. Piran sandstone (Peyto limestone member)

	Feet
1. Shale, sandstone, and limestone: alternating layers of green-gray shale, gray sandstone, and crystalline limestone. Olenellid fragments in limestone common up to the top of unit............	22

EIFFEL PEAK

A section of the lower Cathedral and Mount Whyte formations was measured on the southeast ridge of Eiffel Peak. The Mount Whyte formation is exposed at an approximate altitude of 8,500 feet and the strata are horizontal.

EIFFEL PEAK SECTION (NO. 20)

Middle Cambrian

Cathedral formation

	Feet
6. Dolomite: crystalline, light gray, tan weathering, massive, forming cliff	Not measured
5. Limestone: finely crystalline, very dark gray, thick-bedded, weathering to irregular surfaces...........................	80

Cathedral formation (Ross Lake shale member)

	Feet
4. Shale and limestone: siliceous, gray shale alternating with irregular, thin layers of gray limestone. Near middle of unit, a few inches of fissile, siliceous shale are abundantly fossiliferous (locality C20m)	3

Fossils:

Albertella bosworthi Walcott.........................	c
Albertella nitida Resser...........................	r
Kochina americana (Walcott)......................	r
Mexicella stator (Walcott).........................	c
Ptarmigania rossensis (Walcott)....................	r
Vanuxemella nortia Walcott.........................	c

Cathedral formation (continued)

	Feet
3. Dolomite: crystalline, light gray or cream-colored, weathering light tan, thick-bedded (thickness estimated)................	250
2. Limestone: subcrystalline, medium gray in upper part, light gray in lower part, thick-bedded (thickness estimated)...........	40
1. Dolomite: crystalline, gray, tan weathering, in beds up to 5 inches thick	115
Total measured thickness of Cathedral formation..........	488

Mount Whyte formation

	Feet
1. Limestone and shale: crystalline, dark-gray limestone with tan clay partings and blebs, in beds 1-2 inches thick alternating with siliceous, fine-grained, green-blue-gray, fissile shale. Mostly shale 16-22 and 28-34 feet above base, limestone in other parts of unit. Fossils abundant in limestone 22-28 feet above base, and in shale immediately above and below (locality W20d)	58

FOSSILS:

Amecephalus cleora (Walcott) cc
**Fieldaspis bilobata* Rasetti cc
furcata Rasetti .... rr
**Kochaspis ciffelensis* Rasetti .... r
**Kochiella? maxeyi* Rasetti c
Plagiura cercops (Walcott) c
**Schistometopus collaris* Rasetti .... r
* *convexus* Rasetti c

LOWER CAMBRIAN

St. Piran sandstone (Peyto limestone member)

3. Dolomite: sandy, light gray, tan weathering	13
2. Sandstone: coarse, brown, massive, including round concretions of fine-grained dolomite, resembling algal growths	4
1. Dolomite: sandy, massive, weathering dark tan	12
Total thickness of Peyto limestone member of St. Piran sandstone	29

Note.—On the slope of Eiffel Peak, about ½ mile west of the ridge where the preceding section was measured, the Mount Whyte formation was found to consist of 62 feet of fine-grained, crystalline and oolitic limestone in irregular beds 1-3 inches thick, with tan clay partings and blebs and a few interstratified layers of siliceous shale. The Peyto limestone member of the St. Piran sandstone is 20 feet thick, the upper portion including the usual dolomite concretions.

MOUNT TEMPLE

A section of the Stephen, Cathedral, and Mount Whyte formations was measured on the southwest ridge of Mount Temple from an approximate altitude of 11,000 feet (Stephen-Eldon contact) to 9,200 feet (base of Mount Whyte formation) above Sentinel Pass. All these strata are excellently exposed, undisturbed, and horizontal throughout the mountain.

MOUNT TEMPLE SECTION (NO. 21)

MIDDLE CAMBRIAN

Eldon dolomite

	Feet
1. Dolomite: crystalline, light gray, tan weathering; massive in upper part, partly thin-bedded and mottled near base. Eldon-Stephen contact fairly well defined	Not measured

Stephen formation

	Feet
5. Limestone: very dark gray, finely crystalline, purer and thicker-bedded (up to 4 inches) in upper part; thin-bedded and with tan clay partings and flakes in lower part	168
4. Shale: siliceous, fine-grained, blue-gray, fissile	4
3. Limestone: crystalline, dark gray, with tan clay partings and flakes, in beds 1-2 inches thick	12
2. Shale: siliceous and argillaceous, green- and blue-gray, fissile, darker and harder near base; with a few interstratified thin limestone layers	165
1. Limestone: finely crystalline to fine-grained, mostly dark gray, partly (near the top) banded light gray; mostly in beds 4-5 inches thick, thin-bedded and more argillaceous near base. Fossils abundant in subcrystalline, dark-gray limestone 100-120 feet above base (locality S21b). Argillaceous beds near base yielded pygidia of *Glossopleura*	150

FOSSILS:

**Glossopleura templensis* Rasetti c

**Polypleuraspis insignis* Rasetti c

Total thickness of Stephen formation	499

Cathedral formation

	Feet
9. Limestone: finely crystalline, gray, mottled, thick-bedded, especially in uppermost part. Contact with overlying Stephen formation very sharp	195
8. Limestone and dolomite: limestone as overlying unit in cliffs east and west of ridge, partly replaced on ridge by crystalline, light-gray, tan-weathering dolomite. Dolomite-limestone boundary very irregular	200
7. Limestone: finely crystalline, dark gray, with calcite veinlets, weathering to rough surfaces; mostly in beds up to 4 inches thick, some portions thicker-bedded	155
6. Limestone: subcrystalline, lighter gray than overlying unit, massive	100
5. Limestone: as unit 7	105

Cathedral formation (*Ross Lake shale member*)

	Feet
4. Shale: siliceous, hard, dark gray, with some interstratified nodular limestone layers. Locality C21m	8

FOSSILS:

Albertella bosworthi Walcott
Mexicella stator (Walcott)
Ptarmigania rossensis (Walcott)
Vanuxemella nortia Walcott

Cathedral formation (continued)

3. Limestone: subcrystalline, dark gray, partly mottled, massive	195
2. Limestone: subcrystalline, light gray, partly banded, thick-bedded	45
1. Dolomite: crystalline, light gray, tan weathering, mostly thick-bedded but with some thin-bedded portions	225
Total thickness of Cathedral formation	1,228

Mount Whyte formation

4. Limestone: crystalline to fine-grained, dark gray, in beds up to 4 inches thick in upper part; thinner-bedded and with tan clay partings and flakes in lower part. Contact with overlying Cathedral formation rather arbitrary because of irregular dolomite-limestone boundary	45
3. Shale: siliceous, blue-gray, tan weathering, fissile	53
2. Shale and limestone: siliceous shale with thin, nodular limestone layers	5
1. Limestone: subcrystalline, dark gray, in beds 1-2 inches thick	5
Total thickness of Mount Whyte formation	108

LOWER CAMBRIAN

St. Piran sandstone (*Peyto limestone member*)

2. Sandstone and limestone: gray, calcareous sandstone and crystalline, more or less sandy limestone with abundant olenellid fragments	24
1. Sandstone: coarse, brown, with spherical dolomite concretions resembling algal growths	6
Total thickness of Peyto limestone member of St. Piran sandstone	30

PINNACLE MOUNTAIN

A section of the Mount Whyte formation was measured on the east ridge of Pinnacle Mountain, above Sentinel Pass. Pinnacle Mountain constitutes a fault block downthrown approximately 500 feet with respect to the Mount Temple fault block, the fault line passing through Sentinel Pass. The Mount Whyte formation is exposed at an approximate altitude of 8,700 feet. The beds are horizontal.

PINNACLE MOUNTAIN SECTION (NO. 27)

MIDDLE CAMBRIAN

Cathedral formation

	Feet
1. Dolomite: crystalline, gray, tan weathering, thick-bedded; gradually becoming thinner-bedded near base, forming transition to underlying formation	Not measured

Mount Whyte formation

4. Dolomite and limestone: finely crystalline, light gray, banded dolomite in beds 2-5 inches thick grading laterally into dark-gray limestone	20
3. Limestone: subcrystalline, dark gray, with tan clay partings and flakes, thin-bedded	28
2. Shale: siliceous, gray, tan weathering, fissile; with some thin, nodular limestone layers. Rare fossils in shale (*Amecephalus* sp.).	48
1. Limestone: fine-grained, gray, in thin, irregular beds; some shale in upper part	12
Total thickness of Mount Whyte formation	98

LOWER CAMBRIAN

St. Piran sandstone (*Peyto limestone member*)

3. Limestone and sandstone: sandy, crystalline, gray limestone and calcareous sandstone, with a little siliceous shale. Olenellid fragments abundant throughout the calcareous layers	21
2. Sandstone: dark brown, with round concretions of fine-grained, tan-weathering dolomite resembling algal growths	7
1. Sandstone and dolomite: sandy, gray, tan-weathering dolomite and dolomitic sandstone	15
Total thickness of Peyto limestone member of St. Piran sandstone	43

MOUNT SCHAFFER

Mount Schaffer is cut by a fault into two blocks. The northeastern fault block includes the summit of the mountain. The southwestern block is downfaulted several hundred feet, bringing the base of the Cathedral formation against the upper part of the St. Piran sandstone. The following section was measured in the southwestern fault block. Another fault separates the southwestern part of Mount Schaffer from Park Mountain, which belongs to a still farther downthrown fault block, the middle part of the Cathedral formation in Park Mountain resting against the top of the St. Piran sandstone in the southwestern block of Mount Schaffer.

The section was measured on the slopes and cliffs overlooking McArthur pass, and includes the Mount Whyte formation and the Peyto limestone which here attains considerable thickness and carries more abundant and better-preserved fossils than most of the other sections. The beds dip 15-20° southwest.

MOUNT SCHAFFER SECTION (NO. 22)

MIDDLE CAMBRIAN

Cathedral formation

	Feet
1. Dolomite: crystalline, gray, tan weathering, massive; lowermost portion is massive undolomitized limestone, distinguished from underlying Mount Whyte formation by the thickness of the beds, although the change is not very sharp............	Not measured

Mount Whyte formation

5. Limestone: gray, mottled, subcrystalline, in very irregular beds up to 3 inches thick	25
4. Limestone: gray, shaly, with tan clay partings and flakes........	20
3. Limestone: finely crystalline, partly sandy, gray, weathering to mottled surfaces probably owing to dolomite inclusions; massive, weathering to irregular fragments.....................	45
2. Sandstone: coarse, brown, calcareous in upper part..............	20
1. Shale: siliceous, fine-grained, dark gray, fissile.................	2
Total thickness of Mount Whyte formation................	112

LOWER CAMBRIAN

St. Piran sandstone (*Peyto limestone member*)

5. Sandstone: coarse, light brown................................	30
4. Limestone: crystalline, gray, partly sandy, irregularly and mostly thick-bedded, up to 5 inches. Olenellid fragments and *Bonnia* abundant throughout. Fossils collected near base (locality P22k) and 10 feet below top (locality P22m). U.S.N.M. locality 61d is clearly within this unit......................	60

FOSSILS (loc. P22m):

"Agraulos" unca Walcott..............	r
Bonnia fieldensis (Walcott).........................	cc
Crassifimbra lux (Walcott).........................	r
Olenellus sp.	cc
Paedeumias sp.	r
Zacanthopsis cf. *levis* (Walcott).....................	r

Feet

Fossils (loc. P22k):
"Agraulos" unca Walcott........................... c
Bonnia fieldensis (Walcott)........................ cc
Olenellus sp. cc

3. Limestone: thick, irregular beds of sandy or dolomitic limestone with inclusions of purer limestone, assuming mottled aspect on weathering 60
2. Sandstone: partly calcareous or dolomitic, brown, with concretions of fine-grained dolomite or limestone resembling algal growths 16
1. Limestone: finely crystalline, gray, weathering to mottled surfaces probably owing to dolomite inclusions......................... 32

Total thickness of Peyto limestone member of St. Piran sandstone 198

MOUNT ODARAY

A section of the Stephen, Cathedral, and Mount Whyte formations was measured from the top of the south peak of Mount Odaray down its southeast ridge, then following a broad shoulder that descends in the northeast direction toward Odaray Plateau.

The summit of the south peak of the mountain is formed by the black limestone of the upper Stephen formation, which therefore is not completely represented. The formation is not complete even in the higher north peak.

The beds dip almost uniformly 15-20° southwest across the entire mountain.

Every bed of the Cathedral formation is well exposed and was carefully examined, but the writer was unable to find the Ross Lake shale. It appears exceedingly unlikely that it could have escaped observation, hence it is assumed that it is not developed at this locality.

MOUNT ODARAY SECTION (NO. 6)

Middle Cambrian

Stephen formation

Feet

3. Limestone: subcrystalline, black-gray, more or less argillaceous, in beds 2-4 inches thick, locally grading laterally into dolomite. The dolomitized beds preserve the original stratification and are often banded, a cream-colored dolomite alternating with dark-gray limestone. Thickness of unit not accurate because of slope of ridge almost paralleling the strata. Fossils present at several horizons but abundant only in top 20 feet, just below the summit of the mountain (locality S61)........... 280+

		Feet
Fossils:		
Alokistocare sinuatum Rasetti	r	
**Athabaskia? parva* Rasetti	r	
Bathyuriscus adaeus Walcott	c	
**Chancia odarayensis* Rasetti	r	
**Elrathina marginalis* Rasetti	c	
Olenoides sp.	r	
**Pachyaspis attenuata* Rasetti	c	
Pagetia cf. *P. bootes* Walcott	c	
Peronopsis columbiensis Rasetti	r	
Solenopleurella sp.	r	
Tonkinella stephensis Kobayashi	c	
Zacanthoides divergens Rasetti	r	
* *longipygus* Rasetti	c	
* *submuticus* Rasetti	c	
2. Limestone and shale: black-gray, thin-bedded, shaly limestone alternating with dark-gray and tan siliceous shale. Many of the thin limestone beds are highly fossiliferous, but it is difficult to collect unweathered fossils (locality S6k)		40
Fossils:		
Bathyuriscus adaeus Walcott	cc	
Elrathina parallela Rasetti	cc	
* *spinifera* Rasetti	cc	
Kootenia sp.	r	
Pagetia cf. *P. bootes* Walcott	c	
**Peronopsis columbiensis* Rasetti	cc	
Tonkinella stephensis Kobayashi	c	
1. Shale and limestone: siliceous, fissile, green-gray, tan-weathering shale alternating with crystalline and fine-grained limestone, mostly in thin, lenticular beds. Fossils collected in crystalline limestone layers 12 feet above base (locality S6g). Contact with underlying Cathedral formation very sharp		120
Fossils:		
Ehmaniella burgessensis Rasetti	c	
Solenopleurella sp. No. 1	r	
Total thickness of Stephen formation		440+

Cathedral formation

	Feet
4. Dolomite: crystalline, light gray or cream-colored, weathering pale tan, thick-bedded	1,000
3. Limestone: fine-grained, light gray, with less soluble layers weathering in relief forming banded surfaces: very thick-bedded, in places grading laterally to dolomite	60
2. Dolomite: crystalline, cream-colored, weathering pale tan, thick-bedded	70
1. Dolomite: light gray, crystalline, weathering dark tan, thick-bedded	60
Total thickness of Cathedral formation	1,190

Mount Whyte formation

	Feet
3. Shale and limestone: massive beds composed of alternating layers of gray limestone and siliceous, gray, tan-weathering shale. In top 3-5 feet, beds up to 3 inches thick of black-gray finely crystalline limestone are locally developed and yield fossils (locality W6d)	85
FOSSILS:	
Fieldaspis cf. *F. bilobata* Rasetti ... c	
Kochaspis eiffelensis Rasetti ... r	
2. Limestone: finely crystalline, dark gray, with sandy layers weathering in relief; very thick-bedded, forming cliff	66
1. Shale: siliceous, fine-grained, fissile, dark gray	10
Total thickness of Mount Whyte formation	161

LOWER CAMBRIAN

St. Piran sandstone (Peyto limestone member)

5. Limestone: coarsely crystalline, medium gray, pure or sandy, in thick, irregular beds with poorly developed partings. Olenellids and *Bonnia* common (locality P6k)	81
FOSSILS:	
Bonnia fieldensis (Walcott) ... c	
Olenellus sp ... c	
4. Dolomite: sandy, gray, tan weathering	5
3. Limestone: coarse, sandy, dark tan; with round concretions of fine-grained limestone or dolomite resembling algal growths	8
2. Sandstone: purple or maroon, massive, with concretions as in overlying unit at top and bottom	20
1. Sandstone and limestone: massive beds of irregularly interstratified gray limestone and sandstone	30
Total thickness of Peyto limestone	144

PARK MOUNTAIN

The northeast face and the north ridge of Park Mountain, overlooking Lake McArthur, offer continuous and accessible exposures of the entire Stephen and the lower part of the Eldon formation. Park Mountain is separated by a normal fault from Mount Biddle at the east. Almost immediately southwest of the summit of Park Mountain, a succession of faults brings highly disturbed Upper Cambrian strata to the surface, and no outcrops of the Middle Cambrian are known farther west. Hence Park Mountain, as Mount Odaray and Mount Stephen, lies at the southwest margin of the Middle Cambrian outcrop area where the Middle Cambrian sections present considerable differences from the typical sections of the Bow Range.

In Park Mountain the anomalous character of the section chiefly consists in the unusual lithology of the lower portion of the Eldon formation.

The Eldon formation is not discussed in detail in this paper, but it was mentioned that in the type section on Castle Mountain (Deiss, 1939), on Ptarmigan Peak and Mount Bosworth it consists of over 1,000 feet of dolomite with some calcareous beds. On Mount Stephen, the Eldon includes in the lower portion 150 feet of siliceous shale, most of the rest being dolomite. Hence it was entirely unexpected to find that on Park Mountain the Stephen formation is not overlain by the usual dolomite, but rather by a thick succession of siliceous shales and argillaceous limestones. Several hundred feet of such strata were measured, and there is no doubt that beds of this lithology extend for a considerably greater thickness.

It would be of great interest to observe the lateral change of the Eldon formation from dolomite to siliceous shale. However, most of this change probably took place in an area between Mount Biddle and Park Mountain where the Eldon has been largely eroded away. The writer did not climb Mount Biddle, where possibly the Eldon already shows peculiar lithologic character.

The section given below was measured, for the Eldon formation, in the middle part of the northeast face of the mountain. The Stephen formation here is mostly covered by snow and talus, hence it was measured farther northeast, along the broad north ridge of Park Mountain. This ridge and the nearby slopes offer excellent exposures and opportunity for good fossil collecting. The dip of the strata across all the investigated portion of Park Mountain is 20-24° southwest.

PARK MOUNTAIN SECTION (NO. 10)

MIDDLE CAMBRIAN

Eldon formation

	Feet
4. Shale: siliceous, massive, fine-grained, gray, weathering banded gray and tan; with a few thin limestone layers. Only the basal part of this unit was examined in place, but strata of this lithology certainly extend to the summit of the mountain. Thickness estimated	800+
3. Limestone: crystalline, dark gray, in beds 1-3 inches thick. Abundantly fossiliferous in lower 30 feet (locality E10c).........	70

FOSSILS:

Athabaskia sp.................................. r
Bathyuriscus sp................................ r
Glyphaspis sp.................................. r
Kootenia sp.................................... c
Zacanthoides sp................................ r

	Feet
2. Limestone: fine-grained, argillaceous, dark gray, in beds 1-3 inches thick, gradually changing to purer limestone of overlying unit. In places grades laterally to dolomite lenses, the dolomitized beds preserving the original stratification marked by clay partings. Unit apparently thickens westward; thickness estimated.	360
1. Limestone and shale: limestone as overlying unit, with bands at top and bottom of varying thickness of siliceous, gray, tan-weathering shale enclosing lenses of gray, fine-grained, bright-tan-weathering limestone. Thickness estimated..............	90
Total estimated thickness of Eldon formation..............	1,320+

Stephen formation

3. Limestone: fine-grained or subcrystalline, more or less argillaceous, black-gray, in beds up to 5 inches thick. In upper 50 feet grading into partially dolomitized beds banded light and dark gray. Fossils abundant 180-200 feet above base (locality S1ol) and 15-30 feet above base (locality S1ok)..................	420

Fossils (loc. S1ol):

**Alokistocare cataractense* Rasetti..................... c
Bathyuriscus adaeus Walcott......................... c
**Glyphaspis parkensis* Rasetti......................... c
Kootenia sp. .... r
**Parkaspis endecamera* Rasetti......................... c
Tonkinella stephensis Kobayashi...................... r
**Yuknessaspis paradoxa* Rasetti....................... r
**Zacanthoides divergens* Rasetti...................... r

Fossils (loc. S1ok):

Bathyuriscus adaeus Walcott......................... c
Peronopsis columbiensis Rasetti..................... c
Tonkinella stephensis Kobayashi..................... c
Elrathina sp. c

2. Shale and limestone: massive beds of thin alternating layers of argillaceous, gray, tan-weathering limestone, some purer, fine-grained, gray limestone, and siliceous, gray, tan-weathering shale; mostly shale in middle portion of unit...............	100
1. Shale and limestone: argillaceous, gray, tan-weathering shale alternating with coarsely crystalline, gray, massive limestone. Contact with underlying crystalline, massive, tan-weathering dolomite of Cathedral formation very sharp. Several hundred feet of the Cathedral formation are well exposed...........	28
Total thickness of Stephen formation....................	548

MOUNT FIELD: KICKING HORSE MINE

A good section of the Mount Whyte formation is exposed in the vicinity of the Kicking Horse Mine at the base of Mount Field. The base of the formation, however, is everywhere covered with talus. The beds dip eastward.

The section described below was measured immediately east of the mine. The Cathedral–Mount Whyte boundary must be defined arbitrarily within certain limits, as the upper limestone beds of the Mount Whyte grade laterally into dolomite, and there is no abrupt change in thickness or other characters of the strata. An average horizon for the limestone-dolomite boundary was assumed in determining the thickness of the uppermost unit of the Mount Whyte formation.

KICKING HORSE MINE SECTION (NO. 7)

MIDDLE CAMBRIAN

Mount Whyte formation

		Feet
4. Limestone: finely crystalline, hard, black-gray, in beds 1-3 inches thick; top portion irregularly dolomitized. Fossils collected 40-50 feet above base (locality W7g)		110
FOSSILS:		
**Caborcella rara* Rasetti	r	
**Fieldaspis superba* Rasetti	c	
**Onchocephalus depressus* Rasetti	c	
* *sublaevis* Rasetti	r	
3. Limestone: crystalline or oolitic, dark gray, in beds 1-3 inches thick		5
2. Limestone: crystalline or oolitic, dark gray, with tan clay partings and flakes, in beds 1-2 inches thick; more shaly in lower portion. Fossils collected 72 feet above base (locality W7f), 10 feet above base (locality W7e), and 1-2 feet above base (locality W7d). Also from undetermined horizons within unit (localities W7, W7f′)		75
FOSSILS:		
Amecephalus cleora (Walcott)	r	
**Fieldaspis furcata* Rasetti	cc	
Kochaspis eiffelensis Rasetti	r	
Kochiella? cf. *K. maxeyi* Rasetti	r	
**Oryctocephalites resseri* Rasetti	r	
Schistometopus convexus Rasetti	r	
**Onchocephalus fieldensis* Rasetti	cc	
* *maior* Rasetti	c	
FOSSILS (locality W7e):		
Caborcella skapta (Walcott)	c	
Fieldaspis furcata Rasetti	c	
Plagiura cercops (Walcott)	r	
FOSSILS (loc. W7d):		
Amecephalus cleora (Walcott)		
Caborcella skapta (Walcott)		
Onchocephalus fieldensis Rasetti		

	Feet
1. Shale: siliceous, banded gray and tan. Top of interval forms bench in cliff, crossing portal of Kicking Horse Mine a little above floor. Base of unit and Mount Whyte-St. Piran contact covered by talus. Fossils in thin limestone layers in top 3 feet of interval (locality W7c)	105+

Fossils:

Amecephalus cleora (Walcott)
Caborcella skapta (Walcott)
Fieldaspis furcata Rasetti
Onchocephalus fieldensis Rasetti

Total thickness of Mount Whyte formation	295+

MOUNT FIELD: BURGESS QUARRY

A section of a portion of the Stephen formation was measured on the west slope of the ridge between Mount Field and Mount Wapta, from strata somewhat lower than Walcott's celebrated quarry in the Burgess shale to near the top of the ridge. In the description of the Burgess shale, the problem concerning the stratigraphic position of the beds measured in this section is discussed in detail. The fault block in which Walcott's quarry occurs and where the section was measured is isolated by faults or drift cover from beds of recognizable position in the general section. Hence the assignment of the Burgess shale to the Stephen formation rests on paleontologic evidence. However, the relative ages of three faunules collected from this section rest upon unquestioned stratigraphic evidence, even though their relationship to faunules from other sections remains uncertain.

Throughout the measured section the strata are approximately horizontal and continuously exposed except a portion of the lowermost beds.

BURGESS QUARRY SECTION (NO. 11)

Middle Cambrian

Eldon (?) dolomite

	Feet
1. Dolomite: crystalline, gray, tan weathering, thick-bedded except near base, reaching to top of ridge	Not measured

Stephen formation (Burgess shale lentil: type section)

5. Shale and dolomite: siliceous, gray, tan-weathering shale alternating with thin- and thick-bedded, gray, tan-weathering dolomite	120
4. Shale and limestone: siliceous and calcareous shale, alternating with thin beds of gray limestone; all beds except some of the purer limestone layers weather tan	100

	Feet
3. Shale: in upper part siliceous, argillaceous, and calcareous; in lower part siliceous, hard, fine-grained, dark gray. Fossils 130-140 feet above base (locality S11g)	210

Fossils:

Ehmaniella burgessensis Rasetti.................... cc
Pagetia sp. c
Solenopleurella sp. No. 1........................ c

2. Shale: siliceous, fine-grained, hard, dark gray. This is the celebrated "phyllopod bed" of Walcott. Locality S11f (=U.S.N.M. 35k)	20

Fossils: see list in discussion of faunas.

Stephen formation (continued)

1. Shale: calcareous and siliceous, mostly covered by talus. Fossils abundant but poorly preserved about 60 feet below top of unit (locality S11e)	100+

Fossils:

Paterina cf. *P. zenobia* (Walcott).................. c
Bathyuriscus rotundatus (Rominger)............... c
Elrathina sp. .... r
Kootenia sp. .... r
Olenoides serratus (Rominger)..................... c
Pagetia bootes Walcott............................ c

Total thickness of Stephen formation	550+

Approximately 0.3 mile south of Walcott's quarry and at the same altitude, beds of argillaceous, gray, tan-weathering, thin-bedded limestone are exposed in shallow gullies. These strata would appear to be a lateral continuation of those exposed in Walcott's quarry, notwithstanding the different lithology. However, the beds are not continuously visible between Walcott's quarry and the above-mentioned outcrops, and small faults may be concealed under the drift cover. Hence the writer was unable to ascertain the exact stratigraphic position of this argillaceous limestone in the Burgess quarry section. The beds are abundantly fossiliferous, entire trilobite shields weathering in large numbers on the surfaces of the limestone slabs (locality S11e).

Fossils:

Iphidella cf. *I. fieldensis* Resser.................. c
**Alokistocarella fieldensis* Rasetti.................. c
Bathyuriscus rotundatus (Rominger)............... r
**Elrathina brevifrons* Rasetti...................... cc
Kootenia burgessensis Resser...................... c
Olenoides serratus (Rominger)..................... c
Pagetia bootes Walcott............................ c
Solenopleurella sp. No. 2......................... r

MOUNT STEPHEN

GENERAL DESCRIPTION

No other mountain in the area presents stratigraphic and paleontologic problems comparable to those encountered on Mount Stephen. Hence an especially intensive study was made, about 4 weeks being spent on this mountain alone. Almost every accessible exposure below the Eldon dolomite was examined.

The better to understand the topography, stratigraphy, and structure of Mount Stephen, two photographs of its northwest face (pls. 3, 4) and a large-scale map (fig. 3) are presented. Furthermore, to facilitate the description several minor topographic features are named. The above-mentioned illustrations enable the reader to locate exactly topographic features, stratigraphic units, and fossil localities.

Mount Stephen is bounded at the east by the deep valley of Monarch Creek, which follows a fault line (Cathedral-Stephen fault). A broad ridge (henceforth referred to as the "North Ridge") descends from the summit of the mountain northward to the Monarch Mine and the tunnel of the Canadian Pacific Railway (indicated in incorrect position on the Lake Louise sheet, but placed correctly on the map, fig. 3). Southwest of this ridge extends the precipitous northwest face of the mountain, overlooking the Kicking Horse River. The lower and upper parts of this face are accessible only at a few points, but the middle slope forms a shelf that permits one to traverse easily the entire face at an approximate altitude of 7,000 feet. Deep gullies have been eroded in this face, and the three principal ones are named, in order from northeast to southwest, "North Gully," "Middle Gully," and "Fossil Gully." They are indicated on the above-mentioned map and photographs (fig. 3 and pls. 3, 4).

The portion of the mountain so far described is essentially one fault block of almost horizontal strata. Only minor normal faults, involving displacements probably nowhere exceeding 100 feet, break the continuity of this block (one such fault follows North Gully, others are visible near the Monarch Mine).

A far more important fault, here named the "Fossil Gully fault," follows, in approximate north-south direction, the lower part of Middle Gully, the upper part of Fossil Gully, and traverses horizontally the entire west slope of the mountain at an altitude somewhat exceeding 7,000 feet. The approximate course of this fault is marked in figure 3. The fault continues across the Kicking Horse River and is traceable on Mount Field. The portion of Mount Stephen west of the Fossil Gully fault is upfaulted and the strata dip steeply to the west, approximately paralleling the slope of the mountain. For this

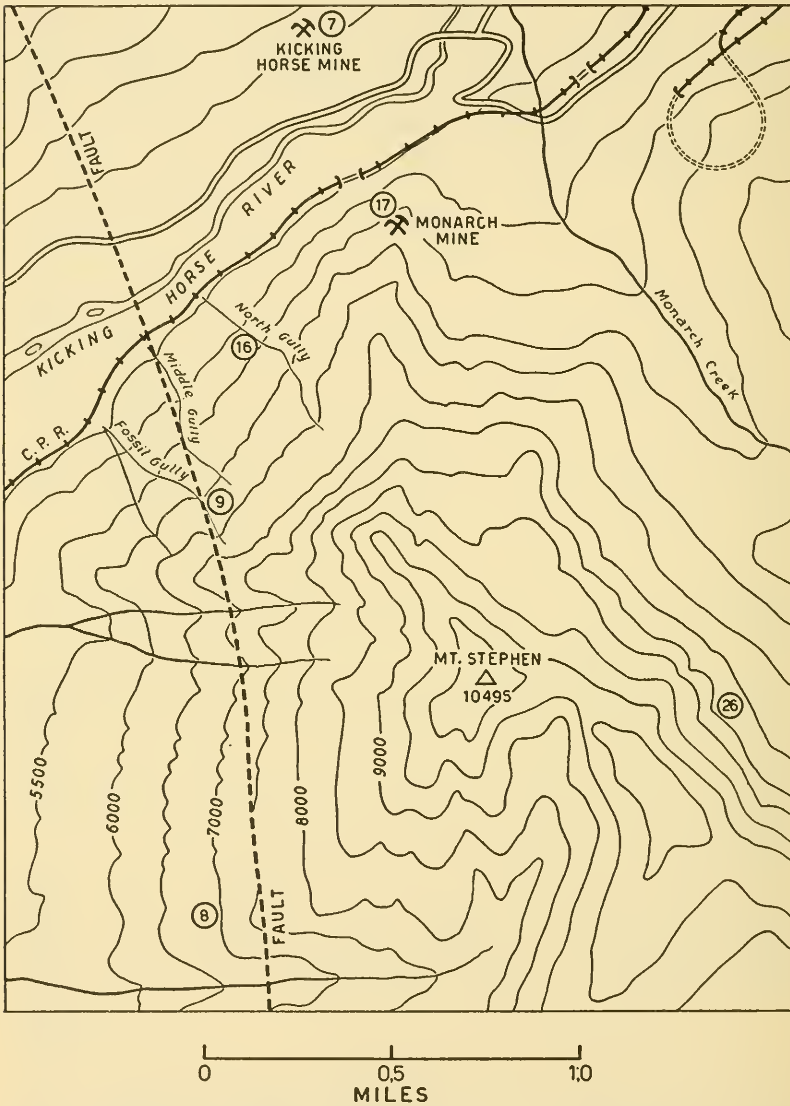

FIG. 3.—Contour map of Mount Stephen indicating fossil localities. West of the Fossil Gully fault (dotted line) the strata are greatly disturbed.

reason, besides the presence of other faults, folding, and cover by glacial drift and vegetation, the portion of Mount Stephen west of the Fossil Gully fault is unfit for stratigraphic work. The celebrated outcrop of the *Ogygopsis* shale occurs in this disturbed area and cannot be placed in the section.

The preceding description shows that the strata underlying the Eldon dolomite can be studied only in the east face (in the valley of Monarch Creek), in the North Ridge, and in the northwest face from North Ridge to Fossil Gully.

In the valley of Monarch Creek, the Mount Whyte and lower formations are not exposed, and a good section of the Cathedral formation cannot be obtained because of the considerable horizontal extent of any accessible section traverse. Hence only a section of the Stephen formation was measured (section No. 26).

The North Ridge is largely inaccessible, and at the level of the Stephen formation forms a bench mostly covered by talus. Only the Mount Whyte formation is accessible and well exposed at the edge of the talus below the Monarch Mine (section No. 17).

The northwest face offers continuous exposures of the entire Middle Cambrian and the uppermost portion of the St. Piran sandstone. A section (No. 16) was measured along North Gully, where the beds almost up to the top of the Mount Whyte formation are excellently exposed and easily accessible. The top unit of the Mount Whyte formation forms an overhanging cliff and the gully cannot be climbed farther.

Middle Gully is accessible in its lowermost part, but soon vertical cliffs prevent further progress. From the top of the talus slope occupying the lower part of Middle Gully, one can easily reach the steep wooded ridge separating Middle Gully from Fossil Gully and follow it until it merges with the slope at the foot of the limestone cliff formed by the top unit of the Mount Whyte formation. Traversing talus slopes almost horizontally in the southwest direction, one reaches the bottom of Fossil Gully where large dolomite boulders emerge from the talus slope. From this point, Fossil Gully is accessible to its termination in the broad ridge that separates the northwest and west faces of Mount Stephen. Furthermore, one can easily climb out of the gully on either side and traverse either the shelf of the northwest face to the North Ridge, or the west slope as far as the outcrop of the *Ogygopsis* shale at the celebrated "Fossil Bed." It is also possible to examine the lower portion of the Cathedral formation in Middle Gully, where it forms easy slopes between the vertical cliffs of the harder underlying and overlying units.

The northeast side of Fossil Gully and the slopes and cliffs above the upper end of Fossil Gully offer a continuous section of approximately horizontal strata (section No. 9) extending from the top unit of the Mount Whyte formation inclusive to the top of the Stephen formation and higher beds if desired. This section is continuous within one fault block with the section measured in North Gully, hence the two can be united and represent a continuous section of the entire portion of the Middle Cambrian studied in this work. In the bottom of Fossil Gully, the beds are somewhat distorted by the Fossil Gully fault. On the southwest side of the gully, the beds are upfaulted by 500 feet with respect to the northeast side. For some distance, before the strata are further disturbed by other faults, the beds are still horizontal and supply another excellent partial section of the upper part of the Mount Whyte and the lower part of the Cathedral. This section is an exact duplicate of the one measured on the other side of Fossil Gully, and it would not be worth mentioning except for the fact that here the Yoho shale member of the Mount Whyte formation is unusually well exposed for collecting and affords one of the richest fossil localities in the entire area (locality W9k).

Walcott (1928, pp. 315-319) described a Mount Stephen section, stating that his traverse extends "from the summit of the mountain down its northeast and north slopes to the track of the Canadian Pacific Railway at the tunnel east of Field." This would indicate that Walcott's theoretical section traverse should follow what is here designated as the North Ridge. As already pointed out, the Mount Whyte formation is the only one that is well exposed and accessible along this traverse. The Cathedral formation is mostly exposed in inaccessible cliffs and it is clear from Walcott's description that it was not measured in place, the thickness being inferred from the difference in elevation between top and bottom. The Stephen formation on North Ridge is partly exposed in inaccessible cliffs, partly covered with talus. Apparently Walcott did not measure here the section of the Stephen formation described as typical, since he affirmed (Walcott, 1928, p. 247) that the type locality of the Stephen formation is the "northwest side of Mt. Stephen." In the description of the section, he placed the *Ogygopsis* shale, stated to be 150 feet thick, in the upper part of the Stephen formation between two units of bluish-black limestone. However, according to Deiss' and the author's observations, the only available outcrop of this shale is at the famous "fossil bed" where the shale forms a deeply weathered dip slope and is separated either by faults or drift cover from any rocks in recognizable stratigraphic position. At the nearest place where a continuous section of the Stephen formation can be measured, above Fossil

Gully (section No. 9) there is no trace of a shale bearing the *Ogygopsis klotzi* faunule anywhere within the explored stratigraphic range from the top of the St. Piran sandstone to the middle of the Eldon dolomite. One must conclude that the *Ogygopsis* shale, at least in its recognizable fossiliferous form, is a narrowly localized deposit that cannot be placed in the section by stratigraphic evidence. In the Fossil Gully section there are, in the undivided Cathedral and Stephen formations, approximately 1,000 feet of shales similar lithologically at least to certain portions of the *Ogygopsis* shale. However, as no fossils could be found in these beds, it remains problematical what part, if any, of these shales is equivalent to the *Ogygopsis* shale.

The writer's thorough investigation of Mount Stephen revealed another important fact that had escaped the attention of previous observers. This is the astonishing lateral change in thickness and lithology of several units that takes place within the mountain from northeast to southwest. Along Monarch Creek the Mount Whyte, Cathedral, and Stephen formations possess normal thickness and lithology (section Nos. 17 and 26; also diagram in fig. 4). In the northwest face from North Ridge to Fossil Gully, within a distance of 1 mile (fig. 3) the character of the section undergoes great changes. The Mount Whyte formation thickens from 302 feet to 578 feet (section No. 9), most of the thickening taking place in shale units in the middle of the formation.

An even greater change affects the Cathedral formation. Along Monarch Creek it consists entirely of dolomite. On the northwest face of Mount Stephen, tongues of shale and thin-bedded limestone begin to appear and rapidly thicken toward the southwest, while the interfingering dolomite tongues thin out. Part of this change takes place in inaccessible cliffs, but good observations of the strata can be made from the opposite side of the valley. At Fossil Gully (section No. 9) the dolomite in the Cathedral formation is reduced to two tongues, 24 and 100 feet thick respectively, while the shale and thin-bedded limestone units have acquired an aggregate thickness of the order of 1,000 feet. The shaly character of the upper part of the Cathedral formation makes it impossible to separate it here from the overlying Stephen formation. Hence the two formations are left undivided in the Fossil Gully section, where their aggregate thickness is 2,214 feet.

Of particular interest are the limestone and shale units 2 and 3 near the base of the Cathedral formation (section No. 9) that begin to appear just west of the Monarch Mine and at Fossil Gully have an

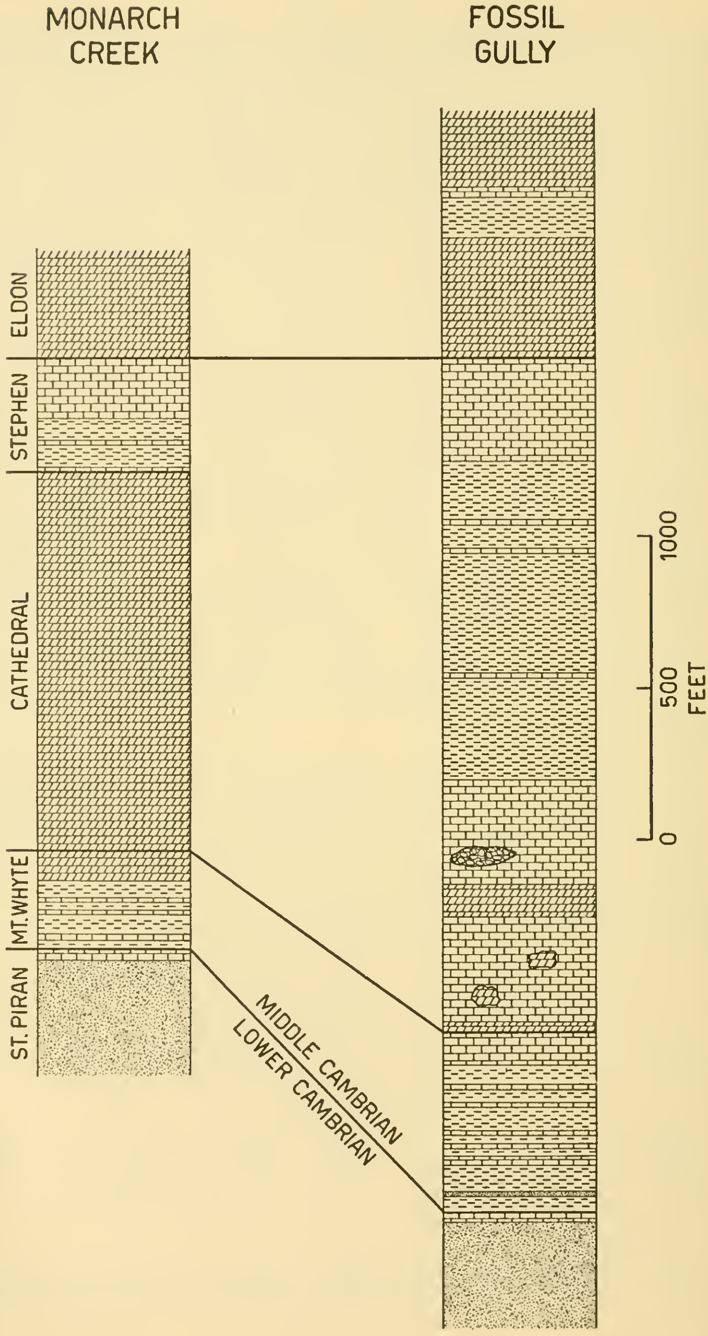

FIG. 4.—Section in the eastern and western parts of Mount Stephen. The thickness of the Cathedral formation at Monarch Creek is estimated.

aggregate thickness of 191 feet. These beds carry remarkable faunules not known anywhere else in the region. These units also include gigantic boulders of dolomite or massive limestone, sometimes up to 30 feet in diameter (pl. 6). These boulders indicate that a portion of Cathedral limestone or dolomite of normal lithology had been sedimented at the northeast prior to deposition of the shales and thin-bedded limestones at the southwest. Probably the massive carbonates represent reefs of algal origin (note the abundance of *Girvanella* in the undolomitized portions of the Cathedral formation in many sections). These reefs appear to have formed a steep submarine slope along which large boulders, possibly incompletely consolidated, could slide and become embedded in the argillaceous sediments being deposited southwest of the margin of the reef. In terms of the sedimentary basins introduced by Walcott (1927) this conclusion may be stated by saying that at the time when the Cathedral formation was deposited, pure carbonates were sedimented in the Bow trough while a considerable amount of fine clastic material was deposited in the Goodsir trough. The conditions that produced the large conglomerate boulders persisted for a considerably long time, since such boulders occur occasionally through a thickness of 650 feet of strata.

MONARCH CREEK

The valley of Monarch Creek separates Cathedral Mountain from Mount Stephen and was eroded along a fault line, Mount Stephen being downfaulted with respect to Cathedral Mountain. In the upper valley of Monarch Creek, a section of the Stephen formation is well exposed and almost entirely accessible. The overlying Eldon dolomite forms the vertical cliffs of the east face of the mountain. The Cathedral formation is entirely exposed, but a section of this formation was not measured because any accessible traverse would involve a considerable horizontal distance, rendering the measurement inaccurate. As far as it could be ascertained, the Cathedral in the east face of Mount Stephen is entirely dolomitic.

The section of the Stephen formation described below was measured at a locality approximately 0.8 mile due east of the summit of Mount Stephen. The strata are approximately horizontal, and the Stephen-Eldon contact is exposed at an estimated altitude of 8,000 feet.

The Stephen-Eldon boundary must be arbitrarily defined within certain limits, as there is no sharp lithologic change, and furthermore near the top of the Stephen or the base of the Eldon there is the usual lateral intergrading of limestone and dolomite.

MONARCH CREEK SECTION (NO. 26)

MIDDLE CAMBRIAN

Stephen formation

		Feet
8.	Limestone: fine-grained, black-gray, in beds 2-5 inches thick. Upper portion not accessible. Thickness estimated	80
7.	Limestone: dark gray, massive	5
6.	Limestone: as unit 8	110
5.	Limestone: gray, in thin, irregular beds with tan clay partings	11
4.	Shale: siliceous, gray, fissile	5
3.	Limestone: as unit 5	7
2.	Shale: in lower fourth siliceous, hard, dark gray, with lenses of coarse, gray limestone; grading upward into siliceous, argillaceous and calcareous shales, green-gray or tan, with some thin-bedded limestone	152
1.	Limestone: gray, irregularly bedded	6
	Total thickness of Stephen formation	376

Cathedral formation

1. Dolomite: coarsely crystalline, gray, tan-weathering, thick-bedded. Contact with overlying Stephen formation very sharp....Not measured

MONARCH MINE

A good section of the Mount Whyte formation can be studied in the cliffs immediately below the Monarch Mine on Mount Stephen, following the edge of the talus slope. If this section were examined isolatedly, it would be difficult to decide where to place the upper boundary of the Mount Whyte formation because the dolomitization of the limestone at this locality extends into lower beds than usual. Hence if the dolomite-limestone contact were taken as the Cathedral-Mount Whyte contact, beds whose equivalents in other sections were included in the Mount Whyte would be assigned to the Cathedral. The criterion adopted was to trace the beds across the northwest face of the mountain from the Monarch Mine to Fossil Gully. Then it is clear that the lowermost 100 feet of dolomite at the Monarch Mine represent the calcareous unit of the Fossil Gully section which carries a faunule of the *Plagiura-Kochaspis* zone and is everywhere included in the Mount Whyte formation. Hence the Cathedral-Mount Whyte contact was placed at the top of these 100 feet of dolomite, a little below the level of the portal of the Monarch Mine, although there is no definite change in lithology at this horizon.

MONARCH MINE SECTION (NO. 17)

MIDDLE CAMBRIAN

Mt. Whyte formation

	Feet
5. Dolomite: crystalline, gray, tan weathering, in beds 2-4 inches thick. Thickness somewhat arbitrary because of indefinite upper boundary of formation	100
4. Shale: siliceous, medium-grained, gray, tan weathering	35
3. Limestone and shale: crystalline, dark-gray limestone in beds 1-3 inches thick, alternating with siliceous, green-gray, tan-weathering shale. Undetermined ptychoparid trilobites were collected in limestone in top 5 feet (locality W17b)	40
2. Shale: siliceous, fissile, green-gray, tan weathering	52
1. Shale and limestone: siliceous, gray shale alternating with dark-gray, hard, siliceous, irregularly bedded limestone. A cranidium of *Amecephalus* sp. was collected 18 feet above base (locality W17a). This unit appears greatly to thicken westward, corresponding to the combined units 1-3 of the Mount Whyte formation in the North Gully section (combined thickness of these units at North Gully 262 feet)	75
Total thickness of Mount Whyte formation	302

LOWER CAMBRIAN

St. Piran sandstone (*Peyto limestone member*)

1. Limestone, shale and sandstone: crystalline, sandy, gray limestone in beds up to 2 feet thick alternating with sandstone and siliceous shale. Olenellids and *Bonnia* common in the calcareous layers .... Not measured

Note.—More abundant and better-preserved fossils were collected from the top 6 feet of the Peyto limestone about ½ mile west of the Monarch Mine, directly above the second of the three sheds of the Canadian Pacific Railway (locality P18m, probably identical with U.S.N.M. locality 35f). The identified species include:

Bonnia fieldensis (Walcott)	cc
Olenellus sp.	cc
Onchocephalus cleon (Walcott)	r
thia (Walcott)	r
Pagetia sp.	r
Piazella pia (Walcott)	r
Syspacephalus charops (Walcott)	cc

NORTH GULLY AND FOSSIL GULLY

As explained in the general description of Mount Stephen, a section extending from the top of the Lower Cambrian through the entire

Middle Cambrian (and possibly a portion of the Upper Cambrian) is exposed, within a single fault block, in the northwest face of Mount Stephen between Fossil Gully and North Gully. For reasons of accessibility, the upper portion of the section (from the top of the Stephen to the uppermost unit of the Mount Whyte inclusive) was measured along the broad ridge that separates the northwest and west faces of Mount Stephen, then down the northeast side of Fossil Gully. A portion of the Mount Whyte formation was also measured in another fault block on the southwest side of Fossil Gully. Finally, the Mount Whyte formation exclusive of the uppermost unit was measured in North Gully. The strata, except in the immediate vicinity of the fault in the bottom of Fossil Gully, are almost horizontal and well exposed throughout.

FOSSIL GULLY SECTION (NO. 9)

MIDDLE CAMBRIAN

Eldon dolomite

	Feet
4. Dolomite: crystalline, gray, tan weathering, massive......	Not measured
3. Limestone: subcrystalline, dark gray, thin-bedded. Thickness estimated	30
2. Shale: siliceous, fine-grained, fissile, finely banded gray, green, and tan. Viewed from a distance forms the "dark band" on the west face of Mount Stephen mentioned by Walcott. Thickness estimated	150
1. Dolomite: crystalline, gray, tan weathering, thick-bedded. Thickness estimated	400
Total measured thickness of Eldon dolomite..............	580

Stephen and Cathedral formations (undivided)

16. Limestone: subcrystalline, black-gray, more or less argillaceous, mostly thin-bedded, partly purer and thicker-bedded (up to 4-5 inches). Upper part grading laterally to dolomite, making Eldon-Stephen boundary arbitrary within 100 feet or more. The thickness given is based on an average horizon for the dolomite-limestone contact. Beds extremely fossiliferous 30-80 feet above base (locality S9k), most of the fossils occurring on weathered surfaces of platy, argillaceous limestone layers.. 300

FOSSILS:

**Alokistocare paranotatum* Rasetti....................	r
Bathyuriscus adaeus Walcott........................	cc
Chancia cf. *C. odarayensis* Rasetti....................	r
**Elrathina parallela* Rasetti	cc
spinifera Rasetti	c

Feet

Kootenia sp. .... r
Pagetia cf. *P. bootes* Walcott.......................... c
Peronopsis columbiensis Rasetti.......................... cc
Tonkinella stephensis Kobayashi.......................... c
Zacanthoides sp. .... r

15. Limestone: subcrystalline, dark gray, with tan clay partings and flakes, in irregular beds 1-2 inches thick.................... 37

14. Shale: siliceous, gray, fissile, tan weathering, with some interstratified thin limestone beds. Also some gray, thin- and irregular-bedded limestone with tan clay partings and flakes; and some smooth-bedded, fine-grained, argillaceous limestone. Unit forms cliff and is partly of difficult access. Thickness estimated 300

13. Limestone: subcrystalline, gray, thin- and irregular-bedded, with tan clay partings and flakes.............................. 8

12. Shale: siliceous, fine-grained, gray.......................... 42

11. Limestone: as unit 13.. 16

10. Shale: siliceous, gray, fine-grained, chunky.................... 350

9. Limestone: crystalline, hard, dark gray, in regular beds up to 6 inches thick. Forms good horizon marker between overlying and underlying shales. Yielded rare, poorly preserved specimens of *Kootenia, Olenoides,* and *Oryctocephalus*........... 12

8. Shale: as unit 10.. 335

7. Limestone: fine-grained, argillaceous, dark gray, in smooth beds 2-4 inches thick. Occasional lenses of dolomite conglomerate including large boulders.................................. 350

6. Dolomite: crystalline, light gray, tan weathering, very massive. Top of this unit is at level of great dolomite boulder emerging from talus in bottom of Fossil Gully...................... 100

5. Limestone: subcrystalline, hard, dark gray, mostly in beds 2-4 inches thick, with occasional massive, lenticular beds. Rare fossils near base (locality C9k)........................... 145

Fossils:
Kootenia sp.
Zacanthoides sp.

4. Limestone: massive single bed of sandy, gray limestone.......... 4

3. Limestone: subcrystalline, hard, dark gray, mostly in beds 2-6 inches thick, with massive, partly lenticular beds near base. Large dolomite or limestone boulders are included in this unit in the slopes of Middle Gully. Fossils collected at top of unit (locality C9j′) and 35 feet below top (locality C9j)......... 116

Fossils (locality C9j′):
Diraphora sp.
Wimanella sp.
Athabaskia sp.
**Chancia bigranulosa* Rasetti
Poliella sp. No. 2

	Feet
Fossils (locality C9j):	
Bathyuriscus sp .... r	
Chancia bigranulosa Rasetti c	
Ogygopsis klotzi (Rominger) c	
Pagetia sp .... r	
Yohoaspis pachycephala Rasetti .... r	
**Zacanthoides sexdentatus* Rasetti c	
2. Limestone and shale: silty, dark-gray limestone in irregular, often lenticular beds; alternating with dark-gray, siliceous, and calcareous shales. *Ogygopsis* common throughout unit. Fossils mostly collected 30-70 feet above base (locality C9h)	75
Fossils:	
Acrothele sp .... r	
**Chancia latigena* Rasetti .... r	
Kootenia sp .... r	
Ogygopsis klotzi (Rominger) c	
* *spinulosa* Rasetti .... r	
Pagetia sp c	
Poliella sp. No. 1 c	
**Syspacephalus tardus* Rasetti c	
**Yohoaspis pachycephala* Rasetti .... r	
Zacanthoides sp. c	
1. Dolomite: crystalline, gray, thick-bedded	24
Total thickness of undivided Stephen and Cathedral formations	2,214

Mount Whyte formation

	Feet
11. Limestone: crystalline, dark gray, with tan clay partings and flakes, in irregular beds 1-4 inches thick. Fossils common at various levels (locality W9f)	95
Fossils:	
Amecephalus cleora (Walcott) .... r	
Fieldaspis furcata Rasetti c	
Kochaspis eiffelensis Rasetti .... r	
Kochiella? maxeyi Rasetti .... r	
Plagiura cercops (Walcott) .... r	
Schistometopus convexus Rasetti .... r	
collaris Rasetti .... r	

Note.—The section was continued downward in another fault block on the southwest side of Fossil Gully. The beds in this block are upfaulted by 500 feet with respect to the strata on the northeast side of Fossil Gully, hence stratigraphically lower beds are easily accessible. This portion of the section is connected to the preceding by means of the readily recognizable contact of units 10 and 11. The strata described in this portion of the section were also measured in North Gully.

Mount Whyte formation (continued)

		Feet
10.	Shale: siliceous, dark gray	40
9.	Limestone: sandy, dark gray, in thin, irregular beds	6
8.	Shale: siliceous, dark gray	32
7.	Limestone: sandy, dark gray, thin-bedded in upper third, thick-bedded in lower two-thirds	18

Mount Whyte formation (*Yoho shale lentil: type locality*)

4-6. Shale: siliceous, fine-grained, fissile, dark gray. Faunule probably ranges throughout unit; fossils abundant 25-80 feet above base (locality W9k) 135

Fossils:

Hyolithes sp.	c
Scenella sp.	cc
Acrothele sp.	r
Acrotreta sp.	c
Dictyonina sp.	r
Paterina? sp.	r
Amecephalus agnesensis (Walcott)	r
**Chancia stenometopa* Rasetti	rr
Ogygopsis klotzi (Rominger)	rr
Oryctocephalus sp. No. 2	rr
**Poliella denticulata* Rasetti	c
prima (Walcott)	r
**Stephenaspis bispinosa* Rasetti	cc
**Syspacephalus gregarius* Rasetti	cc
* *laevigatus* Rasetti	r
perola (Walcott)	r
**Wenkchemnia spinicollis* Rasetti	cc

Total measured thickness of Mount Whyte formation 326

Note.—Lower beds are of difficult access in Fossil Gully. The section was continued downward in North Gully, where the highest measured strata are unit 10 of the Mount Whyte formation. Hence there is a considerable overlap between the two measured sections, units 4-10 having been measured at both localities. The unit representing the Yoho shale lentil in Fossil Gully was numbered 4-6 in order to designate by the same numbers equivalent units in the Fossil Gully and North Gully sections. In the latter the stratigraphic interval representing the Yoho shale is subdivided into three units, numbered 6, 5, and 4.

In North Gully the entire Mount Whyte formation is excellently exposed, and all the beds are accessible except the uppermost units which form a vertical or overhanging cliff. The gully was eroded along a normal fault, the strata being approximately horizontal on either side and the displacement being 50-100 feet, with the southwest side downthrown. All the beds of the Mount Whyte formation, except the lowermost unit, were measured on the northeast side of the gully, and all the fossil localities are also located on this side. The slopes east of the gully offer excellent exposures for collecting.

NORTH GULLY SECTION (NO. 16)

MIDDLE CAMBRIAN

Mount Whyte formation

	Feet
11. Limestone: exposed in inaccessible cliff	Not measured
10. Shale: siliceous, green-gray, tan weathering. Partly exposed in inaccessible cliff. Thickness estimated	50
9. Limestone: crystalline, dark gray, thin-bedded	7
8. Shale: as unit 10	45
7. Limestone: crystalline, hard, dark gray, in beds up to 5 inches thick	15

Mount Whyte formation (Yoho shale lentil)

6. Shale: as unit 10	10
5. Limestone and shale: limestone as unit 7, alternating with some siliceous shale	24
4. Shale: siliceous, fine-grained, dark gray, fissile. Fossils common about 20 feet above base and in thin limestone lenses 30 feet above base (locality W16k)	70

FOSSILS:

Poliella prima (Walcott)	r
Stephenaspis bispinosa Rasetti	c
Syspacephalus gregarius Rasetti	c
perola (Walcott)	r
Wenkchemnia spinicollis Rasetti	cc

Mount Whyte formation (continued)

3. Shale and limestone: siliceous, dark-gray shale alternating with fine-grained or finely crystalline, silty, dark-gray limestone in irregular, often lenticular beds up to 3 inches thick, and rare lenses of purer, crystalline limestone. Fossils common throughout the interval; *Ogygopsis* apparently confined to upper 20 feet of interval, other species may range throughout. Locality W16j in top 20 feet of interval, W16j″ 40-50 feet above base, W16j′ at undetermined horizon within unit	104

FOSSILS (locality W16j):

Acrotreta sp.	c
Ogygopsis klotzi (Rominger)	c
Oryctocephalus sp. No. 1	r
**Piazella tuberculata* Rasetti	r
Poliella cf. *P. denticulata* Rasetti	c
Stephenaspis cf. *S. bispinosa* Rasetti	r

Feet

Syspacephalus crassus Rasetti c
cf. *S. gregarius* Rasetti................ r
* *laticeps* Rasetti c
Wenkchemnia sulcata Rasetti.......................... c

Fossils (locality W16j″):
Syspacephalus crassus Rasetti
laticeps Rasetti
**Wenkchemnia sulcata* Rasetti

2. Shale: siliceous, medium-grained, fissile, dark gray. Trilobite shields are common but the preservation is extremely poor. Better-preserved fossils were collected from thin limestone lenses (locality W16i).................................... 16

Fossils:
Syspacephalus sp.
Wenkchemnia sulcata Rasetti

1. Shale and sandstone: siliceous, green and gray shale alternating with thin layers of fine- to medium-grained, green-gray sandstone. Some thicker sandstone beds (up to 6 inches) in upper part of unit. Considerable cross-bedding in lower part. At top of unit, on northeast side of gully, beds of crystalline, dark-gray limestone yielded fossils (locality W16h)................ 142

Fossils:
Acrotreta sp.
Syspacephalus laticeps Rasetti
Wenkchemnia sulcata Rasetti

Total measured thickness of Mount Whyte formation...... 488

Lower Cambrian

St. Piran sandstone (Peyto limestone member)

1. Sandstone and limestone: gray and brown, partly calcareous sandstone with lenses of sandy or almost pure, crystalline limestone. Olenellid fragments abundant in the calcareous layers.. 30

CAMBRIAN FORMATIONS: LOWER CAMBRIAN

ST. PIRAN SANDSTONE

UPPER BOUNDARY OF THE FORMATION

It is not the purpose of this paper to revise the Lower Cambrian formations. However, the upper portion of the St. Piran sandstone was studied in most of the sections investigated in order to decide where the St. Piran-Mount Whyte contact should be placed. The result of this study was the decision to transfer from the Mount Whyte to the St. Piran the basal limestone unit of the Mount Whyte formation as hitherto understood. This unit is only 20 feet thick in the type section of the Mount Whyte formation.

The St. Piran sandstone was reported by Walcott (1928) to be approximately 2,600 feet thick in the type section, and there is no doubt that the thickness actually exceeds 2,000 feet in most of the sections in the Bow Range where the formation is entirely exposed. In the Slate Mountains Deiss (1939) found the St. Piran to be much thinner, 815 feet in the measured Ptarmigan Peak section. The St. Piran chiefly consists of thick-bedded sandstone and quartzite with some interstratified siliceous shale. Carbonate deposits are totally absent from all except the top beds of the formation. Near the top, calcareous material appears; there is generally a gradual change from purely siliceous to increasingly calcareous, highly ferruginous sandstone, then to more or less sandy limestone, and in many places to pure, crystalline or sometimes oolitic limestone. Often calcareous sandstone or sandy limestone first appears as isolated lenses in the upper portion of the sandstone. Olenellid fragments and *Bonnia* are almost invariably present in the calcareous layers, which in many cases are a true coquina of olenellid tests. It is clear both from stratigraphic and faunal evidence that there is no break between the underlying siliceous sandstone and these more or less calcareous (more rarely dolomitic) beds, hence a formational contact placed between them (as it was hitherto done) would be to a large extent arbitrary. On the other hand, both stratigraphic and paleontologic arguments favor placing a formational boundary at the top of the *Olenellus* beds. The great faunal change that takes place between these beds and those immediately overlying is discussed in another part of this paper. A sharp change in lithology also generally occurs, the crystalline, sandy limestone usually in thick beds being overlain by siliceous shale with interstratified thin limestone or sandstone layers. In most of the sections (see descriptions) the St. Piran-Mount Whyte contact as here defined can be located within a few inches without ambiguity. Furthermore, the erratically varying thickness of the Mount Whyte (see discussion of formation) makes it appear likely that this unit was deposited on a somewhat irregular surface. This fact, coupled with the sudden faunal and lithologic changes, strongly suggests an unconformity at the top of the *Olenellus*-bearing beds. Hence all arguments favor placing the St. Piran-Mount Whyte boundary at the top and not at the base of the *Olenellus*-bearing limestone or calcareous sandstone, contrary to current usage. An analogous suggestion was first made by Burling (1914, 1916).

The St. Piran-Mount Whyte boundary as here defined is at the same time the Lower-Middle Cambrian boundary according to the faunal definition later discussed in this paper. The writer does not believe that series boundaries must necessarily coincide with unconformities and formational boundaries, but in the present instance, in the area investigated, this happens to be the case.

PEYTO LIMESTONE MEMBER

The calcareous beds at the top of the St. Piran sandstone are only 10-30 feet thick in most of the sections studied. However, in two portions of the area investigated, one in the upper Bow Valley, the other, probably of more limited extent, in the upper valley of Cataract Brook, the calcareous beds attain considerable thicknesses, in places exceeding 200 feet. At such localities the unit deserves a name and is here designated as the Peyto limestone member of the St. Piran sandstone.

The type section of the Peyto limestone is chosen in the cliffs formed by the west spur of Mount Thompson on the west side of the upper Bow Valley, north of Bow Lake and south of Peyto Lake (see section No. 15 for a detailed description). At the type locality the Peyto limestone is 278 feet thick and is mostly crystalline or oolitic, medium-gray, thick-bedded limestone, with some more or less calcareous sandstone and a little interstratified gray siliceous shale. Partings in the limestone are poorly developed, hence when the strata are exposed in cliffs they appear very massive. Olenellids and *Bonnia* are present at least in the upper portion of the limestone.

At Hector Creek (section No. 19) the Peyto limestone is well developed, being about 200 feet thick, and presents the same lithology as in the type section. Olenellid fragments are here extremely abundant in most of the calcareous beds.

The Peyto limestone also has considerable thickness in the upper valley of Cataract Brook. The thickness on Mount Odaray (section No. 6) and Mount Schaffer (section No. 22) is 144 and 198 feet respectively. In all the other measured sections the unit is much thinner: 28 feet on Mount Niblock; 20 feet in the Mount Whyte section; 24 feet on Mount Bosworth; 17 feet on Mount Victoria; 30 feet on Mount Cathedral; 22 feet on Popes Peak; 29 feet on Eiffel Peak; 30 feet on Mount Temple; 43 feet on Pinnacle Mountain; 30-40 feet at North Gully on Mount Stephen. Thicknesses at other localities can be obtained from Deiss' published sections (Deiss, like Walcott, included these beds in the Mount Whyte formation). The resulting values are 35 feet on Ptarmigan Peak, and 51 feet at Ross Lake. In the Castle Mountain section, Deiss' description does not suggest the presence of beds assignable to the Peyto limestone. On account of the gradual change from sandstone to limestone and the frequently lenticular character of the limestone layers, exact thicknesses have little significance.

A characteristic bed of the Peyto limestone that is present in many sections is a massive sandstone, sandy limestone or dolomite, generally weathering dark tan, including small, spherical or ovoidal concretions of fine-grained limestone or dolomite approximately an inch in diameter. These concretions resemble algal growths, but are more likely to be inorganic. This bed was observed in the Ptarmigan Peak, Mount Victoria, Eiffel Peak, Mount Temple, Pinnacle Mountain, Mount Schaffer, and Mount Odaray sections. Since no other bed of similar lithology has ever been observed in the Cambrian of the area, the concretionary layer, when present, is an excellent horizon marker.

Fossils occur sparsely through the siliceous portion of the St. Piran sandstone. The oldest faunule was discovered by Walcott (1928, p. 300) and collected again by the writer in sandstone near the base of the formation, approximately 2,000 feet below the top of the Lower Cambrian, near Vermilion Pass at the base of Storm Mountain. The fossils are relatively abundant and fairly well preserved considering the unfavorable lithology. The faunule includes *"Wanneria"* cf. *gracilis* Walcott and a species of *Rustella*. The Peyto limestone is in places highly fossiliferous and carries the *Bonnia fieldensis* faunule.

The name Peyto limestone derives from Peyto Lake, which is approximately 2 miles north of the typical exposure.

CAMBRIAN FORMATIONS: MIDDLE CAMBRIAN

MOUNT WHYTE FORMATION

TYPE SECTION

The Mount Whyte formation was defined by Walcott (1908a) as "alternating bands of limestone and siliceous and calcareous shale," the type locality being described as "Mt. Whyte, above Lake Agnes, and eastern slope of Popes Peak, southwest of Mt. St. Piran." In 1928 (Walcott, 1928, p. 251) the lithology was redescribed as "alternating bands of gray and bluish-black limestone, siliceous and calcareous shales, with some interbedded sandstones near the lower part." The type locality was stated to be the "north slope of Mt. Whyte and southwest of Lake Louise." A section of the formation under the name of the "Lakes Louise and Agnes section" was only published in 1928; the Mount Whyte formation described in this section being apparently measured on or near Mount Whyte. The thickness of the formation was given as 458 feet in the description of the section (Walcott 1928, p. 302) but only 386 feet on page 251 of the same paper.

Notwithstanding the somewhat ambiguous indication of the type locality and thickness, it is clear what beds Walcott intended to include in the Mount Whyte formation, and also that he meant the type section to be in the general area of Mount Whyte. Deiss (1939, p. 998) transferred the type section to Ptarmigan Peak for the following reasons:

> Examination of the Mt. Whyte section indicates that the formation there includes Middle Cambrian limestones in the upper 100 feet or more and does not contain as clearly defined or readily recognizable faunal zones as on Ptarmigan Peak. Walcott not only never specified this section as typical of the Mt. Whyte formation but nearly always referred to sections in other areas when he discussed the formation or its fauna.

In the writer's opinion, every one of the arguments by which Deiss justified his change of the type section is invalid. The entire formation, once Walcott's basal beds are transferred to the St. Piran, is Middle Cambrian. The Mount Whyte formation in the Mount Whyte area includes at least two fossiliferous horizons with characteristic and well-identified faunules. The fact that Walcott gave two type localities (both in the general area of Mount Whyte and within 2½ miles of each other), or that he referred to other sections more often than to the Mount Whyte section in discussing the formation, do not appear sufficient reasons for transferring the type section to a relatively distant area. Furthermore, Deiss' choice of the Ptarmigan Peak area for his new type section is particularly inappropriate, as on Ptarmigan Peak the basal portion of the overlying Cathedral formation (Deiss' "Ptarmigan limestone") is undolomitized and partly thin-bedded, making it unusually difficult to place the upper boundary of the Mount Whyte formation.

The formation was found to be particularly well exposed and accessible at two localities in the Mount Whyte area. The first (section No. 2) is in the cirque above Lake Agnes, between Mount Whyte and Mount Niblock, and approximately corresponds to Walcott's first type locality. The second locality is in the immediate vicinity of Plain of Six Glaciers, 1½ miles southwest of the upper end of Lake Louise (section No. 3) and approximately corresponds to Walcott's second type locality. At Plain of Six Glaciers, the formation is exposed on both sides of the gully between Popes Peak and Mount Whyte. The

Mount Whyte formation was measured on the south side of the gully, on the slope of Popes Peak, because of better exposure, but since the overlying Cathedral and Stephen formations were measured on the ridge of Mount Whyte, the section is referred to as the Mount Whyte section.

For the purpose of reestablishing the type section of the Mount Whyte formation in Walcott's typical area, either the writer's section No. 2 or section No. 3 could be used. Each corresponds to one of the type localities designated by Walcott, and both show closely similar successions of strata. The preference is given to section No. 3 because the formation is here more fossiliferous and more readily accessible.

LITHOLOGY AND THICKNESS

The formation at the type locality at Plain of Six Glaciers, on the east slope of Popes Peak, $1\frac{1}{2}$ miles southwest of the upper end of Lake Louise, consists of 211 feet of gray or greenish siliceous shale, crystalline or oolitic, dark-gray, mostly thin-bedded limestone, and a little interstratified thin-bedded sandstone. Shale and limestone alternate irregularly, but here as in all other sections shale prevails in the lower part and limestone in the upper portion. Many of the limestone beds include blebs and flakes of tan argillaceous material. The lower part of the formation includes beds of shale with thin interstratified nodular layers of limestone.

The St. Piran-Mount Whyte contact and the reasons for transferring Walcott's basal beds of the Mount Whyte to the St. Piran have been discussed. In the type section, the St. Piran-Mount Whyte boundary as here defined is extremely sharp. Furthermore, olenellids occur up to the very top of the Peyto limestone member of the St. Piran, while a totally different Middle Cambrian faunule (the *Poliella prima* faunule) occurs in the Lake Agnes shale lentil of the Mount Whyte formation, 22-27 feet above the top of the *Olenellus*-bearing beds.

The Mount Whyte formation in Walcott's "Lakes Louise and Agnes section" was measured "in the vicinity of Lake Agnes" (Walcott, 1928, p. 302) hence the locality closely corresponds to the one where the writer measured his Mount Niblock section. The writer's measured thickness of the Mount Whyte formation on Mount Niblock is 281 feet. Walcott, in the description of the section, gave a thickness of 458 feet. The excess is due to an obvious error made by Walcott in reporting a thickness of 187 feet for the *Olenellus*-bearing beds (here assigned to the Lower Cambrian Peyto limestone) which in reality are only 28 feet thick. The portion of Walcott's section which is here assigned to the Mount Whyte formation hence has, according to Walcott, a thickness of 271 feet in close agreement with the writer's measured value of 281 feet.

The thicknesses of the Mount Whyte formation as measured in different sections are reported in table 1. In the case of the sections measured by Deiss, the thickness of the formation was reduced by subtracting the beds assignable to the Peyto limestone. Deiss' Ptarmigan Peak section required special attention. Here Deiss recognized the "Ptarmigan limestone" which, in the writer's opinion,

TABLE 1.—*Thickness of the Mount Whyte formation in 18 sections*

Section No.	Locality	Thickness *Feet*	Author (D = Deiss, R = Rasetti)
2	Mount Niblock	281	R
3	Mount Whyte	211	R
4	Ross Lake	264	D
5	Mount Bosworth	389	R
6	Mount Odaray	161	R
9, 16	North Gully-Fossil Gully	578	R
12	Ptarmigan Peak	405	D
15	Bow Lake	503	R
17	Monarch Mine	302	R
19	Hector Creek	480	R
20	Eiffel Peak	58	R
21	Mount Temple	108	R
22	Mount Schaffer	112	R
23	Mount Cathedral	155	R
24	Popes Peak	226	R
25	Mount Victoria	63	R
27	Pinnacle Mountain	98	R
	Castle Mountain	145	D

must be redistributed between the Mount Whyte and Cathedral formations. After examination of the section on Ptarmigan Peak, the writer decided to include the basal 165 feet of Deiss' "Ptarmigan limestone" in the Mount Whyte, the rest in the Cathedral.

The thicknesses reported in table 1 are also represented on a map (fig. 5). The formation is obviously thicker in the northern part of the area investigated, the upper Bow Valley (not comprised in the map) but elsewhere the thickness varies erratically, reaching a minimum of 58 feet on Eiffel Peak and a maximum of 578 feet in the Fossil Gully section on Mount Stephen. The *Fieldaspis bilobata* faunule collected 22-28 feet above the base of the formation on Eiffel Peak is essentially the same as the *Fieldaspis furcata* faunule found in the uppermost 95 feet of the 578 feet of strata at Fossil Gully. The paleontologic evidence seems to indicate that the youngest beds of the formation are approximately of the same age everywhere, while older strata that are present in the thicker sections are absent where the formation is thinner. There seems to be an axis of minimum thickness (indicated in fig. 5) running in a northwest-southeast direction from the bottom of the Yoho Valley to Eiffel Peak, the Mount Whyte formation thickening on either side of this axis. Northeast of the axis the Middle Cambrian formations have the typical facies of the Bow trough. Southwest of the axis at least some of the Middle Cambrian formations have different facies, and we may include at least part of this area in Walcott's Goodsir trough. Southwest of the fault line, parallel to the above-mentioned axis, indicated in figure 5, no Middle Cambrian sediments come to the surface. According to the suggested interpretation, this anticlinal axis developed in late Early Cambrian time and represents a line of maximum unconformity between the Lower and Middle Cambrian sediments.

Although the present work does not include the Mount Assiniboine area, a comment on the unit there defined by Deiss as the Naiset formation is in order. Deiss used the name for 475 feet of siliceous and calcareous shales and argillaceous limestones overlying the Gog formation and underlying the Cathedral dolomite. Walcott had assigned these strata to the Mount Whyte formation. Deiss (1940) used a new name because fossils collected from the upper part of the Naiset were considered of Medial Cambrian age, in contrast with the Early Cambrian age of the fauna of the Mount Whyte formation. If the Mount Whyte formation in the Bow Range and the Naiset formation in the Mount Assiniboine area were proved to be a continuous lithogenetic unit, there would be no need for separate formational names even if this unit were found to transgress the Lower-Middle Cambrian boundary. However, this nomenclatural problem does not arise because there is no faunal difference between the Mount Whyte and Naiset formations, both units including exclusively fossils of Medial Cambrian age. An idea of the fauna of the Naiset formation can be obtained from the fossils collected by Walcott from his locality 62w and which are preserved in the U. S. National Museum. The species include:

- **Amecephalus cleora* Walcott.
- **Caborcella skapta* (Walcott).
- **Olenoides damia* (Walcott).
- *"*Ptychoparia*" *gogensis* Walcott.

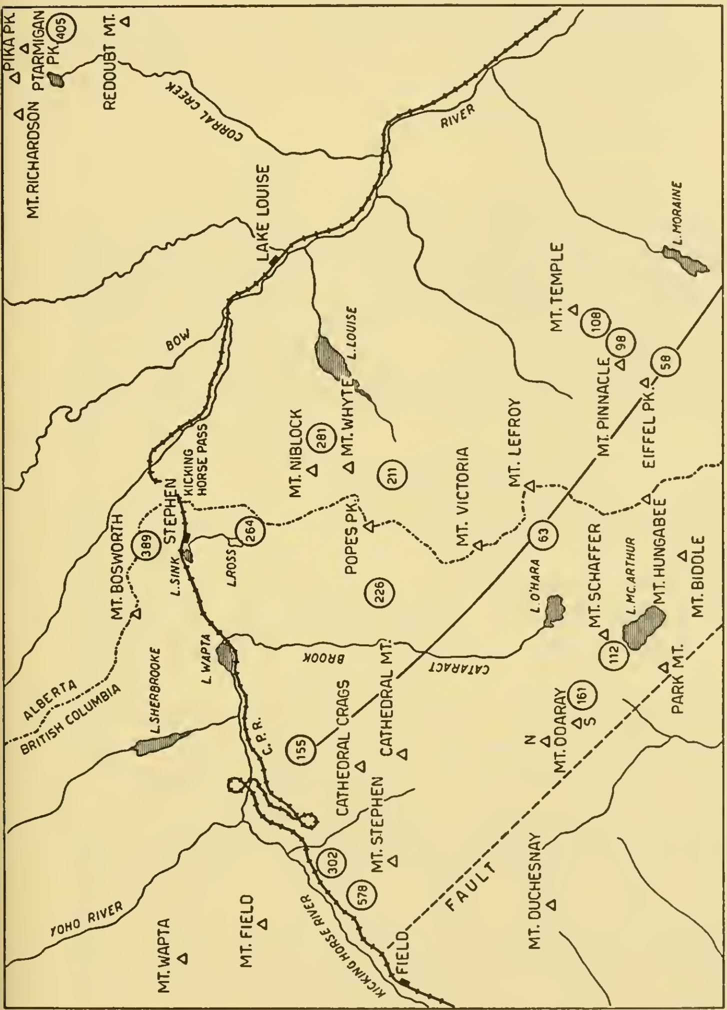

FIG. 5.—Map indicating thickness of the Mount Whyte formation. Thickness (in circles) measured in feet. The solid line represents an axis of minimum thickness. West of the fault indicated by a dotted line no Middle Cambrian strata are exposed.

The first two species are typical of the *Plagiura-Kochaspis* fauna of the Mount Whyte formation. *Olenoides* was not found by the writer in the Mount Whyte formation, but is known elsewhere to range from the upper Lower Cambrian through the Middle Cambrian. The last species is a generalized ptychoparid of little stratigraphic significance. Deiss' fossil list for the upper part of the Naiset confirms that the Naiset formation is an equivalent of the Mount Whyte. Since the lithology is not essentially different, there seems to be no need for a separate formational name.

MOUNT WHYTE–CATHEDRAL CONTACT

The Mount Whyte-Cathedral contact is to a greater or lesser extent arbitrary in most of the sections, suggesting that continuous deposition was taking place. The essential changes are an upward decrease of the amount of clastic material and the thicker character of the beds. Where these changes coincide with a transition from limestone to dolomite, a fairly sharp boundary results (e.g., in the Mount Whyte section). Where the lowermost portion of the Cathedral is calcareous, the contact is more arbitrary (e.g., in the Ptarmigan Peak section). At many localities (e.g., at the Kicking Horse Mine) the boundary between limestone and dolomite does not follow the bedding planes, oscillating within a vertical range of 10-50 feet even within short horizontal distances. At the same time, the thickness of the beds increases and the distinctness of the partings decreases but slowly and gradually. In such sections, the Mount Whyte-Cathedral contact is arbitrary within certain limits. A case of dolomitization of the limestone in the upper portion of the Mount Whyte formation occurs at the Monarch Mine on Mount Stephen. Here the top 100-feet limestone unit of the Mount Whyte is represented by dolomite. The reason for including these beds in the Mount Whyte rather than the Cathedral is that the unit can be traced westward across the face of the mountain, and at Fossil Gully becomes a limestone unit (unit No. 11 of the Fossil Gully section) which carries the *Fieldaspis furcata* faunule characteristic of the upper Mount Whyte.

The character of the Mount Whyte-Cathedral contact is described in the sections.

LAKE AGNES SHALE LENTIL

The name "Lake Agnes shale" was mentioned by Walcott (1917c, p. 93) incidentally in describing a trilobite and never defined or used again. Notwithstanding the small thickness and the limited areal extent of the unit thus designated, the term deserves to be revived to provide a name for the highly fossiliferous shale bearing the *Poliella prima* faunule.

As far as known, the Lake Agnes shale is a lentil developed only in the Mount Whyte area, hence included in the type section of the Mount Whyte formation. It was observed at Plain of Six Glaciers (section No. 3) and on Mount Niblock (section No. 2). At both places, it consists of 5 feet of very fine-grained, green-blue-gray, fissile siliceous shale. Its position is 22-27 feet above the base of the formation at Plain of Six Glaciers and 15-20 feet above the base on Mount Niblock. The former locality, where the unit is better exposed, more readily accessible, and more fossiliferous, is chosen as the type locality. This is also the type locality for the Mount Whyte formation.

In the other sections, the same position is occupied by coarser siliceous shales, often with thin interstratified sandstone layers, and the beds are unfossiliferous.

The name derives from Lake Agnes, which occupies the cirque between Mount Niblock and Mount Whyte.

YOHO SHALE LENTIL

This is also a local unit, appearing in the middle portion of the Mount Whyte formation as a result of the westward thickening of the strata on Mount Stephen. It is known only in the northwest face of Mount Stephen, from a little west of the Monarch Mine to Fossil Gully. The only accessible exposures are in North Gully and Fossil Gully.

At the type locality, in a fault block on the southwest side of Fossil Gully, the Yoho shale lentil consists of 135 feet of dark-gray, fine-grained, fissile siliceous shale. At North Gully, it includes a lower 70-feet unit of similar shale, followed by 24 feet of dark-gray, crystalline, mostly thin-bedded limestone interstratified with siliceous shale, in turn overlain by 10 feet of shale; hence possesses a total thickness of 104 feet.

The Yoho shale is an example of the peculiar character of several Middle Cambrian formations in the western part of Mount Stephen. It may be a tongue extending from unexposed strata existing still farther west, but owing to the very limited exposure it will be designated as a lentil. It will be noticed that the Yoho shale is exposed at the boundary between Walcott's Bow and Goodsir troughs.

The Yoho shale carries the *Stephenaspis bispinosa* faunule that seems to be approximately equivalent to the *Poliella prima* faunule of the Lake Agnes shale. The unit is next only to the *Ogygopsis* shale in the abundance of fossils. The fact that such a remarkably fossiliferous shale had not been discovered earlier shows the superficial character of the previous investigation of Mount Stephen. The name derives from the Yoho River, which flows into the Kicking Horse River near the base of Mount Stephen.

CATHEDRAL FORMATION

TYPE SECTION

The Cathedral formation was originally defined as "massive, arenaceous and dolomitic limestone" (Walcott, 1908a) and its type locality was given as "Cathedral Mountain and Cathedral Crags, east of Mount Stephen and southeast of Mount Bosworth." When the formation was redefined (Walcott, 1928) the type locality was changed to "south face of Mount Bosworth between Hector and Stephen on the Canadian Pacific Railway, also finely exposed in Cathedral Crags east of Mount Stephen." Lithologically the formation was redescribed as "more or less arenaceous, thick and thin layers of hard, gray limestone forming fine cliffs when not broken down."

The change in type locality was opportune, since the strata are well exposed but largely inaccessible in Cathedral Mountain and Cathedral Crags, hence a section was never measured there. Deiss (1939) adopted the Mount Bosworth section as typical and later (Deiss, 1940) measured it on the east ridge of the mountain. Unfortunately, at that locality some of the top beds are cut off by a fault, hence Deiss' measured thickness of 1,085 feet is not complete. The entire formation is present farther west in the south slope of Mount Bosworth, but parts of the beds are covered by talus and soil. It will be shown that the thickness of the Cathedral formation is fairly constant within a relatively large area and averages 1,200 feet in the sections nearest to Mount Bosworth, hence the thickness missing in Deiss' section is not great.

Walcott (1917a) subsequently named another unit, the Ptarmigan formation, supposed to occupy an interval above the Mount Whyte and below the Cathedral. At the type locality, on the south slope of Ptarmigan Peak in the Slate Mountains, the Ptarmigan formation was stated to include 516 feet of limestone. When a first detailed description of the Ptarmigan Peak section was later given (Walcott, 1928, p. 278), the Mount Whyte-Ptarmigan boundary was raised 90 feet, thus reducing the thickness of the Ptarmigan to 426 feet. Deiss (1939) recognized the "Ptarmigan limestone" in the Ptarmigan

Peak section and gave its thickness as 460 feet. He placed the Ptarmigan-Cathedral contact at the boundary between the underlying limestone and the overlying dolomite. By this procedure the thickness of the Cathedral formation in the Ptarmigan Peak section was reduced to 620 feet. Deiss could find only 105 feet of Ptarmigan limestone on Castle Mountain, 195 feet doubtfully assigned to the formation on Mount Bosworth, and none at Ross Lake. The writer does not recognize the "Ptarmigan limestone" for reasons that are fully explained later, hence the beds referred to the Ptarmigan by Deiss are redistributed among other formations. In the Ptarmigan Peak section, the basal 165 feet of Deiss' Ptarmigan are reassigned to the Mount Whyte formation; the remaining 395 feet are typical of the Cathedral (see discussion of lithology) and are included in this formation, thus bringing it to a more normal thickness of 1,015 feet. The 195 feet of Deiss' doubtful Ptarmigan on Mount Bosworth were already reassigned to the Mount Whyte formation. The writer has not examined the Castle Mountain section, but Deiss' description of the lithology makes it clear that the 105 feet which he assigned to the Ptarmigan belong to the Cathedral.

LITHOLOGY AND THICKNESS

The Cathedral formation consists almost entirely of carbonates, mostly in the form of massive limestone or dolomite.

Deiss designated the formation as the "Cathedral dolomite" because of the prevalently dolomitic character of the rock in his measured sections. In the type section on the east ridge of Mount Bosworth, the formation is stated to include 830 feet of dolomite, 247 feet of limestone, and 8 feet of shale. This, however, does not give a correct picture of the average lithology, as many dolomite units grade laterally into limestone. On the south slope of Mount Bosworth, 1 mile west of Deiss' measured section, part of the strata are covered, but all the rock that can be seen, certainly more than half the thickness of the formation, is calcareous. On the east ridge itself, a few hundred feet north of the crest, several intervals that were described by Deiss as dolomite change to limestone. This lateral intergrading of limestone and dolomite was observed in almost all sections where the formation was studied (see also Deiss, 1940, pp. 775-776). The dolomite-limestone-boundary may follow the bedding for considerable distances, as in the south slope of Ptarmigan Peak, where this fact led Deiss to recognize the "Ptarmigan limestone." However, the writer followed the contact around the mountain, in the cliffs of the northwest face and above the lake in the cirque north of Ptarmigan and Pika Peaks. At that locality, the limestone-dolomite contact shifts to a lower horizon, suddenly reducing the "Ptarmigan limestone" from 395 to 100 feet. It is obvious that this contact cannot be used as a formational boundary. At other localities, lenses of limestone in dolomite, lenses of dolomite in limestone, interfingering tongues of limestone and dolomite, and other irregular forms of the limestone-dolomite contact can be observed. The contact is sometimes so sharp that hand specimens were collected where the lateral change of limestone into dolomite takes place within less than one inch. The irregular dolomitization of a dark-gray limestone in the upper Cathedral formation on Mount Temple is illustrated by two photographs on plate 5.

The better to illustrate the lithology and thickness of the Cathedral formation, data from Deiss' and the author's measured sections are collected in table 2. The formation is naturally divided into "lower Cathedral" and "upper Cathedral" by the Ross Lake shale. Where this shale is absent, the formation is left undivided. The table includes the respective thicknesses of limestone and dolomite separately for the lower Cathedral, the upper Cathedral, and the formation as a whole. Inspection of the table shows: (1) Limestone is present in considerable amount, in some of the sections prevailing over dolomite. (2) Dolomite is, on the average, just as abundant in the lower as in the upper part of the formation. These data clearly show the invalidity of the "Ptarmigan formation" based on the distinction between limestone and dolomite. The mixed lithology also makes it advisable to use the term "Cathedral formation" rather than "Cathedral dolomite."

Table 2 also shows the remarkably constant thickness through most of the area, where the formation averages 1,200 feet; excepting the Castle Mountain section where the formation, measured by Deiss, is considerably thinner. The Ross Lake shale, when present, occurs on the average somewhat over 400 feet from the base, hence the lower Cathedral represents from one-third to two-fifths of the formation. Only in the Bow Lake section, at a considerable distance from the other measured sections of the formation, the Ross Lake shale divides the Cathedral into almost equal parts.

The limestones of the Cathedral formation are mostly thick-bedded, often massive without apparent partings for considerable thicknesses, medium to dark gray, sometimes mottled, finely crystalline to fine-grained. Algal concretions (*Girvanella*) are frequently observed.

TABLE 2.—*Thickness and lithology of the Cathedral formation in nine sections*

Section No.	Locality	Thickness of lower Cathedral			Thickness of upper Cathedral			Thickness of formation			
		Limestone	Dolomite	Total	Limestone	Dolomite	Total	Limestone	Dolomite	Shale	Total
2	Mount Whyte	48	415	463	316	385	701	364	800	5	1169
4	Ross Lake	20	391	411	Not measured			Not measured		8	Not measured
5	Mount Bosworth	84	301	385	163+	529+	692+	247+	830+	8	1085+
6	Mount Odaray	Not measured			Not measured			60	1130	0	1190
12	Ptarmigan Peak	Not measured			Not measured			508	512	0	1015
15	Bow Lake	590	0	590	81	565	646	671	565	6	1242
20	Eiffel Peak	40	365	405	Not measured			Not measured		0.5	Not measured
21	Mount Temple	240	225	465	655	100	755	895	325	8	1228
	Castle Mountain	105	198	303	0	472	472	105	670	0.5	775

Many beds contain stringers or irregular inclusions of less soluble material weathering in relief. When the limestone grades laterally into dolomite, two changes are almost invariably apparent: the dark pigment disappears, producing light-gray or cream-colored dolomites even when the corresponding limestone is black-gray; and the texture becomes much more coarsely crystalline. These crystalline dolomites almost invariably weather to a light- to dark-tan color and form rough surfaces under solution. Sometimes limestone is partially dolomitized producing a mottled appearance. The thin- or thick-bedded character of the strata is usually unaffected by the lateral change of limestone into dolomite.

The writer will not attempt to decide the moot question whether the dolomite resulted, as Deiss (1940, p. 776) is inclined to believe, from simultaneous deposition of limestone and dolomite, or an original limestone was secondarily altered to dolomite. In certain cases there is some evidence for secondary dolomitization, for example, in the vicinity of the Monarch Mine, situated in the lowermost portion of the Cathedral formation, where the unusually strong dolomitization affects even the uppermost portion of the Mount Whyte formation and suggests some connection with the formation of lead and zinc deposits (Allan, 1914). At other localities the writer got the impression that the Cathedral is more apt to be dolomitized near faults or other structural disturbances. If this fact were ascertained, it would prove the secondary origin of at least some of the dolomite. However, the observations are not extensive enough to show that the effect is real.

The facies of the formation on Mount Stephen deserves special discussion. As it was mentioned in the description of Mount Stephen, in the eastern part of the mountain the Cathedral formation is entirely dolomitic, and although the thickness was not measured, it appears to be normal. Proceeding westward, units of shale and thin-bedded limestone appear and rapidly thicken at the expense of the interfingering dolomite tongues. At Fossil Gully, 1 mile west of the Monarch Mine, the Cathedral dolomite is reduced to two units, 24 and 100 feet thick respectively, all the rest being replaced by strata of the new facies. At the same time the boundary between the Cathedral and the Stephen becomes indefinite, hence 2,214 feet of beds overlying the Mount Whyte formation and underlying the Eldon dolomite had to be assigned to the undivided Cathedral and Stephen formations. The lower part of these 2,214 feet of strata is fossiliferous and yields faunules unknown elsewhere in the area. It is clear that within Mount

Stephen we observe a sharp transition between two different facies of the Middle Cambrian deposits. A great change was known to affect the Upper Cambrian sediments at nearly the same boundary, the prevalently calcareous formations of the Bow trough (Walcott, 1927) being replaced by the shaly sediments of the Goodsir trough. Now for the first time the evidence presented shows that the distinction between these two sedimentary basins was already developed in Medial Cambrian time. Unfortunately only an extremely narrow area of the Middle Cambrian sediments at the margin of the Goodsir trough is preserved in Mount Stephen. Farther southwest only younger formations are exposed and structural complications accompanied by metamorphism render a study of the stratigraphy difficult. Figure 4 represents in diagrammatic form the succession of beds in both the eastern and western parts of Mount Stephen.

CATHEDRAL–STEPHEN CONTACT

The Cathedral-Stephen contact is one of the best-defined formational boundaries in the area. The thick-bedded limestone or dolomite of the Cathedral is usually overlain by thin-bedded, argillaceous, platy limestone of the Stephen and the contact is sharp in most of the sections. Furthermore, these basal beds of the Stephen are readily recognized by the presence of the *Glossopleura boccar* faunule. In some of the sections (Mount Odaray, Park Mountain, Monarch Creek) the *Glossopleura* fauna seems to be missing, the Stephen formation beginning with the shaly unit that usually forms its middle portion. The Cathedral-Stephen contact is even sharper in these cases.

The time interval between the deposition of the uppermost Cathedral and the lowermost Stephen in the sections where the latter formation has normal lithology does not seem very great, since in the Skoki Valley section (No. 13) a *Glossopleura merlinensis* faunule, collected from the upper Cathedral, is closely related to the *Glossopleura boccar* faunule of the basal Stephen. An unconformity must be present between the Cathedral and the Stephen where the latter does not include beds of the *Glossopleura* zone.

ROSS LAKE SHALE MEMBER

The shale now bearing this name was known for a long time only from drift blocks collected by Walcott at the base of Mount Bosworth. These blocks yielded the abundant *Albertella bosworthi* faunule and were believed by Walcott to belong in the Mount Whyte formation. Burling (1916) first located the shale in place in the Cathedral formation on Mount Bosworth. Walcott (1917a, p. 4) named and defined the shale as follows:

The Ross Lake shale member of the Ptarmigan formation (*Albertella zone*).—A name proposed for the fine siliceous shale carrying the Albertella fauna in the Ptarmigan ? formation.

Type locality.—In cliffs above Ross Lake.

Character.—Dark gray, fine siliceous shale with local fillets and thin layers of gray limestone.

Thickness.—From 7 to 11 feet.

Walcott's reference of the Ross Lake shale to the "Ptarmigan formation" needs no further discussion at this point, as the position of the shale has been explained in describing the Cathedral formation.

The Ross Lake shale is generally a dark blue-gray, fine-grained, fissile siliceous shale. At some localities (e.g., Eiffel Peak) the interval is represented by alternating thin, irregular layers of limestone and siliceous shale. In other sections (e.g., Mount Bosworth, Ross Lake, Mount Temple) the unit is prevalently siliceous, but still includes nodules, lenses or thin layers of gray, finely crystalline limestone. The Ross Lake shale does not exceed 8 feet in thickness, yet is surprisingly widespread for such a thin unit. It extends at least from Mount Temple at the southeast to Bow Lake at the northwest. Furthermore, the writer found the shale present near Sunwapta Pass, at the southern end of Jasper Park, 52 miles northwest of Mount Temple. Whether the unit is continuous throughout this distance or consists of isolated lenses remains undetermined.

The only sections where the shale was searched for and not found, although the Cathedral formation is completely exposed, are the Ptarmigan Peak and Mount Odaray sections. The shale is probably also absent in the eastern part of Mount Stephen, in the valley of Monarch Creek.

The position of the Ross Lake shale in the Cathedral formation and its thickness in various sections are given in table 2.

The Ross Lake shale is highly fossiliferous in almost all outcrops and carries the *Albertella bosworthi* faunule described under the fauna of the *Albertella* zone.

STEPHEN FORMATION

TYPE SECTION

The Stephen formation was first defined by Walcott in 1908 (Walcott, 1908a, pp. 3-4) and described as follows:

Type locality.—Bluish gray and greenish gray limestone and shale band about 2,700 feet up above railroad track on the north and east sides of Mount Stephen.

Thickness.—On Mount Stephen, 562 feet, with 150 feet of local development of Ogygopsis shales at the summit.

The same year Walcott (1908c) published a detailed section of the formation on Mount Stephen, in which he gave the thickness of the formation as 712 feet and thus clarified his earlier statement.

In 1928 (Walcott 1928, pp. 315-319) he again discussed the Stephen formation. The type locality was now stated to be "northwest side of Mount Stephen, above Field." The thickness was again stated to be 712 feet (Walcott, 1928, p. 247) and the lithology described as follows:

> On Mount Stephen, calcareous, siliceous, and finely arenaceous shales with more or less argillaceous matter, superjacent to a thick band of bluish-black limestones in thin layers, which in turn is underlain by a series of oolitic and gray limestones alternating with bands of dolomitic limestone and a few bands of siliceous shale.

On pages 315-319 of the same paper, in the detailed description of the Mount Stephen section, 190 feet of "bluish-gray limestone with bands of dark siliceous shale in lower portion" were transferred from the Eldon to the Stephen, thus bringing the latter formation to a thickness of 912 feet.

In describing Mount Stephen, the writer already pointed out that Walcott's section on that mountain was not derived from the measurement of a continuous succession of strata at any one locality, but is instead a composite section, as evidenced by the inclusion of the *Ogygopsis* shale in the Stephen formation and the description of the Cathedral formation as dolomitic. In the western part of the mountain, where the *Ogygopsis* shale crops out, the Cathedral is not exposed, and at the nearest exposure, above Fossil Gully, is not dolomitic but almost entirely represented by thin-bedded limestone and siliceous shale.

Furthermore, the anomalous lithology of the Cathedral formation in the western part of Mount Stephen (see discussion of formation) makes even a continuous measured section at that locality (the writer's Fossil Gully section) unsuitable for defining the Stephen formation, as the Cathedral-Stephen boundary is not clearly marked either lithologically or faunally. The section in the east face of Mount Stephen (Monarch Creek section) is unsuitable because the Stephen formation at that locality is unfossiliferous and the top portion is inaccessible. Moreover, the succession of strata that might be defined as the Stephen formation both in the eastern and western parts of Mount Stephen is not typical of that portion of the stratigraphic column in the area investigated.

The conclusion is that the type section of the Stephen formation must be established elsewhere than on Mount Stephen. There are several sections that have been accurately measured either by Deiss (on Castle Mountain, Ptarmigan Peak, Mount Bosworth) or by the writer (on Mount Odaray, Park Mountain, Mount Whyte, Mount Temple) and where the formation is excellently exposed. In the Mount Odaray and Park Mountain sections, the Stephen is not typical for the area, these localities being situated at the margin of the "Bow trough" where the facies of the Middle (and Upper) Cambrian sediments undergoes a rapid lateral change. Among all the other sections which are free of this objection, the writer prefers to use the Mount Bosworth section as typical because it was one of the first measured by Walcott (1908, pp. 204-207; 1928, pp. 308-314), has been often cited in the literature, and is nearest to Mount Stephen. The Mount Bosworth section was accurately measured by Deiss (1940) on the south slope of the mountain.

LITHOLOGY AND THICKNESS

At the type locality in the south slope of Mount Bosworth, the Stephen formation as measured by Deiss consists essentially of three units. In ascending order, these are: (1) 134 feet of dark-gray, fine-grained to medium-crystalline limestone, more argillaceous and thin-bedded in the lower part, purer and thicker-bedded in the upper portion; (2) 185 feet of gray and greenish siliceous and calcareous shales with some interstratified thin-bedded limestone; (3) 151 feet of finely crystalline or fine-grained, black-gray, mostly thin-bedded limestone. Thus the total thickness of the formation on Mount Bosworth measured by Deiss is 470 feet.

The same three lithologic units are recognizable in the sections on Castle Mountain and Ptarmigan Peak (Deiss, 1939) and in those measured by the writer on Mount Whyte and Mount Temple. The total reported thickness of the formation is 285 feet on Castle Mountain, 315 feet on Ptarmigan Peak, 495 feet on Mount Whyte, 499 feet on Mount Temple, 440+ feet on Mount Odaray, 548 feet on Park Mountain, and 376 feet in the eastern part of Mount Stephen (Monarch Creek). From these data the thickness appears more variable than it really is, because in Deiss' Castle Mountain and Ptarmigan Peak sections thin-bedded dolomite beds that were included in the basal Eldon probably represent the dolomitized equivalent of a portion of the limestone included in the upper Stephen in the other sections. The writer would transfer from the Eldon to the Stephen 85 feet of dolomite in the Castle Mountain section and 170 feet in the Ptarmigan Peak section, thus bringing the total thickness of the formation in those sections to 370 and 485 feet respectively (see discussion of Stephen-Eldon boundary).

On Park Mountain, Mount Odaray, east Mount Stephen (Monarch Creek) and west Mount Stephen (Fossil Gully) the character of the formation is anomalous in that the basal limestone unit seems to be absent, the middle shaly unit immediately overlying the Cathedral dolomite or limestone (in the Fossil Gully section the upper Cathedral is replaced by shale and the Cathedral-Stephen boundary remains undefined). Faunal evidence also supports the conclusion that, at least on Park Mountain and Mount Odaray, sediments corresponding to the time interval in which the basal limestone was formed elsewhere were not deposited. All these localities where the Stephen formation has anomalous character lie at the southwestern margin of Walcott's Bow trough (Walcott, 1927).

The faunas are described in another part of this paper; however, it is opportune to discuss briefly their distribution within the formation. Wherever the Stephen has a basal limestone unit, it always yielded both to Deiss and the writer faunules of the *Glossopleura* zone. These beds are highly fossiliferous in many of the sections, but yield little besides specimens of *Glossopleura* and *Polypleuraspis*. The overlying, mostly shaly unit was found by the writer to be almost barren. On Mount Odaray, where this unit directly overlies the Cathedral dolomite, it yielded near the base a faunule with *Ehmaniella* and *Solenopleurella,* certainly younger than the fauna of the *Glossopleura* zone. Hence the conclusion that the Stephen at this locality does not include beds of the *Glossopleura* zone. The uppermost unit of the Stephen formation, a black-gray limestone, is barren in some of the sections, while in others (Park Mountain, Mount Odaray, Fossil Gully) it is extremely fossiliferous, yielding rich faunules of the *Bathyuriscus-Elrathina* zone, the most characteristic and widespread fossils being *Bathyuriscus adaeus* and *Tonkinella stephensis.* The writer finds it difficult to establish a correlation between the faunules observed in the Stephen formation above the *Glossopleura* zone and those reported by Deiss from the same beds in the Castle Mountain section. Unfortunately the writer had no opportunity to collect from the Stephen at this locality and thus acquire first-hand evidence on the faunas mentioned by Deiss. According to Deiss, in the Castle Mountain section the fauna of the *Glossopleura* zone is succeeded by several faunules; the lowermost one is characterized by *Ehmaniella* and

Solenopleurella, the next by *Solenopleurella* and *Thomsonaspis,* the uppermost by *Olenoides, Solenopleurella,* and *Thomsonaspis.* The writer did not find any trilobite that could be referred to *Thomsonaspis* in any of his sections; as to the other genera mentioned by Deiss, they suggest analogy with the above-mentioned faunule from the shaly portion of the Stephen on Mount Odaray, and also with the *Ehmaniella burgessensis* faunule of the Burgess shale. On the other hand, Deiss evidently did not find the faunules characterized by *Bathyuriscus adaeus* and *Tonkinella stephensis* in any of his sections, as he could not have failed to comment upon such striking assemblages. The writer's impression is that these assemblages are younger than any of the faunules reported by Deiss from the Stephen formation, but the point cannot be settled until collections from the Castle Mountain section have been examined. The faunules of the *Ogygopsis* and Burgess shales are mentioned in discussing these units.

STEPHEN-ELDON CONTACT

The boundary between the Stephen formation and the overlying Eldon dolomite is artificial and must be located more or less arbitrarily. The situation is similar to that presented by the Mount Whyte-Cathedral boundary, the uncertainty being still greater in the present case. The limestone of the upper Stephen gradually becomes thicker-bedded and changes to dolomite. When a change in thickness of the beds happens to coincide with the limestone-dolomite boundary, apparently the formations can be sharply separated. However, the distinction is illusory, because if the strata are followed laterally, sooner or later the limestone-dolomite contact is observed to shift to a higher or lower horizon, or even not to follow the bedding planes at all. This state of affairs was observed in the eastern and western parts of Mount Stephen, on Mount Bosworth, Mount Whyte, Mount Victoria, Mount Temple, Mount Odaray and elsewhere. Hence the reported thickness of the upermost, calcareous unit of the Stephen is to some extent arbitrary. The writer transferred a portion of thin-bedded dolomite in Deiss' Castle Mountain and Ptarmigan Peak sections from the Eldon to the Stephen because the thickness of the beds is believed to be more significant than the distinction between calcareous and dolomitic composition of the rock.

A better-defined Stephen-Eldon contact would result if the uppermost unit of the Stephen were included in the Eldon. Then the boundary, placed at the contact of an underlying shaly unit and an overlying limestone, would become fairly sharp and independent of the erratic dolomitization of the limestone. The Stephen formation would be reduced to an almost uniform thickness of 249 feet on Castle Mountain, 295 feet on Ptarmigan Peak, 319 feet on Mount Bosworth, 285 feet on Mount Whyte, and 331 feet on Mount Temple. In the "anomalous" sections lacking the basal limestone unit, the thickness would be 120 feet on Mount Odaray, 128 feet on Park Mountain, and 170 feet on east Mount Stephen. The suggested change is not formally adopted here because the Eldon formation has been insufficiently studied.

On Park Mountain, the black limestone here still included in the upper part of the Stephen is not overlain by the usual Eldon dolomite, but by a thick succession of argillaceous limestones and siliceous shales. Apparently no Eldon dolomite was deposited at this place, which is only a few miles from localities (e.g., Mount Stephen, Mount Temple, Mount Bosworth) where the Eldon is normally dolomitic. The anomalous lithology of the Eldon on Park Mountain is analogous to the replacement of the Cathedral dolomite by shale and argillaceous limestone in the western part of Mount Stephen (on Park Mountain the Cathedral is normally dolomitic). Both localities are evidently near the margin of Walcott's Bow trough. The boundaries that separated the Bow and Goodsir troughs apparently oscillated with time. When the Cathedral dolomite and limestone were deposited, Park Mountain was within the limits of normal sedimentation of the Bow trough, while the western part of Mount Stephen received different sediments apparently characteristic of the Goodsir trough at that time. Later the black limestone bearing the abundant *Bathyuriscus adaeus* faunule was deposited identically at both localities. Still later, an almost normal Eldon dolomite (except for 150 feet of interstratified siliceous shale, not present in the other sections) was deposited in the whole area of Mount Stephen; while siliceous shales and argillaceous limestones that appear to have been characteristic of the Goodsir trough at that time, were deposited in Park Mountain. Probably the only locality where this shaly facies of the Eldon is now exposed is Park Mountain, as the shaly facies of the Cathedral outcrops only in Mount Stephen. The character of the sediments of the Bow and Goodsir troughs in earliest Medial Cambrian time was mentioned in discussing the Mount Whyte formation.

OGYGOPSIS SHALE LENTIL

The name "*Ogygopsis* shale" was first used by Walcott (1908c, p. 210) with the statement: "This term is applied to the local development of arenaceous and calcareous shale at the summit of the Stephen formation on the northwest slope of Mount Stephen."

The extremely abundant fossil content of the *Ogygopsis* shale was first noted by Klotz and the fauna was described by Rominger (1887), Matthew (1899), and Walcott (1888, 1908d).

In describing the Mount Stephen section, Walcott (1908c, 1928) stated that the *Ogygopsis* shale is 150 feet thick, and that it overlies an interval of bluish-black limestone and underlies another interval of similar lithology which he assigned to the basal Eldon in 1908 and to the uppermost Stephen in 1928. From this description one might infer that the *Ogygopsis* shale has been observed in an orderly succession of beds and that its position at or near the top of the Stephen formation rests on unquestionable stratigraphic evidence.

Deiss (1940) examined the *Ogygopsis* shale outcrop and made the following remarks:

The *Ogygopsis* fauna occurs in several different kinds of matrix: brown soft platy calcareous finely arenaceous shale in the upper beds; green tan platy harder shale in the underlying beds; black-gray calcareous shale beneath the green and tan interval; and white-buff soft slightly calcareous clay-shale at the base. The shale strikes N. 10° to 20° W., and dips 35° to 42° SW. and more steeply than the slope of Mount Stephen at that place. Consequently, as one ascends the slope one goes down-section through the *Ogygopsis* shale. At an elevation of approximately 7,000 feet the *Ogygopsis* shale rests upon steel-gray, buff-weathering, slightly mottled, thin-bedded Cathedral dolomites instead of being overlain by the Eldon dolomite as had been reported. At 7,200 feet in elevation the Cathedral dolomite is faulted against what appear to be thicker-bedded dolomites of the basal Eldon formation.

The foregoing facts suggest that on Mount Stephen the *Ogygopsis* shale forms the base instead of the upper part of the Stephen formation, that the published type section is largely inaccurate and possibly inverted, and that beds equivalent to the *Glossopleura* zone on Castle Mountain, Ptarmigan Peak and elsewhere are absent.

The only strata with which the *Ogygopsis* shale is seen in contact are the dolomites of uncertain stratigraphic position mentioned by Deiss, as the outcrop is separated by faults from the orderly succession of beds farther north and east. The nearest good section of the strata underlying the Eldon dolomite is exposed and was measured by the writer in and above Fossil Gully (section No. 9; see also fig. 3). At this locality, 1 mile north of the *Ogygopsis* shale outcrop, there occur 1,000 feet of shales (representing portions of the undivided Cathedral and Stephen formations) that are similar lithologically to portions of the *Ogygopsis* shale. However, these shales are almost unfossiliferous, hence a possible equivalence of some part of them to the

Ogygopsis shale cannot be proved. West and south of Fossil Gully, the entire Eldon dolomite is still exposed and undisturbed, while exposures of lower strata are either cut off or greatly disturbed by the Fossil Gully fault. The Eldon dolomite with the locally developed 150 feet of shale (unit 2 of the Eldon dolomite in the Fossil Gully section) can be followed to within a distance of ¼ mile from the *Ogygopsis* shale outcrop. Since this shale appears unfossiliferous and is different lithologically from any of the varieties of *Ogygopsis* shale, it is exceedingly unlikely that it may represent its equivalent.

In conclusion, it appears certain that the *Ogygopsis* shale in its recognizable fossiliferous form is nowhere exposed in an orderly succession of strata and its position must be inferred from faunal evidence. This evidence, discussed in another part of this paper, makes it plausible that the *Ogygopsis* shale lies somewhere between the lower and upper calcareous units of the Stephen formation in its typical sections.

The writer considered the opportunity of giving the *Ogygopsis* shale a proper stratigraphic name derived from a topographic feature instead of using the faunal designation. This was not done for two reasons: (1) following a long-established tradition makes the terminology clearer than the introduction of a new name, and (2) the *Ogygopsis* shale is so poorly known as to thickness and position in the section that it affords little basis for naming a stratigraphic unit.

BURGESS SHALE LENTIL

The name Burgess shale was first used by Walcott in 1911 (Walcott, 1911b, p. 51, footnote) and the unit was defined as follows:

Burgess shale.—This name is proposed as a geographic name for a shale to which the term of Ogygopsis shale was given in 1908 (Smithsonian Miscellaneous Collections, vol. 53, p. 210). It is proposed to call it the Burgess shale of the Stephen formation.

Type locality.—Burgess Pass east of Mount Burgess and on the west slope of Mount Field and the ridge extending to Wapta Peak. . . . The Burgess formation occurs to the southward across the Kicking Horse Canyon in the side of Mount Stephen.

Thickness.—On the west slope of Mount Field, 420 feet; on the northwest slope of Mount Stephen, about 150 feet.

Stratigraphic position.—Above thin bedded, dark gray and bluish-black limestones of the Stephen formation, and beneath a thin bedded limestone below the massive, arenaceous limestones of the Eldon formation that cap Mount Burgess, Mount Field, and Mount Stephen.

This original definition included under the name "Burgess shale" also the *Ogygopsis* shale on Mount Stephen. However, Walcott himself in his later publications never employed the term in this broad sense, limiting the name Burgess shale to the outcrop on the west slope of the ridge between Mount Field and Mount Wapta. In 1928 (Walcott, 1928, p. 320) he gave a detailed section at this locality, specifying that the Burgess shale has a thickness of 410 feet and that the celebrated "phyllopod bed" occurs 30-40 feet above the base. In this, as in his other publication, he considered the Burgess shale an exact equivalent of the *Ogygopsis* shale on Mount Stephen.

It is well known that Walcott quarried the Burgess shale and recovered from it an exceptional fauna and flora including, besides fossils preserved in ordinary manner, an abundance of forms lacking a hard test and representing invertebrate groups never before or after collected from Cambrian deposits. These unique fossils are described in a series of publications (Walcott, 1911a, 1911b, 1911c, 1912a, 1919, 1920, 1931) and their discussion is beyond the scope of this paper.

The writer examined and measured a section at and near Walcott's quarry on the slope of the ridge between Mount Field and Mount Wapta (section No. 11). About 1,100 feet of approximately horizontal and mostly well-exposed strata can be measured within the fault block that includes the quarry. Immediately north of the quarry, the strata are cut off by a normal fault that brings Cathedral dolomite into contact with the Burgess shale. South of the quarry the beds disappear under drift cover, and when they reappear there is no certainty that they represent the same horizon, as the drift seems to conceal a minor fault; moreover, the lithology is different.

The problem of placing these 1,000 feet of strata in the general section cannot be solved by stratigraphic evidence alone, as the succession of beds does not look like any portion of the standard section in the area. Evidently we have here another case of sharp lateral change of facies as we approach the margin of the Bow trough, analogous to the changes that affect the Mount Whyte, Cathedral, and Stephen formations in the western part of Mount Stephen and the Eldon formation on Park Mountain.

The succession of beds in the Burgess Quarry fault block, in ascending order, is the following. The lowermost observable strata are poorly exposed siliceous and calcareous shales, yielding abundant fossils. The faunule is called the *Olenoides serratus* faunule and is almost identical with the faunule of the *Ogygopsis* shale except for the presence of *Pagetia* and the absence of *Ogygopsis*. This interval is overlain by 450 feet mostly consisting of dark-gray siliceous shale with some limestone and dolomite in the upper portion. The "phyllopod bed" of Walcott with its faunule, here named the *Pagetia bootes* faunule, occurs at the base of this unit, while an *Ehmaniella burgessensis* faunule was collected 150 feet higher. These beds are overlain by massive Eldon (?) dolomite that forms the summit of the ridge. We thus have at least 600 feet of almost uninterrupted shaly sediments (there may be more as the lower part of the shale disappears under drift cover) that have no counterpart anywhere in the normal sections. A thick succession of shales occurs in the undivided Cathedral and Stephen formations on Mount Stephen, but there these strata are almost unfossiliferous.

Hence we must resort to paleontologic evidence in order to determine the stratigraphic position of the beds in the Burgess Quarry fault block. This evidence, presented in another part of this paper, makes it likely that the shales here discussed represent a development of the middle portion of the Stephen formation of the typical sections. It is also likely that the lowermost portion of the shales exposed in the Burgess Quarry fault block is at least an approximate equivalent of the *Ogygopsis* shale, hence the latter would be somewhat older than the "phyllopod bed" of Walcott.

FAUNAS

GENERAL STATEMENT

The fossils of the formations considered in this study belong to a number of faunules whose relative ages are known in most cases from unquestionable stratigraphic evidence. The problem of using these data in order to define Middle Cambrian faunal zones of more than local validity presents theoretical and practical difficulties, some of which are briefly discussed.

Within a limited area such as the one here investigated, sharp vertical changes in composition of the faunas may be chiefly attributed to: (1) unconformities, i.e., time intervals not represented by sediments, as the one that occurs at the top of the St. Piran sandstone; (2) barren strata, as much of the Cathedral formation, especially when represented by dolomite; (3) changes in environment and corresponding sedimentary facies, which brought assemblages not greatly different in time, but rather in habitat, to lie over each other in the stratigraphic column; (4) invasion of the basin by organisms that had been gradually evolving elsewhere.

Extensive stratigraphic and paleontologic investigation of a large area is required in order to determine, even approximately, how much of the vertical change of the faunal assemblages in a particular section is due to each of the above-mentioned factors; until this point has been ascertained, subdivision into faunal zones based on that particular section or group of sections can only be tentative.

For the lower part of the stratigraphic range studied in this work, the lowermost portion of the Middle Cambrian, so little is known of the faunal succession elsewhere that the writer felt justified in establishing tentative zones based on the narrow investigated area. The two lowermost Middle Cambrian zones here proposed, the *Wenkchemnia-Stephenaspis* and *Plagiura-Kochaspis* zones, seem distinct enough to deserve separate recognition. However, it is possible that the differences observed are partly due to differences in facies between the corresponding stratigraphic intervals, and it would not be surprising to find in another area the genera here considered characteristic of the respective zones occurring together.

The succeeding *Albertella* and *Glossopleura* zones seem well characterized and can be recognized in most of the Cordilleran sections where the corresponding time intervals are represented. The Middle Cambrian zones above the *Glossopleura* zone so far proposed seem to the writer of doubtful standing. In the Cambrian correlation chart (Howell et al., 1944), the lists of genera considered characteristic of these zones include mixtures of forms from the Cordilleran and Atlantic provinces lumped together on the basis of hypothetical correlations. Even if the genera from the Atlantic province are disregarded, the remaining genera do not appear to be sufficiently distinctive and short ranging to allow a clear definition of the zones.

Middle Cambrian zones have always been defined in terms of trilobites, and the paleontologic material available does not suggest departure from this practice. The writer collected non-trilobitic fossils whenever possible. Next to the trilobites, brachiopods and gastropods (or at least forms usually placed in the latter group) are the most important elements of the faunas. *Hyolithes, Hyolithellus,* and sponge spicules are fairly common in certain beds. These are all the animal groups represented in the Mount Whyte, Cathedral, and Stephen formations apart from the extraordinary fossils of the Burgess shale and other exceptional occurrences of little use for stratigraphic purposes. Besides the trilobites, the other groups that might have value as index fossils are the brachiopods and the gastropods. The former are fairly numerous, but seldom well preserved. Nevertheless it is possible that a paleontologist possessing profound knowledge of the brachiopods and skill in the difficult techniques of preparation could obtain stratigraphic information from these fossils. The excellent work of Bell (1941) on the Cambrian brachiopods of Montana is an example of what can be done in this field. The writer must frankly acknowledge his inadequate competence and list it as one of the reasons for not making use of the brachiopods. The gastropods seem less promising, and a general study of the Cambrian forms would be required before they can acquire stratigraphic value. No new binomial combinations are proposed for nontrilobitic forms even when the present generic reference is known to be erroneous.

Only species collected by the writer from strata in measured sections are used in determining the faunal succession. Exceptions are made for the *Ogygopsis* and Burgess shales where no doubt exists as to the beds from which the fossils were collected.

Deiss published faunal lists, frequently giving only generic identifications or referring to undescribed genera and species. Hence his lists are not quoted as they would add but little information.

FAUNA OF THE BONNIA-OLENELLUS ZONE

Although this paper is primarily concerned with Middle Cambrian stratigraphy and faunas, a brief description of the youngest Lower Cambrian fauna observed in the area is required in order to discuss the problem of the Lower-Middle Cambrian boundary.

Faunal zones for the Lower Cambrian of the Appalachian and Cordilleran provinces have been tentatively defined, but an examination of the basis for the suggested subdivisions shows their highly doubtful standing. The writer believes that the choice of the southern Appalachians for a standard Early Cambrian time scale (Resser, 1933) should be abandoned. The structure in that area is excessively complicated, thick and well-exposed sections of Lower Cambrian strata are lacking, and most of the fossils are known from scattered outcrops of uncertain stratigraphic position. Resser (1938b) named, in ascending order, the *Obolella, Bonnia, Kootenia, Olenellus,* and *Kochiella* zones, the last lacking olenellid trilobites. In the Cambrian correlation chart (Howell et al., 1944) the Lower Cambrian is divided into the *Obolella, Bonnia, Olenellus,* and *Syspacephalus* zones.

The writer does not recognize a post-olenellian Lower Cambrian zone (*Kochiella* or *Syspacephalus* zone for reasons that are fully discussed in the next section of this paper. As to the other proposed zones, the following remarks are indicated. (1) The *Obolella* zone, supposed to lack trilobites, was based on poorly fossiliferous formations of the southern Appalachians. There is no certainty that the absence of olenellids from these beds is not due to unfavorable facies.

Olenellids range through great thicknesses of beds in the Cordilleran province. (2) The *Bonnia* and *Kootenia* zones were chiefly established on the fauna of the reef limestone at Austinville, Va., attributed to the Shady formation. However, Stose and Jonas (1938) questioned the stratigraphic position of the limestone, which occurs in an isolated fault block. It is true that similar faunules occur in orderly sections in southern Labrador and western Newfoundland, but at those localities the faunal succession has been insufficiently investigated. (3) The *Olenellus* zone may represent a shaly facies of the Lower Cambrian deposits rather than a definite time interval. In northwestern Vermont, for example, olenellids seem to prevail when the Lower Cambrian is represented by siliceous shales, while *Bonnia* and small, generalized ptychoparid trilobites are dominant in limestone or dolomite formations, regardless of age.

It is clear that a satisfactory standard time scale for the Early Cambrian will have to be based on an area where thick, orderly, and reasonably fossiliferous successions of Lower Cambrian strata are present. Possibly such sections will be found in western Newfoundland. However, it is more likely that a standard section will be ultimately established in the Cordilleran province, possibly in Sonora (Cooper and Arellano, 1946), or in Nevada, California, or the Canadian Rockies. The area here described is inappropriate for the purpose because most of the Lower Cambrian is unfossiliferous.

The youngest Early Cambrian fauna occurring in the area, the fauna of the Peyto limestone member of the St. Piran sandstone, is listed here in order to illustrate the great faunal change taking place at the Lower-Middle Cambrian boundary. As far as the fossils have been studied, there seems to be little lateral or vertical change in composition of the faunules within the Peyto limestone even where this member attains considerable thickness. Hence these faunules will be listed as one unit. Only the trilobites collected and identified by the writer are listed. This assemblage will be designated as the *Bonnia fieldensis* faunule. An asterisk preceding the name indicates that the type locality and horizon of the species are within the Peyto limestone in the described area.

BONNIA FIELDENSIS FAUNULE

*"*Agraulos*" *unca* Walcott.
**Bonnia fieldensis* (Walcott) (= *columbensis* Resser).
**Crassifimbra lux* (Walcott).
**Olenellus canadensis* Walcott.

Onchocephalus cleon (Walcott).
* *thia* (Walcott).
Paedeumias sp.
Pagetia sp.
Piazella pia (Walcott).
Syspacephalus charops (Walcott).
Zacanthopsis cf. *levis* (Walcott).

To give a correct picture of the composition of the fauna, it must be stated that the Olenellidae are by far the most abundant fossils, some beds being a coquina of their tests. Unfortunately, owing to the large size of these trilobites and the thinness of the test, good specimens are excessively rare. The next in abundance is *Bonnia*, whose thick, well-preserved head and tail shields can be collected from almost any outcrop of the Peyto limestone. The small, generalized Ptychoparioidae are rare except at two localities, on Mount Stephen and Mount Schaffer. *Pagetia* was collected only on Mount Stephen and is very rare. The non-trilobitic forms are chiefly represented by the brachiopod *Nisusia* and the gastropod *Scenella*.

The fauna of the Peyto limestone cannot be definitely assigned to any one of the suggested Lower Cambrian zones. The writer does not see important differences between this fauna and the faunas of the Forteau formation of Labrador and Newfoundland, the Mallet dolomite of northwestern Vermont, and the Shady (?) limestone reefs at Austinville, Va. Resser (1938b) included all these faunas in the *Bonnia* zone, supposed to be older than the *Olenellus* zone. If this interpretation were accepted, the Peyto limestone would be older than such formations as the Rome of the southern Appalachians and the Parker shale of northwestern Vermont. On the other hand, Lochman (1947) suggested the name "*Antagmus-Onchocephalus* zone" for "the uppermost Lower Cambrian zone" in the Cordilleran province. Apparently she had in mind faunas precisely of the type of that occurring in the Peyto limestone. Deiss assigned the fauna of the Peyto limestone (which he considered as the basal portion of the Mount Whyte formation) to a "*Bonnia-Olenellus* zone." Since *Bonnia* and Olenellidae are by far the most common fossils in the Peyto limestone, Deiss' term will be tentatively used. This does not imply that the *Bonnia-Olenellus* zone of Deiss, which appears synonymous with the *Antagmus-Onchocephalus* zone of Lochman, has been recognized to possess general validity even within the Cordilleran province. Its relationship with the tentative zones proposed by Resser remains problematical.

LOWER-MIDDLE CAMBRIAN BOUNDARY

The uncertainty existing about the Lower-Middle Cambrian boundary in the Cordilleran province is chiefly due to three factors: insufficient stratigraphic work, poor knowledge of the faunas, and failure of the stratigraphers, until recent times, to realize clearly the distinction betwen time-stratigraphic and lithologic units (Ashley et al., 1933, 1939; Schenk and Muller, 1941; Moore, 1947). Many authors did not seem to understand the contradiction between the definition of periods and epochs in terms of time, and their attempts to locate the boundaries between the corresponding systems and series by diastrophic or lithologic criteria.

Much of the discussion of the Lower-Middle Cambrian boundary in the Cordilleran province was based on the area here described, as it includes one of the most complete, well-exposed, and fossiliferous records of this portion of the stratigraphic column.

Granted that series are time-stratigraphic units and that faunas supply the only criterion for time equivalence of deposits in distant areas, it follows that the Lower-Middle Cambrian boundary, or the corresponding time boundary between the Waucobian and Albertan epochs, must be defined in terms of faunas.

For many years the Lower Cambrian in North America has been synonymous with the strata carrying the *Olenellus* fauna (Walcott, 1890). This still appears a sound definition, hence the writer considers the Early Cambrian epoch as terminating with the disappearance of the Olenellidae. Obviously there is no certainty that the Olenellidae, or any other group of organisms, appeared or became extinct contemporaneously (or at least within a time interval short enough to be considered negligible on the geologic time scale) even within a single epicontinental sea, such as the one that occupied the Cordilleran geosyncline. The best provisional solution of this difficulty seems to be to define a conventional time equivalence based on a widespread and well-characterized group of fossils (in the present instance the Olenellidae) and use it until the study of the whole faunas in a wide area suggests different correlations. The writer is fully aware of the weakness of correlations based on a single group of organisms. For example, if the Medial Cambrian epoch were defined by the appearance of the Agnostida, the correlation between deposits of the Appalachian and Cordilleran provinces would be very different from the generally accepted one. In the Appalachians, rare agnostids already occur in association with the olenellids, whereas in the Cordilleran province, and especially in the area investigated, there is a wide gap, occupied by several faunas, between the extinction of the olenellids and the appearance of the agnostids. In this instance, evidence from most of the other fossils favors the correlation based on the olenellids, but the true time equivalence may lie somewhere between the extremes resulting from the consideration of each group alone.

In recent times attempts have been made to raise the Lower-Middle Cambrian boundary and thus to admit a post-olenellian Lower Cambrian zone. Examination of the stratigraphic and paleontologic grounds for the suggested modification shows that it was chiefly based on insufficient knowledge of the faunas and misinterpreted stratigraphic evidence. This discussion refers only to the Appalachian and Cordilleran provinces of North America. Precise correlation with the deposits of the Atlantic province and other regions is still uncertain; furthermore, as pointed out by Resser (1933), the Cambrian sequence in North America is far more complete than in other areas and must be used for establishing a generalized time scale.

Resser (1933) tentatively established a post-olenellian Lower Cambrian zone and named it the *Kochiella* zone, stating (Resser, 1933, p. 744) that—

> In the Rocky Mountains the Mount Whyte formation contains the usual olenellid trilobites in its lower portions, but toward the top the *Kochiella* faunas appear. In Manchuria and Greenland similar changes occur, and possibly this portion may be ultimately placed in the Middle Cambrian, even though there is no change in lithology at any place.

The *Kochiella* zone was again used by Resser (1938b) to designate the upper portion of the Rome formation in the southern Appalachians. Resser and Howell (1938) stated that "the uppermost Lower Cambrian is characterized by the *Kochiella* fauna which lacks olenellid trilobites." Howell et al. (1944) recognized a *Syspacephalus* zone as the highest post-olenellian Lower Cambrian zone and listed *Syspacephalus, Inglefieldia,* and *Kochiella* as its characteristic genera.

Let us now examine the facts on which this post-olenellian Lower Cambrian zone was established. The genotype of *Kochiella* and several other species were described by Poulsen (1927) and stated to occur in association with Olenellidae in northwest Greenland. Professor Poulsen confirmed the presence of this association in a personal communication to the writer. Forms that may doubtfully be assigned to *Kochiella* do occur in post-olenellian strata in the Rocky Mountains; still it seems a questionable procedure to name a post-olenellian zone after a genus whose genotype and most of the other described species occur in association with Olenellidae. Similar considerations apply to *Inglefieldia,* whose described species, according to Poulsen, occur in association with Olenellidae in the Cape Kent formation of Greenland. No forms definitely assignable to *Inglefieldia* are known to the writer from the Cordilleran province. Finally, before the present work *Syspacephalus* was known only from the genotype, a species occurring at a single locality in the Peyto limestone on Mount Stephen, where it is associated with *Olenellus* and *Bonnia.* We conclude that the totality of the genotypes and most of the described species of the genera given as characteristic of the uppermost post-olenellian Lower Cambrian zone occur in association with Olenellidae.

The present work shows from unmistakable stratigraphic evidence that *Plagiura cercops* and associated forms, hitherto considered Lower Cambrian, occur above the shale bearing *Amecephalus agnesensis, Poliella prima,* and other species assigned to the Middle Cambrian. The latter assignment appears to the writer entirely correct, hence the *Plagiura* faunule cannot be considered Lower Cambrian. Deiss (1939) recognized a *Plagiura* zone and correctly considered these beds as post-olenellian, but did not give any reasons for his statement that these are "undoubted Lower Cambrian rocks."

The entire Mount Whyte formation was formerly considered Lower Cambrian because of the belief that Olenellidae range through the entire unit. Deiss observed that these trilobites are confined to the basal beds but failed to draw the logical conclusion that there was no longer any basis for assigning the entire unit to the Lower Cambrian. In this work the basal, *Olenellus*-bearing beds are assigned to the underlying St. Piran sandstone, and the Mount Whyte formation thus restricted is considered entirely Middle Cambrian.

The conclusions here adopted are the following:

1. The Early Cambrian, according to tradition, is *defined* as terminating with the disappearance of the Olenellidae. This definition, at least provisionally, applies only to the Appalachian and Cordilleran provinces.

2. In the area investigated, there are no Early-Medial Cambrian transition faunas, the oldest post-olenellian fauna already having fully developed Medial Cambrian character.

3. Formations, being defined as lithologic units, may belong to two epochs. However, in the area studied, the Lower-Middle boundary as above defined coincides with the probably unconformable contact between the Peyto limestone member of the St. Piran sandstone and the Mount Whyte formation. Burling (1914, 1916) and Grabau (1936)

had already suggested placing the Lower-Middle Cambrian boundary at the top of the *Olenellus* zone, i.e., within the Mount Whyte formation as understood at that time.

4. In other areas of the Cordilleran geosyncline, according to published evidence, there seems to be a still greater Lower-Middle Cambrian unconformity, since the *Kochaspis liliana* fauna has been reported almost immediately to overlie the *Olenellus* fauna, thus indicating absence of the intermediate fauna assigned to the *Wenkchemnia-Stephenaspis* zone in this paper.

FAUNA OF THE WENKCHEMNIA-STEPHENASPIS ZONE

The post-olenellian faunas older than the *Albertella* fauna were assigned to a Lower Cambrian *Kochiella* zone by Resser (1938b); to a Lower Cambrian *Plagiura* zone and a Middle Cambrian *Kochaspis* zone by Deiss (1939); to a Lower Cambrian *Syspacephalus* zone and a Middle Cambrian *Kochaspis liliana* zone by Howell et al. (1944). Lochman (1947) did not recognize the existence of a Middle Cambrian zone older than the *Albertella* zone.

The inconsistencies on which the *Kochiella* or *Syspacephalus* zone was based were listed in the discussion of the Lower-Middle Cambrian boundary. The *Plagiura* and *Kochaspis liliana* zones seem to be essentially equivalent, although Deiss considered them distinct enough to be placed in different epochs. Since more and better-preserved fossils from these zones are described in this paper than in all the previous literature, a new approach to the problem is indicated, and two tentative zones are established on the basis of the faunules collected from the Mount Whyte formation and studied in the present work.

The lower zone includes assemblages that were hitherto unknown or misunderstood, and is designated as the *Wenkchemnia-Stephenaspis* zone after two new trilobite genera. The upper zone is designated as the *Plagiura-Kochaspis* zone because it includes the *Plagiura* zone of Deiss and the essentially equivalent *Kochaspis liliana* zone of various authors.

The fauna of the *Wenkchemnia-Stephenaspis* zone occurs in the lower or middle portion of the Mount Whyte formation. However, in several sections the lower part of the Mount Whyte is unfossiliferous; in others (e.g., the Eiffel Peak section) strata of this age apparently were never deposited (see discussion of Mount Whyte formation). Hence our knowledge of the fauna is entirely based on two limited areas: (1) the Mount Whyte-Mount Niblock area, where a faunule of this age occurs in the Lake Agnes shale lentil; and (2) the western part of Mount Stephen, where the lower and middle portions of the Mount Whyte formation are unusually thick and fossiliferous, and yield several faunules of which the youngest is particularly abundant in the Yoho shale lentil.

In the western part of Mount Stephen, in the Fossil Gully and North Gully sections, four faunules assigned to the *Wenkchemnia-Stephenaspis* zone were observed in orderly succession. The oldest of these faunules occurs 140 feet above the top of the Lower Cambrian *Bonnia-Olenellus* zone in the North Gully section, while the youngest occurs in strata immediately underlying the *Plagiura-Kochaspis* zone. The oldest faunule of the *Wenkchemnia-Stephenaspis* zone was collected in limestone at locality W16h and includes the species:

Acrotreta sp.
Syspacephalus laticeps Rasetti.
Wenkchemnia sulcata Rasetti.

The next faunule occurs both in shale and limestone at locality W16i, a few feet above locality W16h, and may be identical with the preceding. The species include:

Syspacephalus sp.
Wenkchemnia sulcata Rasetti.

The third faunule ranges through almost 100 feet of impure limestone and shale in the overlying interval. Collections were made at several horizons (see lists of species from localities W16j, W16j′, W16j″) and showed little change in composition of the faunules, hence these assemblages will be treated as one unit named the *Syspacephalus laticeps* faunule. However, it must be noticed that *Ogygopsis klotzi* was found only in the upper part of this interval. The list of species is the following (an asterisk indicates that the types of the species belong to this assemblage):

SYSPACEPHALUS LATICEPS FAUNULE

Acrotreta sp.
Ogygopsis klotzi (Rominger).
Oryctocephalus sp. No. 1.
**Piazella tuberculata* Rasetti.
Poliella cf. *P. denticulata* Rasetti.
Stephenaspis cf. *S. bispinosa* Rasetti.
**Syspacephalus laticeps* Rasetti.
* *crassus* Rasetti.
cf. *S. gregarius* Rasetti.
**Wenkchemnia sulcata* Rasetti.

The fourth faunule is represented by great numbers of individuals in the Yoho shale lentil (localities W9k, W9k′, W16k), and is designated as the *Stephenaspis bispinosa* faunule from its most striking trilobite. The species include:

STEPHENASPIS BISPINOSA FAUNULE

Hyolithes sp.
Scenella sp.
Acrothele sp.
Acrotreta sp.
Dictyonina sp.
Paterina sp.
Amecephalus agnesensis (Walcott).
**Chancia stenometopa* Rasetti.
Ogygopsis klotzi (Rominger).
Oryctocephalus sp. No. 2.
**Poliella denticulata* Rasetti.
prima (Walcott).
**Stephenaspis bispinosa* Rasetti.
**Syspacephalus gregarius* Rasetti.
* *laevigatus* Rasetti.
perola (Walcott).
**Wenkchemnia spinicollis* Rasetti.

In the Mount Whyte area (localities W2b, W3b; U.S.N.M. 35m), the Lake Agnes shale lentil yields a faunule that is designated by the trilobite *Poliella prima* and includes the species:

POLIELLA PRIMA FAUNULE

Hyolithes sp.
**Acrothele clitus* Walcott.
Acrotreta sp.
**Amecephalus agnesensis* (Walcott).
**Poliella prima* (Walcott).
**Syspacephalus perola* (Walcott).
**Wenkchemnia walcotti* Rasetti.

It is clear from the percentage of common species that the *Stephenaspis bispinosa* and *Poliella prima* faunules are approximately of the same age. The latter is likely to be the younger because of the abundance of *Amecephalus,* which appears to be absent from the earlier faunules of the *Wenkchemnia-Stephenaspis* zone and becomes common in the overlying *Plagiura-Kochaspis* zone.

The identified trilobite genera in the *Wenkchemnia-Stephenaspis* zone are: *Amecephalus, Ogygopsis, Oryctocephalus, Piazella, Poliella, Stephenaspis, Syspacephalus,* and *Wenkchemnia.* The fauna, compared with that of the *Bonnia-Olenellus* zone, is sharply differentiated by the absence of *Bonnia* and the Olenellidae, and the appearance of *Amecephalus, Ogygopsis, Oryctocephalus,* and several genera of the Dolichometopidae, *Poliella, Stephenaspis,* and *Wenkchemnia.* The only genera common with the uppermost Lower Cambrian zone are the generalized ptychoparids *Piazella* and *Syspacephalus,* but little significance should be attributed to the persistence of such forms that are known to range, without differences justifying generic separation, through much of the Lower and Middle Cambrian. On the other hand, the fauna of the *Wenkchemnia-Stephenaspis* zone is rather closely related to those of the overlying *Plagiura-Kochaspis* zone and still higher Middle Cambrian zones, and presents fully developed Middle Cambrian characteristics. Hence the writer considers it amply justifiable to include this zone in the Middle Cambrian, whereas Deiss would consider even a portion of the still higher *Plagiura-Kochaspis* zone as Lower Cambrian. Furthermore, the great faunal change between the *Bonnia-Olenellus* and the *Wenkchemnia-Stephenaspis* zones suggests an unrepresented time interval, i.e., an unconformity between the Peyto limestone and the Mount Whyte formation as it was indicated in discussing these units.

As far as the writer knows, if the fauna of the *Wenkchemnia-Stephenaspis* zone exists in other areas of the Cordilleran province there is no published evidence to indicate it.

FAUNA OF THE PLAGIURA-KOCHASPIS ZONE

The fauna here designated as characteristic of the *Plagiura-Kochaspis* zone is a clearly defined assemblage of closely related faunules occurring in the upper part of the Mount Whyte formation. Some of its species were assigned by Deiss and Resser to the Lower Cambrian (e.g., *Plagiura cercops*), others to the Middle Cambrian (e.g., species of *Kochaspis*), but additional collecting has shown that these fossils occur in the same beds. Furthermore, unquestionable stratigraphic evidence from the Mount Whyte and Fossil Gully sections shows that the *Plagiura-Kochaspis* fauna is younger than any of the faunules assigned to the *Wenkchemnia-Stephenaspis* zone. Since the fauna of the *Wenkchemnia-Stephenaspis* zone was assigned to the Middle Cambrian, *Plagiura cercops* and the associated forms cannot be considered Lower Cambrian.

The upper part of the Mount Whyte formation is generally more fossiliferous than the underlying strata, hence the *Plagiura-Kochaspis* fauna is represented in most of the investigated sections. Several faunules can be distinguished within the zone, although changes are gradual and the general character of the fauna is preserved throughout. The oldest faunule occurs in several sections and is designated as the *Plagiura cercops* faunule although this trilobite ranges into somewhat higher beds. This faunule occurs in limestone and is represented at localities W4c-d, Ross Lake; W5c, Mount Bosworth; W7c-e, Kicking Horse Mine; and several others of Walcott's and the author's localities. The lists from these localities are all essentially the same and include the species:

PLAGIURA CERCOPS FAUNULE

Amecephalus cleora (Walcott).
Caborcella skapta (Walcott).
Fieldaspis furcata Rasetti.
Onchocephalus fieldensis Rasetti.
**Plagiura cercops* (Walcott).
Schistometopus convexus Rasetti.

Amecephalus cleora and *Plagiura cercops* are common at all localities, while the other species are moderately common or rare.

In somewhat higher beds, a few new forms appear and the relative abundances of the others undergo considerable changes. At localities W7f (Kicking Horse Mine) and W9f (Fossil Gully), a highly fossiliferous limestone yields a faunule named the *Fieldaspis furcata* faunule from its most common and striking trilobite. *Plagiura cercops* and *Amecephalus cleora* are rare members of this assemblage. The species include:

FIELDASPIS FURCATA FAUNULE

Amecephalus cleora (Walcott).
**Fieldaspis furcata* Rasetti.
Kochaspis eiffelensis Rasetti.
Kochiella? maxeyi Rasetti.
**Oryctocephalites resseri* Rasetti.
**Onchocephalus fieldensis* Rasetti.
* *maior* Rasetti.
Plagiura cercops (Walcott).
Schistometopus convexus Rasetti.

On Eiffel Peak (locality W20d) a similar faunule occurs abundantly both in limestone and siliceous shale. Its composition is so similar to that of the *Fieldaspis furcata* faunule that it is doubtful whether it should be considered a distinct unit. The chief differences are the great abundance of *Amecephalus cleora* and *Plagiura cercops* and the replacement of *Fieldaspis furcata* (which is extremely rare) by another species of the same genus, *Fieldaspis bilobata,* from which the faunule is named. The species include:

FIELDASPIS BILOBATA FAUNULE

Amecephalus cleora (Walcott).
**Fieldaspis bilobata* Rasetti.
furcata Rasetti.
**Kochaspis ciffelensis* Rasetti.
**Kochiella? maxeyi* Rasetti.
Plagiura cercops (Walcott).
**Schistometopus collaris* Rasetti.
* *convexus* Rasetti.

The youngest faunule of the *Plagiura-Kochaspis* zone was collected at the Kicking Horse Mine, in a limestone 50 feet stratigraphically above the beds carrying the *Fieldaspis furcata* faunule (locality W7g). This faunule is named from the trilobite *Fieldaspis superba* and includes the species:

FIELDASPIS SUPERBA FAUNULE

**Caborcella rara* Rasetti.
**Fieldaspis superba* Rasetti.
**Onchocephalus depressus* Rasetti.
* *sublaevis* Rasetti.

The *Plagiura-Kochaspis* fauna as a whole includes in the area investigated the trilobite genera *Amecephalus, Caborcella, Fieldaspis, Kochaspis, Onchocephalus, Oryctocephalites, Plagiura, Schistometopus,* and a species doubtfully assigned to *Kochiella. Fieldaspis* and *Plagiura,* as far as known, are confined to this zone. The same holds for *Kochaspis* and *Schistometopus* in the area investigated, but the genotype of *Schistometopus* occurs in a younger fauna, and *Kochaspis* is generally considered to range through most of the Middle Cambrian. However, the late Medial Cambrian species assigned to this genus (e.g., *K. unzia* and *K. upis*) are doubtfully congeneric with the genotype, and it is possible that when *Kochaspis* is properly restricted it will be found to be confined to the early Medial Cambrian beds. *Amecephalus* first occurs in the *Wenkchemnia-Stephenaspis* zone and ranges into higher beds, hence is of little stratigraphic value. *Onchocephalus* is based on a Lower Cambrian genotype, but little significance should be attributed to the generic assignment of these generalized ptychoparids.

The *Plagiura-Kochaspis* fauna is clearly demarcated both from the older *Wenkchemnia-Stephenaspis* fauna and from the younger *Albertella* fauna. The composition of the fauna in the Canadian Rockies is such that the name *Plagiura* fauna (or *Plagiura-Fieldaspis* fauna) would be more appropriate, as *Kochaspis* is a rare fossil. However, *Plagiura* and *Fieldaspis* seem to be unknown elsewhere in the Cordilleran province, whereas *Kochaspis* is abundant in strata attributed to this zone (e.g., the genotype, *Kochaspis liliana,* in the Pioche shale of the Highland Range, Nevada). Hence the mixed designation for the zone. Very little has been published on the fossils of the *Plagiura-Kochaspis* zone elsewhere.

FAUNA OF THE ALBERTELLA ZONE

The *Plagiura-Kochaspis* fauna is succeeded in the Canadian Rockies by the *Albertella* fauna which occurs in the Cathedral formation. This is a well-known assemblage of widespread occurrence in the Cordilleran province. The *Albertella*-bearing beds are separated from the Mount Whyte formation by 400 or more feet of unfossiliferous limestone or dolomite, hence a considerable time interval is unrepresented by fossils and it is not surprising to find that the *Albertella* fauna has few elements in common with the *Plagiura-Kochaspis* fauna.

Two faunules definitely belonging to the *Albertella* zone are known in the area. The older faunule occurs abundantly in the Ross Lake shale member of the Cathedral formation and is present in most of the sections where this horizon was investigated. This faunule is designated as the *Albertella bosworthi* faunule from one of the most common species. The fossils are most frequently collected in shale, but most of the species are known also in limestone. The following list includes the species reported from Walcott's localities U.S.N.M. 63j, 63m, and 35c, and from the writer's localities C3m, C4m, C15m, C20m, and C21m. The list of nontrilobitic species is taken from Walcott (1917b) with the modifications given by Resser (1938c).

ALBERTELLA BOSWORTHI FAUNULE

**Coleoloides hectori* (Walcott).
Eocystites? sp.
**Hyolithes cecrops* Walcott.
**Tholiasterella? hindei* Walcott.
**Urotheca parasitum* Resser.
**Acrothele walcotti* Resser.

**Obolus parvus* Walcott.
**Paterina wapta* (Walcott).
**Wimanella rossensis* Resser.
* *walcotti* Resser.
**Albertella bosworthi* Walcott.
* *declivis* Rasetti.
* *microps* Rasetti.
* *nitida* Resser.
Kochina americana (Walcott).
**Mexicella stator* (Walcott).
**Ptarmigania rossensis* (Walcott).
**Vanuxemella nortia* Walcott.

The younger faunule is known only from the Bow Lake section (locality C15n) where it occurs in black-gray limestone immediately above the Ross Lake shale. This assemblage is named the *Albertella limbata* faunule and includes the species:

ALBERTELLA LIMBATA FAUNULE

**Albertella limbata* Rasetti.
* *stenorhachis* Rasetti.
**Kochina macrops* Rasetti.
**Ptarmiganoides bowensis* Rasetti.

The *Albertella* fauna in the Canadian Rockies thus includes the trilobite genera *Albertella, Kochina, Mexicella, Ptarmigania, Ptarmiganoides,* and *Vanuxemella.* All these genera, possibly excepting *Kochina,* are readily recognizable and apparently confined to the zone. Hence the fauna of the *Albertella* zone is excellently characterized. Obviously this is partly due, in the Cănadian Rockies, to the absence of immediately older or younger fossils. The limits that should be assigned to the *Albertella* zone are not so clearly demarcated in other sections of the Cordilleran province. In the Langston (?) formation of Idaho, an assemblage which must be at least partly included in the *Albertella* fauna, was described by Resser (1939b) as the "*Ptarmigania* fauna." In this assemblage *Albertella* is exceedingly rare (Resser did not describe any species of *Albertella,* but the writer collected specimens undoubtedly belonging to this genus). The most common trilobites belong to the genera *Caborcella, Kootenia, Oryctocephalus, Pagetia, Ptarmigania, Ptarmiganoides,* and *Zacanthoides* (only genera collected and identified by the writer are listed, as Resser described a mixture of forms from different horizons and the writer does not accept several of his generic assignments). Of these genera, *Albertella,* *Ptarmigania,* and *Ptarmiganoides* are definitely indicative of the *Albertella* zone, while the others are too long-ranging to give any indication for or against this assignment. Resser united this faunule with a younger one characterized by *Ogygopsis* (Resser's "*Taxioura*") and *Pachyaspis,* but the writer found that these two assemblages occur in different beds. Whether the younger assemblage should still be included in the *Albertella* fauna cannot be decided at present.

Several faunules of uncertain age which may belong to the *Albertella* zone are discussed here, but their fossils were not included in the list of genera from the *Albertella* zone given above.

The shales and impure limestones representing the lower portion of the Cathedral formation in the Fossil Gully section on Mount Stephen yield several faunules that are tentatively assigned to the *Albertella* zone but actually include either long-ranging genera or forms unknown elsewhere, hence cannot be definitely assigned to a faunal zone from paleontologic evidence. Unquestionable stratigraphic evidence shows that these faunules are younger than the fauna of the *Plagiura-Kochaspis* zone; the lowermost occurring about 50 feet above the top of the *Plagiura-Kochaspis* zone. From this stratigraphic position, one would be tempted to infer that this faunule is older than the *Albertella bosworthi* faunule, which occurs in the Ross Lake shale of the Cathedral formation 400 or more feet above the top of the *Plagiura-Kochaspis* zone. However, the Ross Lake shale and the associated *Albertella bosworthi* faunule were not observed in the western part of Mount Stephen, and the section at that locality is very different from the normal sections in the Bow Range. Hence there is no evidence that the strata 50 feet above the top of the *Plagiura-Kochaspis* zone at Fossil Gully are older than the strata 400 feet above the top of the same zone elsewhere; on the contrary, from the paleontologic evidence the writer inclines to believe that they are younger, i.e., that in the Fossil Gully section there is a considerable unconformity at the top of the Mount Whyte formation and that the oldest beds of the Cathedral formation were deposited there after the Ross Lake shale had been sedimented in the normal sections.

The next higher well-identifiable faunule in the Fossil Gully section is the *Bathyuriscus adaeus* faunule of the upper Stephen formation, occuring almost 2,000 feet above the strata containing these faunules of uncertain age.

The lowermost of the faunules tentatively assigned to the *Albertella* zone occurs in the Fossil Gully section at locality C9h and is abundantly but poorly preserved in siltstone and impure, dark-gray limestone through 50 or more feet of strata. This faunule is named the *Yohoaspis pachycephala* faunule and includes the species:

YOHOASPIS PACHYCEPHALA FAUNULE

Acrothele sp.
**Chancia latigena* Rasetti.
Kootenia sp.
Ogygopsis klotzi (Rominger).
* *spinulosa* Rasetti.
Pagetia sp.
Poliella sp. No. 1.
**Syspacephalus tardus* Rasetti.
**Yohoaspis pachycephala* Rasetti.
Zacanthoides sp.

The next faunule was collected about 100 feet higher in the section, in lenticular beds of purer limestone interstratified with slightly argillaceous or silty limestone (localities C9j, C9j′). The fossils from these two horizons are listed together and the faunule is named the *Chancia bigranulosa* faunule from a trilobite that is common at both localities.

CHANCIA BIGRANULOSA FAUNULE

Diraphora sp.
Wimanella sp.
Athabaskia sp.
Bathyuriscus sp.
**Chancia bigranulosa* Rasetti.
Ogygopsis klotzi (Rominger).
Pagetia sp.
Poliella sp. No. 2.
Yohoaspis pachycephala Rasetti.
**Zacanthoides sexdentatus* Rasetti.

FAUNA OF THE GLOSSOPLEURA ZONE

In the Cambrian correlation chart (Howell et al., 1944) the *Albertella* zone is succeeded by a *Zacanthoides-Anoria* zone supposed to be characterized by the trilobite genera *Zacanthoides, Anoria, Dawsonia, Kootenia, Strotocephalus,* and *Clavaspidella.* Lochman (1948) does not recognize the identity of a faunal zone characterized by the restricted occurrence of *Zacanthoides* and *Anoria,* and the writer fully concurs with her criticism. *Zacanthoides* and *Kootenia* range from the uppermost Lower Cambrian through most of the Middle Cambrian and are obviously extremely poor diagnostic genera. *Anoria* probably has a restricted vertical range, but is a typical fossil of the *Glossopleura* zone, as shown by the occurrence of the genotype, *Anoria tontoensis,* in the *Glossopleura* zone of the Grand Canyon area. *Dawsonia* is an Atlantic province genus which for obscure reasons was associated with the other genera from the Cordilleran province in the faunal lists given in the correlation chart; its age relative to the Cordilleran faunas is entirely problematical. *Strotocephalus* (which the writer considers a synonym of *Amecephalus*) is common, as shown in the present work, through the *Wenkchemnia-Stephenaspis* and *Plagiura-Kochaspis* zones and extends into younger beds. *Clavaspidella,* or rather *Athabaskia,* ranges at least from the *Albertella* zone to the *Glossopleura* zone.

In the particular area studied in this work, the problem of recognizing a *Zacanthoides-Anoria* zone does not arise, since in the typical sections the *Albertella* zone is followed by a barren interval (the upper portion of the Cathedral formation) and the next younger faunule is typical of the *Glossopleura* zone. The only possible exception may be represented by the peculiar faunules occurring in the equivalent of the lower part of the Cathedral formation in the Fossil Gully section. These faunules were tentatively assigned to the *Albertella* zone.

The writer prefers to use the term *Glossopleura* zone instead of *Glossopleura-Kootenia* zone as in the correlation chart, because the genotype of *Kootenia* and many other species of the genus occur in much younger strata; *Kootenia* is much too long-ranging to add anything to the definition of the fauna under discussion.

Faunules typical of the *Glossopleura* zone usually occur in the area in the lowermost portion of the Stephen formation, represented by pure or argillaceous limestones. In the discussion of that formation, it was mentioned that in some of the sections, those at the southwestern margin of the area investigated (the Park Mountain, Mount Odaray, and Mount Stephen sections) beds assignable to the *Glossopleura* zone seem to be absent.

However, the oldest faunule of the *Glossopleura* zone was collected from black limestone lenses interstratified with the Cathedral dolomite in the Skoki Valley section (locality C13r). This finding indicates that if the undolomitized portions of the Cathedral formation were searched more extensively and carefully, new faunules might be discovered, representing intervals that are usually barren in the area. The writer was able to discover only two such new faunules, the present one and the *Albertella limbata* faunule previously discussed.

The faunule from locality C13r is designated as the *Glossopleura merlinensis* faunule and includes the species:

GLOSSOPLEURA MERLINENSIS FAUNULE

**Glossopleura merlinensis* Rasetti.
* *skokiensis* Rasetti.
sp.

In the lower portion of the Stephen formation, two faunules of the *Glossopleura* zone were observed. The older faunule occurs at or near the base of the formation, and in the sections studied by the writer appeared to consist of only one species, *Glossopleura boccar,* the type of the genus. This trilobite is common at its type locality on Mount Bosworth (author's locality S5a). According to Deiss, in the Castle Mountain and Ptarmigan Peak sections several other species of trilobites are associated with *Glossopleura boccar.* Unfortunately the writer had no opportunity to examine the Stephen formation at those localities.

GLOSSOPLEURA BOCCAR FAUNULE

**Glossopleura boccar* (Walcott).

In somewhat higher beds, on Mount Temple (locality S21b) and Mount Whyte (locality S3b), another faunule occurs, chiefly characterized by the abundance of the trilobite *Polypleuraspis* in association with various species of *Glossopleura.* The assemblages collected at the two above-mentioned localities are united as one faunule, named from the trilobite *Polypleuraspis insignis.*

POLYPLEURASPIS INSIGNIS FAUNULE

Glossopleura mckeei Resser.
* *stenorhachis* Rasetti.
* *templensis* Rasetti.
**Polypleuraspis insignis* Rasetti.

The fauna of the *Glossopleura* zone is thus represented in the writer's collections from the area by only two genera, *Glossopleura* and *Polypleuraspis,* both apparently confined to the zone. It is surprising that *Polypleuraspis* had so far escaped observation, as it is a common and striking fossil. The genus was previously known from northwest Greenland, where it also occurs in association with *Glosso-*

pleura. The United States National Museum collections contain unidentified pygidia of *Polypleuraspis* from the *Glossopleura* zone of Utah.

It is obvious that the collections from the area give but an extremely incomplete idea of the composition of the fauna of the *Glossopleura* zone, as numerous trilobite genera of the Cordilleran province are known to range from the *Albertella* zone to the *Bathyuriscus-Elrathina* zone, hence undoubtedly existed at the time when the *Glossopleura* beds were deposited. Evidently ecologic conditions favored associations of great numbers of individuals of very few species.

FAUNA OF THE BATHYURISCUS-ELRATHINA ZONE

As we proceed toward the later portion of the Medial Cambrian, the characterization of successive faunas becomes more difficult and the discussion given by the various authors increasingly contradictory and confusing. Deiss (1939, 1940) recognized, above the *Glossopleura* zone, an *Ehmania* zone (known from Montana, Wyoming, and Utah, but not identified in the Canadian Rockies). This is succeeded by a zone which was alternatively called the *"Agnostus"-Bathyuriscus,* the *Bathyuriscus-Elrathia,* and the *Bathyuriscus-Elrathina* zone, and sometimes split into two zones, each characterized by two of the above-mentioned genera. The next higher fauna was designated by Deiss either as the *Thomsonaspis* fauna or as the *Olenoides* (*Neolenus*) fauna. This fauna was stated by Deiss to be present in the Canadian Rockies in the uppermost portion of the Stephen formation (in the Castle Mountain and Ptarmigan Peak sections).

In the Cambrian correlation chart (Howell et al., 1944) the Middle Cambrian zones younger than the *Glossopleura* zone are designated, in ascending order, as the *Bolaspis-Glyphaspis* zone, *Clappaspis* subzone, *Elrathiella-Triplagnostus* subzone, *Olenoides-Marjumia* zone, *Palella-Thomsonaspis* zone, and *Deissella-Centropleura vermontensis* zone. The lists of the genera supposed to characterize these zones again include mixtures of forms from the Atlantic and Cordilleran provinces assumed to be of the same age on the basis of hypothetical correlations between the strata of Vermont and those of the Rocky Mountains. Even if all the Atlantic province genera are disregarded, the writer believes that the assemblages of genera from the Cordilleran province do not constitute clear-cut faunas recognizable over much of that area.

In the area investigated, it appears that all the faunules occurring in the Stephen formation and younger than the *Glossopleura* fauna have many genera in common and may well be assigned to a single faunal zone. This zone seems to correspond approximately to the *Elrathiella-Triplagnostus-Clappaspis* zone of the correlation chart and to the *Bathyuriscus-Elrathina* zone of Deiss. There are several good reasons for discarding the first name. *Elrathiella* is doubtfully distinct from *Elrathia,* and its genotype is a species occurring in Greenland in strata of doubtful stratigraphic position. The genotype of *Triplagnostus* occurs in the Swedish Cambrian, and the assignment of the Cordilleran forms to the genus might be open to question. *Clappaspis,* in the writer's opinion, is not sufficiently distinct from *Ehmaniella* to warrant generic recognition. On the contrary, Deiss' designation seems well chosen, as both *Bathyuriscus* and *Elrathina* are abundant in the faunules of the zone, and even if they are not entirely confined to it, at least they do not appear to constitute important elements of older or younger faunules. Hence the writer adopts the term *Bathyuriscus-Elrathina* zone and tentatively includes in the fauna of the zone all the faunules collected from the Stephen formation above the *Glossopleura* zone.

Unfortunately, in most of the sections the upper two-thirds of the Stephen formation are almost barren of fossils. In other sections highly fossiliferous beds are present, but usually not more than one or two faunules could be identified from a single section. Hence, although several faunules of the *Bathyuriscus-Elrathina* zone are known (some of which are represented by an exceptional wealth of individuals), the order of succession of the faunules presents the most difficult problem of this kind encountered by the writer in the area investigated. In the following discussion it will be made clear how far the order of succession is derived from unquestionable stratigraphic evidence and how much had to be inferred from the study of the fossils.

To clarify the discussion, the faunules of the *Bathyuriscus-Elrathina* zone are designated as usual by a characteristic species and assigned an order number, believed by the writer to represent their most probable order of succession. Faunules collected at different localities and believed to be essentially contemporaneous, although not identical, are listed separately and designated by the same number followed by a dash.

In ascending order, the faunules are: (1) the *Ogygopsis klotzi* faunule; (2) the *Olenoides serratus* faunule; (2′) the *Alokistocarella fieldensis* faunule; (3) the *Pagetia bootes* faunule; (4) the *Ehmaniella burgessensis* faunule; (5) the *Bathyuriscus adaeus* faunule; (6)

the *Tonkinella stephensis* faunule; (6′) the *Parkaspis endecamera* faunule. Each of these faunules and its occurrence will be discussed and the reasons for the assumed relative ages will be presented.

The oldest faunule of the above-mentioned list is believed to be the faunule of the celebrated *Ogygopsis* shale on Mount Stephen (locality S8d=U.S.N.M. locality 14s). In the discussion of the *Ogygopsis* shale lentil it was shown that it is not possible to establish the position of that unit in the section by stratigraphic evidence. Hence the determination of the age of the *Ogygopsis* shale faunule relative to other faunules occurring in the region must entirely depend on the study of the fossils. The faunule is designated, according to tradition, by the trilobite *Ogygopsis klotzi,* although this species has an exceptionally long vertical range, extending from the *Wenkchemnia-Stephenaspis* zone in the Mount Whyte formation to the *Ogygopsis* shale itself. It is remarkable that this genus, common at five different horizons on Mount Stephen, was never observed elsewhere in the Canadian Rockies.

In the following list of species of the *Ogygopsis klotzi* faunule, the non-trilobitic forms are given as identified by Walcott, taking into account Resser's new generic references. Abundance data are included for the trilobites, as the faunule was not listed in the description of the section, but not for the other fossils, as the writer does not possess sufficient first-hand evidence on this point.

OGYGOPSIS KLOTZI FAUNULE

Helcionella belliana (Walcott).
* *romingeri* (Walcott).
* *wheeleri* (Walcott).
Hyolithellus annulatus (Matthew).
* *flagellum* (Matthew).
Hyolithes carinatus Matthew.
Orthotheca corrugata Matthew.
* *maior* Walcott.
Scenella amii (Matthew).
* *columbiana* (Walcott).
Acrotreta depressa Walcott.
Iphidella fieldensis Resser.
Nisusia alberta (Walcott).
Obolus mcconnelli (Walcott).
Anomalocaris canadensis Whiteaves.
Anomalocaris? acutangula Walcott.
* *whiteavesi* Walcott.
Bathyuriscus rotundatus (Rominger)...... cc
Bonnaspis stephenensis (Walcott)......... r

**Burlingia hectori* Walcott	rr
**Chancia palliseri* (Walcott)	r
**Elrathina cordillerae* (Rominger)	cc
Hanburia gloriosa Walcott	rr
**Klotziella ornata* (Walcott)	r
**Kootenia dawsoni* (Walcott)	c
**Ogygopsis klotzi* (Rominger)	cc
**Olenoides serratus* (Rominger)	cc
Oryctocephalus matthewi Rasetti	r
* *reynoldsi* Reed	r
* *walkeri* Matthew	r
Pagetia sp.	r
**Peronopsis montis* (Matthew)	r
**Zacanthoides romingeri* Resser	cc

The reasons for believing the *Ogygopsis klotzi* faunule to be the oldest of the *Bathyuriscus-Elrathina* zone in the area will be set forth after discussing the next faunules, which occur at three different levels in the Burgess Quarry section.

The oldest faunule in the Burgess Quarry section occurs about 60 feet below the celebrated "phyllopod bed" of Walcott. The locality is indicated as S11d and the fossils are abundant but poorly preserved in calcareous and siliceous shales. The faunule is designated as the *Olenoides serratus* faunule from the most common form, and includes the species of the following list.

OLENOIDES SERRATUS FAUNULE

Paterina cf. *P. zenobia* (Walcott).
Nisusia sp.
Bathyuriscus rotundatus (Rominger).
Elrathina sp.
Kootenia sp.
Olenoides serratus (Rominger).
Pagetia bootes Walcott.

A similar, although apparently not identical faunule, was collected in greater abundance 0.3 mile south of Walcott's quarry (locality S11e). Owing to small faults covered by drift, it is difficult to ascertain whether these beds are lower or higher than those of locality S11d, but in any case the difference in age cannot be considerable. The fossils at locality S11e weather on the surface of slabs of argillaceous limestone, and entire carapaces of trilobites are common. The faunule is distinguished from the preceding and designated as the *Alokistocarella fieldensis* faunule.

ALOKISTOCARELLA FIELDENSIS FAUNULE

Iphidella cf. *I. fieldensis* Resser.
**Alokistocarella fieldensis* Rasetti.
Bathyuriscus rotundatus (Rominger).
**Elrathina brevifrons* Rasetti.
Kootenia burgessensis Resser.
Olenoides serratus (Rominger).
Pagetia bootes Walcott.
Solenopleurella sp. No. 2.

The next younger faunule collected from the Burgess Quarry section occurs in the "phyllopod bed" quarried by Walcott (author's locality S11f=U.S.N.M. locality 35k). Notwithstanding the intensive study made by Walcott and others of the exceptionally preserved fossils from the Burgess shale, little has been published on the "conventional" fossils from this bed, the only ones that can be used for the purpose of correlation. Study of the United States National Museum collections revealed that several of the common species of trilobites from locality 35k had never been published. The new species are described in the paleontologic part of this paper.

The following list includes all the brachiopods described by Walcott and by Resser (1938c) and the trilobites identified by the writer. The exceptionally preserved fossils, unknown from other formations, are left out of consideration. The faunule is designated by one of the most common trilobites, *Pagetia bootes*. Abundance data are included for the trilobites but not for the other forms for the reasons mentioned in listing the *Ogygopsis klotzi* faunule.

PAGETIA BOOTES FAUNULE

**Acrothyra gregaria* Walcott.
**Iphidella pulchra* Resser.
**Lingulella waptaensis* Walcott.
**Micromitra burgessensis* Resser.
**Nisusia burgessensis* Walcott.
**Paterina zenobia* (Walcott).
Chancia palliseri (Walcott) .... r
**Ehmaniella burgessensis* Rasetti .... r
* *waptaensis* Rasetti .... r
**Elrathia permulta* (Walcott) .... r
Elrathina cordillerae (Rominger) .... r
**Hanburia gloriosa* Walcott .... rr
**Kootenia burgessensis* Resser c
Olenoides serratus (Rominger) c

**Oryctocephalus burgessensis* Resser........ c
* *matthewi* Rasetti .... r
reynoldsi Reed .... r
**Pagetia bootes* Walcott.................. cc
**Parkaspis decamera* Rasetti............... rr
**Peronopsis montis* (Matthew)............. r
Solenopleurella sp. .... r
**Triplagnostus burgessensis* Rasetti........ cc

The youngest faunule from the Burgess Quarry section occurs in fine-grained, gray siliceous shale 150-160 feet above the base of the quarry. Walcott did not mention the occurrence of fossils at this horizon, although certain layers are fairly covered with trilobite fragments, belonging to three species. The faunule would not present much interest but for the fact that it supplies part of the evidence for determining the stratigraphic position of the Burgess shale lentil. The faunule is designated by the trilobite *Ehmaniella burgessensis* which also occurs, but much less abundantly, in the "phyllopod bed."

EHMANIELLA BURGESSENSIS FAUNULE

Ehmaniella burgessensis Rasetti.
Pagetia sp.
Solenopleurella sp. No. 1.

It is now opportune to discuss the relative ages of the faunules of the *Bathyuriscus-Elrathina* zone listed so far, that is of faunules (1), (2), (2′), (3), and (4). There is unquestionable evidence that faunules (2), (3), and (4) occur in ascending order. Faunule (2′) is almost identical with faunule (2) or possibly intermediate between faunule (2) and (3). Hence the chief problem is to determine the relative age of the *Ogygopsis klotzi* faunule (No. 1) with respect to the faunules occurring in the Burgess Quarry fault block. The writer believes that there is hardly any doubt that the *Ogygopsis klotzi* faunule is older than any other of the above-mentioned faunules. It has many species in common with faunules (2) and (2′), fewer with faunule (3), and none with faunule (4), although in the last case the evidence is less convincing, as faunule (4) includes only three species. Of the species of faunule (2), occurring at the base of the Burgess Quarry section, *Bathyuriscus rotundatus, Elrathina* sp., *Kootenia* sp., and *Olenoides serratus* are identical with or are very similar to some of the most common forms of the *Ogygopsis* shale. The most striking difference between faunules (1) and (2) is that the latter lacks *Ogygopsis* and includes *Pagetia,* which is extremely rare in the

Ogygopsis shale. The fact that *Ogygopsis klotzi* is already present in the Mount Whyte and Cathedral formations adds weight to the assumption that the *Ogygopsis* shale is older than the Burgess shale.

Accepting the above conclusion, there is still the problem of placing all these faunules, (1) to (4), in the general section, because the Burgess Quarry fault block is isolated and its succession of strata does not resemble any portion of the typical sections of the Bow Range. Hence the age of the faunules (1) to (4) relative to the other faunules described in this paper must be determined from the study of the fossils.

In the writer's opinion, the best evidence for solving this problem is supplied by the close resemblance of the youngest faunule of the Burgess Quarry fault block (faunule No. 4, or *Ehmaniella burgessensis* faunule) to a faunule collected from limestone lenses in the shaly basal portion of the Stephen formation on Mount Odaray (locality S6g). The latter faunule includes *Ehmaniella burgessensis* and *Solenopleurella* sp. No. 1, which also occur in the *Ehmaniella burgessensis* faunule in the Burgess Quarry section. Correlation of these horizons is confirmed by the fact that the poorly fossiliferous shaly unit that constitutes the middle portion of the Stephen formation in most of the sections of the Bow Range, at several localities yielded cranidia of *Ehmaniella*. Hence it seems highly plausible to correlate the Burgess shale with some portion of the middle, shaly unit of the Stephen formation, which occurs in the sections of the Bow Range above the beds of the *Glossopleura* zone and below the limestone carrying younger faunules of the *Bathyuriscus-Elrathina* zone (the *Bathyuriscus adaeus* and *Tonkinella stephensis* faunules) still to be discussed. Evidence about the last-mentioned point is supplied by the Mount Odaray section, where the *Ehmaniella burgessensis* faunule occurs 110-150 feet below the *Bathyuriscus adaeus* faunule. On the other hand, the Mount Odaray section does not supply evidence for the relative ages of the *Ehmaniella burgessensis* faunule and the *Glossopleura* fauna, because at that locality, as mentioned in discussing the Stephen formation, strata assignable to the *Glossopleura* zone seem to be missing. However, abundant evidence from other areas in the Cordilleran province, e.g., northwestern Montana, unquestionably proves that the *Bathyuriscus-Elrathina* fauna (to which the *Ehmaniella burgessensis* faunule belongs) is much younger than the *Glossopleura* fauna. Hence in table 3, representing the general order of succession of the faunules, faunules (1) to (4) were placed above the youngest faunule of the *Glossopleura* zone and below the *Bathyuriscus adaeus* faunule.

There remain to be discussed the faunules (5), (6), and (6′), respectively designated by the trilobites *Bathyuriscus adaeus, Tonkinella stephensis,* and *Parkaspis endecamera.* All these faunules occur in pure or argillaceous black-gray limestone in the upper portion of the Stephen formation in the Mount Odaray, Park Mountain, and Mount Stephen (Fossil Gully) sections. Specimens observed in drift blocks show the presence of faunules of this group on Mount Biddle and Mount Field. However, in some of the best-known sections of the Stephen formation such as the Mount Bosworth, Mount Whyte, and Mount Temple sections, the corresponding beds, although similar in lithology, appear to be barren.

The lowermost faunule, designated as the *Bathyuriscus adaeus* faunule because of the great abundance of this trilobite, is known from Mount Odaray (locality S6k), Park Mountain (locality S10k), and Mount Stephen (locality S9k, probably identical with U.S.N.M. locality 58j). The species include:

BATHYURISCUS ADAEUS FAUNULE

**Alokistocare paranotatum* Rasetti.
**Bathyuriscus adaeus* Walcott.
**Chancia odarayensis* Rasetti.
**Elrathina parallela* Rasetti.
* *spinifera* Rasetti.
Kootenia sp.
Pagetia cf. *P. bootes* Walcott.
**Peronopsis columbiensis* Rasetti.
**Tonkinella stephensis* Kobayashi.
Zacanthoides sp.

On Mount Odaray, a similar faunule occurs abundantly 300 feet higher in the section, at locality S6l. This faunule is designated by the trilobite *Tonkinella stephensis,* although this species is equally common in the preceding faunule. The identified forms are the following:

TONKINELLA STEPHENSIS FAUNULE

**Alokistocare sinuatum* Rasetti.
**Athabaskia? parva* Rasetti.
Bathyuriscus adaeus Walcott.
**Chancia odarayensis* Rasetti.
**Elrathina marginalis* Rasetti.
Olenoides sp.
**Pachyaspis attenuata* Rasetti.
Pagetia cf. *P. bootes* Walcott.

Peronopsis columbiensis Rasetti.
Solenopleurella sp.
Tonkinella stephensis Kobayashi.
Zacanthoides divergens Rasetti.
* *longipygus* Rasetti.
* *submuticus* Rasetti.

The third faunule of this group is known only from locality S101 on Park Mountain, where it occurs about 150 feet above the beds carrying the *Bathyuriscus adaeus* faunule. From this occurrence it cannot be determined whether the present faunule is older or younger than the *Tonkinella stephensis* faunule collected on Mount Odaray, but both the stratigraphic position and the number of common forms indicate that there cannot be any considerable difference in age. The chief distinctive feature of the faunule collected on Park Mountain is the abundance of the trilobite *Parkaspis endecamera,* unknown from other localities, by which the faunule is designated; and also of a species of *Glyphaspis*. The identified species are the following:

PARKASPIS ENDECAMERA FAUNULE

**Alokistocare cataractense* Rasetti.
Bathyuriscus adaeus Walcott.
**Glyphaspis parkensis* Rasetti.
Kootenia sp.
**Parkaspis endecamera* Rasetti.
Peronopsis columbiensis Rasetti.
Tonkinella stephensis Kobayashi.
**Yuknessaspis paradoxa* Rasetti.
**Zacanthoides divergens* Rasetti.
* *planifrons* Rasetti.

One more faunule, younger than any so far discussed, was collected on Park Mountain in the lower portion of the calcareous equivalent of the Eldon formation (locality E10c). A list of fossils from this locality is given in the description of the Park Mountain section. From the assemblage of trilobite genera, it appears that this faunule does not greatly differ from those occurring in the upper Stephen formation and still belongs to the *Bathyuriscus-Elrathina* zone.

The *Bathyuriscus-Elrathina* fauna as represented in the Stephen formation includes the trilobite genera *Alokistocare, Alokistocarella, Bathyuriscus, Bonnaspis, Burlingia, Chancia, Ehmaniella, Elrathia, Elrathina, Hanburia, Klotziella, Kootenia, Ogygopsis, Olenoides, Oryctocephalus, Pachyaspis, Pagetia, Parkaspis, Peronopsis, Solenopleurella, Triplagnostus, Tonkinella, Yuknessaspis,* and *Zacanthoides.*

The Agnostida first occur in this zone in the Canadian Rockies. *Alokistocare, Alokistocarella, Chancia, Kootenia, Ogygopsis, Olenoides, Oryctocephalus, Pagetia,* and *Zacanthoides* are all long-ranging genera of little stratigraphic value. *Bathyuriscus* and *Tonkinella* are common genera that seem to be confined to the zone; so are the rarer or more localized forms *Bonnaspis, Burlingia, Hanburia, Klotziella, Parkaspis* and *Yuknessaspis.* The generalized ptychoparids *Ehmaniella, Elrathia, Elrathina, Pachyaspis,* and *Solenopleurella,* whose generic limits are difficult to establish, are not all confined to the zone. However, at least *Elrathina* and *Ehmaniella* are far more abundant in these beds than in lower or higher strata and possess stratigraphic value.

The fauna of the *Bathyuriscus-Elrathina* zone as represented in the Stephen formation is sharply distinct from the fauna of the underlying *Glossopleura* zone. This fact is probably due to an unconformity, within the Stephen formation, between the strata of the *Glossopleura* zone and those of the *Bathyuriscus-Elrathina* zone. The *Ehmania* or *Bolaspis-Glyphaspis* fauna that is believed to occupy this time interval in Montana, Wyoming, and Utah does not seem to be represented in the Canadian Rockies.

ORDER OF SUCCESSION OF THE FAUNULES

In this section all the faunules discussed are tabulated in chronologic sequence. Each faunule was named from a characteristic species and is so designated in the list. Evidence for the relative ages of two faunules may be either direct stratigraphic evidence, the two faunules being collected from the same section from beds in unquestionable order of sequence; or indirect evidence deduced from correlation of different sections or from the study of the fossils. In the second case the order of succession may be considered probable but there cannot be absolute certainty. In order to avoid confusing the results from the two kinds of evidence, in table 3 the first column includes only the faunules whose order of succession is unquestionable. The other columns contain faunules that were collected from partial sections, and are interpolated in the main succession according to the best available evidence. Hence the relative ages of faunules in different columns are only probable. Faunules united in brackets are essentially of the same age, and possible slight differences are not necessarily in the order indicated.

TABLE 3.—*Succession of faunules*

	Lower Cambrian	Middle Cambrian				
	Bonnia-Olenellus zone	*Wenkchemnia-Stephenaspis* zone	*Plagiura-Kochaspis* zone	*Albertella* zone	*Glossopleura* zone	*Bathyuriscus-Elrathina* zone
General section	*Bonnia fieldensis*	*Poliella prima*	*Plagiura cercops* {*Fieldaspis bilobata* {*Fieldaspis furcata* *Fieldaspis superba*	*Albertella bosworthi* *Albertella limbata*	*Glossopleura merlinensis* *Glossopleura boccar* *Polypleuraspis insignis*	*Bathyuriscus adaeus* {*Tonkinella stephensis* {*Parkaspis endecamera*
West Mount Stephen Fossil Gully-North Gully	*Bonnia fieldensis*	*Syspacephalus laticeps* *Stephenaspis bispinosa*	*Fieldaspis furcata*	*Yohoaspis pachycephala* *Chancia bigranulosa*		*Bathyuriscus adaeus*
Burgess Quarry Mount Field						{*Olenoides serratus* {*Alokistocarella fieldensis* *Pagetia bootes* *Ehmaniella burgessensis*
"Fossil bed" Mount Stephen						*Ogygopsis klotzi*

SPECIES NOT DISCUSSED IN THIS PAPER

Several of the species described by Walcott, Matthew, and Resser from the Mount Whyte, Cathedral, and Stephen formations were not collected by the writer, and owing to uncertainty regarding their exact stratigraphic position, it was deemed best not to use these species in discussing the composition of the faunas. Here such species are listed and their probable stratigraphic position is indicated. A few species are also included which will not be dealt with in the systematic part of this work because the writer did not have specimens for study.

"Ptychoparia" cuneas Walcott (type locality U.S.N.M. 35f, Mount Stephen) was undoubtedly collected from the Lower Cambrian Peyto limestone, as shown by the association of the type specimens with olenellids.

The following species, listed with their respective type localities, are almost undoubtedly Middle Cambrian and were collected from various horizons in the Mount Whyte formation:

Species	Type locality
Billingsella marion Walcott	58l
Micromitra (Paterina) charon Walcott	61c
Nisusia (Jamesella) lowi Walcott	58k
Obolus damo Walcott	63g
whymperi Walcott	39j
Wimanella catulus Walcott	63a
Alokistocare stephenense Resser	58k
Fieldaspis celer (Walcott)	58k
Kochaspis carina (Walcott)	35m
cecinna (Walcott)	63a
"Olenopsis" leuka Walcott	58g
"Ptychoparia" adina Walcott	57q
clusia Walcott	58k
cossus Walcott	61a

The next four species were collected by Walcott from the "Ptarmigan" formation on Ptarmigan Peak, hence belong either in the Mount Whyte or the Cathedral formation. From the lower of the two reported fossiliferous horizons in the "Ptarmigan," at locality 63d, Walcott listed the following two species that certainly must be assigned to the Mount Whyte formation and more precisely to the *Plagiura-Kochaspis* zone (see description of *Kochiella? maxeyi* in the systematic part of this work):

"Ptychoparia" cilles Walcott.
"Crepicephalus" chares Walcott.

From the higher fossiliferous horizon in the "Ptarmigan" (locality U.S.N.M. 63b) Walcott reported the species:

Olenoides constans (Walcott).
Albertella cimon (Walcott).

If the reference of *Zacanthoides cimon* Walcott to *Albertella,* suggested by Resser, is correct (as the writer is inclined to believe, although the species is known only from cranidia and there can be no certainty in the reference to *Albertella* without the pygidium), then the higher fossiliferous horizon in the "Ptarmigan" would be close to that of the Ross Lake shale which is not developed in the Ptarmigan Peak section. The writer has already reassigned these beds of the "Ptarmigan" to the Cathedral formation.

Glossopleura stephenensis Resser is based on a flattened, poorly preserved, specifically unidentifiable shield of *Glossopleura* supposedly collected from the *Ogygopsis* shale on Mount Stephen. Since the writer has never seen any representative of the genus in the *Ogygopsis* shale, he suspects that the specimen has been mislabeled.

Bathyuriscus pupa Matthew and *Dolichometopus occidentalis* Matthew, both from the *Ogygopsis* shale, were considered by Walcott and Resser as synonymous. The writer has not seen the types, and the species is not represented either in the United States National Museum collections or in the writer's own. Resser (1935, p. 44) states that "two excellent carapaces have just been discovered in our collections." Upon inspection, the two specimens (on one slab) were found to be labeled from locality 35k (Burgess shale) instead of 14s (*Ogygopsis* shale) as stated by Resser. Furthermore, the matrix resembles neither the Burgess shale nor the *Ogygopsis* shale. These specimens represent *Poliella denticulata,* described in this paper from the Mount Whyte formation on Mount Stephen, hence it is virtually certain that they do not come from the *Ogygopsis* shale; they were probably collected from talus at the base of Mount Stephen.

Oryctocephalus walkeri Matthew is another form from the *Ogygopsis* shale whose exact characters the writer was unable to ascertain. Probably even examination of the types would leave some uncertainty, as the specimens appear to be poorly preserved from Matthew's description. Examination of collections made by the writer and those of the United States National Museum seems to indicate the presence of three species of *Oryctocephalus* in the *Ogygopsis* shale, two of which are definitely *O. reynoldsi* and *O. matthewi.* The individuals that do not appear to belong to either species and may represent *O. walkeri* are too poor to show clearly the specific characters. The latter species may prove to be identical with *O. burgessensis* Resser from the Burgess shale, in which case Resser's name would become a synonym. In the meantime it seems better to use the name *burgessensis* for the well-represented form from the Burgess shale.

GEOGRAPHIC AND VERTICAL DISTRIBUTION OF TRILOBITES

In this section the writer wishes to discuss the vertical range and geographic distribution of some of the trilobite species, genera, and families encountered in the formations described in this paper.

The Olenellidae occur in extreme abundance in the uppermost beds here assigned to the Lower Cambrian, and suddenly disappear, indicating a probable unconformity as it has been mentioned in discussing the contact between the St. Piran sandstone and the Mount Whyte formation, and the Lower-Middle Cambrian boundary.

The earliest observed occurrence of the Agnostida is an unusually late one, since no agnostid was found in beds older than the middle portion of the Stephen formation; probably the oldest one is *Peronopsis montis* from the *Ogygopsis* shale. Furthermore, the agnostids show little variety and a small number of species even when they become abundant in numbers of individuals. In other areas of the Cordilleran province, e.g., in Idaho, agnostids are known from considerably older beds, such as the Langston (?) formation (Resser, 1939b). In the Appalachian province they occur, though rarely, even in late Early Cambrian time. It is clear the Canadian portion of the Cordilleran geosyncline was one of the last seaways of the world to be invaded by the Agnostida.

The Eodiscida, recognized by the writer as an order, seem to be represented in the Cordilleran province exclusively by forms with eyes and free cheeks (*Pagetia*). The blind Eodiscida, common in the Atlantic and Appalachian provinces both in the Lower and Middle Cambrian, are here totally absent. *Pagetia* appears in the Lower Cambrian Peyto limestone; a form collected by the writer from those strata is closely similar to *Pagetia ellsi* Rasetti and other Middle Cambrian species. The presence of *Pagetia* in the Lower Cambrian had already been noticed by the writer in the Appalachian province (Rasetti, 1948a). In the area investigated, *Pagetia* was never observed in the Mount Whyte and Cathedral formations of normal lithology; for example, it was never seen among the thousands of trilobites filling certain layers of the Ross Lake shale, although it existed both before and after the time when the shale was deposited. The same remark applies to many trilobite genera. The next higher occurrence of

Pagetia is in the peculiar silty limestone that replaces a portion of the Cathedral dolomite in the western part of Mount Stephen. The faunule in which *Pagetia* occurs is of somewhat uncertain age, and is here tentatively considered younger than the *Albertella bosworthi* faunule. *Pagetia* becomes common in the Stephen formation.

The family Dorypygidae is represented in the Lower Cambrian by the genus *Bonnia,* common in the Peyto limestone as in most of the limestones of late Early Cambrian age in the Cordilleran and Appalachian provinces. *Kootenia* and *Olenoides* appear much later, although they are already present in the Lower Cambrian of the Appalachian province. *Kootenia* was first observed in the anomalous equivalent of the Cathedral formation on Mount Stephen, and *Olenoides* does not seem to be present in strata older than the middle portion of the Stephen formation. There is no doubt that *Kootenia* existed in the Cordilleran province in strata both older and younger than the Ross Lake shale, yet this is another genus totally absent from that unit.

The family Oryctocephalidae is represented by *Oryctocephalus, Oryctocephalites,* and *Tonkinella. Oryctocephalus* appears in the *Wenkchemnia-Stephenaspis* zone and is evidently long-ranging, as it occurs again in the Stephen formation. As in the preceding cases, this genus shows a wide gap in its vertical distribution in the area, being apparently absent from the Cathedral formation. Of *Oryctocephalites* we know an isolated occurrence in the *Plagiura-Kochaspis* zone. *Tonkinella* seems to be strictly confined to the upper Stephen formation and to be an excellent index fossil.

The families Dolichometopidae and Zacanthoididae may be treated together as the boundary between them is to a large extent arbitrary. In the Lower Cambrian Peyto limestone the genus *Zacanthopsis* was found; no forms definitely assignable to the Dolichometopidae were collected. Such forms, however, are known to be associated with Olenellidae in northwest Greenland (Poulsen, 1927) and in Quebec (Rasetti, 1948a). *Zacanthoides* appears in strata equivalent to a portion of the Cathedral formation in the western part of Mount Stephen. Several dolichometopid genera (*Wenkchemnia, Poliella, Stephenaspis, Fieldaspis*) occur abundantly in the *Wenkchemnia-Stephenaspis* and *Plagiura-Kochaspis* zones and seem to be lacking or extremely rare both in older and younger beds. *Albertella, Vanuxemella, Ptarmigania,* and *Ptarmiganoides* seem to be confined to beds of the *Albertella* zone. *Bathyuriscus* first appears in the Stephen formation and is there represented by several species and extremely numerous individuals. *Glossopleura* and *Polypleuraspis* are abundant in the *Glossopleura* zone and absent from younger beds.

The genus *Ogygopsis* deserves special discussion. Individuals that the writer must assign to a single species, since no morphologic differences were observed, were collected in strata of five different ages ranging over an exceptionally long time interval. *Ogygopsis klotzi* first appears and is very abundant in the *Syspacephalus laticeps* faunule of the *Wenkchemnia-Stephenaspis* zone. The species was found to be extremely rare in the next younger assemblage, the *Stephenaspis bispinosa* faunule of the same zone. It was never observed in the strata of the overlying *Plagiura-Kochaspis* zone. It then reappears abundantly as a member of the *Yohoaspis pachycephala* and *Chancia bigranulosa* faunules in the equivalent of a portion of the Cathedral formation. *Ogygopsis* is totally absent from the beds of the *Glossopleura* zone. It is then extremely abundant in the *Ogygopsis klotzi* faunule (*Ogygopsis* shale), which occurs in the Stephen formation and is younger than the *Glossopleura* fauna. *Ogygopsis klotzi* is associated with five different assemblages in these different occurrences. All these occurrences are on Mount Stephen; evidently *Ogygopsis* was an inhabitant of the Goodsir trough, southwest of the Bow trough, and only occasionally was carried by the waters to the extreme southwestern margin of the Bow trough. Other forms, unknown in the typical Middle Cambrian sections of the Bow Range, occur in the anomalous assemblages of the *Yohoaspis pachycephala* and *Chancia bigranulosa* faunules on Mount Stephen.

The last group of trilobites still to be discussed is the Ptychoparioidae. This superfamily is not divided by the writer into families because of the great difficulties presented by the taxonomy of the group. The lack of satisfactory family divisions and the arbitrary definition of most of the ptychoparid genera renders them poor index fossils, to be avoided for zone definition whenever anything else is available. Generalized ptychoparids (*Piazella, Onchocephalus, Syspacephalus*) appear in the Lower Cambrian Peyto limestone and occur through the overlying Middle Cambrian formations. Most of the Middle Cambrian forms are referred to other genera, but whether this is done or not, little or no significance for correlation should be attributed to generalized ptychoparids. There are, however, a few distinctive Middle Cambrian ptychoparids that do have stratigraphic significance.

The long-brimmed, flat, micropygous forms (here assigned to *Amecephalus* and *Alokistocare;* partly referred in the literature to *Kochiella* or *Strotocephalus*) were first observed in the *Wenkchemnia-Stephenaspis* zone. In Greenland, however, Poulsen (1927) reports *Kochiella* from the Cape Kent formation in association with Olenellidae. These long-brimmed ptychoparids are common in the Stephen formation, but were never observed in the *Albertella* zone, unless *Mexicella* be considered a member of the group.

Two very distinctive ptychoparid genera are *Plagiura* and *Schistometopus,* both collected only from the beds of the *Plagiura-Kochaspis* zone.

A difficult problem, discussed in the systematic part of this paper, is presented by the genera *Kochiella* and *Kochaspis* on account of the uncertain assignment of the pygidia to the cranidia. Until *Kochiella* is better understood it is preferable not to use it for zone designation. *Kochaspis* is well based on the genotype *Kochaspis liliana,* whose head and tail are properly assigned. For this reason, *Kochaspis* was used with *Plagiura* for zone designation. However, some of the other described species of *Kochaspis* were undoubtedly based on arbitrary combinations of ptychoparid heads and bathyuriscid tails.

A general conclusion that can be derived from these remarks on the occurrence of trilobite families and genera is that often even highly fossiliferous formations appear entirely to lack fossils that are known to range through the corresponding stratigraphic intervals and to occur in beds of similar lithology elsewhere. Hence very little significance should be attributed to the absence of genera or families from certain strata. A typical example is that of the Ross Lake shale member of the Cathedral formation, a siliceous shale with limestone beds and nodules. No more than seven species of trilobites, representing five genera, are known from this extremely fossiliferous unit. Evidently ecologic conditions favored this small assemblage of species to the exclusion of a great number of other trilobites that lived at the time. To mention only a few examples, there is no doubt that *Kootenia, Olenoides, Oryctocephalus, Pagetia, Zacanthoides, Ogygopsis,* and a host of ptychoparid genera lived in the Cordilleran province at the time when the Ross Lake shale was deposited. Hence it would not be surprising to find elsewhere a faunule exactly equivalent in age to that of the Ross Lake shale and yet not having any species or even genera in common. The stratigrapher must constantly bear in mind the fact that while the presence of several common species in strata of different areas almost certainly indicates a close time equivalence, lack of common forms does not prove difference in time.

Table 4 indicates the presence of the trilobite genera discussed in this paper in the various zones (*Bonnia-Olenellus* zone of the Lower Cambrian and *Wenkchemnia-Stephenaspis, Plagiura-Kochaspis, Albertella, Glossopleura, Bathyuriscus-Elrathina* zones of the Middle Cambrian). The data in this table refer exclusively to the area investigated, hence the presence of genera in the same zones in other areas is not reported.

TABLE 4.—*Range of trilobite genera in the Canadian Rockies*

Genus	*Bonnia-Olenellus* zone	*Wenkchemnia-Stephenaspis* zone	*Plagiura-Kochaspis* zone	*Albertella* zone	*Glossopleura* zone	*Bathyuriscus-Elrathina* zone
Albertella				x		
Alokistocare						x
Alokistocarella						x
Amecephalus		x	x			
Athabaskia				?		?
Bathyuriscus						x
Bonnaspis						x
Bonnia	x					
Burlingia						x
Caborcella			x			
Chancia		x		?		x
Crassifimbra	x					
Ehmaniella						x
Elrathia						x
Elrathina						x
Fieldaspis			x			
Glossopleura					x	
Hanburia						x
Klotziella						x
Kochaspis			x			
Kochiella?			x			
Kochina				x		
Kootenia				?		x
Mexicella				x		
Ogygopsis		x		?		x
Olenellus	x					
Olenoides						x
Onchocephalus	x		x			
Oryctocephalites ...			x			
Oryctocephalus		x				x
Pachyaspis						x
Paedeumias	x					
Pagetia	x			?		x
Parkaspis						x
Peronopsis						x
Piazella	x	x				
Plagiura			x			
Poliella		x				
Polypleuraspis					x	
Ptarmigania				x		
Ptarmiganoides				x		
Schistometopus			x			
Solenopleurella						x
Stephenaspis		x				

TABLE 4.—Continued

Genus	*Bonnia-Olenellus* zone	*Wenkchemnia-Stephenaspis* zone	*Plagiura-Kochaspis* zone	*Albertella* zone	*Glossopleura* zone	*Bathyuriscus-Elrathina* zone
Syspacephalus	x	x				
Triplagnostus						x
Tonkinella						x
Vanuxemella				x		
Wenkchemnia		x				
Yohoaspis				?		
Yuknessaspis						x
Zacanthoides				?		x
Zacanthopsis	x					

ENVIRONMENT OF DEPOSITION

This section includes a brief discussion of the ecology of the Middle Cambrian deposits and the manner of preservation of the fossils.

Fossils occur in the rocks investigated in several kinds of matrix, which can be divided into three general lithologic types: (1) crystalline or oolitic, thin-bedded limestones; (2) argillaceous, platy limestone; (3) fine-grained, siliceous shales. Massive carbonate formations (e.g., most of the Cathedral formation) appear barren of fossils (apart from the algal concretions designated in the literature as *Girvanella*) even when represented by calcareous limestone where the fossils would be expected to be well preserved if they had originally been present.

The thick Lower Cambrian series in the area consists almost entirely of sandstones, quartzites, and siliceous shales, and is almost barren of fossils, excepting numerous worm trails and burrows. The shaly intervals were carefully searched at various localities, in view of the abundant fossil content reported for beds of this age and lithology elsewhere, but yielded few identifiable fossils. A trilobite faunule collected from quartzitic beds in the lower St. Piran sandstone was mentioned in discussing that unit. In view of the abundant traces of animal life in the less coarse portions of the Lower Cambrian clastics, the scarcity of trilobite shields, brachiopod shells, and other identifiable remains is probably due to the destructive action of scavenging organisms.

Fossils appear abundantly near the top of the Lower Cambrian with the first deposition of carbonates. The uppermost St. Piran beds gradually change to calcareous sandstone, sandy limestone, and finally pure, crystalline limestone; the calcareous sediments in many instances first appearing as lenses in the sandstone. This Lower Cambrian limestone (Peyto limestone member of the St. Piran sandstone) is often filled with comminuted tests of olenellid trilobites. The smaller, thick shells of *Bonnia* and ptychoparid trilobites are usually much better preserved. The conditions of fossilization point to a very low rate of sedimentation for these calcareous Lower Cambrian beds.

The lowermost Middle Cambrian unit (Mount Whyte formation) first consists to a large extent of siliceous shale with thin interstratified sandstone beds, succeeded by alternating shale and limestone; the latter coarsely crystalline or oolitic and predominating in the upper part of the formation. Most of the shale shows worm trails and burrows and appears barren of identifiable fossils. However, local deposits of very fine, siliceous shale lack such worm burrows and yield numerous well-preserved trilobites and other fossils. These localized deposits, here designated as the Lake Agnes and Yoho shale lentils, are approximately of the same age.

The Lake Agnes shale is a blue-green shale yielding chiefly trilobites, accompanied by small inarticulate brachiopods and rare *Hyolithes*. Most of the trilobites are fragmentary, but complete shields of the four species were recovered. Some of these shields preserve the free cheeks while others do not. It is generally assumed that in the first case the living animals, in the second case moults, were entombed. Early larval stages were not observed.

The Yoho shale is far more fossiliferous than the Lake Agnes shale, and small inarticulate brachiopods, gastropods (*Scenella*), and *Hyolithes* are almost as abundant as the most common trilobites. The conditions of fossilization of the trilobites are analogous to those observed in the Lake Agnes shale.

The Cathedral formation yielded fossils at a few localities and horizons from its calcareous beds, but most of the fossils reported from the formation were collected from the Ross Lake shale member. This fine-grained, siliceous shale averages only 5-6 feet in thickness but covers a vast area and contains trilobites and other fossils in great abundance; it represents an interval of clastic sedimentation underlain and overlain by several hundred feet of almost pure carbonates. Besides the trilobites, brachiopods and *Hyolithes* are common. Articulated trilobite carapaces were collected for all the seven species known from the shale; however, the percentage of such shields is probably less than one in a thousand compared to dismembered fragments. Both moults and living animals were entombed.

Larval forms in various stages of growth are associated with the adult trilobites, but the preservation is not good enough to allow a profitable study of the smaller individuals.

A remarkable feature of several faunules preserved in shale, and particularly of the *Albertella bosworthi* faunule of the Ross Lake shale, is the small number of species compared to the number of individuals. Many thousands of trilobite specimens were examined by the writer on the surface of slabs of the Ross Lake shale, yet no additional species were discovered. The collections from limestone beds, owing to the difficulty of examining and recovering fossils that do not appear on weathered surfaces, are much smaller, yet often yielded larger numbers of species than the collections from shaly units, and probably many more forms would be revealed by further collecting. Apparently the ecologic conditions obtaining on the sea bottom where the Ross Lake shale or similar sediments were deposited favored assemblages of a few very prolific species. The Ross Lake shale is remarkable not only for the abundance of a few species but also for the apparently total absence of many trilobite genera that are known to have existed in the Cordilleran province at the time when the shale was deposited and occur in strata of similar age and lithology elsewhere.

The basal portion of the Stephen formation carries faunules preserved in argillaceous or pure, fine-grained or crystalline limestone. The trilobite shields, usually representing only the two genera *Glossopleura* and *Polypleuraspis,* are generally concentrated in certain layers, sometimes covering the upper surfaces of the limestone beds. Entire trilobite shields are rare.

The *Ogygopsis* shale includes beds of different lithologies, as mentioned in discussing that unit; all of them are crowded with fossils, especially the five most abundant species of trilobites. The gastropod *Scenella* and the peculiar crustacean *Anomalocaris* are next in abundance. There is an exceptionally high percentage of articulated trilobite carapaces, but most of them lack the free cheeks, hence are assumed to represent moults. Such conditions of preservation seem to indicate an exceptionally high rate of sedimentation as the delicate trilobite moults, and especially *Anomalocaris,* could not have remained long unburied on the sea bottom without falling apart. The absence of scavenging organisms must have been another essential factor that made possible the preservation of such great numbers of fossils. Lithologically, the varieties of *Ogygopsis* shale seem identical with the barren siliceous shales common in the Middle Cambrian of the area. Most of the trilobite shields are of medium or large sizes.

The Burgess shale and the conditions under which it was deposited were extensively discussed by Walcott (1912a) and a few remarks will suffice. Trilobites, like other fossils, are not abundant, but the percentage of articulated carapaces is higher than in any other sediment known to the writer. Furthermore, most of the shields preserve the free cheeks, hence do not appear to represent moults. Most of the trilobites are from half to full grown, early larval stages being rare.

The uppermost, calcareous portion of the Stephen formation carries abundant fossils at several localities, while similar beds elsewhere seem barren. The fossils occur in a black-gray, fine-grained, more or less argillaceous limestone. Articulated trilobite shields are not uncommon and larval stages are frequently represented.

In two instances it was possible to obtain information on the dependence of faunal assemblages upon the lithology of the sediments. The beds of the *Plagiura-Kochaspis* zone of the Mount Whyte formation on Eiffel Peak (locality W20d) consist of interstratified crystalline limestone and fine-grained, siliceous shale. The *Fieldaspis bilobata* faunule of these beds showed little difference in the relative abundance of the various species between the two types of matrix.

Another case where the composition of a faunule in limestone and shale could be compared is offered by the Ross Lake shale, which at several localities (e.g., Ross Lake, Mount Bosworth, Bow Lake) includes near the middle or at the top beds of pure, crystalline limestone. In the shaly portion, by far the most common fossils are species of *Albertella, Mexicella stator,* and *Vanuxemella nortia.* All these forms are also common in the limestone, in addition to *Ptarmigania rossensis,* which is a rather rare fossil in the shale. Here again the difference in composition of the faunule is slight. *Albertella* has been considered a representative fossil of shaly beds and stated to be rare in limestone deposits (Lochman, 1947). The writer's observations indicate that the only reason why *Albertella* is usually represented by shale specimens in the collections is that such specimens are much more readily noticed in the field and can be collected in great numbers with far less expense of time and work than are required to obtain fossils from limestone. The number of fossils per unit volume of the rock did not appear to be smaller in the limestone than in the shale.

These remarks should not be interpreted to mean that the composition of a faunule is unaffected by the environment of deposition, but rather that in the above-mentioned instances there was essentially a single environment, independent of the deposition of clastic or carbonate sediments. This is made plausible by the fact that limestone layers interbedded with the shale are usually lenticular, hence limestone deposition took place in small, shifting patches on a prevalently argillaceous sea floor. It is not surprising that under such conditions we do not find different types of organisms confined to each kind of sediment.

INDEX OF LOCALITIES

Table 5 includes a list of the author's localities from which fossils were described. The first column gives the locality number, the second column the topographic location (see also localities indicated on maps, figs. 1 and 3). The third column gives the stratigraphic position and lithology. The fourth column gives the approximate altitude in feet.

Table 6 shows the correspondence between all the United States National Museum localities mentioned in the description of the fossils and the equivalent author's localities.

TABLE 5.—*Topographic and stratigraphic position of author's localities*

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
P18m	Northwest slope of Mount Stephen, about ½ mile west of the Monarch Mine, directly above the second of the three sheds of the Canadian Pacific Railway; Yoho Park, British Columbia.	St. Piran sandstone (Peyto limestone member): top 6 feet of limestone. Dark-gray, crystalline limestone.	4,700
P22k	West ridge of Mount Schaffer, above McArthur Pass; 0.4 mile W. 30° S. of the summit of Mount Schaffer; Yoho Park, British Columbia.	St. Piran sandstone (Peyto limestone member): near base of unit 4 of the Mount Schaffer section, about 110 feet above base of member. Dark-gray, crystalline limestone.	7,800
P22m	Same as P22k.	St. Piran sandstone (Peyto limestone member): top 10 feet of unit 4 of Mount Schaffer section, about 160 feet above base of member. Dark-gray, crystalline limestone.	7,800
W2b	South slope of east ridge of Mount Niblock; 0.3 mile NW. of the upper end of Lake Agnes; Banff Park, Alberta.	Mount Whyte formation: unit 2 of Mount Niblock section, 15-20 feet above base of formation. Blue-green-gray, fine-grained siliceous shale.	8,000

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
W3b	Southeast slope of Popes Peak; 0.2 mile west of Plain of Six Glaciers chalet; Banff Park, Alberta.	Mount Whyte formation: lower 5 feet of unit 3 of Mount Whyte section, 22-27 feet above base of formation. Blue-green-gray, fine-grained siliceous shale.	6,800
W3c	Same as W3b.	Mount Whyte formation: unit 5 of Mount Whyte section, 100-112 feet above base of formation. Dark-gray oolitic limestone.	6,900
W4c	Slope 0.2 mile southeast of upper end of Ross Lake; Yoho Park, British Columbia.	Mount Whyte formation: 3-5 feet above base of unit 4 of Ross Lake section, 162-164 feet above base of formation. Dark-gray, oolitic limestone.	6,300
W4c′	Same as W4c.	Mount Whyte formation: unit 4 of Ross Lake section, 160-182 feet above base of formation. Dark-gray, oolitic limestone.	6,300
W4d	Same as W4c.	Mount Whyte formation: 5 feet above base of unit 5 of Ross Lake section, 187 feet above base of formation. Dark-gray, crystalline or oolitic limestone.	6,300
W4d′	Same as W4c.	Same horizon as W4d. Dark-gray, crystalline limestone.	6,300
W4e	Same as W4c.	Mount Whyte formation: near top of unit 5 of Ross Lake section, about 235 feet above base of formation. Dark-gray, crystalline limestone.	6,400
W5b	South slope of Mount Bosworth; 0.4 mile north of western end of Sink Lake; Yoho Park, British Columbia.	Mount Whyte formation: unit 2 of Mount Bosworth section, 24-60 feet above base of formation. Outcrop separated by fault from measured section. Light-gray, crystalline limestone lenses in shale.	6,000

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
W5c	East ridge of Mount Bosworth; 0.9 mile N. 15° E. of western end of Sink Lake; Yoho Park, British Columbia.	Mount Whyte formation: 50 feet above base of unit 5 of Mount Bosworth section, 254 feet above base of formation. Dark-gray, crystalline or oolitic limestone.	7,000
W6d	East slope of south peak of Mount Odaray; 0.5 mile east of summit of south peak; Yoho Park, British Columbia.	Mount Whyte formation: top 3 feet of unit 3 of Mount Odaray section, 158-161 feet above base of formation. Very dark-gray, finely crystalline limestone.	8,200
W7c	Southeast slope of Mount Field; just east of portal of Kicking Horse Mine; Yoho Park, British Columbia.	Mount Whyte formation: top 3 feet of unit 1 of Kicking Horse Mine section, 190-193 feet below top of formation. Dark-gray, crystalline or oolitic limestone.	4,700
W7d	Same as W7c.	Mount Whyte formation: basal 2 feet of unit 2 of Kicking Horse Mine section, 188-190 feet below top of formation. Dark-gray, crystalline limestone.	4,700
W7e	Same as W7c.	Mount Whyte formation: 10 feet above base of unit 2 of Kicking Horse Mine section, 180 feet below top of formation. Dark-gray, crystalline or oolitic limestone.	4,700
W7f	Same as W7c.	Mount Whyte formation: 72 feet above base of unit 2 of Kicking Horse Mine section; 118 feet below top of formation. Dark-gray, crystalline limestone.	4,800
W7f'	Same as W7c.	Mount Whyte formation: unit 2 of Kicking Horse Mine section, more precise horizon unknown (isolated outcrop east of measured	4,700

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
		section traverse). Dark-gray, crystalline limestone.	
W7	Same as W7c.	Mount Whyte formation: unit 2 of Kicking Horse Mine section, more precise horizon unknown (talus). Dark-gray, crystalline limestone.	4,500
W7g	Same as W7c.	Mount Whyte formation: 40-50 feet above base of unit 4 of Kicking Horse Mine section, 60-70 feet below top of formation. Very dark-gray, finely crystalline limestone.	4,800
W9k	Southwest side of Fossil Gully; northwest face of Mount Stephen, Yoho Park, British Columbia.	Mount Whyte formation: 25-80 feet above base of unit 4 of Fossil Gully section. Dark-gray, fine-grained siliceous shale.	6,000
W9k′	About ¼ mile west of locality W9k.	Same as locality W9k. Dark-gray, fine-grained siliceous shale.	6,500
W9f	Southwest and northeast sides of Fossil Gully; northwest face of Mount Stephen, Yoho Park, British Columbia.	Mount Whyte formation: from ⅓ above the base to top of unit 11 of Fossil Gully section; 0-60 feet below top of formation. Dark-gray, crystalline limestone.	5,800 and 6,300
W12c	South slope of Ptarmigan Peak, above Ptarmigan Pass; Slate Mountains, Banff Park, Alberta.	Mount Whyte formation: 120 feet above base of formation. Dark-gray, oolitic limestone.	7,700
W16h	Northeast side of North Gully; northwest face of Mount Stephen; Yoho Park, British Columbia.	Mount Whyte formation: top 3 feet of unit 1 of North Gully section, about 140 feet above base of formation. Dark-gray, crystalline limestone.	5,200
W16i	Same as W16h.	Mount Whyte formation: unit 2 of North Gully section; 142-158 feet above base of formation. Gray, siliceous shale and lenses of gray, crystalline limestone.	5,200

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
W16j	Same as W16h.	Mount Whyte formation: top 20 feet of unit 3 of North Gully section, 242-262 feet above base of formation. Dark-gray siliceous shale and dark-gray, crystalline or fine-grained, silty limestone.	5,300
W16j'	Same as W16h.	Mount Whyte formation: unit 3 of North Gully section (more precise position unknown). Dark-gray, siliceous shale and fine-grained, dark-gray, silty limestone.	5,300
W16j"	Same as W16h.	Mount Whyte formation: 40-50 feet above base of unit 3 of North Gully section; 198-208 feet above base of formation. Dark-gray, siliceous shale and fine-grained, dark-gray, silty limestone.	5,300
W16k	Same as W16h.	Mount Whyte formation: 20-30 feet above base of unit 4 of North Gully section, 282-292 feet above base of formation. Dark-gray, fine-grained siliceous shale and lenses of dark-gray, crystalline limestone.	5,400
W17a	North shoulder of Mount Stephen, directly above the Canadian Pacific Railway tunnel; Yoho Park, British Columbia.	Mount Whyte formation: 18 feet above base of unit 1 of Monarch Mine section. Dark-gray limestone.	4,700
W17b	Same as W17a.	Mount Whyte formation: top 5 feet of unit 3 of Monarch Mine section, 162-167 feet above base of formation. Dark-gray crystalline limestone.	4,900
W19c	West face of northwest spur of Mount Hector; 0.8 mile northeast of the lower end of Hector Lake; Banff Park, British Columbia.	Mount Whyte formation: near middle of unit 2 of Hector Creek section; about 235 feet above base of formation. Dark-gray, oolitic limestone.	6,800

Table 5.—Continued

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
W20d	Southeast ridge of Eiffel Peak; 0.3 mile northeast of the eastern end of Eiffel Lake; Banff Park, Alberta.	Mount Whyte formation: limestone 22-28 feet above base of formation, and shale immediately above and below. Dark-gray, crystalline limestone and green-gray, fine-grained siliceous shale.	8,500
C3m	South ridge of Mount Whyte; 0.3 mile north of Plain of Six Glaciers chalet; Banff Park, Alberta.	Cathedral formation (Ross Lake shale member): unit 4 of Mount Whyte section, 463-468 feet above base of formation. Dark-blue-gray, fine-grained siliceous shale.	8,100
C4m	Northwest slope of the north spur of Popes peak; 0.3 mile southeast of the upper end of Ross Lake; Yoho Park, British Columbia.	Cathedral formation (Ross Lake shale member): 410-418 feet above base of formation. Dark-blue-gray, fine-grained siliceous shale and interbedded gray limestone.	6,700
C5m	East ridge of Mount Bosworth; 1.0 mile north of the western end of Sink Lake; Yoho Park, British Columbia.	Cathedral formation (Ross Lake shale member): 385-394 feet above base of formation. Dark-blue-gray, fine-grained siliceous shale.	7,400
C9h	Southwest and northeast sides of Fossil Gully; northwest face of Mount Stephen; Yoho Park, British Columbia.	Cathedral formation: 30-70 feet above base of unit 2 of undivided Cathedral and Stephen formations of Fossil Gully section. Dark-gray, silty limestone and dark-gray, siliceous shale.	5,900 and 6,400
C9j	Northeast side of Fossil Gully; northwest face of Mount Stephen; Yoho Park, British Columbia.	Cathedral formation: 35 feet below top of unit 3 of undivided Cathedral and Stephen formations of Fossil Gully section. Dark-gray, subcrystalline limestone.	6,000
C9j'	Northeast side of Fossil Gully; northwest face of Mount Stephen; Yoho Park, British Columbia.	Cathedral formation: top of unit 3 of undivided Cathedral and Stephen formations of Fossil Gully section. Dark-gray, subcrystalline limestone.	6,000

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
C9k	Northeast side of Fossil Gully; northwest face of Mount Stephen; Yoho Park, British Columbia.	Cathedral formation: base of unit 5 of undivided Cathedral and Stephen formations of Fossil Gully section. Black-gray, subcrystalline limestone.	6,000
C12k	South slope of Ptarmigan Peak, above Ptarmigan Pass; Slate Range, Banff Park, Alberta.	Cathedral formation: Deiss' 23-feet unit of "Ptarmigan formation." According to reinterpretation of Deiss' section, this unit is 363-386 feet above base of Cathedral formation. Fine-grained, black-gray limestone.	8,000
C13r	Skoki valley; 1 mile N. 15° W. of the summit of Pika Peak; Banff Park, Alberta.	Cathedral formation: 270-275 feet above base of dolomitic portion of formation; probably about 650 feet above base of Cathedral formation. Black-gray, fine-grained limestone.	7,700
C15m	East slope of unnamed mountain on west side of Bow Valley, north of Bow Lake; 1.0 mile northwest of Num-Ti-Jah Lodge; Banff Park, Alberta.	Cathedral formation (Ross Lake shale member): unit 5 of Bow Lake section, 590-596 feet above base of formation. Blue-gray, fine-grained, siliceous shale and gray, crystalline limestone.	8,200
C15n	Same as C15m.	Cathedral formation: unit 6 of Bow Lake section, 596-612 feet above base of formation. Black-gray, fine-grained limestone.	8,200
C20m	Southeast ridge of Eiffel Peak; 0.4 mile northeast of the eastern end of Eiffel Lake; Banff Park, Alberta.	Cathedral formation (Ross Lake shale member): unit 4 of Eiffel Peak section, approximately 400 feet above base of formation. Greenish-gray, fine-grained siliceous shale.	8,900

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithology	Approximate altitude Feet
C21m	Southwest ridge of Mount Temple; 0.3 mile northeast of Sentinel Pass; Banff Park, Alberta.	Cathedral formation (Ross Lake shale member): unit 4 of Mount Temple section, 460-468 feet above base of formation. Dark blue-gray, fine-grained siliceous shale.	9,700
S3b	South ridge of Mount Whyte; 0.6 mile north of Plain of Six Glaciers chalet; Banff Park, Alberta.	Stephen formation: 50-60 feet above base of unit 1 of Mount Whyte section. Dark-gray, finely crystalline or fine-grained limestone.	8,800
S5a	South slope of Mount Bosworth; 0.8 mile N. 30° W. of western end of Sink Lake; Yoho Park, British Columbia.	Stephen formation: basal 10 feet of lowermost unit. Fine-grained, dark-gray, argillaceous limestone.	7,000
S6g	East slope of south peak of Mount Odaray; 0.4 mile southeast of summit of south peak; Yoho Park, British Columbia.	Stephen formation: 12 feet above base of unit 1 of Mount Odaray section. Gray, crystalline limestone lenses in siliceous shale.	9,000
S6k	Southeast ridge of south peak of Mount Odaray; 0.3 mile southeast of summit; Yoho Park, British Columbia.	Stephen formation: unit 2 of Mount Odaray section; 120-160 feet above base of formation. Very dark-gray, fine-grained, argillaceous, platy limestone.	9,100
S6l	Summit of south peak of Mount Odaray; Yoho Park, British Columbia.	Stephen formation: 260 feet above base of unit 3 of Mount Odaray section; 420 feet above base of formation. Very dark-gray, fine-grained limestone.	9,700
S8d	Mount Stephen; 1.5 miles E. 30° S. of Field station; Yoho Park, British Columbia.	Stephen formation; *Ogygopsis* shale at old "fossil bed." Position in section unknown.	6,800
S9k	Northwest face of Mount Stephen; 0.6 mile northwest of summit of mountain, on ridge immediately	Stephen formation: 30-80 feet above base of unit 16 of undivided Cathedral and Stephen formations	7,700

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithohlogy	Approximate altitude Feet
	south of upper end of Fossil Gully; Yoho Park, British Columbia.	of Fossil Gully section. Very dark-gray, fine-grained, more or less argillaceous limestone.	
S10k	Northeast slope of north ridge of Park Mountain; 0.4 mile north of summit; Yoho Park, British Columbia.	Stephen formation: 15-30 feet above base of unit 3 of Park Mountain section; 143-158 feet above base of formation. Very dark-gray, fine-grained or subcrystalline limestone.	8,100
S10l	Same as S10k.	Stephen formation: 180-200 feet above base of unit 3 of Park Mountain section; 308-328 feet above base of formation. Very dark-gray, fine-grained or subcrystalline limestone.	8,300
S10	Northeast slope of Park Mountain, near shore of Lake McArthur; Yoho Park, British Columbia.	Stephen formation: unit 3 of Park Mountain section, more precise horizon unknown (talus). Very dark-gray, subcrystalline limestone.	7,500
S11d	West slope of ridge between Mount Field and Mount Wapta; directly below Walcott's quarry; Yoho Park, British Columbia.	Stephen formation: 60 feet below top of unit 1 of Burgess Quarry section. Not placed in general section. Calcareous and siliceous shale.	7,600
S11e	West slope of ridge between Mount Field and Mount Wapta; about 0.3 mile south of Walcott's quarry; Yoho Park, British Columbia.	Stephen formation: probably at approximate horizon of Walcott's quarry. Gray, fine-grained, argillaceous, thin-bedded limestone.	7,700
S11f	West slope of ridge between Mount Field and Mount Wapta; at Walcott's quarry; Yoho Park, British Columbia.	Stephen formation (Burgess shale member): basal 20 feet of unit 2 of Burgess quarry section (Walcott's "phyllopod bed"). Fine-grained, dark-gray, siliceous shale.	7,700

TABLE 5.—Continued

Locality	Topographic position	Stratigraphic position and lithohlogy	Approximate altitude Feet
S11g	Same as S11f.	Stephen formation (Burgess shale member): 150-160 feet above base of unit 2 of Burgess Quarry section. Fine-grained, dark-gray, siliceous shale.	7,900
S21b	Southwest ridge of Mount Temple; 0.4 mile southwest of summit of mountain; Banff Park, Alberta.	Stephen formation: 100-120 feet above base of unit 1 of Mount Temple section. Very dark-gray, fine-grained or subcrystalline limestone.	10,600

TABLE 6.—*Equivalence of U.S.N.M. and author's localities*

U.S.N.M. locality	Author's locality	Topographic position
14s	S8d	Mount Stephen
35c	C5m	Mount Bosworth
35e	W2b	Mount Niblock
35f	P18m	Mount Stephen
35k	S11f	Mount Field
35m	W3b	Mount Whyte
38k	W20d	Eiffel Peak
57g, 57u	S5a	Mount Bosworth
57s	W5c	Mount Bosworth
58j	S9k	Mount Stephen
61d	P22k	Mount Schaffer
63c	W12c	Ptarmigan Pass
63j	C4m	Ross Lake
63m, 63m'	C5m	Mount Bosworth
63w	C15m	Bow Lake

PART II. PALEONTOLOGY

GENERAL STATEMENT

The fossils described and figured in this paper were selected from approximately 4,000 specimens collected by the writer and several thousand specimens collected by Walcott and preserved in the United States National Museum.

Only trilobites are described. A conservative attitude was followed in naming new species; forms apparently not belonging to described species but poorly represented were left out of consideration unless they seemed to possess special stratigraphic significance; in the latter case they were described and illustrated but left unnamed.

All the types of the species based on material collected by the writer were deposited in the United States National Museum collections.

All the specimens figured in the plates show the upper surface of the test unless otherwise stated.

TERMINOLOGY

The terminology employed in this paper for describing the trilobite shield is essentially the one proposed by Howell et al. (1947), with a few modifications. Ross (1948) raised several objections against the terminology of Howell et al. Some of his suggestions have been adopted.

Ross suggests modification of the meaning of the term "palpebral lobe" in order to give a significance to this portion of the cephalic shield even when the palpebral furrow is obsolete. The writer does not agree with this view, since the palpebral lobe as defined by Ross would designate an area bounded by an arbitrary line, whereas the usual procedure of considering the palpebral lobe bounded by the palpebral furrow makes it a natural unit. When the palpebral furrow is obsolete, the palpebral lobe remains undefined from the rest of the fixed cheek, just as the glabellar area becomes undefined when the dorsal furrow is obsolete.

The writer agrees with Ross' suggestion that the old term "rim" is more appropriate than the term "border" used by Howell et al., and will use "rim" in this paper. The term "anterior limb" to designate collectively the brim, marginal furrow and rim is also accepted.

Ross suggests that the glabella should include the occipital ring.

This proposal has several obvious advantages; however, to avoid unessential changes in terminology the glabella will still designate the axial portion of the cephalic shield exclusive of the occipital ring.

The writer agrees with Ross that measurements taken in the longitudinal direction along the midline should be generally designated as lengths, even if the part being described has greater extension in the transverse direction, such as the occipital ring. However, in certain cases it is impossible to follow this suggestion without distorting the usual meaning of the words beyond a reasonable point. For example, the "width" and "length" of a furrow or spine obviously signify measurements respectively taken across and parallel to the furrow or spine, whatever its direction. It would be impractical to invert the meaning of the two words when the furrow happens to be perpendicular to the axis of the animal. Furthermore, some furrows (e. g., the marginal furrow on the cephalon) describe a semicircle, hence in some portions are parallel, in others perpendicular to the axis of the body.

In this paper the term "midlength" will indicate the extent of the rim, brim, or entire frontal limb in the longitudinal direction. The terms "length," "long," and "short" will also be applied to the occipital ring, to axial and pleural segments of the thorax, and to the posterior limbs to indicate longitudinal extent. The words "width," "wide," and "narrow" will always indicate transverse extent of the same parts. The lateral extent of the brim in the transverse direction in trilobites (of the *Bathyuriscus* type) that have no brim in front of the glabella is designated as "width."

The glabellar furrows are numbered from one to four beginning from the front.

It should be noted that the "width of the fixed cheeks" includes the palpebral lobes.

All descriptions refer to the upper surface of the test unless otherwise indicated.

CLASSIFICATION OF CAMBRIAN TRILOBITES

The writer (Rasetti, 1948a) recently gave a brief discussion of the classification of Cambrian trilobites. Study of the material discussed in the present investigation did not bring out any evidence against the conclusions reached in the above-cited paper; on the contrary, several points received valuable confirmation; particularly the sharp distinction of most of the Lower and Middle Cambrian Opisthoparida of the Appalachian and Cordilleran provinces into the two superfamilies Corynexochoidae (formerly Bathyuriscidea) and Ptychoparioidae. Further distinguishing characters for this subdivision are discussed under the superfamily Corynexochoidae.

The classification here adopted is the following. It must be borne in mind that it includes only those families that are represented in the material studied in this work, hence it is not a complete classification for the trilobites, or even for the Cambrian forms alone.

For superfamily names the uniform ending *-oidae* was adopted, as suggested by the editors of the Treatise on Invertebrate Paleontology, now in preparation.

Order AGNOSTIDA
- Family Peronopsidae
- Family Agnostidae

Order EODISCIDA
- Family Pagetiidae

Order OLENELLIDA
- Family Olenellidae

Order OPISTHOPARIDA
- Superfamily Burlingioidae
  - Family Burlingiidae
- Superfamily Corynexochoidae
  - Family Zacanthoididae
  - Family Dolichometopidae
  - Family Corynexochidae
  - Family Dorypygidae
  - Family Ogygopsididae
  - Family Oryctocephalidae
- Superfamily Ptychoparioidae
  - (Families undefined)

DESCRIPTIONS OF GENERA AND SPECIES OF TRILOBITES

Order AGNOSTIDA

Family PERONOPSIDAE Westergård

Genus PERONOPSIS Hawle and Corda, 1847

Genotype: *Battus integer* Beyrich.

The generic assignment of many Middle Cambrian agnostids from the Cordilleran province presents a problem that will require extensive study before it can be satisfactorily solved. The classification of the agnostid genera was recently discussed by Harrington (1938), Kobayashi (1939), and Westergård (1946) and was based chiefly on the

Atlantic province forms. All these authors agree in assigning most of the agnostid genera to either of two groups, the Peronopsidae and the Agnostidae (considered by Westergård as subfamilies), but were unable to find objective criteria for determining whether a given agnostid belongs to the Peronopsidae or the Agnostidae. The two groups are assumed to represent distinct lineages of descent undergoing parallel development in most of the observable characters. Hence, one could decide to which family an agnostid belongs only through the study of its phylogeny.

So little is known of the agnostids of the Cordilleran province that the above-mentioned procedure is at present impracticable, hence one must resort to morphologic criteria to decide the generic assignment. Two forms discussed in this work are assigned to *Peronopsis* because they closely agree with the genotype and other Atlantic province species attributed to the genus, but an extensive study like that carried out by Westergård for the Scandinavian agnostids might show that we have a case of parallel development in a different stock.

PERONOPSIS MONTIS (Matthew)

Plate 25, figures 11-14

Agnostus montis Matthew, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 43, pl. 1, fig. 6, 1899.

Agnostus montis Matthew, Walcott, Canadian Alpine Journ., vol. 1, No. 2, pl. 3, fig. 7, 1908.

Peronopsis montis (Matthew), Kobayashi, Journ. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 5, p. 115, 1939.

This species is rare both at the type locality on Mount Stephen and in the Burgess shale, where only half a dozen specimens were found among the several hundred agnostids from the locality preserved in the United States National Museum.

Horizon and locality.—Stephen formation (*Ogygopsis* and Burgess shale lentils; *Bathyuriscus-Elrathina* zone). Type locality, U.S.N.M. 14s, Mount Stephen. Also locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Types.—Holotype: Royal Ontario Museum. Plesiotypes: U.S.N.M. Nos. 116215-6.

PERONOPSIS COLUMBIENSIS Rasetti, new species

Plate 33, figures 1-8

Known from numerous cephala and pygidia and several complete shields, all preserved in limestone.

Both shields considerably convex and well rounded. Glabella on the average very slightly tapered, highly elevated posteriorly and low anteriorly, well defined by the dorsal furrow; occupying somewhat more than two-thirds of the cephalic length. Anterior glabellar lobe well rounded, with just a suggestion of a pointed shape; transverse furrow straight. Posterior lobe culminating in an elongated elevation at one-third the distance from the posterior margin. Basal lobes triangular, defined by rather shallow furrows. The basal lobes are united mesially through a very thin occipital ring. Cheeks strongly convex, without trace of a preglabellar furrow. Marginal furrow narrow and deep; rim convex, narrow, of even width all around the cephalon.

The thoracic segments do not show any specific features.

Pygidium with an elevated rachis defined by a well-impressed dorsal furrow. Rachis rapidly tapered from the anterior end to the first transverse furrow, slightly expanded from this level to a little back of the second transverse furrow, then tapering in triangular shape to a rather sharp point. Rachis elevated anteriorly and low posteriorly, terminating at a distance from the posterior marginal furrow somewhat greater than the width of the rim. First transverse furrow represented by a pair of lateral impressions directed inward and somewhat forward; second transverse furrow almost indistinct. An elevated tubercle just in front of the second furrow. Marginal furrow and rim considerably wider than in cephalon. Rim of almost even width, with a pair of small, short marginal spines.

Surface of test smooth. Length of largest entire shield 10 mm. Separated shields indicate the presence of somewhat larger individuals.

This species is very close to *Peronopsis interstricta* (White) from the Wheeler formation of Utah, differing only in minor details in the proportions of the various parts, chiefly the somewhat shorter pygidial rachis.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality S6k, Mount Odaray. Also localities S6l, Mount Odaray; S9k, Mount Stephen; S10k, S10l, Park Mountain.

Types.—Holotype: U.S.N.M. No. 116267. Paratypes: U.S.N.M. Nos. 116268-9.

Family AGNOSTIDAE Jaekel

Genus TRIPLAGNOSTUS Howell, 1935

Genotype: *Agnostus gibbus* Linnarsson.

TRIPLAGNOSTUS BURGESSENSIS Rasetti, new species

Plate 25, figures 1-5

Known from a large number of shields more or less flattened in shale.

Both shields approximately semicircular. Glabella narrow and long, divided by a straight transverse furrow into anterior and posterior lobes; the former slightly more than half as long as the latter. Anterior lobe pointed, narrowly rounded in front. Posterior lobe slightly tapered forward, showing two pairs of short and shallow furrows at the sides; with a small, low tubercle somewhat back of its midpoint. Basal lobes short and wide. Median preglabellar furrow shallow but distinct in all specimens. Marginal furrow narrow and deep; rim narrow, convex. Posterior angles sharp but not extended into spines.

Thoracic segments of the shape usual in the genus. The rachis shows in each segment the large lateral tubercles and, in addition, a small median tubercle close to the anterior margin in the first segment.

Pygidial rachis with two well-impressed transverse furrows. Rachis tapered from the anterior end to the first furrow, expanding from the first furrow to one-third the length of the posterior lobe, hence tapered, narrowly rounded at the posterior end; occupying on the average one-third of the width and four-fifths of the length of the pygidium. Anterior transverse furrow convex forward, posterior furrow straight. Middle lobe with a tubercle reaching the maximum elevation near the posterior margin of the lobe. Pleural lobes convex, confluent behind the rachis. Marginal furrow as in cephalon, rim slightly wider, without marginal spines. In young individuals the rachis does not expand as in the adult and there seems to be a median postrachial furrow.

Surface of test smooth.

Length of largest complete shield 8 mm.

As far as the writer knows, no species referable to *Triplagnostus* had previously been described from the Cordilleran province, although the presence of the genus in that area had been reported. *T. burgessensis* very closely resembles the genotype from the Acado-Baltic province, differing chiefly in the proportionately narrower glabella, shallower preglabellar furrow, and lack of spines at the posterior angles of the cephalon and on the second thoracic segment. These differences are certainly not of generic importance, and the writer does not consider it proper to remove the species from the genus on purely geographic grounds.

Horizon and locality.—Stephen formation (Burgess shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Types.—Holotype: U.S.N.M. No. 116212. Paratypes: U.S.N.M. No. 116213.

Order EODISCIDA

Family PAGETIIDAE Kobayashi

Genus PAGETIA Walcott, 1916

Genotype: *Pagetia bootes* Walcott.

PAGETIA BOOTES Walcott

Plate 25, figures 6-10

Pagetia bootes Walcott, Smithsonian Misc. Coll., vol. 64, No. 5, p. 408, pl. 67, figs. 1, 1a-f, 1916.

Some of the specimens figured are flattened in the usual variety of Burgess shale, others are preserved in a calcareous shale and show most of the original convexity.

Horizon and locality.—Stephen formation (Burgess shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 35k (=author's locality S11f); Burgess Quarry, Mount Field.

Types.—Syntypes: U.S.N.M. Nos. 62855-61. Plesiotypes: U.S.-N.M. No. 116214.

PAGETIA cf. P. BOOTES Walcott

Plate 33, figures 9-11

Specimens of *Pagetia* are fairly common in the black limestone that constitutes the uppermost portion of the Stephen formation in many sections. These fossils easily escape observation because of their very small size. The writer was unable to establish specific differences among the specimens collected; however, as the material is not abundant and close comparison with the type of the genus, *P. bootes,* is made difficult by the different manner of preservation, the specific identification is considered uncertain. The figured specimens preserve their full convexity, and the pygidia show the unbroken axial spine.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Localities S61, Mount Odaray, and S9k, Fossil Gully, Mount Stephen.

Figured specimens.—U.S.N.M. Nos. 116270-1.

PAGETIA, species undetermined

Plate 22, figures 13, 14

A species of *Pagetia* is common in the impure limestones and siltstones that immediately overlie the Mount Whyte formation in the Fossil Gully section. However, the coarse grain of the matrix, the presence of distortion, and the small size of the fossil, make it difficult to ascertain its exact features. Hence specific identification is not attempted.

The cranidium has the usual features found in the typical forms of the genus. The pygidium has a narrow, highly elevated axis showing four rings and a terminal section, which was extended into the usual spine, broken off in all available specimens. The pleural lobes are unfurrowed.

Horizon and locality.—Cathedral formation (*Albertella* (?) zone). Localities C9h and C9j, Fossil Gully, Mount Stephen.

Figured specimens.—U.S.N.M. No. 116192.

Order OPISTHOPARIDA

Superfamily BURLINGIOIDAE

Family BURLINGIIDAE Walcott

Genus BURLINGIA Walcott, 1908

Genotype: *Burlingia hectori* Walcott.

BURLINGIA HECTORI Walcott

Plate 28, figure 1

Burlingia hectori Walcott, Smithsonian Misc. Coll., vol. 53, No. 2, p. 15, pl. 1, fig. 8, 1908.

An unretouched photograph of the holotype of this exceedingly rare species is reproduced.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 14s, Mount Stephen.

Types.—Lectotype: U.S.N.M. No. 53418. Paratype: U.S.N.M. No. 53419.

Superfamily CORYNEXOCHOIDAE

Although this group of trilobites reaches its greatest development in the Appalachian and Cordilleran provinces of North America, the type genus and family from which the name is derived are based on forms from the Atlantic province. The writer does not believe in strict adherence to the priority rule at the family and superfamily levels, hence the names Bathyuriscidae and Bathyuriscidea, proposed by R. Richter (1932), might be accepted in place of Dolichometopidae and Corynexochidea (emended as Corynexochoidae) respectively. R. and E. Richter (1941) abandoned the name Bathyuriscidea in favor of Corynexochidea for priority reasons, and the writer, contrary to his previous usage (Rasetti, 1948a, 1948b), will follow the same procedure.

It must be emphasized that the limits assigned by the writer to the superfamily Corynexochoidae are somewhat different from those defined by Richter (1932) and Kobayashi (1935). The writer would at least provisionally exclude from the superfamily all the post-Cambrian families, whose affinity with the Early and Medial Cambrian Corynexochoidae is doubtful because the lineages cannot be followed through the late Cambrian. On the other hand, it seems impossible to separate from the Corynexochoidae the family Zacanthoididae, placed by Richter in a superfamily Zacanthoididea and by Kobayashi in a suborder Mesonacida. New forms described in the present work make this separation even more arbitrary, as an almost continuous series of genera bridging the gap between *Zacanthoides* and *Bathyuriscus* is now known. Even a family distinction between the two groups is difficult, and is maintained more in order to avoid the family Dolichometopidae attaining an unwieldy size than for any other reason. The only difference between the classification adopted in 1948 and the present one is purely nomenclatural, consisting in the adoption of the superfamily name Corynexochoidae instead of Bathyuriscidea, and the family name Dolichometopidae (originally subfamily Dolichometopinae Walcott of the family Corynexochidae) instead of Bathyuriscidea.

The superfamily Corynexochoidae is here construed to include the families Corynexochidae, Dolichometopidae, Ogygopsididae, Dorypygidae, Zacanthoididae and Oryctocephalidae. This list includes only the families known to have North American representatives in the Medial Cambrian.

The Corynexochoidae are primarily distinguished by the cephalic features, chiefly the long, parallel-sided or expanding glabella occupying, with the occipital ring, all or most of the cephalic length. The glabella often shows four pairs of well-impressed furrows. The palpebral lobes are usually of medium to large size, often curving in semicircular form and coming close to the glabella at both ends. One character that appears common to all the Corynexochoidae, probably the most fundamental that distinguishes this group from the Ptychoparioidae, is the type of ventral cephalic sutures. In several genera of the Corynexochoidae (*Bathyuriscus, Kootenia, Ogygopsis, Olenoides, Oryctocephalus,* etc.) study of shields exposed from the ventral side shows that the hypostoma is directly attached to the anterior margin of the cranidium without an intervening rostrum; the hypostomas of all Corynexochoidae where this part of the shield is known present the same type of structure with strong anterior wings, showing the same type of attachment. Hence, we may safely conclude that the cephalon of the Corynexochoidae consists of four pieces, the cranidium, hypostoma, and free cheeks. The doublures of the free cheeks are widely separated by the hypostoma. In *Ptychoparia,* according to Barrande (see also Stubblefield, 1936) there is a rostrum between the anterior margin of the cranidium and the hypostoma. Although little is known by direct observation of the ventral cephalic sutures in other Ptychoparioidae, it is fairly safe to assume that the same type of sutures as in *Ptychoparia* is of general occurrence. This conclusion is suggested by the considerable distance between the anterior end of the glabella and the anterior margin of the cephalon. The hypostoma in the Ptychoparioidae consequently has a much more posterior position than in the Corynexochoidae, and since the known hypostomas of the former group possess very small anterior wings, they could not have been directly attached to the cranidium. The conclusion that Corynexochoidae and Ptychoparioidae can be separated on the basis of such a fundamental character as the number of pieces constituting the cephalic shield is important for the classification of the Opisthoparida.

Family ZACANTHOIDIDAE Swinnerton

Genus ZACANTHOIDES Walcott, 1888

Genotype: *Olenoides spinosus* Walcott.

ZACANTHOIDES, species undetermined

Plate 21, figures 5-8

Known from numerous cranidia and an articulated shield, all poorly preserved in siltstone or impure limestone.

Glabella parallel-sided, with three distinct pairs of glabellar furrows and the first pair almost obsolete. Occipital ring with a small spine. Frontal limb slightly concave, not differentiated into rim and brim; midlength about one-fourth the glabellar length. Anterior facial sutures widely divergent; hence the limb extends widely at the sides. Palpebral lobes typical of the genus, about three-fourths the glabellar length; maximum width of fixed cheeks sligthly less than glabellar width. Posterior limbs very slender, expanded distally, with a small intergenal spine at the end.

Pygidium of the general shape characteristic of the genus, but showing an unusual degree of reduction of the marginal spines; the first pair is reduced to extremely small spines, the other pairs are absent.

Length of largest cranidium 16 mm.

This form is almost identical with several described species as far as the cranidial features are concerned, but differs from all in the reduction of the pygidial spines. The material is considered too poorly preserved to warrant naming the species, especially since the chief diagnostic features would have to be based on the pygidium of which only one poorly preserved specimen is known.

Horizon and locality.—Cathedral formation (*Albertella*(?) zone). Locality C9h, Fossil Gully, Mount Stephen.

Figured specimens.—U.S.N.M. No. 116180.

ZACANTHOIDES SEXDENTATUS Rasetti, new species

Plate 22, figures 22-27

Known from numerous cranidia and pygidia preserved in limestone but considerably distorted.

Glabella fairly convex in both directions, slightly expanded forward, rounded in front. Four pairs of glabellar furrows visible, the posterior pair fairly deep. Occipital furrow well impressed; occipital ring expanded mesially but not extended into a spine. Brim developed at the sides, but absent mesially or at least undifferentiated from the rim. Brim attaining considerable width at the sides owing to the outward course of the anterior branch of the facial suture. Fixed cheeks slightly convex, on the average horizontal. Palpebral lobes long, with curvature increasing from the anterior to the posterior end; the maximum width of the fixed cheeks is attained almost at the level of the posterior end of the glabella and equals three-fourths the glabellar width. The posterior end of the palpebral lobe forms a rather sharp angle. Posterior limbs not preserved, obviously very slender.

Anterior branch of facial suture starting extremely close to the dorsal furrow at the anterior end of the palpebral lobe, directed almost straight outward and forward to the anterior angle of the cranidium which is rather sharp.

Pygidium twice wider than long, subtriangular, with widely rounded anterior angles. Axis very prominent, tapered, extended into a short postaxial ridge that reaches the margin. Four axial rings and a terminal section visible in most of the specimens. No spines or nodes on the axis. Pleural platforms convex, downsloping; rim flat, delimited by a distinct marginal furrow. Pleura strongly curved, directed backward distally. Three pairs of pleural furrows well impressed, separated by narrow and shallow interpleural grooves. Margin extended into six pairs of flat, regularly spaced spines of decreasing length.

Surface of cranidium smooth. Surface of elevated portions of pygidial axis and pleural lobes with elevated, scattered granules.

Length of largest cranidium 12 mm. Length of largest pygidium 6 mm., width 12 mm.

This species is sharply distinct from most of the others previously described in possessing an expanding glabella and a pygidium with convex pleural platforms and six pairs of spines of equal length. Both these characters would rather suggest reference to *Prozacanthoides*. However, in the writer's opinion the differential characters of the latter genus are rather doubtful, and Resser (1939b) himself assigned to *Prozacanthoides* several species (e.g., all the forms he described from the "*Ptarmigania* strata" of Idaho) that do not comply with his generic diagnosis, but are rather typical of *Zacanthoides*. The genotype of *Prozacanthoides* is a Lower Cambrian form, then there seems to be a gap in the stratigraphic distribution of these trilobites; later in the Medial Cambrian forms appear, some of which, like the present one, are very much like the Lower Cambrian *Prozacanthoides*, while others have the characters of the typical *Zacanthoides*. Awaiting further study, the writers prefer to assign all the Medial Cambrian species to *Zacanthoides*. The described species which most closely resembles the present form is *Z. serratus* Resser, which chiefly differs in the less expanding glabella and flat pleural lobes of the pygidium.

Horizon and locality.—Cathedral formation (*Albertella* (?) zone). Locality C9j, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116196. Paratypes: U.S.N.M. No. 116197.

ZACANTHOIDES ROMINGERI Resser

Plate 27, figures 8-10

Embolimus spinosa ROMINGER, Proc. Acad. Nat. Sci. Philadelphia, 1887, p. 15, pl. 1, fig. 3.

Zacanthoides spinosus (Walcott) (part), WALCOTT, Canadian Alpine Journ., vol. 1, No. 2, pl. 4, fig. 1, 1908.

Zacanthoides romingeri RESSER, Smithsonian Misc. Coll., vol. 101, No. 15, p. 56, 1942.

The nomenclatural history of this trilobite was given by Resser in proposing the new name, *Z. romingeri.* Rominger and Walcott had independently given the same specific name to two trilobites, *Olenoides spinosus* and *Embolimus spinosa.* Both species were subsequently referred to *Zacanthoides* and believed to be identical. Resser observed that the species from Mount Stephen is different from the typical *Zacanthoides spinosus* (Walcott) from Nevada, hence had to make a new name for the former. He also gave a sufficient redescription of the species.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 14s (=author's locality S8d) ; "fossil bed" on Mount Stephen.

Types.—Holotype: Univ. Michigan 4871. Plesiotypes; U.S.N.M. Nos. 102324, 116230.

ZACANTHOIDES SUBMUTICUS Rasetti, new species

Plate 32, figures 11-14

Known from several cranidia and pygidia rather poorly preserved and somewhat flattened in black, argillaceous limestone.

Glabella parallel-sided, with four pairs of furrows relatively well impressed. Occipital furrow well marked; occipital ring extended into a slender spine of moderate length. Structure of the frontal limb as in *Z. romingeri;* limb in front of the glabella reduced essentially to a convex rim, at the sides delimited from the brim by a distinct marginal furrow. Palpebral lobes as in *Z. romingeri.* Anterior facial sutures as in that species, i.e., not quite within the dorsal furrow at the anterior end of the palpebral lobe, then diverging at an average angle of less than 45° ; maximum lateral width of the brim about one-third the glabellar width. Posterior limbs not preserved.

Pygidium subtriangular, one and one-half times wider than long; anterior angles well rounded. Axis prominent, moderately tapered, sloping down steeply to the posterior margin. Three axial rings and a terminal section defined by well-impressed furrows. No spines or nodes on the axial rings. Pleural lobes slightly convex, with a shallow but distinct marginal furrow and a flat rim. Pleural furrows curving backward but not quite reaching a longitudinal direction; furrows and grooves shallow. Margin extended into a pair of small spines at the anterior angles; two other pairs barely distinguishable as slight denticulations of the margin.

Surface apparently smooth. Length of largest cranidium 19 mm. Lenth of pygidium 6.5 mm., width 10 mm.

This species closely resembles *Z. romingeri,* from which it would be difficult to distinguish on the basis of the cranidial features. However, the pygidium differs considerably in the great reduction of the marginal spines. This character also differentiates the species from all others so far described.

Since cranidia and pygidia of two species of *Zacanthoides,* here described as *submuticus* and *longipygus,* occur associated at the same locality, some doubt subsists about the assignment of the two parts of the shield. The pygidia being much more distinctive than the cranidia, pygidia are chosen as holotypes of both species; hence, should the assignment of the two shields prove to be erroneous, the valid descriptions of the species designated by the two names will be those referring to the pygidia.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S6l, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116263. Paratypes: U.S.N.M. No. 116264.

ZACANTHOIDES LONGIPYGUS Rasetti, new species

Plate 32, figures 3-7

Known from numerous cranidia and pygidia preserved in limestone.

Glabella of low convexity, parallel-sided. Four pairs of glabellar furrows impressed; third and fourth pairs rather deep, fourth pair showing a tendency to bifurcate. Occipital furrow well impressed especially at the sides; occipital ring extended into a slender spine of moderate length. Frontal limb differentiated into a very short brim and an upturned, convex rim. The brim has a lateral extent equal to one-half the glabellar width, and near the anterior angles of the cranidium the marginal furrow is well impressed. Palpebral lobes as in *Z. romingeri.* Posterior limbs not preserved. Anterior branch of facial suture coming close to the dorsal furrow in front of the palpebral lobe, then diverging at an angle greater than 45° to form the wide lateral portions of the frontal limb.

Pygidium rather subrectangular than triangular, slightly wider than long (not including the spines). Axis prominent, well tapered, showing three rings and a terminal section, apparently without nodes or spines, reaching the posterior margin. Pleural platforms with very little convexity; marginal furrow shallow, rim poorly defined. Pleural furrows turning backward to assume a longitudinal course; two pairs of furrows visible, interpleural grooves indistinct. Posterior margin extended into three pairs of flat, slender spines of regularly decreasing length, plus two innermost pairs of exceedingly short, barely visible spines.

Surface of test smooth except for a faint reticulated ornamentation of the pygidial pleura.

Length of largest cranidium 20 mm. Length of pygidium 5 mm., width 6 mm.

As this form was collected from the same locality as *Z. submuticus,* some uncertainty exists about the assignment of cranidia and pygidia, as discussed in the description of *Z. submuticus.* A pygidium is chosen as the holotype.

This species closely resembles *Z. romingeri* from the *Ogygopsis* shale and several forms from the Spence shale, *Z. idahoensis* Walcott, *Z. abbreviatus* Resser, and *Z. adjunctus* Resser. *Z. longipygus* differs from all these species in the greater divergence of the facial sutures and in the characters of the pygidium. *Z. romingeri* has a proportionately shorter and wider, more triangular pygidium; the other abovementioned species have the innermost pairs of pygidial spines more strongly developed. *Zacanthoides spinosus* (Walcott) closely resembles the present species as far as the cranidium is concerned, but a close comparison of the two forms is impossible because the other parts of the shield are unknown. Similar considerations apply to the poorly represented species *Z. walapai* Resser.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S6l, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116259. Paratypes: U.S.N.M. No. 116260.

ZACANTHOIDES PLANIFRONS Rasetti, new species

Plate 32, figures 1, 2

Known from three entire shields rather poorly preserved in limestone.

Glabella on the average approximately parallel-sided, slightly expanded in the anterior portion. Third and fourth pairs of glabellar furrows well impressed, first and second pairs shallow but distinct. Occipital ring extended into a slender occipital spine. Frontal limb relatively long for the genus, flat or very slightly concave as a whole, not differentiated into brim and rim. Fixed cheeks two-thirds the glabellar width at their maximum; palpebral lobes about two-thirds the glabellar length, with curvature increasing posteriorly. Posterior limbs expanding distally, with intergenal spines. Anterior facial sutures diverging at an angle somewhat greater than 45°, straight for a considerable length, narrowly curving inward before reaching the anterior margin. Free cheeks with a poorly differentiated rim and flat, moderately long genal spines.

Thorax of nine segments of the usual shape. Axial rings too poorly preserved to determine the presence of nodes or spines.

Pygidium subtriangular. Axis elevated, almost reaching the posterior margin, extended into a postaxial ridge, with three rings separated by shallow furrows and terminal section. Pleural lobes flat. Pleura turned backward and extended into five pairs of flat marginal spines of decreasing size. Spines of first pair almost as long as the pygidium, second to fifth pairs gradually shorter and narrower.

Surface of shield apparently smooth except for anastomosing ridges on the ocular platforms.

Length of largest complete shield 50 mm. Separated fragments indicate the presence of individuals of larger size.

This form differs from all the described species of the genus in the long, flat, undifferentiated frontal limb. The thorax and pygidium are almost identical to those of *Z. romingeri* and several other known species.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S10, Park Mountain.

Types.—Holotype: U.S.N.M. No. 116257. Paratypes: U.S.N.M. No. 116258.

ZACANTHOIDES DIVERGENS Rasetti, new species

Plate 32, figures 8-10

Known from an entire shield and several cranidia, all preserved in limestone.

Glabella moderately convex, somewhat expanded forward, with three pairs of rather shallow glabellar furrows. Occipital furrow well impressed especially at the sides; occipital ring short, extended into an exceedingly short, slender spine. Frontal limb poorly differentiated into rim and brim. Rim upturned, slightly convex, narrow;

brim flat. Width of brim at the sides almost two-thirds the glabellar width. Fixed cheeks flat, slightly upsloping, about two-thirds the glabellar width. Palpebral lobes defined by a distinct palpebral furrow, increasingly curved posteriorly, starting at the level of the anterior third of the glabella and ending somewhat behind the level of the occipital furrow. Posterior limbs not preserved. Free cheeks downsloping, with a much better-defined rim than the frontal limb; genal spines slender, about as long as the glabella. Anterior branch of facial suture directed almost straight outward to the margin, producing sharp anterior angles of the cranidium.

Thorax of nine segments, of the general shape characteristic of the genus, rather rapidly tapered. Axis too poorly preserved to determine the presence of nodes or spines.

Pygidium about one and one-half times wider than long, with a prominent, tapered axis. Three axial rings and a terminal section can be distinguished. Pleural lobes slightly convex; two pairs of pleural furrows start outward and turn backward. Marginal furrow and rim poorly defined; margin extended into four pairs of flat spines of decreasing length.

Surface of test smooth, except for strong anastomosing lines on the ocular platforms, and a few tubercles on the pygidial pleura.

Length of shield 18 mm., of which 7 mm. belong to the cephalon, 7 mm. to the thorax, and 4 mm. to the pygidium.

Only two described species of *Zacanthoides, Z. sampsoni* Resser, and *Z. serratus* Resser, closely resemble the present form, in possessing widely divergent anterior facial sutures. The cranidia of all these species are difficult to distinguish, but differential characters can be found in the pygidia. The pygidium of *Z. serratus* has spines of uniform length, while the pygidium of *Z. sampsoni* has spines of decreasing size, like the present species, but more strongly developed. *Z. sampsoni* also apparently lacks the tubercles on the pygidial pleura. There is no doubt that the three species are very closely related.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality S1ol, Park Mountain. Also locality S6l, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116261. Paratypes: U.S.N.M. No. 116262.

Genus ALBERTELLA Walcott, 1908

Genotype: *Albertella helena* Walcott.

Confusion exists about the species of this genus occurring in the Ross Lake shale at Ross Lake and Mount Bosworth. Walcott recognized two species, *A. bosworthi* and *A. helena*. Resser admitted four species, *A. bosworthi* and three new ones, *similaris, rossensis,* and *nitida*. Study of all the types, additional material in the United States National Museum, and specimens preserved both in shale and limestone, collected by the writer, shows that there are three clear-cut species. However, one of them requires a new name because the four

TABLE 7.—*Differential characters of three species of Albertella*

A. bosworthi	*A. nitida*	*A. microps*
Glabella slightly expanded toward the front.	Glabella very slightly tapered.	Glabella slightly expanded toward the front.
Palpebral lobes strongly curved, about $\frac{2}{3}$ the glabellar length.	Palpebral lobes moderately curved, about $\frac{1}{2}$ the glabellar length.	Palpebral lobes weakly curved, about $\frac{1}{3}$ the glabellar length.
Maximum width of fixed cheeks over $\frac{2}{3}$, minimum $\frac{1}{10}$ of glabellar width.	Maximum width of fixed cheeks $\frac{1}{2}$, minimum $\frac{1}{4}$ of glabellar width.	Maximum width of fixed cheeks over $\frac{1}{2}$, minimum $\frac{1}{2}$ of glabellar width.
Thorax with macropleural development of fourth segment.	Thorax with macropleural development of third segment.	Thorax with macropleural development of third segment.
Pygidium longer than wide.	Pygidium somewhat wider than long.	Pygidial width $\frac{5}{3}$ of length.
Pygidial axis with 5 to 7 distinct rings plus terminal section. Axial spines or nodes strong.	Pygidial axis with 4 rings plus terminal section. Axial nodes weak, or indistinct.	Pygidial axis with 3 rings plus terminal section. Axial nodes moderately prominent.
Pleural lobes slightly concave, horizontal.	Pleural lobes convex, down-sloping.	Pleural lobes convex, down-sloping.

names used by Resser cover only two species. Two other species are described from other localities.

To facilitate identification of the three species occurring at Ross Lake and Mount Bosworth, the chief differences are summarized in Table 7.

It will be noticed that the species of *Albertella* vary considerably in several respects, chiefly the extent of the brim in front of the glabella, the divergence of the anterior facial sutures, the length of the palpebral lobes, the number of segments represented in the pygidium. On the other hand, the thorax, whenever known, shows a constant number of seven segments. The differences in the cephalic characters are as important as those which, in other cases, were considered sufficient for generic distinction. However, when the whole shield is considered, it clearly appears that all the species assigned to *Albertella* are closely related, since intermediate forms bridge the gaps between the more distant species.

ALBERTELLA BOSWORTHI Walcott

Plate 17, figures 1-9

Albertella bosworthi WALCOTT (part), Smithsonian Misc. Coll., vol. 53, No. 2, p. 22, pl. 1, figs. 4-6 (not fig. 7), 1908; vol. 67, No. 2, p. 38, pl. 7, figs. 3-3b (not figs. 2-2b), 1917.
Albertella similaris RESSER, Smithsonian Misc. Coll., vol. 95, No. 4, p. 2, 1936.

Resser separated his new species *similaris* from *bosworthi* stating that it differs "in its longer pleura, wider pygidium, and striated free cheeks." Examination of the material shows that the proportions of the pygidium vary slightly and continuously due to distortion; the surface of the free cheeks presents different aspects according to the manner of preservation. The character of the "length" (in the terminology used here the "width") of the thoracic pleura, if one examines only the holotypes of the respective species, at first sight appears to be a valid one. However, when numerous shields are examined, it is clear that there is a continuous range of variation in this character, the holotype of *A. bosworthi* representing an extreme case of the form with narrow pleura. The three entire shields illustrated in this paper show different degrees in width of the pleura. The species is also variable in other characters, e.g., the number of segments visible on the pygidial axis, which may vary between five and seven besides the terminal section, and the distinctness of the axial nodes. The holotype of *A. bosworthi* seems to be an individual with a few segments on the pygidial axis, although this part of the shield is only partly preserved (in Walcott's illustration, the pygidial axis was partly restored from other specimens). However, in other individuals, narrow thoracic pleura are associated with numerous axial segments in the pygidium. The conclusion is that the variation in these characters is continuous and uncorrelated, making it impossible to recognize two clear-cut species. Hence the name *similaris* Resser is placed in synonymy.

Cranidia and pygidia preserved in the limestone interstratified with the Ross Lake shale show some characters that are not clearly apparent from shields flattened in shale. The glabella slightly expands forward in the anterior half and has a moderate transverse and longitudinal convexity, the latter mostly concentrated in the anterior portion. Two posterior pairs of glabellar furrows distinct, other two pairs very shallow. Occipital ring long, flat, with a very small node at the posterior margin. Undifferentiated anterior limb somewhat concave, extending in front of the glabella. Fixed cheeks slightly convex, on the average horizontal; palpebral furrow deep. Surface of cranidium finely granulated.

Horizon and locality.—Cathedral formation (Ross Lake shale member; *Albertella* zone). Type locality U.S.N.M. 35c, Mount Bosworth. Other localities U.S.N.M. 63m, Mount Bosworth; U.S.N.M. 63j, Ross Lake; C3m, Mount Whyte; C4m, Ross Lake; C5m, Mount Bosworth; C15m, Bow Lake; C20m, Eiffel Peak; C21m, Mount Temple.

Types.—Lectotype (designated by Resser): U.S.N.M. No. 53416. Paratypes: U.S.N.M. Nos. 53413, 53415. Plesiotypes: U.S.N.M. Nos. 63762-4, 116151-3.

ALBERTELLA DECLIVIS Rasetti, new species

Plate 17, figures 10-15

Known from several cranidia and associated pygidia preserved in limestone.

Glabella parallel-sided, rather strongly convex transversely and flat longitudinally for the posterior two-thirds; steeply sloping downward in the anterior third. Third and fourth pairs of glabellar furrows moderately deep, other two pairs indistinct. Occipital furrow well impressed at the sides, shallow mesially; occipital ring with a small node near the posterior margin. Undifferentiated frontal limb flat, steeply inclined; anterior facial sutures directed straight forward for a short distance in front of the eyes, then converging, thus producing a nasute extension of the brim in front of the glabella. Fixed cheeks on the average horizontal, their maximum width five-sixths of the glabellar width. Palpebral lobes very long, semicircular, set off by a well-impressed palpebral furrow. Anterior end of palpebral lobe extended into a short ocular ridge; posterior end distant from the glabella about two-fifths the glabellar width. Posterior limbs slender, of undetermined width.

Pygidium considerably longer than wide. Axis very strongly convex, slightly tapered, showing five rings plus a terminal section; a strong node or spine on each ring. The axis reaches the posterior rim. Pleural lobes on the average horizontal, slightly concave in the transverse direction. Several pleural furrows impressed, the first four pairs very distinct. Rim convex, fairly well differentiated. Pleural spines starting at the level of the pygidial midpoint; appearing as an extension of the second pleural segment. Spines of unknown length, probably not greatly divergent.

Surface of all the prominent parts of cranidium and pygidium finely granulose.

Length of largest cranidium 15 mm., width between the palpebral lobes 16 mm. Length of largest pygidium 11 mm., width 8 mm.

This species most resembles *A. bosworthi* in all the cranidial features, except the structure of the anterior limb. *A. bosworthi* has divergent anterior facial sutures and a short, concave rim in front of the glabella instead of the flat, nasute, downsloping limb of the present species. This character, unique among the known species of *Albertella,* also distinguishes it from *A. robsonensis* Resser. The pygidium is almost indistinguishable from that of *A. bosworthi.*

Horizon and locality.—Cathedral formation (*Albertella* zone). Type locality C15m, Bow Lake.

Types.—Holotype: U.S.N.M. No. 116154. Paratype: U.S.N.M. No. 116155.

ALBERTELLA NITIDA Resser

Plate 18, figures 1-7

Albertella helena Walcott (part), Smithsonian Misc. Coll., vol. 53, No. 2, p. 19, pl. 2, figs. 7-9 (only), 1908; vol. 67, No. 2, pl. 7, figs. 5, 5a (only), 1917.
Albertella rossensis Resser, Smithsonian Misc. Coll., vol. 95, No. 4, p. 2, 1936.
Albertella nitida Resser, Smithsonian Misc. Coll., vol. 95, No. 4, p. 2, 1936.

The form from the Ross Lake shale is probably specifically distinct from *A. helena* from the Gordon shale. Among the differences is the size, the largest individuals from the Ross Lake shale being only half as large as those from Montana.

Resser made two species without clearly stating the differential characters. He based *A. rossensis* on a pygidium figured by Walcott, but assigned to it as paratypes several unfigured entire shields. Study of all the type material, and of additional specimens in limestone, shows that although there are two species, Resser's holotypes both belong to the same species. The name *nitida* is maintained because its holotype is a much better specimen.

This species is now well known from specimens in shale showing the general proportions, and separated fragments in limestone showing the convexity and surface characters. Owing to the previous confusion, a new complete description is given.

Glabella almost parallel-sided, slightly tapered forward; moderately convex transversely and longitudinally, the longitudinal convexity stronger anteriorly. Four pairs of glabellar furrows usually distinguishable, decreasing in depth from the posterior to the anterior pair. Occipital furrow shallow but impressed throughout. Occipital ring moderately long, rounded, bearing a small node near the posterior margin. Frontal limb undifferentiated at the sides, somewhat concave; a short rim in front of the glabella. Limb at the sides less than one-third the glabellar width; anterior facial sutures slightly divergent, anterior angles of cranidium rather well rounded. Palpebral lobes moderately curved, set off by a well-impressed palpebral furrow; about half as long as the glabella; ocular ridges distinct. Maximum width of fixed cheeks somewhat over one-half the glabellar width; fixed cheeks moderately convex and on the average downsloping. Posterior limbs not as wide as the occipital ring, parallel-sided, rounded at the extremity; reaching the base of the genal spine.

Free cheeks with wide ocular platforms and a narrow, slightly convex rim. Genal spines slender.

Thorax of seven segments. Axial rings with nodes faint but distinct in some specimens, indistinct in others. Pleura with a broad, shallow, oblique furrow. Pleura of the third segment longer than those of any other segment and with stronger and longer spines. There is also a special development of the spines of the last segment, but not as strong as in the third segment.

Pygidium somewhat broader than long. Axis strongly prominent, tapered, occupying most of the pygidial length; showing four rings plus a terminal section. Axial nodes very faint or absent. Pleural lobes weakly convex, downsloping. Three or four pairs of pleural furrows visible; interpleural grooves barely indicated. Marginal spines appearing as extensions of the first two pleural segments together; long, straight, more or less divergent. Rim poorly defined, usually indistinct in flattened specimens.

The proportions of an undistorted shield are the following: length of cephalon 8.5 mm.; length of thorax 11 mm.; length of pygidium 5 mm., width 7 mm. Length of largest shield 36 mm.

Entire surface of shield finely and densely granulated.

Horizon and locality.—Cathedral formation (Ross Lake shale member; *Albertella* zone). Type locality U.S.N.M. 63j, Ross Lake. Other localities U.S.N.M. 35c, Mount Bosworth; C3m, Mount Whyte; C4m, Ross Lake; C5m, Mount Bosworth; C15m, Bow Lake; C20m, Eiffel Peak.

Types.—Holotype: U.S.N.M. No. 63766. Paratypes: U.S.N.M. Nos. 53402, 53404, 53405, 53406, 63764, 63765. Holotype of "*Albertella rossensis*": U.S.N.M. No. 53403. Plesiotypes: U.S.N.M. No. 116156-8.

ALBERTELLA MICROPS Rasetti, new species

Plate 19, figures 1-8

Known from entire shields flattened in shale and separate cranidia and pygidia in limestone.

Although this is the least common of the three species of *Albertella* in the Ross Lake shale, it is surprising that it should have escaped attention. The United States National Museum collections contain several specimens.

Glabella strongly convex in both directions, almost parallel-sided. When flattened, it appears to expand in front because of the greater convexity of the anterior portion. Glabellar furrows and occipital furrow about as distinct as in *A. nitida.* Brim at the sides half the glabellar width. Anterior facial sutures not divergent. Rim differentiated by gradually curving upward rather than by a definite marginal furrow, extremely reduced mesially, shorter than in *A. nitida,* where in turn it is shorter than in *A. bosworthi.* Ocular ridges distinct; palpebral lobes only one-third the glabellar length, weakly curved, rather elevated, set off by distinct palpebral furrows. Anterior end of palpebral lobe distant from glabella one-half the glabellar width; maximum width of fixed cheeks somewhat greater. Posterior limbs much less slender than in the two preceding species. Posterior facial suture directed straight outward; posterior margin of cranidium and accompanying marginal furrow curving forward. Hence the posterior limbs are tapered distally.

Thorax of seven segments. Axis prominent, apparently with axial nodes. Pleura distinct from those of the other species in that the spines do not start from the posterior margin but near the middle of each pleuron. Spines of the third segment exceptionally long and strong.

Pygidium five-thirds wider than long, composed of a lesser number of segments than in the preceding species. Axis strongly prominent, tapered, almost reaching the margin; showing three rings and a terminal section. Axial nodes distinct. Pleural lobes convex, sloping steeply to a distinct rim. Three pleural furrows rather strong; two pairs of interpleural grooves narrow and shallow. Spines appearing as extensions of the first two pleural segments together; straight and very long, at least four times the pygidial length; rather strongly divergent.

Length of the largest shield 30 mm. However, most of the specimens do not exceed two-thirds of this size.

Surface of cranidium with elevated granules, much less numerous than in *A. nitida*. Surface characters of thorax not preserved. Pygidia in limestone apparently smooth.

Horizon and locality.—Cathedral formation (Ross Lake shale member; *Albertella* zone). Type locality U.S.N.M. 63m, Mount Bosworth. Other localities C3m, Mount Whyte; C4m, Ross Lake; C5m, Mount Bosworth; C15m, Bow Lake.

Types.—Holotype: U.S.N.M. No. 116163. Paratypes: U.S.N.M. Nos. 116164-6.

ALBERTELLA LIMBATA Rasetti, new species

Plate 18, figures 8-17

Known from numerous cranidia and pygidia preserved in limestone.

Glabella almost parallel-sided, slightly expanded in front, fairly convex transversely; longitudinal convexity strong only anteriorly. Three pairs of glabellar furrows rather short but well impressed; occipital furrow also well impressed. Occipital ring expanded mesially, triangular, with a rather indistinct node. Frontal limb flat, almost horizontal, with an extremely shallow furrow at the sides, a direct extension of the frontal portion of the dorsal furrow; this may represent the marginal furrow, indicating that the area in front of the glabella is the rim. Anterior facial sutures very strongly divergent, starting a short distance from the dorsal furrows at the anterior end of the palpebral lobes. Hence the widely rounded anterior angles of the cranidium flare out for a considerable distance. Fixed cheeks horizontal, their maximum width about three-fourths the glabellar width. Palpebral lobes about two-thirds the glabellar length, strongly curved; palpebral furrows well impressed. Distance from posterior end of palpebral lobe to dorsal furrow about one-fourth the glabellar width. Posterior limbs extremely slender, expanded distally, somewhat wider than the occipital ring.

Pygidium about equally wide and long. Axis strongly convex, tapered, showing five axial rings (with nodes) and a terminal section; extended into a short postaxial ridge that reaches the margin. Pleural lobes convex, rather strongly downsloping. Pleural furrows and interpleural grooves together forming wide depressions, separated by sharp, narrow ridges. Three such pairs are well marked, the successive ones less distinct. Rim narrow, flat, differentiated by a distinct marginal furrow. Pleural spines directed straight backward, of unknown length; their outer outline being a straight extension of the lateral margin of the pygidium.

Surface of both shields apparently smooth.

Length of the largest cranidium 11 mm.; width and length of the largest pygidium 10 mm.

This species most resembles *A. cimon* (Walcott) in the cranidial features, but possesses a much wider frontal limb. The pygidium of Walcott's species is unknown. The pygidium is of the general type of that of *A. bosworthi,* differing chiefly in the convexity of the pleural lobes.

Horizon and locality.—Cathedral formation (*Albertella* zone). Type locality C15n, Bow Lake.

Types.—Holotype: U.S.N.M. No. 116159. Paratypes: U.S.N.M. No. 116160.

ALBERTELLA STENORHACHIS Rasetti, new species

Plate 18, figures 18-21

Known from several pygidia well preserved in limestone.

Pygidium equally long and wide. Axis moderately tapered, elevated, occupying almost the entire pygidial length and one-third of the width, extended into a short postaxial ridge that reaches the posterior margin. Six axial rings and a terminal section defined by distinct furrows. Axial rings each with a transverse tubercle, broken off in the available pygidia. Pleural lobes on the average horizontal. Pleural platforms slightly convex, with at least five pairs of wide furrows impressed. Interpleural grooves narrow, impressed only proximally. Marginal furrow wide and shallow, rim slightly convex and moderately wide. The marginal spines appear as extensions of the first and second pleura together, and are directed backward and slightly outward; total length unknown. Surface of posterior part of pleural lobes with characteristic wrinkles. Length of largest pygidium 10 mm., width 10 mm.

This form is described, notwithstanding the lack of an associated cranidium, because the pygidium cannot be confused with those of described species. It is obviously close to *A. bosworthi* and *A. declivis,* differing from both chiefly in the somewhat shorter axis and the lesser relative width of the axis with respect to the pleural lobes.

Horizon and locality.—Cathedral formation (*Albertella* zone). Locality C15n, Bow Lake.

Types.—Holotype: U.S.N.M. No. 116161. Paratypes: U.S.N.M. No. 116162.

Family DOLICHOMETOPIDAE Walcott

Genus ATHABASKIA Raymond, 1928

Genotype: *Athabaskia ostheimeri* Raymond.

ATHABASKIA, species undetermined

Plate 22, figures 11, 12

Known from one cranidium and one pygidium preserved in limestone and doubtfully assigned to the same species.

The pygidium is the part of the shield that can definitely be assigned to *Athabaskia* and will be described first. Entire pygidium semicircular, almost twice wider than long, with rounded anterior angles. Axis prominent, slightly tapered, extended into a postaxial ridge that reaches the margin. Three axial furrows visible. Pleural platforms convex, downsloping; marginal furrow wide, setting off a slightly upturned rim. Pleural furrows and grooves both well impressed; four pairs of each are visible, and terminate in the marginal furrow, each furrow being close to the corresponding groove in the manner characteristic of *Athabaskia*.

The associated cranidium very doubtfully assigned to the species has a long, narrow, slightly expanded, convex glabella. Lateral compression exaggerates the narrowness of the glabella in this specimen. Four pairs of glabellar furrows and occipital furrow shallow. Occipital ring expanded into a thick spine of unknown length. Frontal limb reduced to a short rim; brim at the sides well developed transversely; anterior angles of cranidium very sharp. Fixed cheeks slightly convex. Palpebral lobes less than half the glabellar length. Anterior branch of facial suture paralleling the dorsal furrow, posterior branch paralleling the posterior margin. Posterior limbs deeply furrowed.

Surface of both shields smooth. Length of cranidium 10 mm. Width of pygidium 7 mm., length 4 mm.

The pygidium of this species is typical of a group of species of *Athabaskia*, especially resembling *A. anax* (Walcott) from the Spence shale. The cranidium, if it belongs to the genus, has unusually short palpebral lobes and strong occipital spine.

Horizon and locality.—Cathedral formation (*Albertella* (?) zone). Locality C9j′, Fossil Gully, Mount Stephen.

Figured specimens.—U.S.N.M. Nos. 116190-1.

ATHABASKIA? PARVA Rasetti, new species

Plate 31, figures 11, 12

Known from several cranidia preserved in limestone.

Glabella moderately convex, expanding forward especially in the anterior third, defined by a well-impressed dorsal furrow. Glabellar furrows very faint. Occipital furrow straight and of uniform depth throughout; occipital ring rather long, with a rounded posterior margin. Brim and rim almost wholly obsolete, except for a very narrow and short lateral strip in front of the palpebral lobes. Fixed cheeks slightly convex, on the average horizontal, reaching their maximum width posteriorly, where they are somewhat more than half as wide as the glabella at the same level. Palpebral lobes narrow, about two-thirds the glabellar length, first directed outward and backward, then curving to assume a straight backward course in their posterior portion. Palpebral furrow narrow but well impressed. Posterior limbs not exposed in the available specimens.

Surface of test smooth. Length of largest cranidium 4 mm.

This species is tentatively assigned to *Athabaskia,* since generic references in this group of trilobites cannot be reasonably certain unless the pygidium is known. The cranidial features are intermediate between those of *Athabaskia* and *Glossopleura.* This species closely resembles a form described by Resser from the Middle Cambrian of the Grand Canyon as *Clavaspidella kanabensis,* differing chiefly in the less-expanded glabella. Resser included *Athabaskia* in *Clavaspidella.*

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S61, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116253. Paratype: U.S.N.M. No. 116254.

Genus BATHYURISCUS Meek, 1873

Genotype: *Bathyuriscus haydeni* Meek.

BATHYURISCUS ADAEUS Walcott

Plate 31, figures 1-6

Bathyuriscus adaeus Walcott, Smithsonian Misc. Coll., vol. 64, No. 5, p. 334, pl. 47, figs. 3, 3a-c, 1916.

Walcott's brief description of this exceedingly common species appears sufficient to characterize it.

The surface of the cephalon is finely granulated. The largest pygidium observed has a length of 13 mm. and a width of 24 mm. By comparison with the proportions of smaller complete shields, it appears that a full-grown individual had a length of 50 mm.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 58j, Mount Stephen (probably close to or identical with the author's locality S9k). Other localities S6k, Mount Odaray; S6l, Mount Odaray; S9k, Mount Stephen; S10k, Park Mountain; S10l, Park Mountain.

Types.—Syntypes: U.S.N.M. Nos. 62631-4. Plesiotypes: U.S.N.M. Nos. 116249-50.

BATHYURISCUS ROTUNDATUS (Rominger)

Plate 28, figures 2, 3

Embolimus rotundata Rominger, Proc. Acad. Nat. Sci. Philadelphia, 1887, p. 16, pl. 1, figs. 4, 5.

Bathyuriscus howelli Walcott (part), Walcott, Amer. Journ. Sci., ser. 3, vol. 36, p. 165, 1888.

Bathyuriscus howelli Walcott (part), Matthew, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 50, 1899.

Bathyuriscus rotundatus (Rominger), Walcott, Smithsonian Misc. Coll., vol. 53, No. 2, p. 41, 1908; Canadian Alpine Journ., vol. 1, No. 2, pl. 4, fig. 2, 1908; Smithsonian Misc. Coll., vol. 64, No. 5, p. 346, pl. 47, figs. 2, 2a-b, 1916.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 14s, Mount Stephen.

Types.—Holotype: Acad. Nat. Sci. Philadelphia. Plesiotypes: U.S.N.M. Nos. 62629-30; 116232.

BATHYURISCUS? species undetermined

Plate 22, figures 15, 16

Two cranidia referable to *Bathyuriscus* are figured, notwithstanding the poor state of preservation, because of the unusual interest of the faunules from the equivalent of the Cathedral formation in the Fossil Gully section.

Glabella long and narrow, strongly convex, expanded forward. Posterior glabellar furrows well impressed, other three pairs very shallow. Occipital ring not preserved. Frontal limb reduced to a short rim; at the sides represented by the undifferentiated brim and rim, of width not much greater than the length of the frontal rim. Anterior angles of cranidium rounded, closely following the outline of the glabella. Fixed cheeks rather narrow, somewhat convex. Palpebral lobes about half the glabellar length, set off by a distinct palperal furrow, of about uniform curvature. Posterior limbs slender, parallel-sided. Surface of cranidium smooth. Length of largest cranidium 8 mm.

Although the described specimens do not show any differences of generic importance from typical species of *Bathyuriscus,* the generic identification in trilobites of this group cannot be considered certain in the absence of the pygidium.

Horizon and locality.—Cathedral formation (*Albertella* (?) zone). Locality C9j, Fossil Gully, Mount Stephen.

Figured specimens.—U.S.N.M. No. 116193.

FIELDASPIS Rasetti, new genus

Glabella occupying almost the entire cranidial length, expanded in front. Dorsal furrow well impressed; four pairs of glabellar furrows and occipital furrow distinct. Brim and rim poorly differentiated from each other laterally, almost obsolete in front of the glabella. Palpebral lobes about half the glabellar length, curved, narrow, close to the glabella at the anterior end. Posterior limbs wide and slender, situated at a considerably lower level than the palpebral lobes.

Thorax apparently of nine segments in the genotype. Pleura curving backward, the last ones enveloping the pygidium.

Pygidium with prominent axis almost reaching the margin. Pleural lobes more or less strongly bilobate, with weak furrows and grooves, undefined marginal furrow and wide, flat or concave rim.

Genotype.—*Fieldaspis furcata* Rasetti, new species.

Stratigraphic range.—Middle Cambrian (*Plagiura-Kochaspis* zone).

Remarks.—This is another dolichometopid genus whose isolated cranidia cannot be distinguished generically from *Athabaskia, Ptarmigania, Dolichometopsis, Stephenaspis,* and possibly several others. *Fieldaspis* differs from each of them in the characteristic shape of the pygidium.

FIELDASPIS FURCATA Rasetti, new species

Plate 15, figures 1-8

Known from an entire shield and numerous fragments excellently preserved in limestone.

Glabella moderately convex in both directions, somewhat expanded in the anterior two-thirds. Posterior glabellar furrows oblique, well impressed; three other pairs transverse, shorter and shallower but distinct. Occipital furrow shallow mesially; occipital ring expanded mesially, rounded, with a small node at the posterior margin. Rim almost obsolete in front of the glabella. Limb laterally consisting of narrow strips, somewhat expanded at the anterior angles. Anterior outline of cranidium moderately and evenly curved. Palpebral lobes somewhat more than half the glabellar length; slighty elevated above the rest of the fixed cheeks, set off by a distinct palpebral furrow, curved, the curvature increasing posteriorly. Anterior end of palpebral lobe very close to the glabella, posterior end at a distance of one-third the glabellar width. Posterior end of palpebral lobe at the level of the occipital furrow. Fixed cheeks horizontal. Posterior limbs very slender, at a much lower level than the palpebral lobes; slightly expanded distally, wider than the occipital ring.

Hypostoma of the general bathyuriscid type. Anterior wings, representing the fused rostrum, stout, curving backward. Posterior lobe small, set off by a shallow but uninterrupted furrow. Maculae narrow and long, oblique, elevated. Rim narrow, expanded into a pair of blunt, backward-directed spines at the level of the maculae.

Thorax apparently of nine segments; there is the possibility that one or two segments might be concealed in the known articulated specimen, but this seems unlikely. The axial rings apparently had no spines, although this part is not well preserved and does not permit a definitive statement. Pleura curving backward, the posterior ones beginning to curve very near the axis, extended into long, flat spines. Pleural furrows wide and rather deep, sharply delimited anteriorly. Pleura of the last segment enveloping the pygidium.

Pygidium of equal length and width, subquadrate in shape except for the deep median notch. Axis occupying half the pygidial length, prominent, tapered, with two pairs of furrows well impressed only at the sides; extended into a postaxial ridge that reaches the margin at the median notch. Pleural lobes slightly convex proximally and concave distally, strongly bilobate, almost straight laterally. Two pairs of furrows and one pair of interpleural grooves faintly impressed proximally.

Surface of the shield generally smooth, except for wrinkles on some portions of the pleural lobes of the pygidium.

Length of largest cranidium 14 mm., of largest pygidium 11 mm. The proportions are about the same in the smaller articulated shield.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality W7f, Kicking Horse Mine, Mount Field. Also localities W9f, Fossil Gully, Mount Stephen, and W20d, Eiffel Peak.

Types.—Holotype: U.S.N.M. No. 116136. Paratypes: U.S.N.M. No. 116137.

FIELDASPIS BILOBATA Rasetti, new species

Plate 16, figures 1-7

Known from numerous cranidia and pygidia preserved in limestone.

Glabella strongly convex transversely and fairly convex longitudinally, moderately expanded in the anterior half. Four pairs of glabellar furrows well impressed. Occipital furrow deep laterally but very shallow mesially. Occipital ring extended into a moderately long, slender spine. Frontal limb almost entirely obsolete in front of the glabella, developed at the side and differentiated into a flat brim and an upturned rim. Maximum width of limb at the sides about one-third the glabellar width. Fixed cheeks slightly convex, on the average horizontal, with maximum width one-half the glabellar width, showing an elongated tubercle at the posterior end. Palpebral lobes delimited by a well-impressed furrow, strongly curved posteriorly. Posterior limbs slender, parallel-sided, wider than the occipital ring. Anterior facial sutures more divergent than the dorsal furrow; hence the brim increases in width toward the front.

Pygidium one and one-half times wider than long. Axis strongly elevated, moderately tapered, showing three rings and a terminal section. Axial furrows shallow mesially. A short postaxial ridge reaches the posterior margin. Pleural lobes widely rounded at the anterior and posterior angles, extended laterally farther back than on the midline, thus producing a distinct median notch. Pleural platforms downsloping; marginal furrow indistinct, rim wide and concave. Three or four pairs of pleural furrows impressed proximally, not extending across the rim. Interpleural grooves distinct for a short distance.

Surface of test smooth.

Length of largest cranidium 14 mm. Length of largest pygidium 10 mm., width 15 mm.

This species differs from the genotype, *F. furcata,* chiefly in the somewhat shorter and more strongly curved palpebral lobes, presence of an occipital spine, parallel-sided instead of expanding posterior limbs, and much lesser backward extension of the pleural lobes of the pygidium.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality W20d, Eiffel Peak.

Types.—Holotype: U.S.N.M. No. 116146. Paratypes: U.S.N.M. No. 116147.

FIELDASPIS cf. F. BILOBATA Rasetti

Plate 16, figures 8, 9

Specimens collected in limestone of the Mount Whyte formation on Mount Odaray slightly differ from specimens of *F. bilobata* from the type locality in the deeper axial furrows on the pygidium and larger size, some cranidia reaching a length of 24 mm. These differences do not appear specifically significant.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W6d, Mount Odaray.

Figured specimens.—U.S.N.M. No. 116148.

FIELDASPIS SUPERBA Rasetti, new species

Plate 16, figures 10-18

Known from numerous cranidia and pygidia and a specimen preserving thorax and pygidium, all preserved in limestone.

Glabella similar to that of *F. furcata* but more strongly expanded in the anterior portion. Four pairs of glabellar furrows well impressed. Occipital ring long, extended into a short, blunt spine. Rim in front of the glabella short and flat. Frontal limb at the sides not differentiated into brim and rim, wider than in *F. furcata* owing to the strong divergence of the anterior facial sutures. Fixed cheeks as in *F. furcata* but more definitely upsloping. There is an elongated turbercle between the dorsal furrow and the posterior end of the palpebral lobe. Because of this elevation there is a considerable drop between the level of the fixed cheeks and that of the posterior limbs. Posterior limbs very slender, slightly expanded distally, considerably wider than the occipital ring.

Hypostoma very strongly tapered backward, truncated posteriorly. A shallow furrow separates the anterior portion, representing the fused rostrum and including the anterior wings, from the main body of the hypostoma. Posterior furrow well impressed and continuous across the hypostoma, situated very near the posterior end. Marginal furrow and rim well developed around the posterior portion. Maculae well developed. A pair of marginal spines at the level of the maculae.

Thorax of eight-plus segments. The axial rings may possess nodes or spines. Pleura with a triangular, elongated ridge at their proximal end as in most of the bathyuriscid trilobites. Pleural furrows well impressed. Pleura turned backward distally, extending into sharp spines.

Pygidium more than one and one-half times wider than long. Axis slightly tapered, not strongly elevated, with four rings and a terminal section delimited by shallow furrows. A low postaxial ridge reaches the margin. Pleural lobes giving the entire pygidium a subrectangular or slightly cordiform shape, with widely rounded anterior angles and a shallow median notch. Four pairs of broad, shallow pleural furrows impressed; interpleural grooves distinct proximally. Marginal furrow broad and essentially limited to a series of deeper impressions in the pleural furrows. Pleural platforms slightly convex and downsloping. Rim wide, flat, poorly defined. A pair of marginal spines, appearing as extensions of the second and third pleura together, straight, directed outward and backward, slightly upsloping, longer than the entire pygidium.

Surface smooth except for faint wrinkles on the pleural lobes of the pygidium.

Length of largest cranidium 26 mm. Length of largest pygidium 21 mm., width 36 mm.

This species differs from the others assigned to the genus in possessing long pygidial spines. This character brings the species close to *Stephenaspis*. However, the broad-based spines of this species present closer analogy with the rounded lobes of *F. furcata* than with the spines of *Stephenaspis bispinosa*. The cranidium is almost identical with that of *F. bilobata* which has a bilobate instead of a spinose pygidium.

A pygidium almost identical with that of the present species (except for the lesser relative width, which may be due to distortion) was described by Walcott as *Crepicephalus celer*. Resser united with it a cranidium from the same locality described by Walcott as *Ptychoparia clusia* and made of these two fragments a species of *Kochaspis*. There is no doubt that Walcott's pygidium belongs either to the present species or to a closely related one, hence the ptychoparid head bearing the name *Ptychoparia clusia* is entirely unrelated. In the case of *Fieldaspis superba*, although no complete specimen is known, the intimate association of numerous fragments and the absence of any other large trilobite from the same beds makes the assignment of pygidium and cranidium to one species virtually certain.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W7g, Kicking Horse Mine, Mount Field.

Types.—Holotype: U.S.N.M. No. 116149. Paratypes: U.S.N.M. No. 116150.

Genus GLOSSOPLEURA Poulsen, 1927

Genotype: *Dolichometopus boccar* Walcott.

GLOSSOPLEURA BOCCAR (Walcott)

Plate 24, figures 1-6

Dolichometopus boccar Walcott, Smithsonian Misc. Coll., vol. 64, No. 5, p. 363, pl. 53, figs. 1, 1a-f, 1916.
Glossopleura boccar (Walcott), Poulsen, Medd. Grønland, vol. 70, p. 268, 1927.
Glossopleura bosworthensis Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 31, 1935.
Glossopleura nitida Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 31, 1935.
?*Glossopleura stephenensis* Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 31, 1935.

Resser's species *bosworthensis* and *nitida* were based on small specimens in limestone, while the individuals that he regarded as typical of *G. boccar* are large shields flattened in shale. Shaly and calcareous layers alternate at the type locality on Mount Bosworth, and examination of Walcott's and the writer's collections shows that the differences observed by Resser may be entirely attributed to the size of the individuals and the manner of preservation. Hence Resser's names are placed in synonymy. *Glossopleura stephenensis* is based on a specifically unidentifiable shield of *Glossopleura* supposed to have been collected from the *Ogygopsis* shale. The writer has never seen *Glossopleura* in those beds and suspects that the specimen has been mislabeled.

Horizon and locality.—Stephen formation (*Glossopleura* zone). Type locality U.S.N.M. 57g (=author's locality S5a), Mount Bosworth. Also locality U.S.N.M. 57u, Mount Bosworth.

Types.—Syntypes: U.S.N.M. Nos. 62703-8. Plesiotypes: U.S.-N.M. Nos. 116204-5.

GLOSSOPLEURA TEMPLENSIS Rasetti, new species

Plate 24, figures 14-17

Known from numerous cranidia and pygidia and an entire shield, all preserved in limestone.

This species closely resembles the genotype, *G. boccar,* hence instead of giving a complete description, only the specific differences will be listed. The cranidium differs from that of *G. boccar* in that the glabella expands slightly in front of the palpebral lobes, and the brim is not as completely obliterated as in that species. The glabellar furrows are faintly impressed, at least in young cranidia, whereas cranidia of *G. boccar* of the same size show hardly any trace of furrows. This character also separates the present species from *G. mckeei* which occurs approximately at the same horizon.

The pygidium of *G. templensis* differs from that of *G. boccar* in the greater relative length (ratio of width to length about 1.60 in *G. boccar,* 1.40 in *G. templensis*). In the present species the doublure is narrower, the axis relatively longer, and the axial furrows are almost entirely obliterated.

The complete shield has a length of 25 mm., but fragments indicate the presence of individuals of considerably larger size. The largest pygidium collected has a length of 16 mm. and a width of 22 mm.

Horizon and locality.—Stephen formation (*Glossopleura* zone). Locality S21b, Mount Temple.

Types.—Holotype: U.S.N.M. No. 116209. Paratypes: U.S.N.M. No. 116210.

GLOSSOPLEURA MCKEEI Resser

Plate 24, figures 9-12, 18

Dolichometopus productus Walcott (part), Smithsonian Misc. Coll., vol. 64, No. 5, p. 369, pl. 53, figs. 4, 4a, 1916.

Dolichometopus tontoensis Walcott (part), Smithsonian Misc. Coll., vol. 64, No. 5, p. 373, pl. 51, figs. 1d', 1d", 1h, 1916.

Glossopleura mckeei Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 33. 1935; in McKee and Resser, Carnegie Inst. Washington Publ. 563, p. 196, pl. 21, figs. 1-5, 1945.

Specimens well preserved in the limestones of the lower Stephen formation are referred to this species, described from the Bright Angel shale of the Grand Canyon area.

The material from the type area includes pygidia in sandstone preserving the convexity, and accurate comparison of the proportions with the specimens collected by the writer failed to disclose any differences of specific value. The comparison of the cranidia is less significant, first because only flattened cranidia from the type locality are available, secondly because specific differences in *Glossopleura* are usually more apparent in the pygidia than in the cranidia.

Horizon and locality.—Stephen formation (*Glossopleura* zone). Locality S3b, Mount Whyte.

Types.—Holotype (from the Bright Angel shale of Arizona): U.S.N.M. No. 62714. Plesiotypes: U.S.N.M. No. 116208.

GLOSSOPLEURA STENORHACHIS Rasetti, new species

Plate 24, figures 7, 8

Known from numerous pygidia well preserved in limestone.

Pygidium 1.5-1.6 times wider than long, moderately convex. Axis tapered, reaching three-fourths of the pygidial length, extended into a short postaxial ridge that does not reach the margin. Width of axis at the base one-fourth of the pygidial width. Five or six segments, defined by shallow furrows, visible on the upper surface of the axis. Pleural lobes slightly convex, moderately downsloping, showing faint pleural furrows even on the upper surface. Rim slightly concave, flat marginally. Width of doublure one-fifth the pygidial width.

Surface smooth. Length of largest pygidium collected 13 mm., width 21 mm. The cranidium has not been identified; it is possibly difficult to distinguish from that of the associated and more common species *G. mckeei.*

This species closely resembles *G. perryi* Deiss, also known only from pygidia, but can be distinguished by possessing a relatively narrower, less prominent axis and a narrower doublure.

Horizon and locality.—Stephen formation (*Glossopleura* zone). Locality S3b, Mount Whyte. Specimens in the United States National Museum show that this form occurs in the Stephen formation on Castle Mountain in association with *G. boccar.*

Types.—Holotype: U.S.N.M. No. 116206. Paratypes: U.S.N.M. No. 116207.

GLOSSOPLEURA SKOKIENSIS Rasetti, new species

Plate 23, figures 6-10

Known from several cranidia and pygidia preserved in limestone.

Glabella moderately convex, strongly expanded especially in front of the anterior end of the palpebral lobes. Four pairs of glabellar furrows faintly impressed, the posterior pair oblique and somewhat deeper than the others. Occipital furrow impressed throughout; occipital ring moderately long, with a suggestion of a small node. Brim reduced to narrow, poorly defined strips at the sides; no brim or rim in front of the glabella. Palpebral lobes about two-thirds the glabellar length, set off by rather well-impressed palpebral furrows; posterior portion of palpebral lobe curving somewhat inward. Maximum width of fixed cheeks greater than half the glabellar width. Posterior limbs not preserved, but evidently very slender.

Pygidium with a strongly prominent, cylindrical axis occupying more than two-thirds of the length. Six rings and a terminal section defined by extremely shallow furrows. A postaxial ridge extends to the posterior margin, which is slightly notched mesially. Pleural platforms faintly furrowed, downsloping. Rim moderately wide, concave. Anterior outline of pygidium slanting backward, anterior angles widely rounded.

Surface of both shields showing very fine, wavy lines.

Length of largest cranidium 7 mm. Length of largest pygidium 5.5 mm., width 9 mm.

This species is extremely close to *G. walcotti* Poulsen from northwest Greenland, differing in minor characters such as the slightly more expanded glabella and more rounded anterior angles of the pygidium. *G. expansa* Poulsen has a glabella that expands more suddenly in its anterior portion, and a somewhat different pygidium.

Horizon and locality.—Cathedral formation (*Glossopleura* zone). Locality C13r, Skoki Valley.

Types.—Holotype: U.S.N.M. No. 116200. Paratypes: U.S.N.M. No. 116201.

GLOSSOPLEURA MERLINENSIS Rasetti, new species

Plate 23, figures 1-5

Known from several cranidia and pygidia preserved in limestone.

Glabella rather strongly expanded especially in front of the anterior end of the palpebral lobes, with its minimum width back of the middle. Convexity of glabella moderate in both directions; glabellar furrows almost indistinct. Occipital furrow visible mesially; occipital ring with a small node. Brim at the sides reduced to narrow strips, poorly differentiated from the glabella because the dorsal furrow is almost obsolete in front of the palpebral lobes. No differentiated rim in front of the glabella. Palpebral lobes about two-thirds the glabellar length, the anterior portion directed obliquely, the posterior part directed straight backward; maximum width of the fixed cheeks not more than half the glabellar width. Palpebral furrow well distinct. Posterior limbs very slender, about as wide as the occipital ring, directed somewhat backward.

Pygidium with a prominent, slightly tapered axis in which six rings and a terminal section are defined by extremely shallow furrows. Axis occupying two-thirds of the pygidial length and extended into a short postaxial ridge that does not reach the margin. Pleural platforms downsloping, very faintly furrowed. Rim very wide, slightly concave. Anterior outline of pygidium not very oblique, posterior outline semicircular, median notch almost indistinct. Anterior angles rather narrowly rounded.

Surface of cranidium and of prominent areas of pygidium covered with extremely fine, wavy lines.

Length of the largest cranidium 10 mm. Length of the largest pygidium 20 mm., width 32 mm.

This species differs from the preceding in that the fixed cheeks are narrower, the glabellar furrows shallower and the rim occupies a much greater fraction of the pygidial area. The last-mentioned character distinguishes it from the species described by Poulsen, and also from *G. mckeei*. In the latter species, the dorsal furrow is much shallower.

Formation and locality.—Cathedral formation (*Glossopleura* zone). Locality C13r, Skoki Valley.

Types.—Holotype: U.S.N.M. No. 116198. Paratypes: U.S.N.M. No. 116199.

GLOSSOPLEURA, species undetermined

Plate 24, figure 13

Represented by a single cranidium preserved in limestone.

Dorsal furrow exceedingly shallow, delimiting a uniformly convex glabella. Brim entirely absent both in front and at the sides of the glabella. Palpebral lobes set off by an almost indistinct palpebral furrow, and showing almost uniform curvature. Occipital furrow faintly impressed mesially; occipital ring slightly elevated at the posterior margin.

The cranidium of this species resembles more closely the smoother forms from the Stephen formation, such as *G. boccar* and *G. mckeei,* rather than the more strongly furrowed species with which it is associated. It does not appear worth while naming the species as the pygidia usually supply the most significant specific characters in this genus.

Horizon and locality.—Cathedral formation (*Glossopleura* zone). Locality C13r, Skoki Valley.

Figured specimen.—U.S.N.M. No. 116211.

Genus KLOTZIELLA Raymond, 1928

Genotype: *Bathyuriscus ornatus* Walcott.

KLOTZIELLA ORNATA (Walcott)

Plate 28, figures 7, 8

Bathyuriscus ornatus Walcott, Smithsonian Misc. Coll., vol. 53, No. 2, p. 39, pl. 1, figs. 1-3, 1908; Canadian Alpine Journ., vol. 1, No. 2, pl. 3, fig. 3, 1908; Smithsonian Misc. Coll., vol. 64, No. 5, p. 346, pl. 46, figs. 4, 4a-b, 1916.

Klotziella ornata (Walcott), Raymond, Amer. Journ. Sci., ser. 5, vol. 15, No. 88, p. 310, 1928.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 14s (=author's locality S8d), Mount Stephen.

Types.—Syntypes: U.S.N.M. Nos. 53420, 53421, 53423. Plesiotypes: U.S.N.M. No. 116235.

PARKASPIS Rasetti, new genus

Dolichometopid trilobites with pygidium much smaller than the cephalon.

Glabella long and narrow, moderately expanded forward, reaching the anterior margin of the cranidium except for a very reduced rim. Occipital furrow and four pairs of glabellar furrows well impressed. Brim and rim at the sides of the glabella narrow. Fixed cheeks slightly convex, about half the glabellar width. Palpebral lobes narrow, curved, somewhat less than half the glabellar length. Posterior limbs wider than the occipital ring, short, parallel-sided, deeply furrowed. Free cheeks convex, wide, with well-defined rim and strong genal spines.

Thorax of 11 segments in the genotype and 10 segments in another species. Axis occupying about one-fourth of the width. Pleura deeply furrowed, with the usual elongated triangular ridge at their inner ends; extended into short, backward-directed spines.

Pygidium subtriangular, about twice wider than long. Axis prominent, not tapered, composed of three segments and a terminal section; not quite reaching the posterior margin. Pleural lobes flat, without distinct marginal furrow or rim; with three pairs of pleural furrows, faint interpleural grooves, and a denticulated margin.

Genotype.—*Parkaspis endecamera* Rasetti, new species.

Stratigraphic range.—Middle Cambrian (*Bathyuriscus-Elrathina* zone).

Remarks.—The species on which the genus is based closely resembles *Bathyuriscus;* in fact, the cranidia of *Parkaspis endecamera* and *Bathyuriscus adaeus* are so much alike that difficulty would have been encountered in assigning the proper shields to each species, if complete specimens had not been available. However, there are differences of generic value in the thorax and pygidium. *Parkaspis* has 11 or 10 thoracic segments whereas all known species properly assigned to *Bathyuriscus* have 9. The pygidium of *Parkaspis* is proportionately smaller than in *Bathyuriscus,* has fewer segments both in the axis and pleural lobes, indistinct interpleural grooves, a denticulated margin, and lacks a rim.

Another genus with which *Parkaspis* may be closely compared is *Poliella.* Species assigned to *Poliella* have from 8 to 11 thoracic segments, and pygidia of the same relative size as *Parkaspis.* However, the cranidia of *Poliella* have longer palpebral lobes and less deeply impressed dorsal and glabellar furrows. Furthermore, the triangular ridges on the thoracic pleura are poorly developed in *Poliella. Ptarmigania* also resembles *Parkaspis* in the general shape of cranidium and pygidium, but has fewer (8) thoracic segments and the anterior angles of the cranidium are widely rounded.

The name is derived from Park Mountain.

PARKASPIS ENDECAMERA Rasetti, new species

Plate 31, figures 7-10

Known from numerous specimens, including complete shields slightly flattened in argillaceous limestone.

Glabella slightly tapered in the posterior third, expanding in the anterior third, narrowest at the level of the third pair of glabellar furrows. Glabella rather strongly convex in both directions, the longitudinal convexity increasing anteriorly. Dorsal furrow deep. Four pairs of glabellar furrows: anterior pair deep, short, terminating in the anterior pit at the dorsal furrow; second and third pairs short and shallow; fourth pair longer, deep, oblique. Occipital furrow moderately deep, continuous; occipital ring apparently possessing a spine or node, broken off in all available specimens. Rim very short in front of the glabella, longer at the sides where it is separated from the brim by a distinct marginal furrow. Anterior angles of cranidium narrowly rounded. Fixed cheeks somewhat convex and upsloping, about half the glabellar width at their maximum. Palpebral lobes very narrow, long, curved, set off by a deep palpebral furrow. Distance from posterior end of palpebral lobe to posterior margin about one-third the length of palpebral lobe. Posterior limbs wider than the occipital ring, short, parallel-sided, deeply and broadly furrowed, bearing a short, very slender intergenal spine at the extremity. Free cheeks fairly convex; marginal furrow well impressed, rim convex, moderately wide, genal spines reaching the level of the middle of the thorax.

Thorax of 11 segments. Axis occupying about one-fourth of the width. The axial rings may have possessed spines or nodes, broken off in all available shields. Pleura with a triangular, elongated ridge at their inner ends; broadly furrowed, curving backward near the end into short, sharp spines.

Pygidium twice wider than long. Axis prominent, not tapered, abruptly terminated, not quite reaching the posterior margin. Three rings and a terminal section defined by moderately impressed furrows; the axial rings apparently possessed nodes, broken off in the available specimens. Pleural lobes slightly downsloping. Three pairs of broad, rather shallow pleural furrows impressed, not reaching the margin; interpleural grooves distinct but very shallow and narrow. No distinct marginal furrow and rim. Margin with three pairs of small spines, and two or three more pairs represented by a faint waviness of the outline.

Surface of the test covered with exceedingly fine granules.

Length of holotype, the largest complete shield, 52 mm., of which 18 mm. belong to the cephalon, 25 mm. to the thorax, and 9 mm. to the pygidium.

This species cannot be confused with any described trilobite when complete shields are available. Separate cranidia, however, may easily be confused with those of the associated *Bathyuriscus adaeus.* The chief distinguishing features are the greater lateral development of the brim, the separation of brim and rim by a marginal furrow, and especially the great depth of the first pair of glabellar furrows in *Parkaspis,* whereas they are almost obsolete in *Bathyuriscus adaeus.*

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality S1ol, Park Mountain.

Types.—Holotype: U.S.N.M. No. 116251. Paratypes: U.S.N.M. No. 116252.

PARKASPIS DECAMERA Rasetti, new species

Plate 27, figure 11

Known from a single specimen flattened in shale.

Cephalon poorly preserved on account of the flattening and displacement of the free cheeks. The glabella appears to expand less than in the genotype, and the glabellar furrows seem to be shallower.

Thorax of 10 segments. Axis proportionately wider than in *P. endecamera.* Pleura with a more distinct geniculation, situated nearer the proximal than the distal end of each pleuron. Pleura tapered distally into sharp spines, directed almost straight outward instead of backward as in the genotype.

Pygidium similar to that of *P. endecamera,* differing in the more tapered axis, and two instead of three distinct pleural furrows. Interpleural grooves narrow but distinct.

Length of shield 20 mm.

Horizon and locality.—Stephen formation (Burgess shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Type.—Holotype: U.S.N.M. No. 116231.

Genus POLIELLA Walcott, 1916

Genotype: *Bathyuriscus* (*Poliella*) *anteros* Walcott.

POLIELLA PRIMA (Walcott)

Plate 12, figures 10-13

Bornemannia prima Walcott, Smithsonian Misc. Coll., vol. 53, No. 5, p. 213, 1908. (Nomen nudum.)

Bathyuriscus (*Poliella*) *primus* Walcott (part), Smithsonian Misc. Coll., vol. 64, No. 5, p. 352, pl. 46, figs. 6, 6a (only), 1916.

Bornemannia prima (Walcott), Vogdes, Trans. San Diego Soc. Nat. Hist., vol. 4, pt. 2, p. 92, 1925.

Poliella prima (Walcott, part), Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 44, 1935.

?Poliella castlensis Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 44, 1935.

A description of the species as now restricted follows.

Glabella apparently weakly convex, defined by a shallow dorsal furrow, subparallel-sided, slightly expanded in front. Glabellar furrows very shallow, almost indistinct. Rim flat, developed at the sides and in front of the glabella. Brim developed only at the sides, slightly downsloping, delimited by somewhat divergent anterior facial sutures. Palpebral lobes almost half the glabellar length, very narrow, moderately curved, set off by distinct palpebral furrows. Anterior end of palpebral lobe almost in contact with the glabella, posterior end somewhat more distant; maximum width of fixed cheeks slightly less than half the glabellar width. Posterior limbs very slender, slightly expanded distally.

Thorax of eight segments. Axis slightly less than one-third the thoracic width. Axial rings apparently without nodes or spines. Pleura broadly furrowed, the anterior ones almost straight, the posterior ones curving more and more backward; those of the last segment partly enveloping the sides of the pygidium. Fulcrum not very pronounced, situated at one-third the distance from the axis in the anterior segments and about one-fourth in the posterior segments.

Pygidium somewhat less than twice broader than long. Shape of entire pygidium ovate; anterior angles widely rounded, posterior margin entire. Axis tapered, occupying two-thirds of the length, with two distinct rings and a terminal section. Pleura curving backward; besides the anterior furrow, one or two shallow, almost indistinct furrows; interpleural grooves indistinct. Marginal furrow and rim indistinct.

Surface apparently smooth. Length of largest shield 18 mm., of which 7.0 mm. belong to the head, 7.4 mm. to the thorax, and 3.6 mm. to the tail.

Horizon and locality.—Mount Whyte formation (Lake Agnes and Yoho shale lentils; *Wenkchemnia-Stephenaspis* zone). Type locality U.S.N.M. 35m, southwest of Lake Louise. Also localities W2b, Mount Whyte; W3b, Plain of Six Glaciers; W9k, Fossil Gully, Mount Stephen.

Types.—Lectotype (designated by Resser): U.S.N.M. No. 62624. Paratype: U.S.N.M. No. 62623. Holotype of *Poliella castlensis:* U.S.N.M. No. 62626. Plesiotypes: U.S.N.M. Nos. 116111-2.

POLIELLA DENTICULATA Rasetti, new species

Plate 12, figures 6-9

Known from several shields and numerous cranidia and pygidia partially flattened in shale.

Cranidium typical of the genus. Glabella expanded forward in the anterior half, with shallow furrows. Occipital ring of medium length, apparently with a small node. Rim distinct at the sides, upturned, greatly reduced in front of the glabella. Brim developed only at the sides, consisting of strips about one-eighth the width of the glabella. Palpebral lobes half the glabellar length, straight in the anterior part, curving backward posteriorly; set off by a distinct palpebral furrow. Maximum width of the fixed cheeks somewhat more than half the glabellar width. Posterior limbs very slender, parallel-sided, equaling in width the occipital ring.

Thorax of 10 segments. Axial rings possessing nodes or spines, broken off in all available specimens. Anterior pleura almost straight, curving backward more and more as one proceeds toward the pygidium; terminating in spines, short in the anterior segments and longer posteriorly; those of the last pleuron enveloping the sides of the pygidium. Pleural furrows broad, starting from the anterior angle of each pleuron and running somewhat obliquely outward and backward.

Pygidium transversely ovate, twice wider than long. Axis tapered, with three rings and a terminal section, reaching not far from the posterior margin. Pleura curving backward; three broad pleural furrows are impressed, and two narrow, short interpleural grooves are visible. Anterior angles drawn into a pair of very short spines. Posterior margin wavy, indicating two or three pairs of exceedingly short spines. Margin with a median notch. Marginal furrow and rim almost indistinct.

Surface apparently smooth.

Length of largest shield 34 mm., of which 12 mm. belong to the head, 17 mm. to the thorax, and 5 mm. to the pygidium.

This species is similar to *P. prima,* from which it differs in possessing 10 instead of 8 thoracic segments, wider fixed cheeks, longer palpebral lobes, and denticulated pygidium. These characters also distinguish it from other described species.

Horizon and locality.—Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Type locality W9k, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116109. Paratypes: U.S.N.M. No. 116110.

POLIELLA cf. P. DENTICULATA Rasetti

Plate 9, figures 7, 8

Known from numerous cranidia preserved in limestone.

The observable characters do not show any specific differences between these cranidia and those of *P. denticulata* as far as the different manner of preservation allows an accurate comparison. In the absence of a pygidium, specific identification cannot be reasonably certain.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Locality W16j, North Gully, Mount Stephen.

Figured specimens.—U.S.N.M. No. 116082.

POLIELLA, species undetermined No. 1

Plate 22, figures 17-19

Known from numerous cranidia and one pygidium poorly preserved in silty limestone.

Glabella slightly expanded in the anterior third, with traces of glabellar furrows. Occipital furrow shallow, occipital ring slightly expanded mesially but not extended into a spine. Rim greatly reduced, brim absent in front of the glabella. At the sides the limb has only one-sixth the width of the glabella and does not widen at the anterior angles, the facial suture being parallel to the dorsal furrow. Palpebral lobes narrow, about two-thirds the glabellar length, evenly curved.

Maximum width of fixed cheeks about two-thirds the glabellar width. Distance from posterior end of palpebral lobe to dorsal furrow one-half the glabellar width. Posterior limbs slender, slightly expanded distally, equaling in width the occipital ring.

A pygidium tentatively assigned to the species has a prominent, slightly tapered axis composed of two rings and a terminal section. Pleural lobes downsloping; pleura curved backward, with three pairs of distinct furrows; marginal furrow and rim indistinct. Shape of entire pygidium transversely ovate, with a slight median notch in the posterior outline.

Length of largest cranidium 8 mm. Length of pygidium 3.3 mm., width 4.7 mm.

Horizon and locality.—Cathedral formation (*Albertella* (?) zone). Locality C9h, Fossil Gully, Mount Stephen.

Figured specimens.—U.S.N.M. No. 116194.

POLIELLA, species undetermined No. 2

Plate 22, figures 20, 21

Two poorly preserved pygidia are tentatively assigned to *Poliella*. Even the generic identification cannot be certain owing to the poorly preserved material and the lack of the corresponding cranidium.

The pygidium is transversely suboval, almost twice wider than long. Anterior angles widely rounded. Axis moderately prominent, showing three rings and a terminal section, not quite reaching the posterior margin, which has a shallow median notch. Pleura turned backward; three pairs of furrows visible, interpleural grooves indistinct. Pleural platforms slightly convex, almost horizontal; rim narrow, poorly defined, slightly concave. There is a pair of exceedingly small spines at the posterior angles. Surface apparently smooth. Length of pygidium 5 mm., width 9 mm.

Horizon and locality.—Cathedral formation (*Albertella* (?) zone). Locality C9j′, Fossil Gully, Mount Stephen.

Figured specimens.—U.S.N.M. No. 116195.

Genus POLYPLEURASPIS Poulsen, 1927

Genotype: *Polypleuraspis solitaria* Poulsen.

A species of this genus, described by Poulsen on a single pygidium, occurs abundantly in certain beds of the *Glossopleura* zone in the Canadian Rockies. Complete shields of the new form have been recovered. A more complete diagnosis of the genus is based on the new material.

Entire shield with considerable transverse convexity. Cephalon and pygidium of equal length, thorax somewhat longer than the other two parts of the dorsal shield. Glabella long and narrow, expanded forward, reaching the anterior margin of the cranidium. Occipital furrow and four pairs of shallow glabellar furrows visible. Brim and rim obsolete. Palpebral lobes narrow, almost half the glabellar length; fixed cheeks about one-third the glabellar width. Posterior limbs small, narrowly triangular. Free cheeks wide, with a narrow rim and short, slender genal spines.

Thorax of seven segments. Axis strongly convex. Pleura broadly furrowed, tapering distally to backward-directed spines.

Pygidium of approximately equal length and width. Axis strongly prominent, moderately tapered, multisegmented, almost reaching the posterior margin. Pleural lobes downsloping, with numerous furrows and a narrow, concave rim.

This genus is obviously closely related to *Glossopleura,* from which it differs chiefly in the characters of the pygidium.

POLYPLEURASPIS INSIGNIS Rasetti, new species

Plate 23, figures 11-15

Known from large numbers of separate cranidia and pygidia and a few articulated shields, all excellently preserved in limestone.

Glabella long and narrow, moderately expanded forward, reaching the anterior margin of the cranidium, moderately convex in either direction. Glabellar furrows shallow; first pair indistinct, directed inward and forward; second and third pairs better impressed, transverse; fourth pair directed inward and backward. Occipital furrow moderately deep; occipital ring rather short and simple. Brim and rim absent or indistinct both in front and at the sides of the glabella, as in *Glossopleura.* Fixed cheeks approximately horizontal, one-third the glabellar width. Palpebral lobes narrow, somewhat less than half the glabellar length, demarcated by a distinct palpebral furrow; anterior end of palpebral lobe in contact with the dorsal furrow; anterior part of lobe straight, oblique, posterior part curving backward and approximately parallel to the dorsal furrow. Posterior limbs somewhat narrower than the occipital ring, short, triangular, delimited by an almost straight posterior branch of the facial suture. Free cheeks wide, slightly convex, with a narrow rim defined by a well-impressed marginal furrow and short, slender, backward-directed genal spines.

Thorax of seven segments. Axis as wide as the occipital ring in its anterior half, slightly tapered posteriorly. There is no evidence for axial spines or nodes. Pleura broadly furrowed, curving backward and tapering to slender, sharply pointed spines. The pleural lobes are as wide as the axis.

Pygidium of about equal length and width, subtriangular. Axis strongly elevated above the pleural lobes, moderately tapered, almost occupying the whole pygidial length and less than one-third of the width. About 8 to 10 axial segments are distinguishable, separated by shallow furrows becoming indistinct posteriorly. Approximately the same number of furrows distinguishable on the pleural lobes; furrows broad, separated by narrow ridges. Pleural lobes steeply downsloping. Rim narrow and concave; doublure rather narrow, its margin clearly visible as an impression on the dorsal side of the shield.

Surface of shield smooth.

Length of complete shield 23 mm. Length of largest cranidium 10 mm.; length of largest pygidium 12 mm., width 14 mm.

This species differs from the genotype, *P. solitaria* Poulsen, known from a single pygidium, in the greater proportionate length of this portion of the shield and the more distinct concave rim. Poulsen's species also occurs in association with *Glossopleura*.

Horizon and locality.—Stephen formation (*Glossopleura* zone). Type locality S21b, Mount Temple. Also locality S3b, Mount Whyte.

Types.—Holotype: U.S.N.M. No. 116202. Paratypes: U.S.N.M. No. 116203.

Genus PTARMIGANIA Raymond, 1928

Genotype: *Bathyuriscus rossensis* Walcott.

PTARMIGANIA ROSSENSIS (Walcott)

Plate 19, figures 9-16

Bathyuriscus rossensis Walcott, Smithsonian Misc. Coll., vol. 67, No. 2, p. 46, pl. 5, figs. 5, 5a-d, 1917.

Bathyuriscus cf. *B. rossensis* Walcott (part), Smithsonian Misc. Coll., vol. 67, No. 2, p. 49, pl. 5, figs. 6a, 6a' (only), 1917.

Ptarmigania rossensis (Walcott), Raymond, Amer. Journ. Sci., ser. 5, vol. 15, No. 88, p. 310, 1928.

The species has been adequately described by Walcott, and is based on specimens in shale. Walcott also described specimens collected from limestone interstratified with the Ross Lake shale as *Bathyuriscus* cf. *rossensis*. Resser made a new species, *Ptarmigania longula,* for the large cranidium in limestone illustrated by Walcott. Examination of the type material appears to show that this cranidium is specifically different from *P. rossensis,* hence Resser's species may at least provisionally be considered as valid. However, the numerous other specimens in limestone in the United States National Museum collections, including the pygidium figured by Walcott, are entirely typical of *P. rossensis,* hence the name *longula* is restricted to the type cranidium.

Horizon and locality.—Cathedral formation (Ross Lake shale member; *Albertella* zone). Type locality U.S.N.M. 63j, Ross Lake. Other localities C4m, Ross Lake; C5m, Mount Bosworth; C15m, Bow Lake; U.S.N.M. 35c, 63m, Mount Bosworth.

Types.—Lectotype (hereby designated): U.S.N.M. No. 63733. Paratypes: U.S.N.M. Nos. 63729-32. Specimen described as *"Bathyuriscus* cf. *rossensis":* U.S.N.M. No. 63735. Plesiotype: U.S.N.M. No. 116167.

PTARMIGANOIDES Rasetti, new genus

Dolichometopid trilobites closely related to *Ptarmigania* and distinguishable from the latter genus only by the pygidial features.

Glabella long and narrow, somewhat expanded forward, reaching the anterior margin of the cephalon except for an exceedingly short rim. Glabellar furrows generally well developed; four pairs visible in some of the species. Occipital ring usually extended into a spine. Brim and rim at the sides of the glabella not sharply differentiated from each other. Fixed cheeks approximately horizontal, somewhat convex; maximum width equaling half the glabellar width. Palpebral lobes curved, narrow, long, set off by a deep palpebral furrow. Posterior limbs slender.

Thorax probably of seven segments. Axis strongly convex.

Pygidium large, with a very prominent axis occupying most of the length. Pleural platforms downsloping; marginal furrow shallow, often reduced to a series of pits. Margin extended into at least four pairs of strong, cylindrical spines. A strong upright spine on the first axial ring.

Genotype.—*Ptarmiganoides bowensis* Rasetti, new species.

Stratigraphic range.—Middle Cambrian (*Albertella* zone).

Remarks.—Poulsen (1927) based his genus *Dolichometopsis* on the genotype, *D. resseri,* and other species from the Lower Cambrian Cape Kent formation of northwest Greenland. Poulsen tentatively assigned to the genotype a small, nonspinose pygidium. Later Resser (1939b) described a series of species from the *Albertella* zone (*"Ptarmigania* strata") of Idaho. These species present cranidia, as Resser himself states, generically indistinguishable from *Ptarmigania* associated with strongly spinose, *Kootenia*-like pygidia. Resser concluded that Poulsen had probably assigned a wrong pygidium to *Dolichometopsis* and that the latter genus is characterized by spinose pygidia, hence assigned all the species in question to *Dolichometopsis* and modified the diagnosis of the genus accordingly.

Resser's procedure has already been questioned by Kobayashi (1942) and the writer (Rasetti, 1948a). The writer does not doubt that Resser's assignment of the spinose pygidia to his cranidia is correct, but sees no reason to assume that the original species of *Dolichometopsis* from the Lower Cambrian of Greenland possess similar pygidia. It is a common occurrence among dolichometopid trilobites to find almost identical cranidia associated with a great variety of pygidia, and in such cases generic characters must be based on the features of the entire shield and not of the cranidium alone. Furthermore, the great difference in age between the two groups of species favors placing them in different genera. Hence the writer proposes the new name *Ptarmiganoides* for the forms with a *Ptarmigania*-like cephalon and a *Kootenia*-like pygidium that Resser assigned to *Dolichometopsis*. As genotype the writer chooses a new species from the *Albertella* zone of the Canadian Rockies, as for this form, notwithstanding the lack of complete specimens, the association of the fragments of the shield leaves no doubt as to the assignment of cranidium and pygidium to one species.

Ptarmiganoides, as the name indicates, is undoubtedly a close relative of the contemporaneous *Ptarmigania* from which it differs in the structure of the pygidium.

Besides the genotype, the following species described by Resser should be included in *Ptarmiganoides: Dolichometopsis alia, D. comis, D. communis, D. gravis, D. gregalis, D. lepida, D. mansfieldi, D. media, D. potens, D. pouleni, D. propinqua, D. stella.* Possibly some of these species are synonymous, but further study and additional material would be required to discuss this question properly.

PTARMIGANOIDES BOWENSIS Rasetti, new species

Plate 20, figures 1-9

Known from numerous cranidia, free cheeks, and pygidia excellently preserved in limestone.

Glabella long, slightly expanded forward, well rounded in front, showing considerable convexity in both directions, delimited by a deep dorsal furrow. First pair of glabellar furrows faint but visible, second pair indistinct, third pair about as deep as the first, fourth pair longer and deeper than the others, oblique. Occipital furrow well impressed across the glabella; occipital ring extended into a short, blunt spine.

Rim in front of the glabella exceedingly short; rim and brim at the sides fairly extended, poorly differentiated by a shallow marginal furrow. Anterior angles of cranidium well rounded. Fixed cheeks somewhat upsloping from the dorsal furrow, slightly convex, about half the glabellar width. Palpebral furrow very deep; palpebral lobes narrow, straight in the anterior portion, regularly curved posteriorly, slightly over half the glabellar length. Posterior limbs very slender, not entirely preserved in any specimen. Anterior facial sutures somewhat divergent in front of the eyes, turning inward with a wide curve after crossing the marginal furrow; posterior branch directed straight outward. Free cheeks with convex ocular platforms, a wide, flat rim, and genal spines of unknown length.

Pygidium with approximately semicircular outline. Axis strongly prominent, subcylindrical, rounded posteriorly, almost reaching the posterior margin, composed of four segments and a terminal section. There is an upright spine of unknown length on the first segment and a small node on the second. Pleural platforms convex and downsloping, showing three distinct furrows and rather indistinct grooves. Marginal furrow wide and fairly well impressed, deepening into four pairs of broad pits in correspondence with the pleural furrows. Rim convex, extended into six pairs of spines. Spines of the first four pairs about equally strong, approximately half the length of the pygidium. Spines of the fifth pair much thinner and shorter; spines of the sixth pair very short and blunt.

Surface of cranidium with granulations particularly marked on the posterior portion of the glabella and the fixed cheeks. Surface of pygidium with irregular, elevated, wavy lines.

Length of the largest cranidium 20 mm.; length of the largest complete pygidium (inclusive of the spines) 10 mm., width 18 mm. Fragments indicate the presence of individuals of larger sizes.

This species differs from any of those described by Resser under the genus *Dolichometopsis* in possessing six instead of four marginal pygidial spines.

Horizon and locality.—Cathedral formation (*Albertella* zone). Locality C15n, Bow Lake.

Types.—Holotype: U.S.N.M. No. 116172. Paratypes: U.S.N.M. No. 116173.

STEPHENASPIS Rasetti, new genus

Glabella occupying almost the entire cranidial length, moderately expanded forward, well delimited by the dorsal furrow. Four pairs of distinct glabellar furrows. Brim and rim developed at the sides;

only an exceedingly short rim in front of the glabella. Fixed cheeks less than half the glabellar width. Palpebral lobes about half the glabellar length, curved, close to the glabella at both ends. Posterior limbs slender, parallel-sided.

Thorax of nine segments. Axis occupying less than one-third of the width. Pleura curved backward and extended into long, cylindrical spines. Each pleuron carries an elongated triangular ridge at its inner end and is broadly furrowed. The pleura of the last segment envelop the pygidium.

Pygidium subrectangular. Axis prominent, almost reaching the posterior margin, with several distinct segments. Pleura flat, with furrow and grooves curving backward; straight sides extended into a pair of spines; rim poorly defined.

Genotype.—Stephenaspis bispinosa Rasetti, new species.

Stratigraphic range.—Middle Cambrian (*Wenkchemnia-Stephenaspis* zone).

Remarks.—The genotype and only known species has many characters that place it in an intermediate position between *Zacanthoides, Albertella* on one side and *Bathyuriscus, Poliella, Fieldaspis* and related genera on the other. However, when the combination of all characters is considered, it appears that this form cannot be assigned to any of the above-mentioned genera.

Stephenaspis differs from *Zacanthoides* chiefly in the reduction of the frontal limb and different pygidium. *Albertella* has a somewhat similar pygidium, but a thorax with seven segments and characteristic macropleural development of certain segments. The cephalic characters do not greatly differ from those of *Poliella* and *Ptarmigania,* but the thorax, with its long spines, has a different aspect, and the pygidia differ considerably. Probably the most closely related genus is *Fieldaspis,* which differs chiefly in the greater distance of the posterior end of the palpebral lobe from the dorsal furrow and the shape of the pygidium.

STEPHENASPIS BISPINOSA Rasetti, new species

Plate 10, figures 1-6

Known from a large number of entire shields partially flattened in shale.

Glabella prominent, expanded forward in the anterior half, delimited by a deep dorsal furrow. Posterior glabellar furrows fairly deep, oblique, not quite meeting mesially. Next pair shorter and shallower, transverse. Second pair impressed like the preceding, directed slightly forward. First pair shortest, shallow. Occipital furrow straight, well impressed; occipital ring long, extended into a slender occipital spine. Anterior outline of cranidium fairly straight. Brim developed only at the sides; rim short, upturned, greatly reduced in front of the glabella. Anterior facial sutures rather divergent; anterior angles of cranidium narrowly rounded. Palpebral lobes half the glabellar length, narrow, set off by a distinct palpebral furrow. Anterior end of palpebral lobe almost in contact with the dorsal furrow; palpebral lobe straight in its anterior portion, curving posteriorly. Posterior limbs slender, parallel-sided, about as wide as the occipital ring, without intergenal spines. Free cheeks wide, with a distinct rim and genal spines of moderate length.

Thorax of nine segments with a strongly prominent axis. Each ring carried a spine, which is broken off in all the available specimens. Pleura first directed straight transversely, then rather suddenly curving backward. Pleural spines increasing in length from the first to the last segment. The spines of the last segment are almost parallel to the sides of the pygidium.

Pygidium $1\frac{1}{2}$ times wider than long. Axis slightly tapered, strongly prominent, showing three or four rings and a terminal section, without axial spines; extended into a short postaxial ridge that reaches the margin. Pleura flat, bent backward as the thoracic pleura. First pleuron curving straight backward and extended into a pair of straight spines about two-thirds the pygidial length. Three pairs of rather shallow pleural furrows and interpleural grooves, ending in a shallow, wide marginal furrow. Rim flat, poorly defined. Posterior outline of pygidium with distinct mesial notch.

Free cheeks with transverse, anastomosing ridges. Rest of surface apparently smooth.

Length of adult shield 45 mm., of which 14 mm. belong to the head, 20 mm. to the thorax, and 11 mm. to the tail.

Horizon and locality.—Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Type locality W9k, Fossil Gully, Mount Stephen. Other locality W16k, North Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116091. Paratypes: U.S.N.M. No. 116092.

STEPHENASPIS cf. S. BISPINOSA Rasetti

Plate 10, figures 7-9

Known from several pygidia well preserved in limestone.

The available material does not show definite differences between this form and the typical *S. bispinosa* from the Yoho shale, apart from those attributable to the different manner of preservation. Since the cranidium is not known, definite identification is not indicated. The pygidium has almost horizontal pleural platforms and an upturned flat rim, making the pleural lobes slightly concave as a whole. The flattening of the shields in the Yoho shale makes it difficult to ascertain whether the pygidium of *S. bispinosa* had the same relief. The axis may be slightly longer in the present form.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Locality W16j, North Gully, Mount Stephen.

Figured specimens.—U.S.N.M. No. 116093.

Genus VANUXEMELLA Walcott, 1916

Genotype: *Vanuxemella contracta* Walcott.

VANUXEMELLA NORTIA Walcott

Plate 20, figures 10-13

Vanuxemella nortia Walcott, Smithsonian Misc. Coll., vol. 64, No. 3, p. 222, pl. 36, fig. 5, 1916; vol. 67, No. 2, p. 37, pl. 7, fig. 7, 1917.

Vistoia prisca Walcott, Smithsonian Misc. Coll., vol. 75, No. 3, p. 122, pl. 17, fig. 14, 1925.

Walcott's generic description illustrates most of the characters of this species. The writer collected and illustrates here excellently preserved cranidia and pygidia in limestone, showing certain details better than the shields flattened in shale.

The pygidium has the two anterior pairs of pleura terminating in short, falcate ends beyond the general outline of the shield. There is a pair of small, sharp spines at the posterolateral angles. Axial and pleural furrows are extremely shallow on the outer surface, but quite distinct on the interior cast.

Horizon and locality.—Cathedral formation (Ross Lake shale member; *Albertella* zone). Type locality U.S.N.M. 35c, Mount Bosworth. Also localities C5m, Mount Bosworth; C4m, Ross Lake; C20m, Eiffel Peak; C15m, Bow Lake; C21m, Mount Temple; U.S.N.M. 63j, Ross Lake; U.S.N.M. 63w, Bow Lake.

Types.—Holotype and paratypes: U.S.N.M. No. 61728. Plesiotypes: U.S.N.M. Nos. 116174-5.

WENKCHEMNIA Rasetti, new genus

Glabella expanded forward in the anterior part, defined by a shallow dorsal furrow; glabellar furrows shallow. Frontal limb poorly differentiated into rim and brim, extremely reduced in front of the glabella. Palpebral lobes narrow, oblique, about one-third the glabellar length; their posterior end distant from the dorsal furrow by more than half the glabellar width. Posterior limbs wider than the occipital ring, slightly tapered, rounded distally; distance from posterior end of palpebral lobe to posterior margin equal to the length of palpebral lobe.

Thorax of 9 segments. Pleura straight, broadly furrowed, not extended into long spines.

Pygidium twice wider than long; subtriangular. Axis prominent, furrowed, occupying most of the length. Pleural furrows almost straight, wide; interpleural grooves almost indistinct. Marginal furrow and rim narrow, poorly defined.

Genotype.—*Wenkchemnia walcotti* Rasetti, new species.

Stratigraphic range.—Middle Cambrian (*Wenkchemnia-Stephenaspis* zone).

Remarks.—The species assigned to this genus show close affinity with *Bathyuriscus* and especially *Poliella*. *Wenkchemnia* differs from *Bathyuriscus* in the shallower dorsal furrow, small, transverse pygidium, and less distinct interpleural grooves. In *Poliella* the palpebral lobes are longer, the posterior limbs are slender and do not taper but rather expand distally, and the last thoracic segments curve backward enveloping the pygidium.

The name derives from Wenkchemna Pass in the Bow Range.

WENKCHEMNIA WALCOTTI Rasetti, new species

Plate 11, figures 1-3

Bathyuriscus (*Poliella*) *primus* Walcott (part), Smithsonian Misc. Coll., vol. 64, No. 5, p. 352, pl. 46, fig. 6b (only), 1916.

In describing *Bathyuriscus* (*Poliella*) *primus*, Walcott remarked both in the text and in the legend of the plate that there were specimens of two types, differing in the number of thoracic segments and the shape of the posterior limbs. Resser's choice of a lectotype restricts the name *Poliella prima* to the form with long palpebral lobes, slender and expanding posterior limbs, and eight thoracic segments, which is a good species of *Poliella*. The form with tapered posterior limbs, short palpebral lobes, nine thoracic segments, and wide, short pygidium presents sufficient differences to induce the writer to make it the type of a new genus.

Known from numerous entire shields flattened in shale. Glabella moderately expanded forward in the anterior half, delimited by a shallow dorsal furrow. Three or four pairs of glabellar furrows visible but very shallow. Occipital furrow better impressed; occipital ring moderately long, with a very short spine. Brim developed only at the sides; rim slightly upturned, greatly reduced in front of the glabella. Anterior facial suture parallel to the dorsal furrow, distant from it one-fifth the glabellar width. Palpebral lobes defined by a shallow palpebral furrow, narrow, moderately curved, obliquely placed, about one-third the glabellar length, their posterior end distant from the glabella slightly more than one-half the glabellar width, and situated on the transverse line through the posterior fourth of the glabella. Posterior limbs tapered, slightly wider than the occipital ring; about half of the width comprised within the palpebral lobes. Free cheeks rather narrow.

Thorax of nine segments. Axis slightly tapered, occupying somewhat less than one-third of the width. Pleura bent downward at geniculation, which is situated at half the length of each pleuron; furrowed for the entire length, directed transversely.

Pygidium twice wider than long, widely subtriangular. Anterior margin almost straight. Axis prominent, somewhat tapered, with three distinct segments and a terminal section, occupying most of the pygidial length. Pleural lobes slightly convex. Pleural furrows shallow, three or four being visible; interpleural grooves indistinct. Marginal furrow shallow but distinct; rim narrow, convex.

Surface apparently smooth.

Length of largest shield observed about 30 mm., of which 10 mm. belong to the head, 15 mm. to the thorax, and 5 mm. to the tail.

Horizon and locality.—Mount Whyte formation (Lake Agnes shale lentil; *Wenkchemnia-Stephenaspis* zone). Type locality W3b, Plain of Six Glaciers. Also localities U.S.N.M. 35m, southwest of Lake Louise, and U.S.N.M. 35e, Mount Whyte.

Types.—Holotype: U.S.N.M. No. 116098. Paratypes: U.S.N.M. Nos. 62625, 116099-100.

WENKCHEMNIA SPINICOLLIS Rasetti, new species

Plate 11, figures 4-8

Known from numerous cranidia, pygidia, and entire shields partly flattened in shale.

Glabella of moderate convexity, defined by a shallow dorsal furrow, rather strongly expanded in the anterior third. Glabellar furrows very shallow. Occipital furrow shallow; occipital ring extended into a slender spine about one-fourth the glabellar length. Brim and rim poorly differentiated from each other at the sides; rim flat, greatly reduced in front of the glabella. Palpebral lobes about one-third the glabellar length, narrow, delimited by a shallow palpebral furrow; maximum width of the fixed cheeks near the posterior end of the palpebral lobes and equal to two-thirds of the glabellar width. Posterior limbs slightly tapered, rounded distally, somewhat wider than the occipital ring. Distance from posterior end of palpebral lobe to posterior margin about equal to length of palpebral lobe. Anterior facial sutures divergent, approximately parallel to the dorsal furrow.

Thorax of nine segments. Axial segments each with a spine or node, broken off in all available specimens. Pleura straight, widely furrowed, truncated at the extremity, the posterior end produced into a sharp but very short spine.

Pygidium twice wider than long. Anterior outline almost straight, anterior angles narrowly rounded. Axis strongly prominent, moderately tapered, showing three rings and a terminal section defined by shallow furrows, not quite reaching the posterior margin. Pleural lobes slightly downsloping. Four pairs of rather wide, shallow pleural furrows and very faint, narrow interpleural grooves. Marginal furrow very shallow, rim slightly convex and poorly defined. Rim of first pleural segment extended into a pair of short, blunt spines.

Surface apparently smooth.

Proportions of an entire shield are: Length of cephalon 7 mm., of thorax 8 mm., of pygidium 3.3 mm. Length of largest shield observed 40 mm.

This species is very similar to the genotype, from which it differs chiefly in the occipital spine, axial spines on the thorax, and small spines at the anterior angles of the pygidium.

Horizon and locality.—Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Type locality W9k, Fossil Gully, Mount Stephen. Also locality W16k, North Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116101. Paratypes: U.S.N.M. No. 116102.

WENKCHEMNIA SULCATA Rasetti, new species

Plate 11, figures 9-15

Known from numerous cranidia, a few pygidia, and entire shields preserved in limestone and shale.

The species is so similar in all parts of the carapace to *W. spinicollis* that it is sufficient to describe it by listing the differences. The fact that all specimens of *W. spinicollis* are more or less flattened in shale while those of the new species preserve the full convexity makes an exact comparison difficult. Nevertheless the following differences do not appear to be due to the different manner of preservation. In the new species the dorsal furrow is somewhat deeper, making the glabella better defined, and the glabellar furrows are also deeper. The occipital ring carries only a short, blunt spine. The thorax presents no differences. The pygidium has the small marginal spines at the anterior angles as in *W. spinicollis,* but the marginal furrow and rim are narrower and less well defined.

Length of a complete shield 18 mm. Length of the largest cranidium 13 mm.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Type locality W16j", North Gully, Mount Stephen. Other localities W16j, W16i, W16h, North Gully.

Types.—Holotype: U.S.N.M. No. 116103. Paratypes: U.S.N.M. Nos. 116104-6.

Undetermined pygidium No. 1

Plate 15, figures 10, 11

Several specimens of this pygidium were collected from the *Plagiura-Kochaspis* zone at various localities It has been impossible to assign it with certainty to any of the associated cranidia, hence the systematic position of this form remains obscure. It appears likely that the pygidium belongs to a dolichometopid trilobite.

Entire pygidium subcircular, about as wide as long. Axis large, occupying two-thirds of the length and more than half of the width; strongly prominent, relatively short and wide, cylindrical; composed of two rings and a terminal section, very poorly defined. A steep postaxial slope reaches the posterior margin. Pleural lobes narrow, concave in the transverse direction, without distinct rim, showing but traces of segmentation. Anterior angles well rounded, posterior outline uniformly curved.

Surface smooth. Length of largest pygidium 6 mm., width 6.5 mm.

The writer does not know of any described pygidium resembling the present one.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Localities W4c-d, Ross Lake; W20d, Eiffel Peak.

Figured specimens.—U.S.N.M. No. 116141.

Undetermined pygidium No. 2

Plate 10, figure 10

Known from a single specimen in limestone.

This pygidium is subtriangular, truncated posteriorly. Axis moderately tapered, strongly prominent, showing three rings and a terminal section, extended into a short post-axial ridge that reaches the margin. Pleural lobes approximately horizontal, flat, with five distinct, broad furrows and very shallow interpleural grooves. Anterior angles well rounded. Rim flat, narrow, differentiated by upturning rather than by a marginal furrow. Length of pygidium 8 mm., width 12 mm.

This pygidium resembles that of *Stephenaspis* except that it lacks marginal spines. It almost certainly belongs to a dolichometopid trilobite. It is described because so little is known of the fauna of the *Wenkchemnia-Stephenaspis* zone.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Locality W16j, North Gully, Mount Stephen.

Figured specimen.—U.S.N.M. No. 116094.

Family CORYNEXOCHIDAE Angelin

Genus BONNASPIS Resser, 1936

Genotype: *Karlia stephenensis* Walcott.

BONNASPIS STEPHENENSIS (Walcott)

Plate 28, figures 4-6

Menocephalus salteri ROMINGER (not Devine), Proc. Acad. Nat. Sci. Philadelphia, 1887, p. 16, pl. 1, fig. 6.

Karlia stephenensis WALCOTT, Proc. U. S. Nat. Mus., vol. 11, p. 445, 1889; Canadian Alpine Journ., vol. 1, No. 2, pl. 3, fig. 4, 1908; Smithsonian Misc. Coll., vol. 64, No. 3, p. 224, pl. 36, fig. 8, 1916.

Corynexochus romingeri MATTHEW, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 47, pl. 2, fig. 3, 1899.

Corynexochus stephenensis (Walcott), WALCOTT, Smithsonian Misc. Coll., vol. 64, No. 5, p. 324, pl. 55, figs. 5-5c, 1916.

Bonnaspis stephenensis (Walcott), RESSER, Smithsonian Misc. Coll., vol. 95, No. 4, p. 5, 1936.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 14s (=author's locality S8d), Mount Stephen.

Types.—Holotype: U.S.N.M. No. 61731. Paratypes: U.S.N.M. Nos. 62717, 62718. Plesiotype: U.S.N.M. No. 116233.

Family DORYPYGIDAE Kobayashi

Genus KOOTENIA Walcott, 1889

Genotype: *Bathyuriscus* (*Kootenia*) *dawsoni* Walcott.

KOOTENIA DAWSONI (Walcott)

Plate 27, figures 4-7

Bathyuriscus (*Kootenia*) *dawsoni* WALCOTT, Proc. U. S. Nat. Mus., vol. 11, p. 446, 1889.
Dorypyge dawsoni (Walcott), MATTHEW, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 56, pl. 3, fig. 1, 1899.
Dorypyge (*Kootenia*) *dawsoni* (Walcott), WALCOTT, Canadian Alpine Journ. vol. 1, No. 2, pl. 3, fig. 9, 1908.
Kootenia dawsoni (Walcott), WALCOTT, Smithsonian Misc. Coll., vol. 67, No. 4, p. 131, 1918.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 14s, Mount Stephen.

Types.—Syntypes: U.S.N.M. No. 108495. Plesiotype: U.S.N.M. No. 116229.

KOOTENIA BURGESSENSIS Resser

Plate 28, figures 9-11

Kootenia dawsoni WALCOTT (part), Smithsonian Misc. Coll., vol. 67, No. 4, p. 131, pl. 14, figs. 2, 3, 1918.
Kootenia burgessensis RESSER, Smithsonian Misc. Coll., vol. 101, No. 15, p. 27, 1942.

Horizon and locality.—Stephen formation (Burgess shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 35k, Burgess Quarry, Mount Field. Also locality S11e, Mount Field.

Types.—Holotype: U.S.N.M. No. 65511. Paratypes: U.S.N.M. Nos. 65512, 65533. Plesiotypes: U.S.N.M. No. 116234.

Genus OLENOIDES Meek, 1877

Genotype: *Paradoxides nevadensis* Meek.

OLENOIDES SERRATUS (Rominger)

Plate 27, figures 1-3

Ogygia serrata ROMINGER, Proc. Acad. Nat. Sci. Philadelphia, p. 13, pl. 1, figs. 2, 2a, 1887.
Olenoides nevadensis (Walcott, not Meek), WALCOTT, Amer. Journ. Sci., ser. 3, vol. 36, p. 165, 1888.
Neolenus serratus (Rominger), MATTHEW, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 53, 1899.
Neolenus granulatus MATTHEW, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 55, pl. 2, figs. 1a-c, 1899.

Neolenus serratus (Rominger), WALCOTT, Canadian Alpine Journ., vol. 1, No. 2, pl. 4, fig. 1, 1908; Smithsonian Misc. Coll., vol. 67, No. 4, p. 126, pls. 14-23, 1918.

Olenoides serratus (Rominger), KOBAYASHI, Journ. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 4, pt. 2, p. 153, 1935.

Horizon and locality.—Stephen formation (*Ogygopsis* and Burgess shale lentils). Type locality U.S.N.M. 14s, Mount Stephen. Also locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Types.—Holotype: Acad. Nat. Sci. Philadelphia. Plesiotypes figured by Walcott: U.S.N.M. Nos. 57656-7, 58588, 58590, 65510, 65513-15, 65519-21. Plesiotypes figured by the writer: U.S.N.M. Nos. 116227-8.

OGYGOPSIDIDAE Rasetti, new family

Genus OGYGOPSIS Walcott, 1889

Genotype: *Ogygia klotzi* Rominger.

The genus *Ogygopsis* was assigned to the Ordovician family Asaphidae, on the basis of superficial resemblance of the entire shield and especially the macropygous development. However, this resemblance is not substantiated by the really significant diagnostic features. In the *Asaphidae,* the free cheeks meet along a median ventral suture. Warburg (1925) remarked that the course of the dorsal sutures in *Ogygopsis* does not suggest a structure of the ventral sutures of the type observed in the *Asaphidae,* hence the placement of the genus in the family is questionable. Study of the abundant material of *Ogygopsis klotzi* from the *Ogygopsis* shale fully supports Warburg's assumption. Shields exposed from the ventral side show that the free cheeks are widely separated by the anterior portion of the hypostoma, i.e., there is a pair of ventral sutures instead of a median suture as in the *Asaphidae.* The hypostoma is fused with the rostrum. This type of cephalic sutures is observed in the trilobites here assigned to the superfamily Corynexochoidae. *Ogygopsis* entirely agrees with this group not only in the course of the cephalic sutures but also in the general features of the shield. In many respects *Ogygopsis* is intermediate between the Dorypygidae and the Dolichometopidae; the cephalon is like *Kootenia,* the pygidium resembles those of *Orria* and other macropygous Dolichometopidae. The hypostoma, however, is relatively wider posteriorly than in any of the genera of these two families and the anterior wings are less developed than in the Dorypygidae and Dolichometopidae. These characters suggest the assignment of *Ogygopsis* to a new family Ogygopsididae. The characters of the family are those of the type genus since no other described genera appear to belong in the Ogygopsididae.

Ogygopsis was known only from the type species, *Ogygopsis klotzi,* until Resser (1939b) described a new genus, *Taxioura,* based on a new species, *Taxioura typicalis,* from the "*Ptarmigania* strata" of Idaho. The only significant difference that the writer could discover between *Taxioura typicalis* and *Ogygopsis klotzi* is the lack of interpleural furrows in the former species. This is not regarded as a character of generic importance, hence the writer considers *Taxioura* as a subjective synonym of *Ogygopsis.*

On Mount Stephen, *Ogygopsis* ranges through an exceptional thickness of strata and occurs in five different faunules, apparently represented by the same species. The earliest occurrence of *Ogygopsis* is in the *Syspacephalus laticeps* faunule of the *Wenkchemnia-Stephenaspis* zone. The next occurrence is in the *Stephenaspis bispinosa* faunule of the same zone. The next higher occurrences are in the *Yohoaspis pachycephala* and *Chancia bigranulosa* faunules, tentatively assigned to the *Albertella* zone, collected from the shaly and calcareous equivalent of the lower Cathedral formation on Mount Stephen. The latest occurrence is in the *Ogygopsis* shale, whose faunule belongs to the *Bathyuriscus-Elrathina* zone.

OGYGOPSIS KLOTZI (Rominger)

Plate 12, figures 1-5; Plate 21, figures 1-3; Plate 29, figures 6-8

Ogygia klotzi ROMINGER, Proc. Acad. Nat. Sci. Philadelphia, 1887, p. 12, pl. 1, fig. 1.

Ogygopsis klotzi (Rominger), WALCOTT, Proc. U. S. Nat. Mus. vol. 11, p. 446, 1889; Canadian Alpine Journ., vol. 1, No. 2, pl. 4, fig. 4, 1908; Smithsonian Misc. Coll., vol. 64, No. 5, p. 377, pl. 66, figs. 1, 1a-b, 1916.

Ogygia (*Ogygopsis*) *klotzi* Rominger, MATTHEW, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 58, 1899.

This species was collected at five different horizons ranging from the *Wenkchemnia-Stephenaspis* zone in the Mount Whyte formation to the *Ogygopsis* shale of the Stephen formation which is the typical horizon. Entire shields are known from four of these horizons, and show no difference in the thorax, which has eight segments in all specimens. The cranidia and pygidia were compared as accurately as permitted by the imperfect state of preservation. All specimens from the *Ogygopsis* shale are flattened to a greater or lesser extent according to size. Specimens from the Cathedral formation (localities C9h, C9j) are either flattened or not according to the shaly or calcareous composition of the layer in which they occur, but in either case are poorly preserved in the coarse matrix. Identical conditions of preservation obtain at locality W16j in the *Wenkchemnia-Stephenaspis* zone of the Mount Whyte formation. Distortion is present at all localities and horizons. Notwithstanding these circumstances, a relatively accurate comparison of the material from different beds is favored by the large size of this trilobite and the possibility of comparing specimens preserved in the same type of matrix. This study did not reveal differential characters in the cranidium or pygidium. Hence *Ogygopsis klotzi* seems to possess a vertical range unprecedented among Cambrian trilobites. Specimens from different horizons are figured.

Horizon and locality.—(1) Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 14s, Mount Stephen.

(2) Cathedral formation (*Albertella* (?) zone). Localities C9j, C9h, Fossil Gully, Mount Stephen.

(3) Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Locality W9k, Fossil Gully, Mount Stephen.

(4) Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Locality W16j, North Gully, Mount Stephen.

Types.—Holotype: Acad. Nat. Sci. Philadelphia. Plesiotypes: U.S.N.M. Nos. 62846-8, 116107-8, 116178, 116239, 24040.

OGYGOPSIS SPINULOSA Rasetti, new species

Plate 21, figure 4

Known from a single pygidium preserved in impure limestone and not flattened.

The pygidium resembles the associated *O. klotzi* in all respects except the lack of interpleural furrows, somewhat shorter axis, and especially the denticulated margin. Each pleural segment is extended into a minute spine, nine pairs being distinguishable, the last two represented by a faint waviness of the margin. Length 22 mm., width 30 mm.

Horizon and locality.—Cathedral formation (*Albertella* (?) zone). Locality C9h, Fossil Gully, Mount Stephen.

Type.—Holotype: U.S.N.M. No. 116179.

Family ORYCTOCEPHALIDAE Beecher

This family represents a very homogeneous, closely interrelated group of genera when spurious forms that at one time or other were included in the Oryctocephalidae are eliminated. The writer considers the family to include the genera *Oryctocara, Oryctocephalites, Oryctocephalus,* and *Tonkinella.*

Genus ORYCTOCEPHALUS Walcott, 1886

Genotype: *Oryctocephalus primus* Walcott.

ORYCTOCEPHALUS, species undetermined No. 1

Plate 9, figure 24

A single cranidium of a species of *Oryctocephalus* is figured in order to present what probably is the earliest known occurrence of the genus.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Locality W16j, North Gully, Mount Stephen.

Figured specimen.—U.S.N.M. No. 116090.

ORYCTOCEPHALUS, species undetermined No. 2

Plate 9, figure 23

A species of *Oryctocephalus* is exceedingly rare in the Yoho shale. Specific identification is not attempted as this form is represented only by flattened cranidia.

Horizon and locality.—Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Locality W9k, Fossil Gully, Mount Stephen.

Figured specimen.—U.S.N.M. No. 116089.

ORYCTOCEPHALUS REYNOLDSI Reed

Plate 29, figures 4, 5

Oryctocephalus reynoldsi Reed, Geol. Mag., new ser., dec. IV, vol. 6, No. 8, p. 359, text fig., 1899.

Oryctocephalus reynoldsi Reed, Walcott, Canadian Alpine Journ., vol. 1, No. 2, pl. 3, fig. 1, 1908.

This rare species, described from the *Ogygopsis* shale, also occurs in the Burgess shale. An excellently preserved shield from the latter locality is figured, as well as a specimen from the type locality.

Horizon and locality.—Stephen formation (*Ogygopsis* and Burgess shale lentils; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 14s, Mount Stephen. Also locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Types.—Holotype: Woodwardian Museum. Plesiotypes: U.S.N.M. Nos. 24078, 116237-8.

ORYCTOCEPHALUS BURGESSENSIS Resser

Plate 26, figures 1-3

Oryctocephalus primus KOBAYASHI (not Walcott), Journ. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 4, pt. 2, p. 147, pl. 15, fig. 1, 1935.

Oryctocephalus burgessensis RESSER, Smithsonian Misc. Coll., vol. 97, No. 10, p. 37, 1938.

Resser's brief description of the species can be supplemented, thanks to the abundant material available.

Glabella moderately expanded forward in the posterior half, somewhat pear-shaped, almost reaching the anterior margin of the head. First pair of glabellar furrows indistinct, second and third pairs represented by fairly deep lateral pits, fourth pair consisting of lateral pits connected by a shallow transverse furrow; occipital furrow deep but not reaching the dorsal furrow. Occipital ring short and simple. Fixed cheeks somewhat narrower than the glabella. Ocular ridges straight, parallel to the anterior margin of the cephalon. Palpebral lobes slightly oblique, moderately curved; distance from posterior end of palpebral lobe to posterior margin of cephalon somewhat less than length of palpebral lobe.

Thoracic axis without nodes or spines. Pleural furrows starting near the anterior end of each pleuron, first directed obliquely outward and backward, then parallel and close to the posterior margin of the pleuron. Pleura terminating in slender, straight spines increasing in length from the first to the seventh segment; those of the seventh segment exceeding in length the remaining portion of the pleuron.

Pygidial axis tapered, occupying about two-thirds of the pygidial length, with five segments and a short terminal section, without nodes or spines. Six pairs of pleural furrows all well impressed, the furrows of the last pairs directed longitudinally and close to each other. First to third pairs of interpleural grooves almost indistinct, fourth and fifth pairs well impressed, slightly concave outward while the corresponding pleural furrows are convex outward. Six pairs of long, slender marginal spines. Spines of the first to third pairs about equally long and strong, spines of fourth pair strongest and longest, still directed outward, spines of fifth and sixth pairs slenderer, straight, directed slightly inward. Average length of spines somewhat less than pygidial length.

Surface of test smooth. Length of adult shield, exclusive of spines, 16 mm.

This species is in almost all characters intermediate between the two other forms occurring in the Burgess shale, *O. reynoldsi* and

O. matthewi. It may be synonymous with *O. walkeri* Matthew, but the question cannot be decided without studying the types of the latter species.

Horizon and locality.—Stephen formation (Burgess shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Types.—Holotype: U.S.N.M. No. 96487. Plesiotypes: U.S.N.M. No. 116220.

ORYCTOCEPHALUS MATTHEWI Rasetti, new species

Plate 26, figures 4, 5

Known from several complete shields flattened in shale.

The cranidium does not require a complete description, as it is almost identical with that of *O. burgessensis,* possibly excepting slightly shallower glabellar furrows and shorter palpebral lobes.

Thoracic axis without spines or nodes. Pleural furrows wider and shallower than in *O. burgessensis.* Pleural spines short, rapidly tapered, even the longest, those of the seventh segment, not equaling half the length of the pleuron.

Pygidial axis tapered, without nodes or spines, showing five rings and a terminal section, occupying two-thirds of the pygidial length. Pleural lobes with six pairs of furrows, the last two shallower; furrows of the last pair parallel to each other. First three pairs of interpleural grooves indistinct, last two pairs shallow but distinct, dividing the spaces between pleural furrows more evenly than in *O. burgessensis.* Six pairs of marginal spines, all tapered, relatively short, of about equal strength.

Surface of test smooth. Length of largest shield 16 mm.

This species differs from the associated *O. burgessensis* chiefly in the shortness of the marginal thoracic and pygidial spines.

Horizon and locality.—Stephen formation (Burgess and *Ogygopsis* shale lentils; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 35k, Burgess Quarry, Mount Field. Also locality U.S.N.M. 14s, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116221. Paratypes: U.S.N.M. No. 116222.

Genus ORYCTOCEPHALITES Resser, 1939

Genotype: *Oryctocephalites typicalis* Resser.

ORYCTOCEPHALITES RESSERI Rasetti, new species

Plate 15, figure 9

Known from two cranidia preserved in limestone.

Glabella expanded forward, well rounded in front, moderately convex transversely and longitudinally, defined by a narrow but rather well-impressed dorsal furrow. Glabellar furrows represented by three pairs of round pits; the posterior and median ones connected across the glabella by shallow furrows. Occipital furrow consisting of deep pits at the sides and shallow median portion; not reaching the dorsal furrow. Anterior pits well developed, indenting the sides of the glabella immediately in front of the ocular ridges. Anterior outline of cranidium strongly oblique at each side. Rim short, convex. Brim represented by short bands at the sides between the border and the ocular ridges. Ocular ridges well developed, parallel to the anterior margin. Palpebral lobes narrow, somewhat elevated, about two-fifths the glabellar length. Fixed cheeks downsloping, slightly concave; anterior width about one-third the glabellar width, posterior width almost equal the glabellar width. Posterior limbs not entirely preserved, but evidently not extending far beyond the palpebral lobes, strongly bent downward distally. Posterior marginal furrow deep.

Surface covered with exceedingly fine granules. Length of largest cranidium 6.5 mm.

The species is assigned to *Oryctocephalites* rather than *Oryctocephalus* because of the expanding glabella and the strongly curved anterior outline of the cranidium. It differs from *O. typicalis* Resser in the strong development of the anterior pits and the concavity of the fixed cheeks.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W7f, Kicking Horse Mine, Mount Field.

Types.—Holotype: U.S.N.M. No. 116139. Paratype: U.S.N.M. No. 116140.

Genus TONKINELLA Mansuy, 1916

Genotype: *Tonkinella flabelliformis* Mansuy.

TONKINELLA STEPHENSIS Kobayashi

Plate 31, figures 13-18

Tonkinella stephensis Kobayashi, Journ. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 4, pt. 2, p. 149, pl. 15, figs. 2-5, 1935.

This species was adequately described by Kobayashi, except for his statement that the thorax has six segments. The only entire shield that was available to him is very poorly preserved, and the error is explicable. Better-preserved shields show unmistakably that there are only five thoracic segments even in the largest individuals.

A well-preserved cranidium among the material illustrated by Kobayashi is chosen as lectotype. Among the specimens collected by the writer is an unusually large shield 25 mm. long.

This species is a common, readily recognizable diagnostic fossil of the black limestones that constitute the upper portion of the Stephen formation.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 58j, Mount Stephen, probably close to or identical with the author's locality S9k. Other localities S6k, S6l, Mount Odaray; S10k, S10l, Park Mountain; S9k, Mount Stephen.

Types.—Lectotype and paratypes: U.S.N.M. No. 108497. Plesiotypes: U.S.N.M. Nos. 116255-6.

Family undetermined

Genus HANBURIA Walcott, 1916

Genotype: *Hanburia gloriosa* Walcott.

HANBURIA GLORIOSA Walcott

Plate 25, figure 15

Hanburia gloriosa Walcott, Smithsonian Misc. Coll., vol. 64, No. 3, p. 226, pl. 36, figs. 2, 3, 1916.

Hanburia gloriosa Walcott, Kobayashi, Journ. Fac. Sci. Imp. Univ. Toyko, sect. 2, vol. 4, pt. 2, p. 143, pl. 14, fig. 15, 1935.

Besides the shield figured by Walcott and a few other poor specimens from the the type locality, there is available an impression of a shield collected from the *Ogygopsis* shale by Resser.

All the specimens are flattened and the characters of the cephalon are somewhat obscure. Walcott questioned the presence of dorsal facial sutures. Kobayashi stated that "In examining the type specimens under the high magnification with crossed light, they are seen to have the same kind of facial suture and eyes as in *Ogygopsis*."

The writer disagrees with this conclusion and believes that the species has no dorsal cephalic sutures. Examination of casts of the new specimen supports this conclusion. The lines that Kobayashi assumed to be sutures seem to be cracks formed in the flattening of the shield, as they appear on one side only in each specimen, and in different positions in the various specimens; furthermore, the writer was unable to detect any trace of palpebral lobes. Apparently *Hanburia* was a blind trilobite, with free cheeks confined to the doublure and a marginal cephalic suture as in the Conocoryphidae. However, the expanding glabella and the general aspect of the shield indicate a blind relative of the Dolichometopidae or other families of the Corynexochoidae, and no relationship with the Conocoryphidae which are obviously an aberrant branch of the Ptychoparioidae. Until more becomes known of this trilobite, it seems better to leave its more precise systematic position undetermined.

Horizon and locality.—Stephen formation (Burgess and *Ogygopsis* shale lentils; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 35k, Mount Field. Also locality U.S.N.M. 14s, Mount Stephen.

Types.—Syntypes: U.S.N.M. Nos. 61724-5.

Superfamily PTYCHOPARIOIDAE

The superfamily name Ptychoparioidae (emendation of Ptychopariidea R. Richter, 1932) is used instead of the new name Conocoryphidea (Conocoryphoidae) suggested by R. and E. Richter (1941) for priority reasons.

The writer does not believe that the priority rule should be followed at the family, superfamily, and order levels whenever its strict application would require one of these groups to be named after a genus either poorly known, or nontypical in morphology, age, or geographical distribution; any of these reasons may induce future taxonomists to remove the genus from the group that it is supposed to represent, thus causing instability and confusion in nomenclature. In the present case *Ptychoparia* and the Ptychopariidae are perfectly typical examples of the large group of trilobites assembled under the superfamily name, whereas *Conocoryphe* represents an aberrant stock whose close relationship with the Ptychopariidae has even been questioned (Poulsen, 1927).

The great difficulty of classifying the Ptychoparioidae is well known to every student of Cambrian faunas. We find an immense number of forms intergrading in all observable characters and thus making many of the suggested generic subdivisions appear artificial and of questionable practical application. The status of the proposed family arrangements is even more doubtful.

Students of the Cambrian up to the first decade of this century solved the problem by referring almost all these trilobites to *Conocephalites* or *Ptychoparia*. However, with the discovery of new forms it became apparent that the genus *Ptychoparia* was attaining an unwieldy size, and many new genera were established. Today the genera made to receive forms that earlier workers placed in *Ptychoparia* number over 75 for the Lower and Middle Cambrian forms of North America alone (exclusive of the Atlantic province) ; to which an even greater number of genera based on European, Asiatic, and Australian forms could be added. Many more genera were established for Upper Cambrian species.

Yet everyone who undertakes the study of a Cambrian fauna soon meets ptychoparid forms that do not possess the exact combination of characters of any described genus, according to present standards of close discrimination. Short of falling back on the old practice (with which the writer at times feels strongly inclined to sympathize), of using *Ptychoparia* s. l., the only course left is to make further new genera.

The taxonomy of this group, beset with intrinsic difficulties, has been made more confused by the careless work of Cambrian paleontologists. The most objectionable practice responsible for unnecessary confusion has been basing new genera on poorly represented genotypes. For example, some of the important Lower Cambrian genera, such as *Periomma, Antagmus, Billingsaspis, Onchocephalus,* etc., were based on species known from one or a few poorly preserved, often fragmentary cranidia. These forms are difficult to discriminate from each other even when complete cranidia ideally preserved in limestone are available; the problem becomes almost hopeless when generic names are tied to weathered and distorted specimens. Several genera were based on such poor genotypes, when excellently preserved material both from the Appalachian and the Cordilleran provinces was readily available.

Another source of difficulties, which cannot be laid to the door of Cambrian paleontologists, is that some of the genera were based exclusively on the characters of the cranidium; this is the almost general rule for species preserved in limestone, where all the parts of the shield occur separately, and the simple, small ptychoparid pygidia and thoracic segments escape observation, or cannot be assigned to definite cranidia. However, when genera were founded on genotypes known from specimens in shale, often generic characters were taken from features of the entire shield, whereas the cranidial characters could be less accurately ascertained because of the flattening and poor preservation of the test. It is sometimes exceedingly difficult to compare genera based on specimens preserved in the two different manners.

It appears that few of the characters used to distinguish ptychoparid genera are of great significance; in fact, in other groups of trilobites similar characters would not be considered of generic importance. Some of these characters and the general evolutionary trends of the ptychoparids deserve a brief discussion.

The Ptychoparioidae, in their more primitive forms appearing in the Early Cambrian, are typically micropygous (Rasetti, 1948a). These generalized ptychoparids are usually characterized by well-developed dorsal, glabellar, and marginal furrows; the conical glabella occupies a moderate fraction of the cephalic area, the brim and rim are well developed, the anterior facial sutures slightly diverge toward the front, the frontal portion of the suture is marginal. The thorax, when known, usually includes 12 to 20 simple segments. The pygidium is small, transverse, often appearing composed of one or two segments only. Distinguishing generic characters can usually be found only in the cranidia. Forms that have been assigned to *Antagmus, Piazella, Ptychoparella, Onchocephalus, Proliostracus, Syspacephalus,* etc., typify this group of primitive, generalized ptychoparids. *Ptychoparia* itself, although of Medial Cambrian age, has not greatly evolved from these older forms.

In Medial Cambrian times we note two distinct evolutionary tendencies. One is toward an extension and flattening of the brim and rim, widening of the doublure, and reduction of the proportionate size of the glabella; genera like *Alokistocare* and *Amecephalus* exemplify this tendency. Often groups evolved in the opposite direction, leading to forms with very convex cranidia, large glabellae, strong, convex rims and narrow doublures. These trilobites, as generally all the very convex forms, developed a thicker test than in the preceding group. *Solenopleura* is the typical example. However, generalized ptychoparids as described under the first group remained abundant throughout the Medial Cambrian epoch.

In the later part of the Medial Cambrian, certain ptychoparids became macropygous, with corresponding reduction of the number of thoracic segments; in certain cases, the tail became as large as the head. *Asaphiscus* and *Glyphaspis* are outstanding examples.

A somewhat anomalous group of ptychoparids, beginning in early Medial Cambrian time, developed spinose pygidia. *Kochaspis* is the typical genus of this group, and possibly the Upper Cambrian *Crepicephalus* is its descendant.

There are thus at least two groups of ptychoparids where the characters of the pygidium are important for generic distinction.

However, in most cases only cranidia are available, and it may be very difficult to separate such forms as the micropygous *Alokistocare* from the macropygous *Glyphaspis,* or to distinguish cranidia of *Kochaspis* from those of several genera with simple pygidia.

It is likely that at least some of these various modifications of the ptychoparids developed independently in different stocks, so that genera based on these characters may not represent phylogenetic groups. However, since more significant characters for the subdivision of the ptychoparids, if they existed in the living animal, are unknown to us, there is little justification for separating apparently similar forms on the mere suspicion that they may not be closely related. A similar procedure was adopted by R. and E. Richter in uniting all the blind ptychoparids under the family Conocoryphidae, in spite of the strong suspicion that the genera of this family derived from different stocks of oculate ptychoparids.

A tendency that is observed in several groups in Medial Cambrian time is the reduction of the furrows, culminating in smooth forms that are the most difficult to classify. Their similarity is of little significance, being based on the absence rather than the presence of common diagnostic features.

A recent attempt to classify a group of Lower Cambrian ptychoparid genera was made by Lochman (1947). She discussed the genera *Antagmus, Litocodia, Onchocephalus, Periomma, Periommella, Plagiura, Plagiurella, Proliostracus, Ptychoparella,* and *Syspacephalus,* and established two new genera, *Crassifimbra* and *Piazella.* Two of these genera (*Plagiura-Plagiurella* and *Periommella*) are very distinctive and require no comments. The others all belong to the generalized, most difficult group of ptychoparids. Lochman intended to make the generic distinctions in this group less subjective by establishing a list of "diagnostic generic features." She believes that "a definite, recognizable variation in any one of these features constitutes a valid generic distinction."

The features mentioned are chiefly proportions of the various cranidial parts and angles between surfaces. As an example, she separates two genera chiefly on the basis of the width of the fixed cheeks being three-fourths and two-thirds of the glabellar width respectively. The writer, having measured that ratio for a considerable number of Lower and early Middle Cambrian ptychoparids, found, as expected, values ranging anywhere between 0.5 and 1.0 without any preference for the simple fractions mentioned by Lochman. Whatever limits are set to the generic characters, there will always be intermediate cases. Furthermore, the writer does not consider some of the proportions used by Lochman as important. For example, the relative width of the fixed cheeks is known to vary to a great extent even within some of the genera of trilobites that represent the best-established phylogenetic units.

A set of diagnostic generic features may be used, as done by Lochman, as a temporary expedient to put a certain degree of order in a difficult group such as the Lower Cambrian ptychoparids, but it should be understood that its adoption is apt to lead to an excessively artificial grouping of forms. It must be remembered that many of the best-established phylogenetic groups of extinct organisms cannot be defined in terms of the characters preserved in the fossils, yet we are able to recognize such groups through their morphologic and chronologic continuity.

An example that illustrates the above-mentioned principle is the following. The Olenidae of the Atlantic province are one of the best-established trilobite groups, their intergrading genera showing an obvious affinity. Yet the writer believes that it is impossible to formulate a set of diagnostic features that will give an objective description of the olenid shield and enable one to decide whether a certain trilobite belongs to the Olenidae or not. It is likely than an objective definition of the Olenidae would be possible if the soft parts were preserved; as many groups of living animals could no longer be defined if we were to use only the characters that would be preserved in a fossil.

The genera of the Ptychoparioidae are not assigned to families and are arranged in alphabetical order.

Genus ALOKISTOCARE Lorenz, 1906

Genotype: *Conocephalites subcoronatus* Hall and Whitfield.

Several generic names are available for Middle Cambrian ptychoparid trilobites with flat cranidium, long, on the average concave frontal limb, wide fixed cheeks, numerous thoracic segments and a small pygidium. The forms of this type are numerous and intergrade in most of their characters, hence it is difficult to establish generic limits. The generic names *Alokistocare* Lorenz, *Amecephalus* Walcott, *Chancia* Walcott, *Amecephalina* Poulsen, and *Strotocephalus* Resser have been proposed. Resser did not recognize *Amecephalus* which he considered a synonym of *Alokistocare*.

The genotype of *Alokistocare* is known only from cranidia. If forms known from complete shields and described by Resser as *Alokistocare* belong to the genus, they appear to differ from *Ame-*

cephalus piochensis in possessing somewhat narrower fixed cheeks and in the different form of the thoracic pleura, which extend into falcate terminations in *Amecephalus piochensis,* while they remain almost straight in the forms assigned to *Alokistocare. Chancia* (genotype: *Chancia ebdome* Walcott) differs from the other above-mentioned genera in the more convex fixed cheeks and better-defined rim. *Amecephalina* is based on a cranidium from Greenland (*Amecephalina mirabilis* Poulsen) to which Poulsen tentatively assigned a fairly large, multisegmented pygidium. If this part of the shield belongs to the species the genus deserves recognition, otherwise it is doubtful whether the cephalic characters would justify generic separation from *Amecephalus* or *Alokistocare. Strotocephalus* (genotype: *Strotocephalus gordonensis* Resser) is known only from cranidia which, as far as the writer can see, do not differ generically from *Amecephalus* or *Alokistocare.* Finally it should be mentioned that *Kochiella* cannot be easily distinguished from *Amecephalus* or *Alokistocare* as far as the cranidia are concerned, while the characters of other parts of the shield are uncertain (see discussion of genus).

The writer, at least provisionally, recognizes *Amecephalus* and *Alokistocare* as distinct on the basis of the above-mentioned characters; however, it must be borne in mind that the diagnostic features assigned to *Alokistocare* are uncertain because they are in part derived from species other than the genotype. *Amecephalus,* as here construed, occurs on the average in older strata than *Alokistocare.* Of the forms described in this paper, those assigned to *Amecephalus* occur in the *Wenkchemnia-Stephenaspis* and *Plagiura-Kochaspis* zones, while the species assigned to *Alokistocare* occur in the *Bathyuriscus-Elrathina* zone. In other areas of the Cordilleran province, species assignable to these genera frequently occur also in the *Albertella* and *Glossopleura* zones.

ALOKISTOCARE PARANOTATUM Rasetti, new species

Plate 33, figures 17, 18

Known from several cranidia preserved in limestone.

Glabella tapered, moderately convex, somewhat truncated in front. Glabellar furrows very shallow. Occipital furrow deep at the sides, shallow mesially; occipital ring expanded backward mesially, bearing a small node. Frontal limb two-thirds as long as the glabella, on the average concave mesially; brim convex and downsloping at the sides. Rim flat, upturned with respect to the brim; midlengths of rim and brim about equal. Marginal furrow deeper laterally than mesially.

Fixed cheeks slightly convex and upsloping, almost as wide as the glabella at the maximum. Palpebral lobes almost half the glabellar length, moderately wide, set off by well-impressed palpebral furrows. Ocular ridges thick and prominent. Posterior limbs deeply furrowed. Anterior facial sutures somewhat divergent, almost straight to the anterior margin; anterior angles of cranidium narrowly rounded. Posterior branch forming slender posterior limbs, wider than the occipital ring. Distance from posterior end of palpebral lobe to posterior margin somewhat less than length of palpebral lobe.

Surface of test densely covered with fine granules.

Length of largest cranidium 7.5 mm.

This form very closely resembles several species described by Resser from the Lakeview limestone of Idaho, especially *A. natale* and *A. notatum*. The new species chiefly differs from *A. natale* in the deeper dorsal furrow and shallower glabellar furrows; from *A. notatum* in the greater relative midlength of the brim.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S9k, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116277. Paratypes: U.S.N.M. No. 116278.

ALOKISTOCARE SINUATUM Rasetti, new species

Plate 34, figures 1, 2

Known from several cranidia preserved in limestone.

Glabella weakly convex, strongly tapered, moderately truncated in front, with somewhat concave sides. Fourth pair of glabellar furrows turning backward and almost isolating the basal glabellar lobes; third pair shorter and very shallow, first and second pairs indistinct. Occipital furrow impressed throughout; occipital ring short, bearing at most a small node. Frontal limb somewhat more than two-thirds the length of the glabella, with little relief. Brim convex laterally, on the average flat mesially; rim of moderate thickness, convex, set off by a distinct marginal furrow. There is a median swelling of the anterior portion of the brim that extends backward mesially for about one-third of the midlength of the brim. In such cases, it is difficult to decide whether the marginal furrow is the one in front of this swelling (as assumed in the foregoing description) or the one back of it (i.e., the swelling belongs to the rim rather than the brim). Fixed cheeks somewhat upsloping and convex. Ocular ridges straight, moderately prominent. Palpebral lobes not preserved; apparently of size and position usual in the genus. Anterior facial sutures considerably divergent; anterior angles of cranidium widely rounded. Posterior branch almost parallel to the posterior margin, defining slender, deeply furrowed posterior limbs.

Length of largest cranidium 18 mm.

Surface of test covered with small granules, among which are scattered granules of a much larger size; brim with the usual longitudinal anastomosing lines.

This species differs from all the described forms of the genus in the shape of the glabella and glabellar lobation.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S6l, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116281. Paratypes: U.S.N.M. No. 116282.

ALOKISTOCARE CATARACTENSE Rasetti, new species

Plate 34, figures 3, 4

Known from numerous cranidia preserved in limestone but more or less flattened and distorted.

Glabella weakly convex, relatively wide and short, tapered at average rate, straight-sided, truncated in front. Glabellar furrows very shallow, visible chiefly as smooth areas on the otherwise strongly ornamented surface. Occipital furrow impressed throughout; occipital ring short and simple. Frontal limb as long as the glabella, on the average slightly concave mesially. Rim upturned, poorly defined by a very broad marginal furrow. Brim with a strong median swelling, more posteriorly situated than in *A. sinuatum.* A faint, sinuous line defines the posterior margin of the swelling, and should possibly be interpreted as the marginal furrow. Fixed cheeks slightly convex and upsloping. Ocular ridges straight, fairly prominent; palpebral lobes not preserved. Anterior facial sutures considerably divergent; anterior angles of cranidium well rounded. Posterior branch almost parallel to the posterior margin, defining slender posterior limbs.

A probable incomplete thorax shows 22 segments.

Surface of test covered with very fine granules, among which are scattered granules of a much larger size. On the brim and free cheeks the granules tend to arrange themselves along the usual anastomosing lines.

Length of largest cranidium 20 mm. Length of incomplete shield with cephalon and 22 thoracic segments, 58 mm.

This species resembles several forms described by Resser from the Spence shale; it apparently differs from all of them in the considerable swelling of the brim and in the surface ornamentation.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S1ol, Park Mountain.

Types.—Holotype: U.S.N.M. No. 116283. Paratypes: U.S.N.M. No. 116284.

Genus ALOKISTOCARELLA Resser, 1938

Genotype: *Alokistocarella typicalis* Resser.

ALOKISTOCARELLA FIELDENSIS Rasetti, new species

Plate 30, figures 3-5

Known from numerous shields somewhat flattened in argillaceous limestone.

Glabella moderately tapered, rounded in front, of average convexity. Glabellar furrows indistinct; occipital furrow straight, moderately impressed; occipital ring short and simple. Frontal limb somewhat shorter than half the glabellar length, on the average concave. Rim occupying more than half the midlength of the limb, delimited by a shallow marginal furrow, slightly concave and upturned. Fixed cheeks somewhat more than half the glabellar width. Palpebral lobes small, narrow, situated slightly in advance of the glabellar midpoint. Ocular ridges faint. Distance from posterior end of palpebral lobe to posterior margin about three times length of palpebral lobe. Posterior limbs deeply furrowed. Anterior branch of facial suture slightly divergent in front of the eye, curving across the rim. Posterior branch first directed outward and somewhat backward, then curving backward. Width of posterior limbs greater than width of occipital ring. Free cheeks with poorly defined rim and short, slender genal spines.

Thorax of 17 segments. Axial rings simple. Pleura considerably wider than axis; geniculation near halfway in anterior pleura, shifting nearer axis in posterior pleura. Pleural furrows rather narrow and deep, close to anterior margin of pleura.

Pygidium small, three times wider than long, subelliptical. Axis faintly elevated, occupying about four-fifths of the length and more than one-third of the width, rounded at the end. Axial furrows shallow. Two pairs of shallow pleural furrows, almost paralleling the margin, hence curving backward and then slightly inward. Rim indistinct.

Surface of test smooth, as far as can be ascertained from the moderately well-preserved specimens.

Length of largest cranidium 10 mm. Length of holotype specimen 13.8 mm., of which 4.9 mm. belong to the cephalon, 8 mm. to the thorax, and 0.9 mm. to the pygidium.

This species appears referable to the genus, insofar as its cranidial characters agree with those of the genotype, known from cranidia alone. The species could not be referred to *Alokistocare* on account of the larger proportions of the glabella with respect to the other cranidial parts, and the writer did not find any other described genus combining the characters of concave frontal limb, numerous thoracic segments and very small pygidium. Compared with *A. typicalis,* the present species has shorter and less-elevated palpebral lobes and a somewhat different structure of the frontal limb.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S11e, Mount Field.

Types.—Holotype: U.S.N.M. No. 116241. Paratypes: U.S.N.M. No. 116242.

Genus AMECEPHALUS Walcott, 1924

Genotype: *Ptychoparia piochensis* Walcott (part).

AMECEPHALUS AGNESENSIS (Walcott)

Plate 10, figures 11-15

Olenopsis? agnesensis Walcott, Smithsonian Misc. Coll., vol. 57, No. 8, p. 242, pl. 36, fig. 2, 1912; idem (part), vol. 67, No. 3, pl. 13, fig. 5, 1917.

Kochiella agnesensis (Walcott), Walcott, Smithsonian Misc. Coll., vol. 75, No. 5, p. 302, 1928.

Alokistocare agnesensis (Walcott), Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 9, 1935.

This species is common in the Lake Agnes shale, where it is represented by complete shields. These, however, are flattened, hence the convexity cannot be ascertained, and close comparison with forms preserved in limestone is difficult. A new description follows.

Entire shield subelliptical, the posterior portion of the thorax tapering rapidly to a small pygidium. Cranidium of the general shape typical of *Amecephalus.* The convexity cannot be ascertained, all known specimens being flattened in shale, but apparently was not great. Dorsal furrow apparently very shallow. Glabella narrow, moderately tapered, somewhat truncated in front. Glabellar furrows almost indistinct, occipital furrow shallow. Length of glabella (inclusive of occipital ring) about three-fifths of cranidial length. Brim and rim poorly differentiated by a narrow, shallow marginal furrow, closer to the anterior margin than to the glabella. The rim appears to have been concave. Ocular ridges starting near the anterior end of the glabella and directed slightly backward. Palpebral lobes about half the glabellar length, set off by a shallow palpebral furrow. Distance from posterior end of palpebral lobe to posterior margin somewhat more than half the length of palpebral lobe. Posterior limbs extending beyond the palpebral lobes for about two-thirds the distance from the dorsal furrow to the palpebral lobe. Free cheeks with rim about as wide as the ocular platform, extending into moderately long genal spines.

Thorax of 16 segments. Axis occupying on the average one-fifth of the width. Pleura with a broad furrow, whose anterior margin is well marked, while posteriorly the furrow merges into the flat portion of the pleuron. Anterior pleura wholly straight and bluntly terminated, while the posterior ones have increasingly long falcate terminations; the last ones to some extent envelop the pygidium.

Pygidium triangular, about twice wider than long. Axis fairly prominent, showing at least three segments, reaching the posterior margin. Pleura with three pairs of shallow furrows; apparently convex, without differentiated rim.

Surface smooth. Length of largest shield 43 mm.

This species is similar to *Amecephalus piochensis* (Walcott), from which it differs chiefly in the somewhat longer palpebral lobes, lesser number of thoracic segments, and proportionately larger pygidium. It differs from *A. cleora* in the different relative midlengths of the brim and rim.

Horizon and locality.—Mount Whyte formation (Lake Agnes and Yoho shale lentils; *Wenkchemnia-Stephenaspis* zone). Type locality U.S.N.M. 35m, southwest of Lake Louise. Other localities W3b, Plain of Six Glaciers, and W9k, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 58363. Plesiotypes: U.S.N.M. Nos. 116095-7.

AMECEPHALUS CLEORA (Walcott)

Plate 15, figures 12-20

Olenopsis cleora Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 74, pl. 13, figs. 3, 3a, 1917.

Alokistocare cleora (Walcott), Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 9, 1935.

?Olenopsis crito Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 75, pl. 11, figs. 6, 6b, 1917.

?*Kochiella crito* (Walcott), RESSER, Smithsonian Misc. Coll., vol. 93, No. 5, p. 39, 1935.
?*Inglefieldia birdsalli* HOWELL, Wagner Free Inst. Sci. Bull., vol. 11, No. 4, pl. 1, fig. 1, 1936.

This species, described by Walcott from the Mount Assiniboine district, is exceedingly common and widespread in the *Plagiura-Kochaspis* zone. Scores of excellent cranidia in limestone and a few articulated shields in shale were collected. *Olenopsis crito* is based on a few cranidia poorly preserved in sandstone, and as far as can be ascertained from the existing material is identical with *Olenopsis cleora*. The new material available allows a more complete description of the species.

Cranidium as a whole with little convexity. Glabella tapered, truncated in front, delimited by a shallow dorsal furrow. Glabellar furrows exceedingly shallow. Occipital furrow shallow, occipital ring short and simple. Frontal limb long, divided into rim and brim by a very shallow, sometimes indistinct marginal furrow. The characters of the rim vary to some extent with the size of the individual. In small cranidia, of 3-5 mm. length, the marginal furrow is better defined, and the rim itself is marked by a shallow transverse depression; the rim is more or less upturned with respect to the brim. In large individuals, the rim has a tendency to become more definitely concave and the marginal furrow to become obliterated, the whole frontal limb possessing a concave longitudinal profile in which no sharp change in slope between brim and rim is appreciable. In every case, the midlength of the rim is somewhat greater than that of the brim. Fixed cheeks flat, slightly upsloping, their maximum width equaling the glabellar width. Ocular ridges very low. Palpebral lobes narrow, somewhat elevated, about half the glabellar length, with strongest curvature near the middle. Distance from posterior end of palpebral lobe to posterior margin little more than half the length of palpebral lobe. Posterior limbs almost parallel-sided, wider than the occipital ring. Anterior branch of facial suture considerably divergent in front of the eye, gently curving inward across the marginal furrow and rim, the frontal portion marginal for a considerable distance. Posterior branch almost straight outward, narrowly curving backward near its distal end. Free cheeks flat, with genal spines of moderate length.

Thorax rapidly tapered in the posterior third, giving the entire shield a subelliptic shape. Pleura broadly furrowed, straight in the proximal portion; terminating in long, flat spines that in the posterior segments are directed straight backward. The only shield in which the thorax appears complete has 17 segments. Pygidium small, poorly preserved in the only specimen where it is present.

Surface smooth. Length of a complete shield 46 mm. Fragmentary cranidia indicate that the species attains a somewhat larger size.

This species closely resembles *A. agnesensis,* from which it chiefly differs in the relative midlengths of brim and rim and in possessing 17 instead of 16 thoracic segments.

Inglefieldia? birdsalli Howell was described from a single poorly preserved shield collected from the talus at Sentinel Pass, between Pinnacle Mountain and Mount Temple. The specimen is certainly an *Amecephalus* but does not allow specific identification. Since *Amecephalus cleora* is common in limestone and shale of the *Plagiura-Kochaspis* zone in that area, whereas strata carrying *Amecephalus agnesensis* are not known to be present, the specimen is tentatively referred to the former species.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality U.S.N.M. 62w, Mount Assiniboine district. Other localities U.S.N.M. 60e, Ptarmigan Peak; W3c, Plain of Six Glaciers; W4c-e, Ross Lake; W5c, Mount Bosworth; W7c-d and W7f, Kicking Horse Mine; W9f, Fossil Gully; W20d, Eiffel Peak.

Types.—Holotype: U.S.N.M. No. 64396. Holotype and paratype of *Olenopsis crito:* U.S.N.M. Nos. 64371-2. Plesiotypes: U.S.N.M. Nos. 116142-3.

Genus CABORCELLA Lochman, 1948

Genotype: *Caborcella arrojosensis* Lochman.

CABORCELLA SKAPTA (Walcott)

Plate 13, figures 1-4

Ptychoparia skapta Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 95, pl. 12, figs. 9, 9a, 1917.

Antagmus skapta (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 2, 1937.

This species was based on an incomplete cranidium, collected in the Mount Assiniboine district. Specimens collected by the writer in the limestones of the Mount Whyte formation at several localities are identical with the type in all the characters that can be ascertained; hence they are assigned to the species. This procedure is supported by the fact that the fauna at the type locality (U.S.N.M. loc. 62w) includes other forms of the *Plagiura* zone, proving at least approximate equivalence of the respective horizons at Mount Assiniboine and Ross Lake.

Walcott gave a satisfactory description of the type cranidium as far as it is preserved. Some additional remarks are based on the new, more complete cranidia. The fixed cheeks are rather strongly convex and on the average slightly downsloping, thus placing the palpebral lobes slightly below the level of the dorsal furrow. Palpebral lobes about one-fourth the glabellar length, rather elevated. Distance from posterior end of palpebral lobe to posterior margin somewhat greater than length of palpebral lobe. Posterior limbs somewhat wider than occipital ring. Posterior branch of facial suture directed almost straight outward behind the eye, sharply turning backward in crossing the broad distal portion of the marginal furrow. Anterior branch appearing directed straight forward when seen from above, sharply turning inward in crossing the marginal furrow, marginal for a long distance in the median portion. Entire surface covered with fine granules of one size.

This species seems referable to *Caborcella* rather than to any other described genus. It closely agrees with the genotype in all essential features, differing chiefly in the better-defined border and less-tapered glabella. Another species that the writer would refer to *Caborcella* is *Poulsenia granosa* Resser (1939b, p. 59, pl. 13, figs. 19-30), whose cranidium differs from that of *C. skapta* in the straighter ocular ridges, less convex fixed cheeks, coarser granules, and larger size.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality U.S.N.M. 62w, Mount Assiniboine district. Other localities W4c-d, Ross Lake; W5c, Mount Bosworth; W7c-e, Kicking Horse Mine.

Types.—Holotype: U.S.N.M. No. 64392. Plesiotypes: U.S.N.M. No. 116113.

CABORCELLA RARA Rasetti, new species

Plate 15, figures 21-23

Known from two cranidia preserved in limestone.

Entire cranidium strongly convex. Glabella of moderate convexity, strongly tapered in the posterior two-thirds, almost parallel-sided in the anterior third, rounded in front. Three pairs of shallow glabellar furrows; occipital furrow well impressed at the sides. Occipital ring expanded mesially, imperfectly preserved in both specimens. Brim convex and downsloping; marginal furrow deep; rim convex and strongly upturned, arched transversely. Fixed cheeks convex and downsloping, about two-thirds the glabellar width at its midpoint. Palpebral lobes small, elevated, at the level of the glabellar midpoint.

Ocular ridges wide, not strongly prominent. Posterior limbs somewhat narrower than the occipital ring, deeply furrowed. Distance from posterior end of palpebral lobe to posterior margin almost twice the length of palpebral lobe. Anterior facial sutures slightly convex outward, on the average slightly convergent from the eyes to the marginal furrow. Posterior branch with curvature increasing from the eye to the posterior margin.

Entire surface of cranidium densely covered with very fine granules; in addition, large scattered tubercles on the elevated portions.

Length of largest cranidium 7 mm.

This form seems referable to *Caborcella,* although it differs from the genotype in the narrowness and more definitely downsloping position of the fixed cheeks.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W7g, Kicking Horse Mine, Mount Field.

Types.—Holotype: U.S.N.M. No. 116144. Paratype: U.S.N.M. No. 116145.

Genus CHANCIA Walcott, 1924

Genotype: *Chancia ebdome* Walcott.

Walcott gave a good description of the generic characters of *Chancia.* Forms agreeing with the genotype are common at several horizons in the Middle Cambrian; however, some of the described species that should be assigned to *Chancia* were placed by Resser in *Elrathia, Ehmaniella,* or other genera with which they do not agree owing to the great width of the fixed cheeks and the large number of thoracic segments.

CHANCIA LATIGENA Rasetti, new species

Plate 21, figures 15-17

Known from several cranidia poorly preserved in shale or impure limestone, and a specimen preserving a portion of the thorax.

Glabella rather strongly convex transversely, less convex longitudinally, moderately tapered, fairly rounded in front. Third and fourth pairs of glabellar furrows well impressed, second pair short and faint. Occipital furrow deep at the sides, shallow mesially; occipital ring bearing a node. Brim slightly convex, downsloping. Rim somewhat more than half as long as the brim, slightly convex, tapered laterally, set off by an almost straight marginal furrow. Fixed cheeks moderately convex, on the average somewhat downsloping, slightly wider than the glabella; palpebral lobes small, situated at the level of the glabellar midpoint. Ocular ridges moderately elevated. Posterior limbs considerably wider than the occipital ring. Distance from posterior end of palpebral lobe to posterior margin more than twice length of palpebral lobe. Anterior facial sutures not divergent even immediately in front of the eyes, then curving inward and converging, producing widely rounded anterior angles of the cranidium. Posterior branch directed outward and slightly backward behind the eye.

Surface of test densely covered with fine granules.

Length of the largest cranidium 14 mm., width between extremities of the posterior limbs 32 mm.

This species is readily distinguished from the genotype, *C. ebdome,* by the greater width of the fixed cheeks and the different proportions of frontal brim and rim.

Horizon and locality.—Cathedral formation (*Albertella*(?) zone). Locality C9h, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116184. Paratypes: U.S.N.M. No. 116185.

CHANCIA BIGRANULOSA Rasetti, new species

Plate 22, figures 1-6

Known from numerous cranidia preserved in limestone but considerably distorted.

Glabella moderately tapered, fairly convex in both directions, somewhat truncated in front. Glabellar furrows very shallow; however, in some specimens four pairs are distinguishable under proper lighting. Occipital furrow well impressed throughout; occipital ring rather short, bearing a node. Frontal limb consisting of brim and rim; in most specimens two transverse furrows are visible on the limb. This raises the question, which one should be considered as the marginal furrow. The writer believes that in similar cases (e.g., in *Kochiella;* see discussion of that genus) the furrow nearer the glabella is the marginal furrow, the other being a furrow across the rim proper. In the present species the brim is slightly convex and downsloping; the rim is convex near the cranidial margin, but on the whole has a somewhat concave profile because of the transverse impression. The midlength of the rim is greater than that of the brim. The rim tapers rapidly at the sides. Fixed cheeks convex, on the average slightly downsloping, almost as wide as the glabella. Palpebral lobes small, elevated, situated at the level of the glabellar midpoint; ocular ridges strong. Posterior limbs considerably wider than the occipital ring. Distance from posterior end of palpebral lobe to posterior margin about one and a half times the length of palpebral lobe. Anterior branch of facial suture almost straight from the eye to the marginal furrow, directed slightly outward; anterior angles of cranidium narrowly rounded. Posterior branch reaching the posterior margin with almost uniform curvature.

Surface of entire cranidium densely covered with small granules, among which are scattered tubercles of a much larger size.

Length of largest cranidium 13 mm.

This species differs from all others assigned to the genus in the character of the frontal limb and the type of surface ornamentation. In several features this form is intermediate between *Piazella* and *Chancia*, but seems better placed in the latter genus.

Horizon and locality.—Cathedral formation (*Albertella*(?) zone). Type locality C9j', Fossil Gully, Mount Stephen: also locality C9j, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116186. Paratypes: U.S.N.M. No. 116187.

CHANCIA PALLISERI (Walcott)

Plate 29, figures 1-3

Ptychoparia palliseri Walcott, Canadian Alpine Journ., vol. 1, No. 2, p. 244, pl. 3, fig. 6, 1908.

Elrathia palliseri (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 10, 1937.

No description of this form has ever been given. Hence it is considered opportune to give a complete description accompanied by a discussion of the generic position.

Known from numerous shields flattened in shale.

Glabella moderately tapered, rounded in front. Two pairs of glabellar furrows rather well impressed. Convexity of glabella cannot be determined from the flattened specimens. Frontal limb about two-thirds as long as the glabella, consisting mostly of brim; rim short, apparently somewhat upturned. Fixed cheeks appearing slightly narrower than the glabella in flattened specimens; however, if the glabella had preserved its convexity, it would probably not appear wider than the fixed cheeks. Ocular ridges moderately elevated; palpebral lobes small, situated slightly in advance of the glabellar midpoint. Distance between posterior end of palpebral lobe and posterior margin about twice length of palpebral lobe. Posterior limbs wider than occipital ring. Anterior facial sutures fairly divergent, straight from the eye to a short distance from the marginal furrow, then curving inward; anterior angles of cranidium not widely rounded. Posterior branch straight for a considerable portion, then curving backward.

Thorax long, with a moderately tapered axis. Pleura straight for a considerable distance, curving backward into short spines distally; these spinose endings are more pronounced in the median portion of the thorax. Pleural furrow well impressed over the entire length of each pleuron.

The number of thoracic segments appears variable in this species, as in some other cases among multisegmented ptychoparids (see description of *Elrathina cordillerae*). Walcott figured the holotype as possessing 23 thoracic segments. Of the three complete specimens from the type locality (U.S.N.M. locality 14s, the *Ogygopsis* shale bed on Mount Stephen) preserved in the United States National Museum, two (including the holotype) have 23 segments and one has only 20 segments. Several complete specimens from the Burgess shale (locality 35k) have 20 segments. The writer collected a good impression of a complete specimen from the type locality, and this shows 21 segments. These various specimens do not appreciably differ in size, hence the differences in the number of thoracic segments are certainly not due to growth stages. As in the case of *Elrathina cordillerae,* it must be concluded that the number of thoracic segments in certain species is not absolutely constant. No such case was ever observed by the writer among bathyuriscid trilobites, where the number of thoracic segments does not exceed a dozen.

Pygidium small, transverse. Axis occupying less than one-third of the width and most of the length, distinctly segmented. Pleural lobes with three or four distinct pairs of furrows and three pairs of interpleural grooves.

Surface apparently smooth except for the usual longitudinal anastomosing lines on the brim.

The proportions of a complete shield with 20 thoracic segments are the following: Total length 35 mm.; length of cephalon 11 mm.; length of thorax 21 mm.; length of pygidium 3 mm.

This species appears to agree in all essential generic features with *Chancia,* differing from the genotype chiefly in the different proportions of brim and rim. It disagrees with *Elrathia* in the great width of the fixed cheeks, smaller palpebral lobes, great number of thoracic segments, and small pygidium.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 14s, Mount Stephen, identical with the writer's locality S8d. Also Burgess shale lentil; locality U.S.N.M. 35k, Mount Field.

Types.—Holotype: U.S.N.M. No. 94344. Plesiotypes: U.S.N.M. No. 116236.

CHANCIA ODARAYENSIS Rasetti, new species

Plate 33, figures 15, 16

Known from a few cranidia and two specimens with most of the thorax, all poorly preserved in limestone.

Glabella moderately tapered, fairly convex in both directions, not sharply truncated in front. Glabellar furrows shallow. Occipital ring apparently bearing a node. Brim convex, downsloping. Rim separated from the brim by a shallow marginal furrow, on the average horizontal, slightly concave. Midlength of rim somewhat greater than midlength of brim. Fixed cheeks convex, on the average horizontal, as wide as the glabella. Ocular ridges fairly prominent, straight, directed slightly backward. Palpebral lobes small, semicircular, not greatly elevated. Posterior limbs considerably wider than the occipital ring, deeply furrowed. Distance from posterior end of palpebral lobe to posterior margin about twice length of palpebral lobe. Anterior facial sutures directed forward for a short distance in front of the eyes, then turning inward with a wide curve; anterior angles of cranidium well rounded. Posterior branch almost straight for most of the length, narrowly rounding off the ends of the posterior limbs.

A possibly complete thorax shows 22 segments. Pygidium small, triangular, transverse, with a prominent axis reaching the posterior margin and strongly furrowed pleural lobes.

Surface of test finely granulated.

Length of the largest cranidium 7 mm., of cephalon and thorax together 25 mm.

This species differs from the others described chiefly in the proportions of the fixed cheeks and palpebral lobes and in the structure of the frontal limb.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality S6l, Mount Odaray. Specimens collected at locality S9k, Mount Stephen, doubtfully belong to the species.

Types.—Holotype: U.S.N.M. No. 116274. Paratypes: U.S.N.M. Nos. 116275-6.

CHANCIA STENOMETOPA Rasetti, new species

Plate 8, figure 20

Known from several cranidia slightly flattened in shale, and a specimen preserving a portion of the thorax.

Glabella proportionately long and narrow, moderately tapered, strongly convex transversely, with well-defined anterior angles, rounded in front. Glabellar furrows well impressed, decreasing in depth from the fourth to the second pair; first pair indistinct. Occipital furrow deep; occipital ring short, apparently simple. Brim about half the glabellar length, convex, downsloping; rim short, convex, set off by a wide, fairly deep marginal furrow. Fixed cheeks as wide as the glabella, rather flat, probably horizontal. Ocular ridges curved, well marked. Palpebral lobes small, semicircular, elevated. Posterior limbs considerably wider than the occipital ring. Distance from posterior end of palpebral lobe to posterior margin about twice length of palpebral lobe. Anterior branch of facial suture convex outward, on the average directed forward from the eye to the marginal furrow, then curving inward rather sharply across the rim. Posterior branch rather straight for most of the distance.

An incomplete thorax shows approximately 15 segments. Pleura deeply furrowed.

Surface of cranidium densely covered with very fine granules, besides a much smaller number of larger granules; the frontal brim shows, in addition, faint longitudinal ridges.

Length of the largest cranidium 12 mm.

This species agrees in the essential features with the generic diagnosis of *Chancia,* although the narrowness of the glabella gives the cranidium an unusual aspect. It is also to be noted that it is a much earlier form than all others assigned to the genus.

Horizon and locality.—Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Locality W9k, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116078. Paratypes: U.S.N.M. No. 116079.

Genus EHMANIELLA Resser, 1937

Genotype: *Crepicephalus* (*Loganellus*) *quadrans* Hall and Whitfield.

EHMANIELLA BURGESSENSIS Rasetti, new species

Plate 30, figures 9-16

Ptychoparia permulta Walcott (part), Smithsonian Misc. Coll., vol. 67, No. 4, p. 145, pl. 21, fig. 1 (only), 1918.

Elrathia permulta (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 10, 1937.

Known from several complete shields and numerous cranidia and pygidia, preserved in siliceous shale and more or less flattened; besides a few cranidia and pygidia preserved in limestone.

Glabella moderately tapered, straight-sided, fairly rounded in front, convex in both directions, slightly keeled. First pair of glabellar furrows represented by short, shallow pits; following three pairs longer and rather well impressed. Occipital furrow straight, well impressed throughout. Occipital ring somewhat expanded mesially, bearing a node. Frontal limb slightly convex, downsloping, divided by the marginal furrow into brim and rim; midlength of brim about twice midlength of rim. Marginal furrow well impressed, and fairly straight, rim convex, tapered at the sides. Fixed cheeks convex, slightly downsloping, about two-thirds the glabellar width. Ocular ridges strong, fairly straight, moderately oblique. Palpebral lobes about one-fourth the glabellar length, somewhat elevated, narrow; proportionately longer in young individuals. Distance from posterior end of palpebral lobe to posterior margin about twice length of palpebral lobe. Anterior branch of facial suture divergent in front of the eye, almost straight to the anterior margin; anterior angles of cranidium narrowly rounded. Posterior branch directed outward and backward without much curvature. Free cheeks with short genal spines.

Thorax of 13 segments. Axis slightly tapered. Pleura almost straight in dorsal view, deeply furrowed, with poorly defined geniculation; terminating in fairly sharp but short spines.

Pygidium twice wider than long, subtriangular. Axis moderately tapered, elevated, showing four or five rings and a terminal section; occupying about five-sixths of the pygidial length. Pleural lobes downsloping; first pleuron less fused than the others, delimited by a well-impressed interpleural groove; extended at the sides into a pair of short, sharp, backward-directed marginal spines. Other interpleural grooves less distinct; five pairs of pleural furrows impressed. Marginal furrow distinct, rim narrow.

Surface of cranidium covered with very fine granules. Brim and free cheeks with the usual anastomosing lines.

Length of largest complete shield 27.5 mm., of which 9 mm. belong to the cephalon, 15 mm. to the thorax, and 3.5 mm. to the pygidium.

This species closely resembles the genotype, *E. quadrans* (Hall and Whitfield). An accurate comparison with the types of *quadrans* is impossible because the latter are very poorly preserved. Better-preserved material from Utah in the United States National Museum collections may be assumed to represent the genotype species, and affords a more significant comparison. *E. burgessensis* appears to differ from *quadrans* chiefly in the presence of small marginal pygidial spines, slightly shorter palpebral lobes, and lesser number of distinct interpleural grooves in the pygidium.

E. burgessensis also closely resembles *E. basilica* Resser from the Grand Canyon, differing mainly in the straighter anterior marginal furrow, straighter ocular ridges, and presence of marginal pygidial spines.

Horizon and locality.—Stephen formation (Burgess Shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 35k, Burgess Quarry, Mount Field. The species is much more common at locality S11g, Mount Field. Several specimens were collected from limestone at locality S6g, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116245. Paratypes: U.S.N.M. No. 65516; Nos. 116246-8.

EHMANIELLA WAPTAENSIS Rasetti, new species

Plate 30, figures 6-8

Known from numerous shields partly flattened in shale. Entire shield ovate.

Glabella tapered at the usual rate, straight-sided, fairly rounded in front. Three pairs of shallow glabellar furrows. Occipital furrow deep and straight; occipital ring rather short, possibly bearing a small node. Brim downsloping; rim convex, almost unifomly wide around the cephalon, defined by a deep marginal furrow; midlengths of brim and rim equal. Fixed cheeks somewhat less than two-thirds the glabellar width. Ocular ridges fairly prominent. Palpebral lobes about one-fourth the glabellar length; distance from posterior end of palpebral lobe to posterior margin slightly greater than length of palpebral lobe. Facial sutures as in other species of the genus. Free cheeks with very short genal spines.

Thorax of 13 segments. Axis somewhat tapered. Pleura deeply furrowed; geniculation somewhat nearer to the dorsal furrow than to the end of the pleura. Distal end of pleura rounded.

Pygidium relatively small, more than twice wider than long. Axis tapered, not greatly elevated, with two or three very shallow furrows. Pleural lobes with one or two pairs of pleural furrows and interpleural grooves distinct.

Surface of test covered with granules, larger on the glabella than on the other portions of the shield.

Length of the largest cranidium 4.5 mm. Length of an entire shield 9.0 mm., of which 3.4 mm. belong to the cephalon, 4.6 mm. to the thorax, and 1.0 mm. to the pygidium.

This species differs from the genotype and other forms hitherto assigned to *Ehmaniella* in the longer palpebral lobes and lesser relative midlength of the brim. It is more similar, as far as the cranidial features are concerned, to species assigned to *Clappaspis,* a genus that the writer would include in *Ehmaniella.* The present species appears to differ from the forms described by Deiss and Resser as *Clappaspis* in the different surface ornamentation and longer palpebral lobes.

Horizon and locality.—Stephen formation (Burgess shale lentil; *Bathyuriscus-Elrathina* zone). Locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Types.—Holotype: U.S.N.M. No. 116243. Paratypes: U.S.N.M. No. 116244.

Genus ELRATHIA Walcott, 1924

Genotype: *Conocoryphe* (*Conocephalites*) *kingii* Meek.

ELRATHIA PERMULTA (Walcott)

Plate 30, figures 1, 2

Ptychoparia permulta Walcott (part), Smithsonian Misc. Coll., vol. 67, No. 4, p. 145, pl. 21, fig. 2 (only), 1918.
Elrathia permulta (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 10, 1937.
Elrathia dubia Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 11, 1937.

Resser correctly recognized that the two individuals illustrated by Walcott as *Ptychoparia permulta* belong to distinct species. However, in making a new species, *Elrathia dubia,* he designated as holotype the same specimen that Walcott had unmistakably indicated as the holotype of *permulta.* Hence *dubia* becomes an objective synonym of *permulta,* and the other form lacks a name. The latter species is a typical *Ehmaniella* and is described in this paper as *E. burgessensis.*

Horizon and locality.—Stephen formation (Burgess shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 35k (=author's locality S11f); Burgess Quarry, Mount Field.

Types.—Holotype: U.S.N.M. No. 65517. Plesiotypes: U.S.N.M. No. 116240.

Genus ELRATHINA Resser, 1937

Genotype: *Conocephalites cordillerae* Rominger.

Forms belonging to this genus are abundant in most of the strata of the *Bathyuriscus-Elrathina* zone. The writer found considerable difficulty in recognizing clear-cut species within the available material. The specific characters, if any, consist in small differences in the proportions of the cranidial parts, and are often masked by individual variability or by flattening, distortion, and other effects of imperfect preservation. It is especially difficult to make an accurate comparison between specimens preserved in shale and limestone. Hence the validity of the species described below is presented as somewhat doubtful.

One fact that emerged from a close study of species of *Elrathina* is that the number of thoracic segments within a single species appears to be variable within narrow limits, instead of being absolutely constant as assumed by most modern authors. Apparently a variable number of thoracic segments is observed only among multisegmented, micropygous ptychoparids.

ELRATHINA CORDILLERAE (Rominger)

Plate 26, figures 7-9

Conocephalites cordillerae ROMINGER, Proc. Acad. Nat. Sci. Philadelphia, 1887, p. 17, pl. 1, fig. 7.

Ptychoparia cordillerae (Rominger), WALCOTT, Amer. Journ. Sci., ser. 3, vol. 36, p. 165, 1888; Canadian Alpine Journ., vol. 1, No. 2, pl. 3, fig. 5, 1908; Smithsonian Misc. Coll., vol. 67, No. 4, p. 144, pl. 21, fig. 4 (3 and 5?), 1918.

Ptychoparia cordillerae (Rominger), MATTHEW, Trans. Roy. Soc. Canada, ser. 2, vol. 5, sect. 4, p. 44, pl. 1, fig. 7, 1899.

Elrathina cordillerae (Rominger), RESSER, Smithsonian Misc. Coll., vol. 95, No. 22, p. 11, 1937.

The number of thoracic segments in this species varies between 17 and 19, 18 being the most common number and 19 the rarest. These differences are certainly not due to growth stages as they occur in individuals of the same size; they are present at both localities where the species was collected.

Part of the difference in the number of thoracic segments is due to the last thoracic segment being sometimes included in the pygidium, which then appears to consist of two segments instead of one. However, individuals with the smaller pygidium still may have 18 or 19 thoracic segments, while individuals with the larger pygidium may have 17 or 18 thoracic segments. This shows that the variability in the number of thoracic segments is not entirely due to anchylosis of a normally free thoracic segment with the pygidium.

Horizon and locality.—Stephen formation (*Ogygopsis* shale lentil; *Bathyuriscus-Elrathina* zone). Type locality U.S.N.M. 14s (=author's locality S8d), Mount Stephen. Also locality U.S.N.M. 35k, Burgess Quarry, Mount Field.

Types.—Syntypes: Acad. Nat. Sci. Philadelphia. Plesiotypes: U.S.N.M. Nos. 65518, 57658, 17831, 116225-6.

ELRATHINA PARALLELA Rasetti, new species

Plate 33, figures 19-22

Known from numerous cranidia and complete specimens, all preserved in limestone.

Glabella almost parallel-sided, narrow, rounded in front. Glabellar furrows indistinct. Occipital furrow shallow; occipital ring short, bearing a small node. Frontal limb as a whole downsloping, about equally divided into brim and rim mesially; marginal furrow shallow; slopes of rim and brim almost equal. Fixed cheeks convex, on the average downsloping; their maximum width approximately equaling the glabellar width. Palpebral lobes narrow, somewhat less than one-third the glabellar length; their centers situated somewhat in advance of the glabellar midpoint but not quite on a transverse line through the anterior third of the glabella. Ocular ridges very faint, slightly curved. Distance from posterior end of palpebral lobe to posterior margin about twice length of palpebral lobe. Posterior limbs considerably wider than the occipital ring, well rounded distally.

Thorax of 17 or 18 segments in the specimens where it is sufficiently well preserved for the segments to be counted. Pleura straight in dorsal view, moderately bent down at geniculation which occurs on the average somewhat beyond the midpoint of each pleuron. Extremity of pleura rounded.

Pygidium small, transverse, with one distinct pair of pleural furrows.

Surface of test smooth.

Length of an apparently full-grown shield 21.2 mm., of which 7 mm. belong to the head, 13 to the thorax, and 1.2 to the tail.

This species is very similar to the genotype, *E. cordillerae,* and a very accurate comparison between the two forms is difficult owing to the different manner of preservation. The new species differs in having the geniculation of the thoracic pleura closer to the middle than to the distal end of each pleuron, and in possessing a less triangular pygidium with a relatively narrower axis. Other possible differences are the proportionately narrower and longer glabella and the slightly longer and more posteriorly situated palpebral lobes.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality S9k, Mount Stephen. Also locality S6k, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116279. Paratypes: U.S.N.M. No. 116280.

ELRATHINA BREVIFRONS Rasetti, new species

Plate 26, figure 6

Known from numerous shields partly flattened in argillaceous limestone.

Owing to the close resemblance of this species to the genotype, *E. cordillerae,* it will be sufficient to point out the differential characters instead of giving a complete description.

The cranidium differs from that of *E. cordillerae* in the reduction of the midlength of the brim; the dorsal and marginal furrows almost meet mesially.

The geniculation of the thoracic segments is situated near the middle of each pleuron instead of near the distal end. The pleura terminate in short spines instead of being rounded as in *E. cordillerae.* Most of the specimens have 18 thoracic segments; some have 19. The pygidium is subelliptical instead of subtriangular as in *E. cordillerae.*

The present species also closely resembles *E. fecunda* Deiss, differing chiefly in the lesser midlength of the brim. Another closely related species is *Elrathia spencei* Resser, which is fully typical of *Elrathina* in all characters except the one, which does not appear of generic importance, of having genal spines, whereas in *E. cordillerae* and the present species the genal angle is rounded. *E. spencei* further has a more convex cranidium and a proportionately narrower and longer pygidium.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S11e, Mount Field.

Types.—Holotype: U.S.N.M. No. 116223. Paratypes: U.S.N.M. No. 116224.

ELRATHINA SPINIFERA Rasetti, new species

Plate 34, figures 11-14

Known from numerous cranidia preserved in limestone.

Cranidium closely similar in all its proportions to that of *E. cordillerae,* possibly excepting a somewhat greater midlength of the rim.

The chief distinctive character is the presence of a short, backward-directed occipital spine.

Surface of test smooth. Length of largest cranidium 7 mm.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Type locality S6k, Mount Odaray. Also locality S9k, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116289. Paratypes: U.S.N.M. Nos. 116290-1.

ELRATHINA MARGINALIS Rasetti, new species

Plate 34, figures 8-10, 15

Known from numerous cranidia and a specimen with part of the thorax, all preserved in limestone.

The cranidium has the same general appearance as in *E. cordillerae,* hence is described by pointing out the differential characters, consisting in the greater general convexity, strong elevation of the glabella, and greater depth of the marginal furrow, which defines a more convex and elevated rim than in the other species of the genus here discussed. The occipital ring bears a node. The geniculation of the thoracic pleura occurs at about two-thirds the distance from the proximal end. The pleura do not terminate into spines.

Surface of test smooth. Length of largest cranidium 6 mm.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S6l, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116287. Paratypes: U.S.N.M. No. 116288.

Genus GLYPHASPIS Poulsen, 1927

Genotype: *Asaphiscus capella* Walcott.

GLYPHASPIS PARKENSIS Rasetti, new species

Plate 34, figures 5-7

Known from numerous cranidia and pygidia and an entire shield, all preserved in limestone but more or less flattened and distorted.

Glabella weakly convex, tapered, truncated in front. Glabellar furrows very faint; occipital furrow shallow but impressed throughout, occipital ring short, bearing a small node. Frontal limb concave, poorly separated into a brim and rim of about equal midlengths by a wide, shallow marginal furrow. Total midlength of frontal limb almost equal to glabellar length. Fixed cheeks about two-thirds the glabellar width. Palpebral lobes more than half as long as the glabella, moderately curved, narrow, set off by a well-impressed palpebral furrow. Ocular ridges strong. Anterior facial sutures considerably divergent and almost straight for a considerable distance; anterior angles of cranidium narrowly rounded. Posterior branch almost parallel to posterior margin, defining slender, deeply furrowed posterior limbs.

Thorax of 10 segments. Axis not tapered. Pleural furrows increasing in depth from the proximal end of the pleura to the geniculation.

Pygidium somewhat less than twice wider than long, as wide as the cephalon. Axis reaching about three-fourths the length of the pygidium, tapered, showing approximately six rings and a terminal section; no axial nodes or spines. Pleural platforms convex, rim wide, concave. Six or seven pairs of increasingly shallow pleural furrows, separated by shallower and less distinct interpleural grooves.

Surface of test smooth except for anastomosing lines on the brim and free cheeks.

Length of the largest cranidium 20 mm. Cephalon, thorax, and pygidium each of approximately equal length.

This species resembles two forms described by Deiss from Montana. *Glyphaspis paucisulcata* Deiss, known from the pygidium alone, differs from the present species in the much more widely rounded anterior angles. The other species, *G. storeyi,* is extremely similar to *G. parkensis* in the pygidial features, but the cranidium of *G. storeyi* appears to differ in the longer palpebral lobes and narrower fixed cheeks. The two forms are doubtless very closely related.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S1ol, Park Mountain.

Types.—Holotype: U.S.N.M. No. 116285. Paratypes: U.S.N.M. No. 116286.

Genus KOCHASPIS Resser, 1935

Genotype: *Crepicephalus liliana* Walcott.

It appears reasonably certain that *Crepicephalus liliana* was based on the correct combination of cranidium and pygidium. Slabs of sandstone from the Pioche shale (Comet shale of Deiss) of the Highland Range, Nevada, preserved in the United States National Museum, are covered with cranidia and pygidia of this species, the only associated species being *Oryctocephalus primus.* Of the three species from the Mount Whyte formation assigned to *Kochaspis, K. celer* and *K. chares* were apparently based on illegitimate combinations of a ptychoparid head and a bathyuriscid tail (see descriptions of *Fieldaspis superba* and *Kochiella? maxeyi*). The writer inclines to believe that the third species, *K. cecinna,* is a good species of *Kochaspis* founded on correct association of the two shields. The writer was unable to collect *K. cecinna,* but found a new species of the genus at several localities in the *Plagiura-Kochaspis* zone. Owing to the rarity of this trilobite, there is no certainty that the assignment of cranidium and pygidium to one species is correct, but it appears at least probable.

KOCHASPIS EIFFELENSIS Rasetti, new species

Plate 14, figures 4-10

Known from numerous cranidia and a few pygidia preserved in limestone.

Glabella rather strongly convex transversely, moderately convex longitudinally, moderately tapered, straight-sided, rather truncated in front. Four pairs of glabellar furrows impressed; first pair very short, second and third pairs longer, fourth pair still longer and showing a tendency to bifurcate at the inner end. Occipital furrow well impressed, shallower in the middle. Occipital ring short, bearing a node. Frontal brim slightly convex, downsloping. Rim almost flat, differentiated from the brim by its upturned position; in young individuals the rim is appreciably convex. Midlengths of brim and rim almost equal; midlength of entire frontal limb about half the glabellar length. Fixed cheeks flat, very slightly downsloping; maximum width almost equaling the glabellar width. Ocular ridges well developed, straight, strongly oblique. Palpebral lobes curved, slightly elevated, set off by a shallow palpebral furrow; their length about one-third the glabellar length. Posterior limbs incompletely preserved in available specimens.

Pygidium subrectangular, about twice wider than long, with pleural lobes extended into a pair of strong, long spines. Axis cylindrical, strongly elevated, composed of two rings and a terminal section, not quite reaching the posterior margin. Pleural lobes convex, downsloping. Two pairs of pleural furrows impressed; these become deeper in crossing the marginal furrow (which is otherwise obsolete) and extend for some distance on the base of the spines. Spines strong, directed backward and somewhat outward, of unknown total length as they are broken off in the few available pygidia.

Surface of cranidium and pygidium densely covered with fine granules of one size.

Length of largest cranidium 14 mm. Length of pygidium 5 mm., width 10 mm.

This species closely resembles *K. cecinna* (Walcott) from which it differs chiefly in the flatter and wider anterior rim, lesser number of pleural furrows in the pygidium, and lack of large granules on the surface of the test.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality W20d (=U.S.N.M. 38k), Eiffel Peak. Other localities W6d, Mount Odaray; W7f, Kicking Horse Mine; W9f, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116125. Paratypes: U.S.N.M. Nos. 116126-8. The holotype is a cranidium, hence the name will remain attached to the cranidium if the assignment of cranidium and pygidium to one species should prove to be erroneous.

Genus KOCHIELLA Poulsen, 1927

Genotype: *Kochiella tuberculata* Poulsen.

The genotype and several other species were described by Poulsen from the Lower Cambrian Cape Kent formation of northwest Greenland. Poulsen did not assign a pygidium to any of his species, but described from the same beds a spinose pygidium as *Crepicephalus* cf. *cecinna* Walcott. Resser (1935, p. 39) assigned this pygidium to *K. tuberculata.* Following this assignment, Resser described several Middle Cambrian species of *Kochiella* as combinations of an *Amecephalus*-like cephalon and a spinose pygidium. At least in certain instances, e.g., *Kochiella mansfieldi* (Resser 1939b, p. 57), the association appears warranted by the existing material. However, there is no certainty that the assignment of the pygidium of *K. tuberculata* is correct, hence the generic characters of the pygidium remain undetermined, and it is difficult to decide what forms should be included in *Kochiella.*

A cranidium occurring at several localities in the *Plagiura-Kochaspis* zone agrees generically with *Kochiella tuberculata,* but since the pygidia of either form are unknown, the generic assignment of the species from the Mount Whyte formation is doubtful. A spinose pygidium occurs rarely in the same beds, and the cranidia to which it could be assigned are either the one being discussed or that of *Kochaspis eiffelensis.* The second solution appears the most likely to be correct and was adopted. There remains no pygidium assignable to the new form, which makes it plausible that this part of the shield was small and featureless as in *Amecephalus.* If this were proved to be the case, possibly *Amecephalus* would be the proper generic assignment for the form under discussion.

It should be mentioned in this connection that whenever Resser described species of *Kochiella* or similar cranidia he repeatedly referred to a transverse line across the brim being the "impression of doublure on upper surface" (Resser, 1935, pp. 8, 38; 1939b, pp. 51, 57). Not only does this line appear in specimens in limestone where there is no trace of flattening, but Resser described this feature in cranidia lacking the free cheeks, where obviously the doublure could not be impressed on the dorsal shield because it was not present when the specimen was buried in the sediment. The line is simply the marginal furrow, and its closeness to the glabella in certain cases indicates a considerable midlength of the rim.

KOCHIELLA? MAXEYI Rasetti, new species

Plate 13, figures 5-8

Known from numerous cranidia preserved in limestone. Glabella fairly convex, its cross section being of inverted V-shape; strongly tapered, with slightly concave sides, somewhat truncated in front. Second, third, and fourth pairs of glabellar furrows well impressed at the sides; first pair very short but distinct. Occipital ring set off by a well-impressed furrow, short, bearing a node. Frontal limb divided by a narrow and shallow, but distinct, marginal furrow into a slightly convex brim and a concave rim of equal midlengths; total midlength of limb almost equaling the glabellar length. Fixed cheeks flat, upsloping. Ocular ridges slightly curved, strongly elevated. Palpebral lobes narrow, somewhat elevated, sharply curved in the middle, almost half the glabellar length; width of fixed cheeks about equal to glabellar width. Posterior limbs wider than the occipital ring, short, parallel-sided. Anterior sutures somewhat divergent in front of the eyes, curving inward across the rim. Posterior branch directed almost straight outward.

Surface of cranidium densely covered with very fine granules, among which are scattered granules of a much larger size; brim with irregular, longitudinal ridges.

Length of largest cranidium 18 mm.

The cranidium of this species is very similar to that described by Walcott as *Crepicephalus chares*. However, the pygidium assigned by Walcott to the species is, in the writer's opinion, the pygidium of a bathyuriscid trilobite of the genus *Fieldaspis*. No pygidia assignable to the cranidium here described were collected by the writer. Hence, pending decision as to whether the name *chares* should apply to the cranidium or the pygidium (no holotype was designated either by Walcott or by subsequent authors) the writer believes that confusion will be avoided by describing this form under a new name rather than tentatively identifying it with the cranidium of *Crepicephalus chares*. The reasons for the tentative assignment of the species to *Kochiella* were mentioned in the discussion of the genus.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality W20d, Eiffel Peak. Other locality W9f, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116114. Paratypes: U.S.N.M. Nos. 116115-6.

KOCHIELLA? cf. K. MAXEYI Rasetti

Plate 13, figure 9

A cranidium collected from the Mount Whyte formation on Mount Field differs from the types of the species in the greater relative midlength of the anterior rim. Such a small difference does not warrant naming a new species unless it should prove a constant feature of the specimens at that horizon and locality.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W7f, Kicking Horse Mine, Mount Field.

Figured specimen.—U.S.N.M. No. 116117.

Genus KOCHINA Resser, 1935

Genotype: *Olenopsis americanus* Walcott.

KOCHINA AMERICANA (Walcott)

Plate 19, figures 20-23

Olenopsis americanus Walcott, Smithsonian Misc. Coll., vol. 57, No. 8, p. 243, pl. 36, figs. 8-11, 1912.

Olenopsis cf. *americanus* Walcott, Smithsonian Misc. Coll., vol. 67, No. 2, p. 37, pl. 6, figs. 8-8b, 1917.

Kochina americana (Walcott), Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 40, 1935.

Kochina bosworthensis Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 40, 1935.

The types of this species were described from the Gordon shale of Montana. Later Walcott stated that specimens from the Ross Lake shale were apparently identical with those from the type locality.

Resser separated the form from the Ross Lake shale under a new name, *Kochina bosworthensis,* without stating the characters that differentiate the new species. Study of the types shows that, as far as can be ascertained from the existing material, the two forms are identical.

It is possible to supplement Walcott's description of the species, thanks to the discovery of additional material. Cranidia preserved in the limestone interstratified with the Ross Lake shale show the convexity, which has been lost to a large extent in the specimens in shale. The convex fixed cheeks rise from the dorsal furrow almost to the level of the glabella. The frontal limb is turned down rather strongly at the sides, and the rim shows a moderate convexity. The reproduced photographs show these characters clearly.

The impression of a complete shield in the Ross Lake shale, discovered by the writer, shows for the first time the size and shape of the pygidium. The thorax, apparently complete although some of the segments are slightly displaced, shows 17 segments. The pygidium is approximately semicircular, more than twice wider than long. The axis occupies somewhat more than half the length, and about one-fourth of the width; it is slightly tapered and consists of two distinct segments plus a terminal section. The pleural lobes show three or four pairs of shallow furrows and fainter interpleural grooves. The proportions of the parts of the shield are given by the following measurements. Cranidium: length 10 mm., width 28 mm.; thorax: length 22 mm.; pygidium: length 5 mm., width 11 mm.

Surface of cranidium densely covered with small granules.

Resser compared the genus with *Kochiella*. If the pygidium of *Kochiella* is large and spinose like that of *Kochaspis* (as believed by Resser), then *Kochina* with its small, simple pygidium is not close to the above-mentioned genera. Even the cranidia show only a moderate resemblance.

Horizon and locality.—The types are from the Gordon shale of Montana. In the area the species occurs in the Cathedral formation (Ross Lake shale member; *Albertella* zone). Localities C3m, Mount Whyte; C4m and U.S.N.M. 63j, Ross Lake; C5m and U.S.N.M. 35c, Mount Bosworth; C15m, Bow Lake; C20m, Eiffel Peak; U.S.N.M. 63m', Mount Bosworth.

Types.—Syntypes (from the Gordon shale): U.S.N.M. Nos. 58368-71. Lectotype and paratype of *Kochina bosworthensis* Resser: U.S.N.M. Nos. 63749-51. Plesiotypes: U.S.N.M. Nos. 116170-1.

KOCHINA MACROPS Rasetti, new species

Plate 19, figures 17-19

Known from a few cranidia preserved in limestone.

Glabella rather strongly tapered, rounded in front, moderately convex. Posterior glabellar furrows wide and shallow; two other pairs almost indistinct. Occipital furrow well-impressed at the sides, shallow mesially; occipital ring short. Brim slightly convex, strongly downsloping laterally; midlength of brim equal to midlength of rim. Rim tapered laterally, flat, slightly arched transversely, defined by an almost straight marginal furrow. Fixed cheeks flat, upsloping, almost as wide as the glabella. Ocular ridges straight. Palpebral lobes fairly wide, curved, defined by shallow palpebral furrows, about half the glabellar length, continuing the upward slope of the fixed cheeks. Distance from posterior end of palpebral lobe to posterior margin less than half length of palpebral lobe. Anterior facial sutures on the average parallel, slightly convex outward, widely curving across marginal furrow and rim. Posterior branch parallel to posterior margin; posterior limbs wide and short.

Elevated parts of cranidium covered with granules of different sizes.

Length of holotype cranidium 8 mm. Fragments indicate the presence of individuals of larger size.

This species differs from *K. americana* in the proportionately wider and shorter glabella, different proportions of brim and rim, flat instead of convex fixed cheeks, straight ocular ridges, and much larger palpebral lobes.

Horizon and locality.—Cathedral formation (*Albertella* zone). Locality C15n, Bow Lake.

Types.—Holotype: U.S.N.M. No. 116168. Paratypes: U.S.N.M. No. 116169.

Genus MEXICELLA Lochman, 1948

Genotype: *Mexicella mexicana* Lochman.

MEXICELLA STATOR (Walcott)

Plate 20, figures 14-19

Agraulos stator Walcott, Smithsonian Misc. Coll., vol. 64, No. 3, p. 173, pl. 36, fig. 6, 1916; vol. 67, No. 2, p. 28, pl. 6, fig. 6, 1917.

Alokistocare stator (Walcott), Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 9, 1935.

Mexicella stator (Walcott), Lochman, Journ. Paleontol., vol. 22, p. 457, 1948.

Walcott's diagnosis adequately describes this species. Cranidia in limestone are figured in order to show the convexity of the various parts which cannot be well ascertained from specimens in shale.

Horizon and locality.—Cathedral formation (Ross Lake shale member; *Albertella* zone). Type locality U.S.N.M. 35c, Mount Bosworth. Other localities U.S.N.M. 63j, Ross Lake; C3m, Mount Whyte; C4m, Ross Lake; C5m, Mount Bosworth; C15m, Bow Lake; C20m, Eiffel Peak; C21m, Mount Temple; U.S.N.M. 63m', Mount Bosworth.

Types.—Holotype: U.S.N.M. No. 61729. Paratype: U.S.N.M. No. 61729a. Plesiotypes: U.S.N.M. Nos. 116176-7.

Genus ONCHOCEPHALUS Resser, 1937

Genotype: *Ptychoparia thia* Walcott.

ONCHOCEPHALUS THIA (Walcott)

Plate 8, figures 1, 2

Ptychoparia thia Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 96, pl. 12, fig. 6, 1917.

Onchocephalus thia (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 20, 1937.

Onchocephalus thia (Walcott), Lochman, Journ. Paleontol., vol. 21, p. 63, 1947.

This species has been discussed by Lochman in her revision of several Lower Cambrian ptychoparid genera. The writer finds it exceedingly difficult to establish sharp lines of division between the present genus and other genera of generalized ptychoparids. Besides the genotype, which is a Lower Cambrian form, several species from the early Medial Cambrian beds are assignable to *Onchocephalus*.

A cranidium collected by the writer from the type horizon is figured.

Horizon and locality.—St. Piran formation (Peyto limestone member; *Bonnia-Olenellus* zone). Type locality U.S.N.M. 35h, Mount Bosworth. Also locality P18m, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 64388. Plesiotype: U.S.N.M. No. 116070.

ONCHOCEPHALUS FIELDENSIS Rasetti, new species

Plate 14, figures 11-14

Known from numerous cranidia excellently preserved in limestone.

Glabella moderately tapered, fairly convex transversely and longitudinally, rounded in front, defined by a dorsal furrow which is fairly deep posteriorly but very shallow in front. Traces of three pairs of glabellar furrows are visible on the upper surface. Occipital furrow fairly deep laterally, shallow mesially. Occipital ring expanded mesially, bearing a small node. Brim convex, downsloping. Rim weakly convex, expanded mesially where it attains the same length as the brim; marginal furrow wide and shallow. Ocular ridges very low, curving backward. Palpebral lobes at the level of the glabellar midpoint, one-third the glabellar length, narrow, set off by a distinct palpebral furrow. Fixed cheeks downsloping, their maximum width two-thirds the glabellar width. Distance from posterior end of palpebral lobes to posterior margin equal to length of palpebral lobe. Posterior limb as wide as the occipital ring. Anterior branch of facial suture straight forward from palpebral lobe to marginal furrow. Posterior branch first directed outward, then curving backward to meet posterior margin at a right angle.

Surface covered with very fine and not greatly elevated granules.

Length of largest cranidium 5 mm.

This species is very similar to the genotype, *O. thia,* differing chiefly in the more definitely downsloping fixed cheeks, proportionately narrower and longer glabella, and lesser midlength of the rim.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality W7f, Kicking Horse Mine, Mount Field. Also locality W7c, Kicking Horse Mine, Mount Field.

Types.—Holotype: U.S.N.M. No. 116129. Paratypes: U.S.N.M. No. 116130.

ONCHOCEPHALUS DEPRESSUS Rasetti, new species

Plate 14, figures 15-17

Known from numerous cranidia well preserved in limestone.

This form is so similar to the preceding species that it will be sufficient to list the differential features instead of repeating a complete description of the cranidium. Compared with *O. fieldensis,* the midlength of the rim is, on the average, somewhat greater in proportion to the midlength of the brim. The ocular ridges are considerably more conspicuous, while the palpebral lobes are a little shorter. The general convexity of the glabella and the whole cranidium, as well as the surface ornamentation, are as in the preceding species.

Length of the largest cranidium 3.5 mm.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W7g, Kicking Horse Mine, Mount Field.

Types.—Holotype: U.S.N.M. No. 116131. Paratypes: U.S.N.M. No. 116132.

ONCHOCEPHALUS MAIOR Rasetti, new species

Plate 14, figures 19-23

Known from numerous cranidia well preserved in limestone.

Glabella moderately convex in both directions, with slightly concave sides, moderately tapered, not sharply truncated in front. Glabellar furrows shallow; three pairs visible in most specimens. Occipital furrow deep at the sides, shallow mesially; occipital ring somewhat elevated, bearing a small node. Brim convex, downsloping; rim convex, set off by a well-impressed marginal furrow, slightly swollen mesially; midlength of rim somewhat greater than midlength of brim. Fixed cheeks slightly convex, on the average downsloping, about two-thirds the glabellar width. Ocular ridges prominent, somewhat curved, definitely oblique. Palpebral lobes small, elevated, situated at the level of the glabellar midpoint. Posterior limbs about as wide as the occipital ring, deeply furrowed. Distance from posterior end of palpebral lobe to posterior margin somewhat greater than length of palpebral lobe. Anterior facial sutures slightly divergent in front of the eyes, curving inward after crossing the marginal furrow. Posterior branch almost straight outward and backward for some distance, then curving backward to posterior margin.

Surface of cranidium covered with granules of average size.

Length of largest cranidium 9 mm.

This species differs from the associated *O. fieldensis* chiefly in the slightly concave sides of the glabella, greater relative midlength of rim, deeper dorsal furrow, more prominent ocular ridges, and greater size. Compared with the genotype, *O. thia,* the entire cranidium, and the glabella in particular, are proportionately longer and narrower in the present species.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W7f, Kicking Horse Mine, Mount Field.

Types.—Holotype: U.S.N.M. No. 116134. Paratypes: U.S.N.M. No. 116135.

ONCHOCEPHALUS SUBLAEVIS Rasetti, new species

Plate 14, figure 18

Known from a few cranidia preserved in limestone.

This species is so similar to *O. maior* that it will be sufficient to mention the differential characters. The only significant differences that the writer was able to ascertain are the much finer surface granulation and the absence of an occipital node. The palpebral lobes are broken off in the available cranidia, but apparently had the same position and size as in *O. maior.*

Length of largest cranidium 7 mm.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W7g, Kicking Horse Mine, Mount Field.

Type.—Holotype: U.S.N.M. No. 116133.

Genus PACHYASPIS Resser, 1939

Genotype: *Pachyaspis typicalis* Resser.

PACHYASPIS ATTENUATA Rasetti, new species

Plate 33, figures 12-14

Known from numerous cranidia preserved in limestone.

Glabella relatively long and narrow, strongly convex, moderately tapered, rounded in front. Two pairs of shallow glabellar furrows. Occipital furrow well impressed, occipital ring short, bearing a small node. Brim convex, downsloping, with a pair of wide, shallow depressions running forward and outward from the anterior corners of the glabella. Rim upturned, well defined by the marginal furrow; midlength of brim about three times midlength of rim. Fixed cheeks convex, on the average slightly downsloping, almost equaling the glabella in width. Ocular ridges strong, starting from the anterior angles of the glabella and running rather obliquely outward and backward. Palpebral lobes well defined by the palpebral furrows, moderately wide, about one-fourth the length of the glabella. Distance from posterior end of palpebral lobe to posterior margin about twice length of palpebral lobe. Posterior limbs deeply and widely furrowed. Anterior sutures almost straight to anterior margin and slightly convergent; posterior branch running outward and backward to posterior margin without much curvature.

Surface of test densely covered with fine granules and showing a few scattered larger granules. Brim with the usual anastomosing lines, more apparent on the impression of the lower surface.

Length of largest cranidium 10 mm.

This species closely resembles the genotype, *P. typicalis,* in the essential cranidial features; the other parts of the shield are unknown in both forms. The present species chiefly differs in the definitely convergent anterior facial sutures, less strongly downsloping fixed cheeks, and more marked longitudinal lines on the brim. The same features distinguish the new species from *P. moorei* Resser.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S6l, Mount Odaray.

Types.—Holotype: U.S.N.M. No. 116272. Paratypes: U.S.N.M. No. 116273.

Genus PIAZELLA Lochman, 1947

Genotype: *Ptychoparia pia* Walcott.

PIAZELLA PIA (Walcott)

Plate 8, figures 3-5

Ptychoparia pia Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 93, pl. 12, fig. 8, 1917.
Antagmus pia (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 1, 1937.
Piazella pia (Walcott), Lochman, Journ. Paleontol., vol. 21, p. 69, 1947.

This Lower Cambrian species has been sufficiently described by Walcott and by Lochman. However, all the published figures are poor, hence a good specimen collected by the writer from the typical horizon and locality is illustrated.

Horizon and locality.—St. Piran sandstone (Peyto limestone member; *Bonnia-Olenellus* zone). Type locality U.S.N.M. 35f, Mount Stephen. Also author's locality P18m, Mount Stephen, probably identical with the preceding.

Types.—Holotype: U.S.N.M. No. 64391. Plesiotype: U.S.N.M. No. 116071.

PIAZELLA TUBERCULATA Rasetti, new species

Plate 8, figures 6-10

Known from several cranidia preserved in limestone.

Glabella moderately convex, tapered, rather sharply truncated in front, with slightly concave sides. Three pairs of shallow glabellar furrows; first pair indistinct. Occipital furrow deep at the sides, shallow mesially. Occipital ring bearing a small node. Brim convex and downsloping at the sides, reduced to a short length mesially. Rim thick, convex, demarcated by a deep marginal furrow, expanded backward mesially. Midlength of rim somewhat greater than midlength of brim. Fixed cheeks slightly convex and downsloping, almost equaling the glabella in width. Ocular ridges wide and rather prominent. Palpebral lobes elevated, somewhat less than one-third the glabellar length. Distance from posterior end of palpebral lobe to posterior margin greater than length of palpebral lobe. Posterior limbs considerably wider than occipital ring, deeply furrowed. Anterior facial sutures divergent in front of the eyes, slightly convex outward to the marginal furrow, then definitely curving inward. Posterior branch reaching the posterior margin with a wide curve.

Surface of test covered with small granules, among which are scattered larger tubercles.

Length of largest cranidium 13 mm.

This species appears to agree with the genotype, *P. pia,* in all the essential features, particularly the great relative width of the fixed cheeks. It differs from that species chiefly in the surface ornamentation.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Locality W16j, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116072. Paratypes: U.S.N.M. No. 116073.

Genus PLAGIURA Resser, 1935

Genotype: *Ptychoparia? cercops* Walcott.

PLAGIURA CERCOPS (Walcott)

Plate 13, figures 10-16

Ptychoparia? cercops Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 81, pl. 12, figs. 1, 1a-d, 1917.
Plagiura cercops (Walcott), Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 43, 1935.
Plagiura cercops (Walcott), Lochman, Journ. Paleontol., vol. 21, p. 66, 1947.
Ptychoparia? cleadas Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 83, pl. 12, fig. 2, 1917.
Plagiurella cleadas (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 23, 1937.
Plagiura cleadas (Walcott), Lochman, Journ. Paleontol., vol. 21, p. 66, 1947.

Lochman showed that there is no reason for the generic separation of the two species described by Walcott. Further material collected by the writer shows continuous growth series between the small cranidia on which *Ptychoparia cleadas* was based, and the large cranidia representing the typical *Ptychoparia cercops.* Hence the former name is placed in synonymy.

The chief features that differentiate the cranidia of the young from the adults are the presence of shallow glabellar furrows, the deeper dorsal and occipital furrows, the distinct ocular ridges, and the presence of a well-differentiated, convex anterior rim. In mature individuals the rim becomes flat and less differentiated from the brim, yet the marginal furrow does not become entirely obsolete.

Complete articulated shields are unknown; however, the association of cranidium and pygidium was observed in so many instances as to make the assignment virtually certain. The writer collected a shield in shale preserving the pygidium and 15 thoracic segments, possibly representing the complex thorax. The thoracic axis is slightly tapered. The pleura show a fairly sharp geniculation at about one-third the length from the the proximal end. The pleura terminate in sharp, flat, slightly falcate spines. Pleural furrows well impressed at the geniculation, shallow proximally and distally. Length of thorax and pygidium 19 mm., of pygidium 2 mm.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality U.S.N.M. 63c, Ptarmigan Pass. Type locality for *Ptychoparia cleadas* U.S.N.M. 57s, Mount Bosworth. Other localities W4c, W4d, Ross Lake; W5c, Mount Bosworth; W9f, Mount Stephen; W19c, Hector Creek; W20d, Eiffel Peak.

Types.—Holotype: U.S.N.M. No. 64378. Paratypes: U.S.N.M. Nos. 64377, 64379-81. Holotype of *Ptychoparia cleadas:* U.S.N.M. No. 64382. Plesiotypes: U.S.N.M. Nos. 116118-9.

Genus SCHISTOMETOPUS Resser, 1938

Genotype: *Schistometopus typicalis* Resser.

The genus was described from a single cranidium. One of the characters of the genus, as stated by Resser, is the elevation of the central portion of the rim while the lateral portions are depressed. Although the only known specimen of *S. typicalis* is badly flattened in shale, careful examination seems to prove that this feature was really present in the animal and is not due to an accident of preservation.

A species from the Mount Whyte formation does not possess an elevated median portion of the rim but agrees so well with *Schistometopus typicalis* in all other features that a separate genus does not seem indicated. Resser himself had referred this form to *Schistometopus* in labels attached to specimens in the United States National Museum.

SCHISTOMETOPUS CONVEXUS Rasetti, new species

Plate 13, figures 17-22

Known from numerous cranidia preserved in limestone.

Glabella moderately tapered, straight-sided, rather truncated in front, strongly convex in both directions. Glabellar furrows moderately impressed. Posterior pair oblique, showing a tendency to bifurcate near their inner ends. Third pair also directed inward and backward, shorter than the posterior pair. Second pair shorter, shallower, and directed inward and slightly forward. There is a bare trace of the first pair. Occipital furrow deep, straight; occipital ring expanded mesially, bearing a small node. Dorsal furrow deep. Brim absent mesially, convex and downsloping laterally. Rim convex, almost straight; marginal furrow somewhat turned backward mesially and confluent with the dorsal furrow in front of the glabella. Fixed cheeks convex, on the average horizontal; maximum width somewhat more than half the glabellar width. Ocular ridges strongly oblique; palpebral lobes about one-third the glabellar length, moderately wide, set off by well-impressed palpebral furrows; their midpoint situated somewhat back of the glabellar midpoint. Total width of posterior limbs slightly less than width of occipital ring. Distance from posterior end of palpebral lobe to posterior margin less than length of palpebral lobe. Posterior marginal furrow deep. Anterior facial sutures slightly convex outward and somewhat divergent; posterior branch directed straight outward behind palpebral lobe, then curving backward.

Entire surface of cranidium covered with small granules, among which are scattered a few much larger granules; the latter form a somewhat regular pattern.

Length of the largest cranidium 13 mm.

This species chiefly differs from the genotype, *S. typicalis* Resser, in lacking the elevated median portion of the anterior rim, and having only three pairs of distinct glabellar furrows.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Type locality W20d, Eiffel Peak. Other localities W4c-d, Ross Lake; W5c, Mount Bosworth; W7f, Kicking Horse Mine; W9f, Fossil Gully.

Types.—Holotype: U.S.N.M. No. 116120. Paratypes: U.S.N.M. Nos. 116121-2.

SCHISTOMETOPUS COLLARIS Rasetti, new species

Plate 14, figures 1-3

Known from several cranidia preserved in limestone. All the available specimens are exfoliated, hence the description is based on the appearance of the internal cast.

Glabella moderately tapered, rounded in front, strongly convex in both directions. Three pairs of glabellar furrows fairly well impressed. Occipital ring extended into a slender, short spine. Brim at the sides of glabella convex, downsloping; in front of the glabella reduced to an exceedingly short length but not entirely eliminated as in *S. convexus*. Marginal furrow straighter than in *S. convexus;* rim convex, thicker mesially and tapered laterally. Fixed cheeks considerably convex, on the average downsloping, between half and two-thirds the glabellar width. Ocular ridges less prominent and less oblique than in *S. convexus*. Palpebral lobes smaller than in *S. convexus*. Posterior limbs subtriangular; distance between posterior end of palpebral lobe and posterior margin about twice the length of palpebral lobe. Anterior facial sutures slightly divergent for a short distance in front of the eyes, then curving inward and becoming convergent.

Characters of surface unknown. Length of largest cranidium 13 mm.

This species is undoubtedly a close relative of *S. convexus,* with which it is associated in the *Plagiura-Kochaspis* zone. Most of the differences from the preceding species, mentioned in the description, bring it closer to the average ptychoparid.

Horizon and locality.—Mount Whyte formation (*Plagiura-Kochaspis* zone). Locality W20d, Eiffel Peak.

Types.—Holotype: U.S.N.M. No. 116123. Paratypes: U.S.N.M. No. 116124.

Genus SOLENOPLEURELLA Poulsen, 1927

Genotype: *Solenopleurella ulrichi* Poulsen.

The genotype of *Solenopleurella* is known from a single cranidium collected in the Cape Wood formation of northwest Greenland. Forms that have been assigned to the genus are common in some of the Middle Cambrian formations of the Appalachian and Cordilleran provinces, and some of the species are represented by complete shields. These forms, provided they are congeneric with the genotype, may be used to supplement the generic diagnosis by stating that the thorax has 14-16 segments with simple pleura rounded at the extremity, and the pygidium is small, transverse, showing about two segments on the axis and pleural lobes.

Resser (1945) assigned to a species of *Solenopleurella* a large pygidium that certainly does not belong to the genus.

Several other genera of ptychoparids are very close to *Solenopleurella* and intergrade in such a way that further study may lead to uniting all these forms in one genus. These genera are *Crusoia* Walcott, 1924 (genotype: *Crusoia cebes* Walcott) ; *Spencia* Resser, 1939 (genotype: *Spencia typicalis* Resser) ; *Stauroholcus* Resser, 1939 (genotype: *Stauroholcus typicalis* Resser). The last two genera are obviously synonymous, the only differential character being the unimportant presence of an occipital spine in *Stauroholcus*. The forms of this group show all intermediate stages between a small occipital node and a strong spine.

SOLENOPLEURELLA, species undetermined No. 1

Plate 25, figures 17, 18

Apparently the same form of *Solenopleurella* occurs in the Burgess shale and in supposedly equivalent beds on Mount Odaray, where the fossils were collected from limestone lenses in shale. The different manner of preservation makes an accurate comparison difficult.

This form closely resembles *S. diligens* Resser from the Grand Canyon. Owing to the insufficient material, specific identification is not attempted.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Localities S6g, Mount Odaray, and S11g, above Burgess Quarry, Mount Field.

Figured specimens.—U.S.N.M. Nos. 116218-9.

SOLENOPLEURELLA, species undetermined No. 2

Plate 25, figure 16

A second species of *Solenopleurella* is represented by a few weathered shields, one being almost complete.

The cranidium appears to differ from that of the preceding form in possessing a less-thickened rim. The elevated portions of the glabella were weathered away in the available cranidia.

The thorax consists of 14 segments. The pleura have the geniculation much closer to the proximal than to the distal end, and are rounded at the extremity. The pleural furrows decrease in depth toward the pygidium. The pygidium is small, more than twice wider than long, and shows barely a trace of two pairs of pleural furrows. Length of cranidium 5 mm., of thorax 8.4 mm., of pygidium 1.3 mm.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S11e, Mount Field.

Figured specimen.—U.S.N.M. No. 116217.

Genus SYSPACEPHALUS Resser, 1936

Genotype: *Agraulos charops* Walcott.

This genus, recently discussed by Lochman (1947), is somewhat better characterized than most of the other genera of Early Cambrian and early Medial Cambrian generalized ptychoparids, chiefly because of the unusual anterior position of the palpebral lobes and the convergence of the anterior facial sutures.

The type species is from the Lower Cambrian Peyto limestone. Nevertheless, it is figured here because it is important that the genotypes in this difficult group of trilobites be illustrated as well as possible.

Several Middle Cambrian species are assigned to the genus, as they wholly agree with the generic characters of the Lower Cambrian genotype. Some of the new forms are known from complete shields, hence the generic diagnosis may be completed by stating that the thorax consists of 13 to 15 segments and the pygidium is small, transverse, with only two distinct segments. Thorax and pygidium do not supply any characters than can be used to discriminate this genus from similar generalized ptychoparids.

SYSPACEPHALUS CHAROPS (Walcott)

Plate 8, figures 11-13

Agraulos charops WALCOTT, Smithsonian Misc. Coll., vol. 67, No. 3, p. 67, pl. 13, figs. 2, 2a, 1917.

Syspacephalus charops (Walcott), RESSER, Smithsonian Misc. Coll., vol. 95, No. 4, p. 28, 1936.

Syspacephalus charops (Walcott), LOCHMAN, Journ. Paleontol., vol. 21, p. 64, 1947.

A specimen from the typical horizon and at least approximately the type locality is figured.

Horizon and locality.—Peyto limestone member of the St. Piran sandstone (*Bonnia-Olenellus* zone). Type locality U.S.N.M. 35f, Mount Stephen. Plesiotypes from locality P18m, Mount Stephen.

Types.—Holotype and paratypes: U.S.N.M. No. 64395. Plesiotype: U.S.N.M. No. 116074.

SYSPACEPHALUS GREGARIUS Rasetti, new species

Plate 8, figures 14-19

Known from a large number of cranidia and several complete shields in shale, and several cranidia in limestone preserving the full convexity.

Glabella slightly tapered, truncated in front, rather strongly convex, defined by a dorsal furrow that is deep at the sides and shallow in the frontal portion. Three pairs of glabellar furrows well impressed; fourth furrow directed backward, third transverse, second directed slightly forward. Occipital furrow deep; occipital ring elevated, bearing a node. Brim and fixed cheeks convex; fixed cheeks on the average slightly downsloping. Rim convex, expanded mesially, its midlength about two-thirds of the brim midlength. Marginal furrow almost obsolete mesially. Fixed cheeks almost as wide as the glabella. Palpebral lobes about one-third the glabellar length, somewhat elevated, situated somewhat in advance of the glabellar midpoint. Ocular ridges narrow, transverse, slightly curved. Anterior facial suture directed slightly inward, curving across the border; posterior branch almost straight, narrowly curving near the distal end. Distance from posterior end of palpebral lobe to posterior margin of cranidium somewhat greater than length of palpebral lobe. Posterior limbs about as wide as occipital ring. Free cheeks small and rounded at the genal angle.

Thorax of 14 segments. Pleura deeply furrowed, rounded at the distal end.

Pygidium small, elliptical, about three times wider than long. Axis with two visible segments. Pleural lobes showing one distinct pair of furrows and traces of another.

Surface characterized by small scattered tubercles.

Length of largest cranidium 4.8 mm. Most of the specimens are somewhat smaller. The length of an average complete shield is 12 mm.

This species resembles in all characters of generic significance the genotype, *S. charops*. Chief distinctive features are the greater convexity of the fixed cheeks, deeper glabellar furrows, more elevated palpebral lobes, and different course of the ocular ridges.

Horizon and locality.—Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Type locality W9k, Fossil Gully, Mount Stephen. Other locality W16k, North Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116075. Paratypes: U.S.N.M. Nos. 116076-7.

SYSPACEPHALUS LATICEPS Rasetti, new species

Plate 9, figures 1-6

Known from numerous cranidia preserved in limestone.

Glabella slightly tapered, straight-sided, truncated in front, most elevated posteriorly, with the third and fourth glabellar furrows fairly well impressed and traces of one or two other pairs. Occipital furrow deep at the sides; occipital ring expanded mesially, bearing a small node. Brim and fixed cheeks convex; fixed cheeks on the average downsloping. Rim flat, slightly upturned with respect to the brim; rim midlength about half of the brim midlength. Fixed cheeks almost as wide as the glabella. Palpebral lobes slightly elevated, about one-fourth the glabellar length, situated in advance of a line through the anterior third of the glabella. Ocular ridges weak, starting forward from the dorsal furrow, distally curving backward, on the average transverse. Anterior facial suture directed somewhat inward in front of the eyes, curving farther inward after crossing the marginal furrow, marginal for a short distance. Posterior branch directed almost straight outward and backward; distance from posterior end of palpebral lobe to posterior margin of cranidium more than twice the length of palpebral lobe. Posterior limbs considerably wider than the occipital ring.

Surface smooth except for faint longitudinal lines on the brim.

Length of largest cranidium 6.5 mm.

This species closely resembles the genotype, *S. charops,* in all features of generic significance. It is readily distinguished by the better-impressed glabellar furrows, wider posterior limbs, and lack of a median boss on the frontal limb.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Type locality W16j, North Gully, Mount Stephen. Other localities W16j″ and W16h, North Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116080. Paratypes: U.S.N.M. No. 116081.

SYSPACEPHALUS PEROLA (Walcott)

Plate 9, figures 17-22

Ptychoparia perola Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 91, pl. 12, figs. 7, 7a, 1917.

Inglefieldia perola (Walcott), Resser, Smithsonian Misc. Coll., vol. 95, No. 22, p. 14, 1937.

Antagmus perola (Walcott), Lochman, Journ. Paleontol., vol. 21, p. 62, 1947.

Known from a large number of cranidia and several articulated shields preserved in shale.

All the characters can be ascertained except the exact degree of convexity because of the partial flattening of the shields. The position of the palpebral lobes and the convergence of the facial sutures in front of the eyes exclude reference of the species to *Inglefieldia* or *Antagmus,* whereas all characters of generic significance agree with the genotype of *Syspacephalus.*

Walcott gave a sufficient description of this species, except for the statement that the free cheeks have genal spines. Study of the type material in the United States National Museum shows that the specimen on which he based this observation is a free cheek of the associated species *Amecephalus agnesensis*. The writer collected several individuals preserving the free cheeks and these show that the genal angle is rounded.

The present species differs from *S. charops* chiefly in the deeper glabellar furrows, reduced marginal portion of the facial suture, and the course of the ocular ridges.

Horizon and locality.—Mount Whyte formation (Lake Agnes and Yoho shale lentils; *Wenkchemnia-Stephenaspis* zone). Type locality U.S.N.M. 35m, southwest of Lake Louise. Other localities W2b, Mount Niblock; W3b, Plain of Six Glaciers; W9k, Fossil Gully, Mount Stephen.

Types.—Lectotype (hereby designated): U.S.N.M. No. 64389. Paratype: U.S.N.M. No. 64390. Plesiotypes: U.S.N.M. Nos. 116087-8.

SYSPACEPHALUS LAEVIGATUS Rasetti, new species

Plate 9, figures 9-11

Known from several cranidia and a complete shield, all preserved in shale and slightly flattened.

Glabella tapered, unfurrowed, not sharply truncated in front. Occipital ring expanded, bearing an indistinct node. Frontal limb and fixed cheeks convex. Limb faintly divided into brim and rim by a marginal furrow that is distinct only at the sides; brim longer than rim. Fixed cheeks about two-thirds the glabellar width. Palpebral lobes narrow, slightly elevated, situated on a transverse line through the anterior third of the glabella. Ocular ridges indistinct, faintly curved, directed transversely. Anterior branch of facial suture directed slightly inward in front of the eyes, gently curving across the rim; marginal portion of moderate extent. Posterior branch directed outward and backward behind the eye, then curving backward, Distance from posterior end of palpebral lobe to posterior margin at least twice length of palpebral lobe. Width of posterior limbs approximately equal to width of occipital ring.

Thorax of 13 segments. Pleura broadly furrowed, rounded at the distal end.

Pygidium small, transverse, about three times wider than long. Axis almost reaching the posterior margin, pleural lobes about as wide as the axis. Both axis and pleural lobes show one furrow and traces of a second pair.

Surface smooth.

Length of largest cranidium 7 mm. Length of a complete shield 14 mm.

Horizon and locality.—Mount Whyte formation (Yoho shale lentil; *Wenkchemnia-Stephenaspis* zone). Type locality W9k, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116083. Paratypes: U.S.N.M. No. 116084.

SYSPACEPHALUS CRASSUS Rasetti, new species

Plate 9, figures 12-16

Known from numerous cranidia preserved in limestone and an entire shield in shale.

Glabella slightly tapered, strongly convex, rounded in front, considerably elevated above the fixed cheeks. Two pairs of short glabellar furrows of medium strength. Occipital furrow well impressed; occipital ring expanded, bearing a strong node. Brim and fixed cheeks convex. Rim about half the length of the brim on midline, slightly convex; marginal furrow indistinct mesially. Fixed cheeks on the average slightly downsloping, about two-thirds the glabellar width. Ocular ridges transverse, slightly curved. Palpebral lobes rather elevated, about one-third the glabellar length, their centers situated somewhat in advance of the glabellar midpoint. Anterior facial suture directed somewhat inward in front of the eye, curving across the rim, marginal for a considerable distance. Posterior branch directed outward and backward, curving backward near the distal end. Distance from posterior end of palpebral lobe to posterior margin somewhat greater than length of palpebral lobe. Width of posterior limbs equal to width of occipital ring.

The thorax has 14 segments and the pygidium is small, transverse as in *S. gregarius*.

Surface covered with scattered granules. Length of largest cranidium 4 mm.

This species differs from the genotype, *S. charops,* in several features, chiefly the greater proportional size and elevation of the glabella, distinctness of the glabellar furrows, elevation of the palpebral lobes, and surface ornamentation. The first two characters also separate it from *S. gregarius* which it resembles in most of the other features.

Horizon and locality.—Mount Whyte formation (*Wenkchemnia-Stephenaspis* zone). Type locality W16j, North Gully, Mount Stephen. Other locality W16j", North Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116085. Paratypes: U.S.N.M. No. 116086.

SYSPACEPHALUS TARDUS Rasetti, new species

Plate 22, figures 7-10

Known from numerous cranidia moderately well preserved in silty limestone.

Glabella of average convexity, slightly tapered, rounded in front. Glabellar furrows indistinct. Occipital furrow shallow; occipital ring not greatly expanded, possibly bearing a node. Brim convex, downsloping; marginal furrow rather straight; rim on the average horizontal, slightly convex, with a swelling on the median line visible in most of the specimens. Midlength of rim equal to midlength of brim. Fixed cheeks convex, on the average slightly downsloping, somewhat more than two-thirds the glabellar width. Ocular ridges faint. Palpebral lobes small, elevated, situated on a transverse line through the anterior third of the glabella. Distance from posterior end of palpebral lobe to posterior margin more than twice length of palpebral lobe. Posterior limbs slightly wider than occipital ring. Anterior facial sutures slightly convergent in front of the eyes, curving inward across the rim. Posterior branch directed almost straight outward behind the eye, then rather sharply turning backward.

Surface of test apparently smooth. However, the state of preservation would not allow the detection of very small granules.

Length of largest cranidium 6 mm.

This species, although much younger than the genotype, appears entirely to agree with the generic characters of *Syspacephalus* and it does not seem appropriate to remove it from the genus on account of its age. Compared with the genotype, *S. charops,* the present species differs chiefly in the greater convexity of the anterior portion of the glabella and the horizontal rather than downsloping position of the rim.

Horizon and locality.—Cathedral formation (*Albertella*(?) zone). Locality C9h, Fossil Gully, Mount Stephen.

Type.—Holotype: U.S.N.M. No. 116188. Paratypes: U.S.N.M. No. 116189.

YOHOASPIS Rasetti, new genus

Ptychoparid trilobites known from the cranidium.

Cranidium as a whole with considerable relief. Glabella strongly convex transversely, moderately tapered, rounded in front, defined by a deep dorsal furrow; glabellar furrows indistinct, occipital furrow shallow. Frontal limb consisting of rim only, as the marginal furrow runs into the dorsal furrow in front of the glabella. Rim long, downsloping; marginal furrow almost straight. Fixed cheeks strongly convex, not rising to the level of the glabella, almost as wide as the glabella. Palpebral lobes narrow, moderately long, rather straight, set off by a distinct palpebral furrow, situated at the level of the glabellar midpoint. Ocular ridges poorly defined. Posterior limbs rather slender, tapered, deeply furrowed. Anterior facial sutures somewhat divergent in front of the eyes, curving inward across the rim, probably marginal on the median line. Posterior branch directed almost straight outward and a little backward.

Genotype.—*Yohoaspis pachycephala* Rasetti, new species.

Stratigraphic range.—Middle Cambrian (*Albertella*(?) zone).

Remarks.—*Yohoaspis* is a rather large ptychoparid trilobite that can be compared with other genera only as far as the cranidial features are concerned, since the other parts of the shield are unknown. Its chief diagnostic features are the strong convexity of the fixed cheeks and especially the structure of the frontal limb, consisting of a thick rim only. The confluence of the dorsal and marginal furrows in front of the glabella occurs to a greater or lesser degree in several genera of Lower and Middle Cambrian ptychoparids, but seldom to such a complete extent as in the present instance. The genera presenting this feature differ from *Yohoaspis* in the proportions and convexity of other cranidial parts.

The name is derived from the Yoho River.

YOHOASPIS PACHYCEPHALA Rasetti, new species

Plate 21, figures 9-14

Known from several cranidia preserved in shale or impure limestone, the latter preserving the convexity.

Glabella moderately tapered, rounded in front, strongly convex in both directions, defined by a deep dorsal furrow. Glabellar furrows very faint. Occipital furrow deep laterally, shallow mesially; occipital ring apparently short and simple. Brim developed only at the sides, convex. Rim occupying the entire frontal limb mesially because of the confluence of the dorsal and marginal furrows; rim downsloping, slightly concave as a whole, convex marginally; marginal furrow almost straight. Fixed cheeks well convex, on the average downsloping. Palpebral lobes small, elevated, situated on the transverse line through the glabellar midpoint. Ocular ridges faint. Posterior limbs deeply furrowed, wider than the occipital ring. Distance from posterior end of palpebral lobe to posterior margin about twice length of palpebral lobe. Anterior facial sutures divergent in front of the eyes, turning inward with a wide curve across the rim. Posterior branch fairly straight for a distance behind the eye, then gradually curving backward.

Surface of test densely covered with very fine granules.

Length of largest cranidium 20 mm.

Horizon and locality.—Cathedral formation (*Albertella*(?) zone). Type locality C9h, Fossil Gully, Mount Stephen. Also locality C9j, Fossil Gully, Mount Stephen.

Types.—Holotype: U.S.N.M. No. 116181. Paratypes: U.S.N.M. Nos. 116182-3.

YUKNESSASPIS Rasetti, new genus

Ptychoparid trilobites with multisegmented thorax and a small pygidium.

Glabella moderately convex, tapered, straight-sided, sharply truncated in front. Dorsal furrow unusually deep at the sides. Frontal limb as long as the glabella, chiefly consisting of a convex brim, with a short rim. Fixed cheeks about equaling the glabellar width, upsloping. Ocular ridges starting from the anterior angles of the glabella, unusually strong and prominent. Palpebral lobes short and narrow. Posterior limbs wider than the occipital ring, widely furrowed. Distance from posterior end of palpebral lobe to posterior margin greater than length of palpebral lobe.

Thorax of at least 14 segments in the genotype. Axis moderately tapered. Pleura straight, widely furrowed. Pygidium unknown. From the rate of tapering of the thorax it is certain that this part of the shield was small.

Genotype.—*Yuknessaspis paradoxa* Rasetti, new species.

Stratigraphic range.—Middle Cambrian (*Bathyuriscus-Elrathina* zone).

Remarks.—The genus cannot be confused with any described ptychoparid, chiefly on account of the great depth of the dorsal furrow, strength of the ocular ridges, and long, convex brim that almost rises to the level of the glabella.

The name is derived from Mount Yukness.

YUKNESSASPIS PARADOXA Rasetti, new species

Plate 32, figures 15-18

Known from two cranidia and a specimen with attached thorax, all preserved in limestone.

Glabella moderately tapered, with slightly concave sides, sharply truncated in front, strongly convex transversely but moderately convex longitudinally. Two or three pairs of oblique glabellar furrows are barely indicated. Occipital furrow consisting of a pair of narrow, oblique, rather deep impressions at the sides connected by a shallow median furrow. Occipital ring extended into a spine. Dorsal furrow wide and deep at the sides, narrow and moderately deep in front of the glabella. At the sides of the anterior portion of the glabella the dorsal furrow forms a pair of deep pits, from which the ocular ridges rise with unusual prominence. Frontal limb equaling the glabella in length. Brim strongly convex, almost rising to the level of the glabella; marginal furrow narrow but well impressed, rim convex, its midlength about one-eighth of the midlength of the brim. Fixed cheeks flat, upsloping, but not reaching the level of the glabella; approximately equaling the glabella in width. Ocular ridges originating at the level of the anterior angles of the glabella, first directed outward, then slightly curving backward. Palpebral lobes upsloping, about one-fourth the glabellar length, set off by a narrow palpebral furrow. Posterior limbs triangular, considerably wider than the occipital ring. Distance from posterior end of palpebral lobe to posterior margin greater than length of palpebral lobe. Marginal furrow on posterior limbs wide and deep. Anterior facial sutures divergent in front of the eyes, then describing a wide curve and crossing the rim obliquely. Posterior branch directed fairly straight outward and backward.

Thorax of 14 segments in the only specimen where this portion of the shield is preserved. From the rate of tapering of the last segments it is clear that this thorax is either complete or almost complete, and that the pygidium was small. Pleural lobes with a fairly sharp geniculation but no great convexity. Pleura straight, furrowed, not extended into spines.

Surface of glabella smooth. Surface of fixed cheeks with fine reticulated ornamentation. Surface of brim with coarse, longitudinal anastomosing lines.

Length of holotype cranidium 15 mm.; length of another specimen preserving cranidium and thorax 26 mm.

Horizon and locality.—Stephen formation (*Bathyuriscus-Elrathina* zone). Locality S1ol, Park Mountain.

Types.—Holotype: U.S.N.M. No. 116265. Paratype: U.S.N.M. No. 116266.

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EXPLANATION OF PLATES

Plate 1. South face of Mount Temple (11,636 feet)

Showing over 4,000 feet of horizontal Lower and Middle Cambrian strata. P = St. Piran; W = Mount Whyte; C = Cathedral; S = Stephen; E = Eldon.

Plate 2. Middle Cambrian strata on Mount Stephen and Park Mountain

Upper: Northeast shoulder of Mount Stephen. The portal of the Monarch Mine is visible in the upper left corner. P = St. Piran; W = Mount Whyte; C = Cathedral. Note the westward thickening of the lowermost portion of the Mount Whyte formation.

Lower: East face of Park Mountain. C = Cathedral; S = Stephen; E = Eldon. The Eldon is here represented by an unusual shaly and calcareous facies.

Plate 3. Northwest face of Mount Stephen

Photograph taken from the summit of Mount Field. P = St. Piran; W = Mount Whyte; SC = Cathedral + Stephen (undivided); E = Eldon. NG = North Gully; MG = Middle Gully; FG = Fossil Gully. Dotted line represents Fossil Gully fault. The dark band above the letter E in the Eldon is a siliceous shale.

Plate 4. Lower part of the northwest face of Mount Stephen

Photographed from the south slope of Mount Field. P = St. Piran; W = Mount Whyte; C = Cathedral. NG = North Gully; MG = Middle Gully; FG = Fossil Gully. Dotted line represents Fossil Gully fault.

Plate 5. Interfingering limestone and dolomite in the Cathedral formation

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Plate 6. Anomalous lithology of the Cathedral formation on Mount Stephen

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Plate 7. East face of Mount Odaray

Photographed from the west shoulder of Mount Schaffer. P = St. Piran; W = Mount Whyte; C = Cathedral; S = Stephen. The cliff at the top of the St. Piran is formed by the Peyto limestone member. The section was measured on the slope of the south peak (left).

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(All the figured specimens are preserved in limestone.)

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(All the figured specimens are preserved in limestone unless otherwise indicated.)

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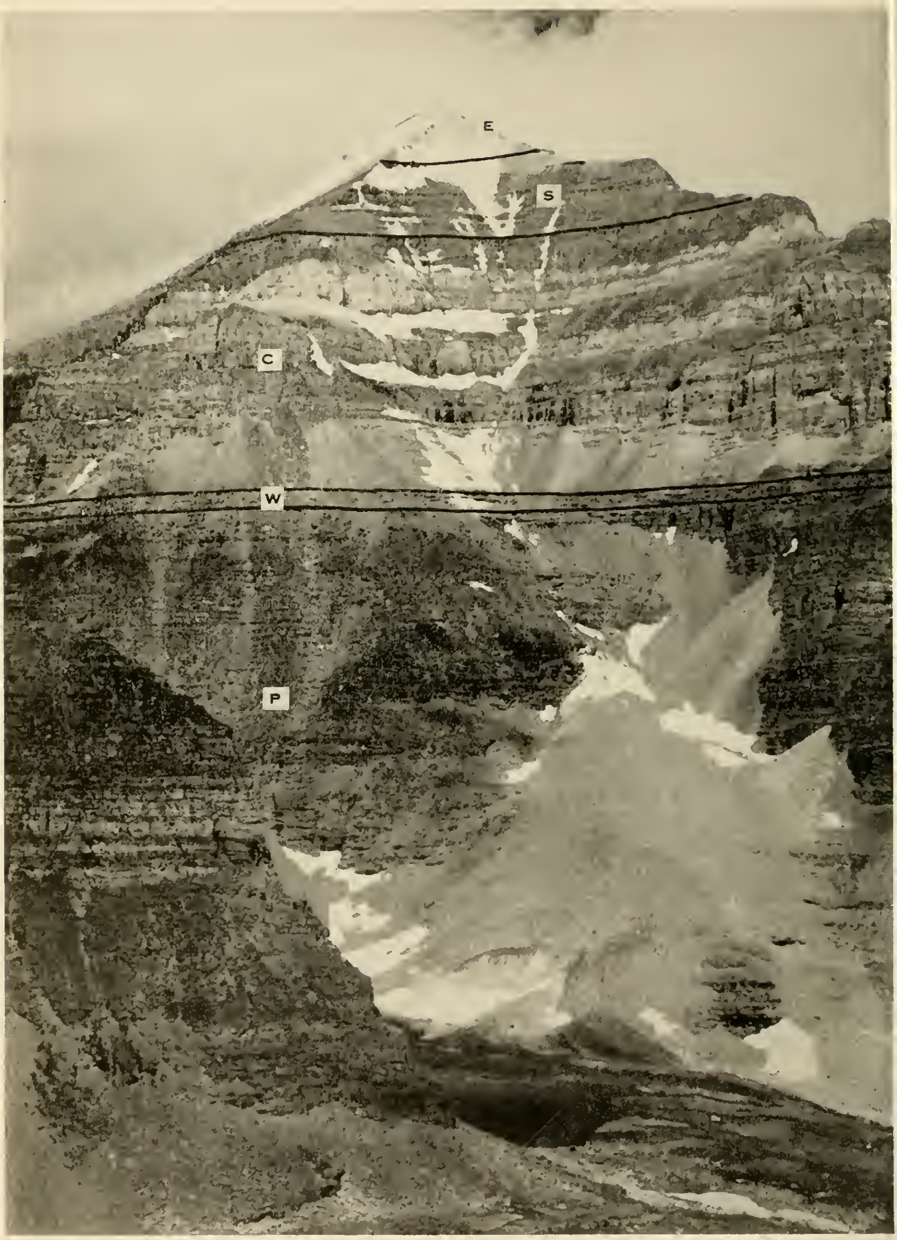

SOUTH FACE OF MOUNT TEMPLE (11,636 FEET)

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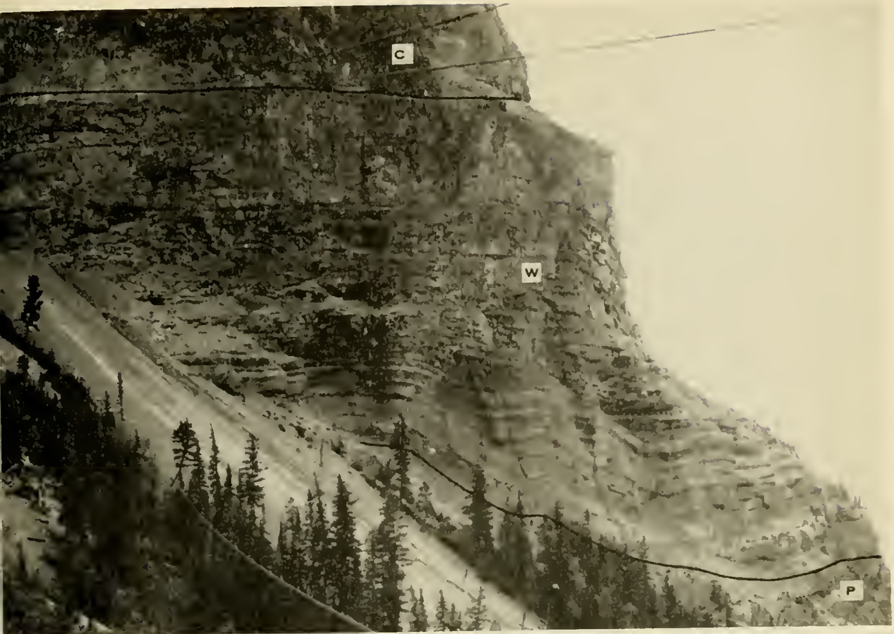

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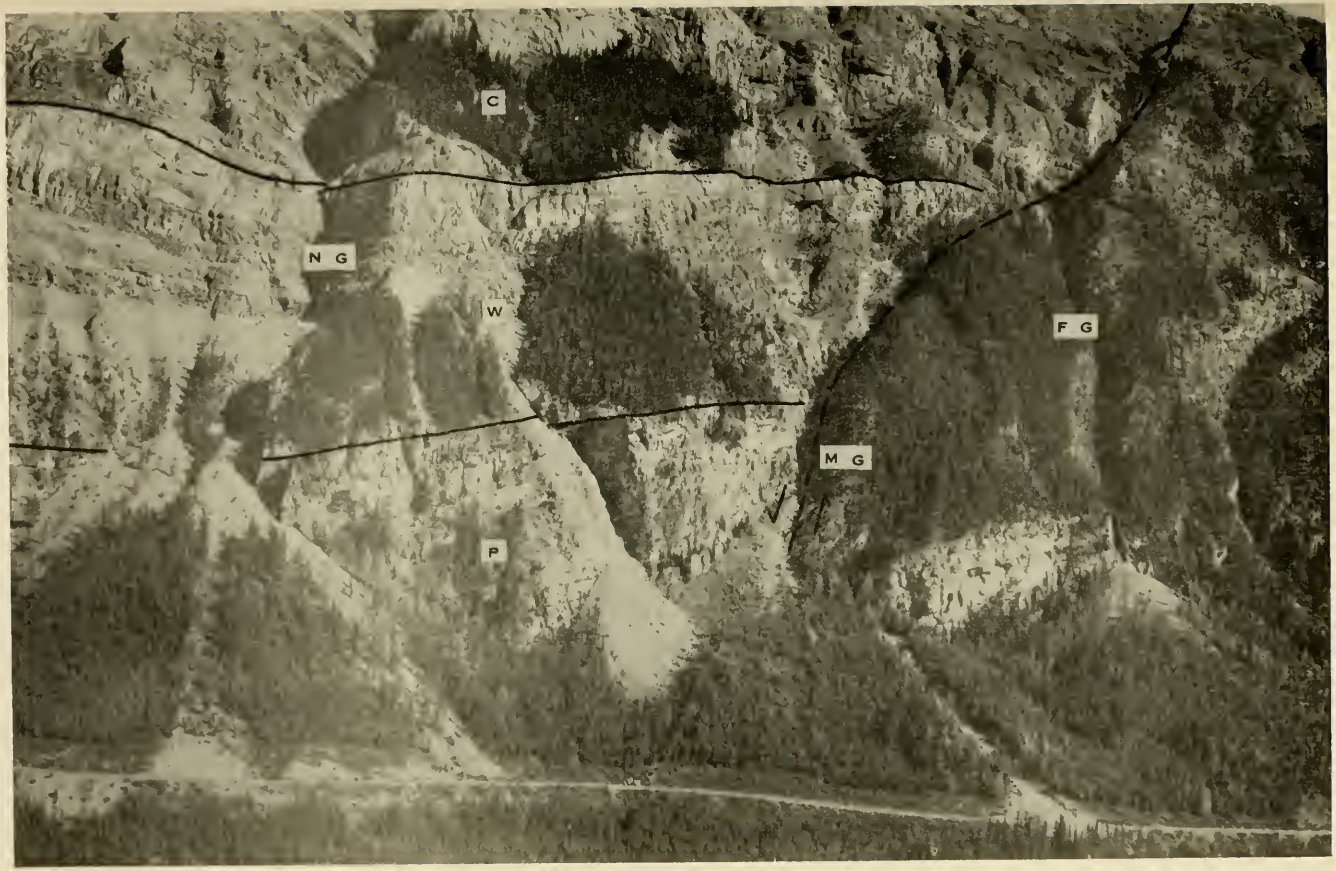

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INTERFINGERING LIMESTONE AND DOLOMITE IN THE CATHEDRAL FORMATION

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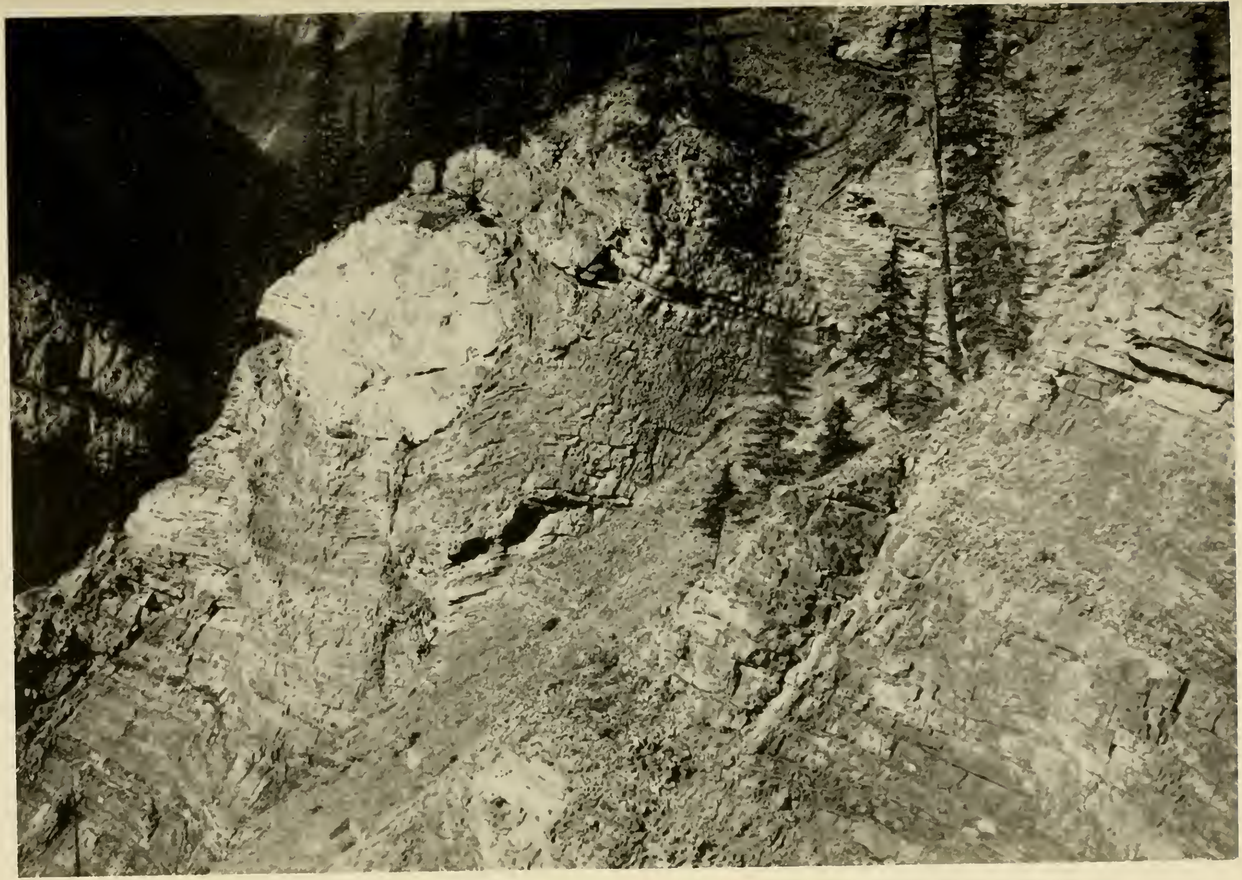

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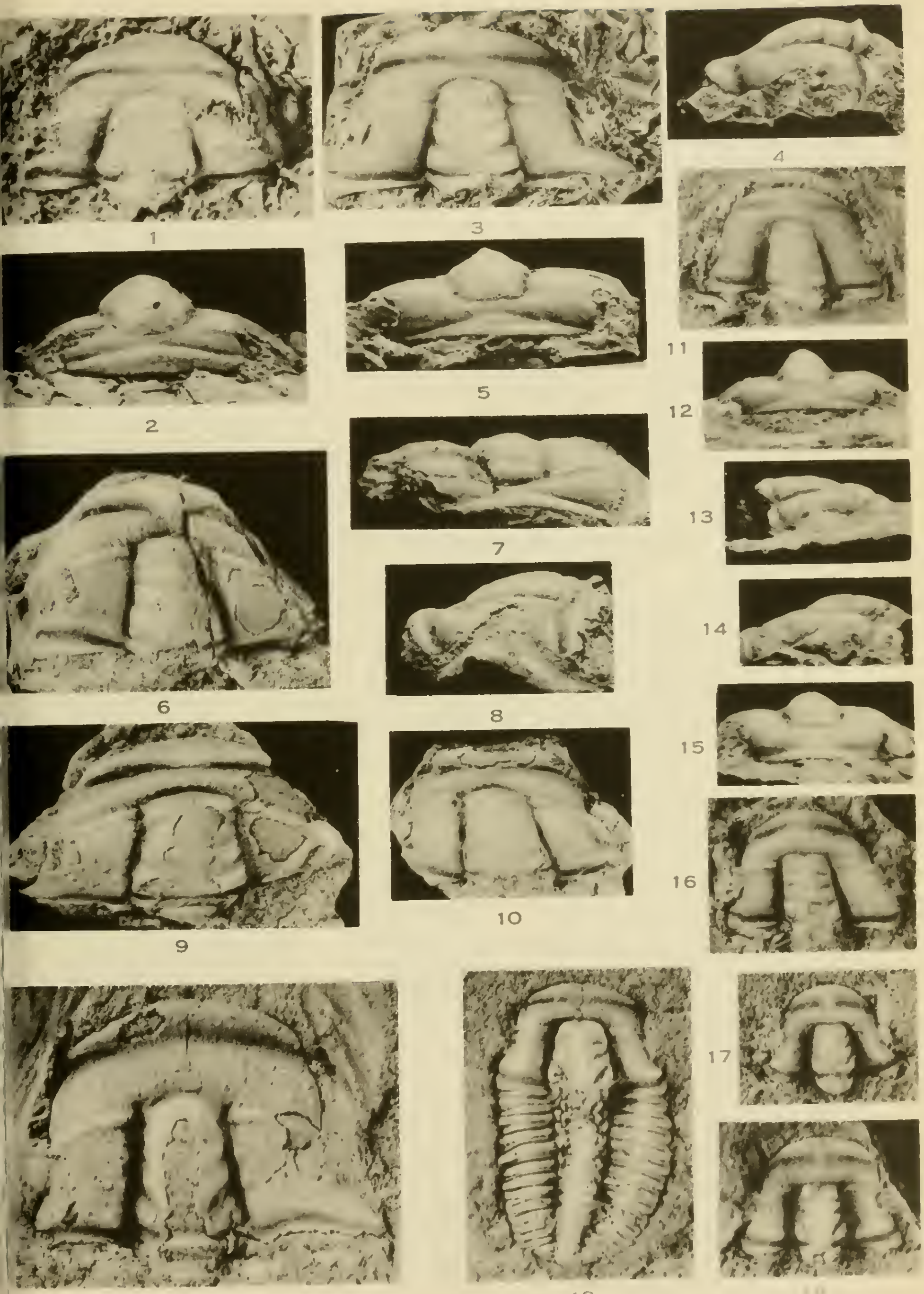
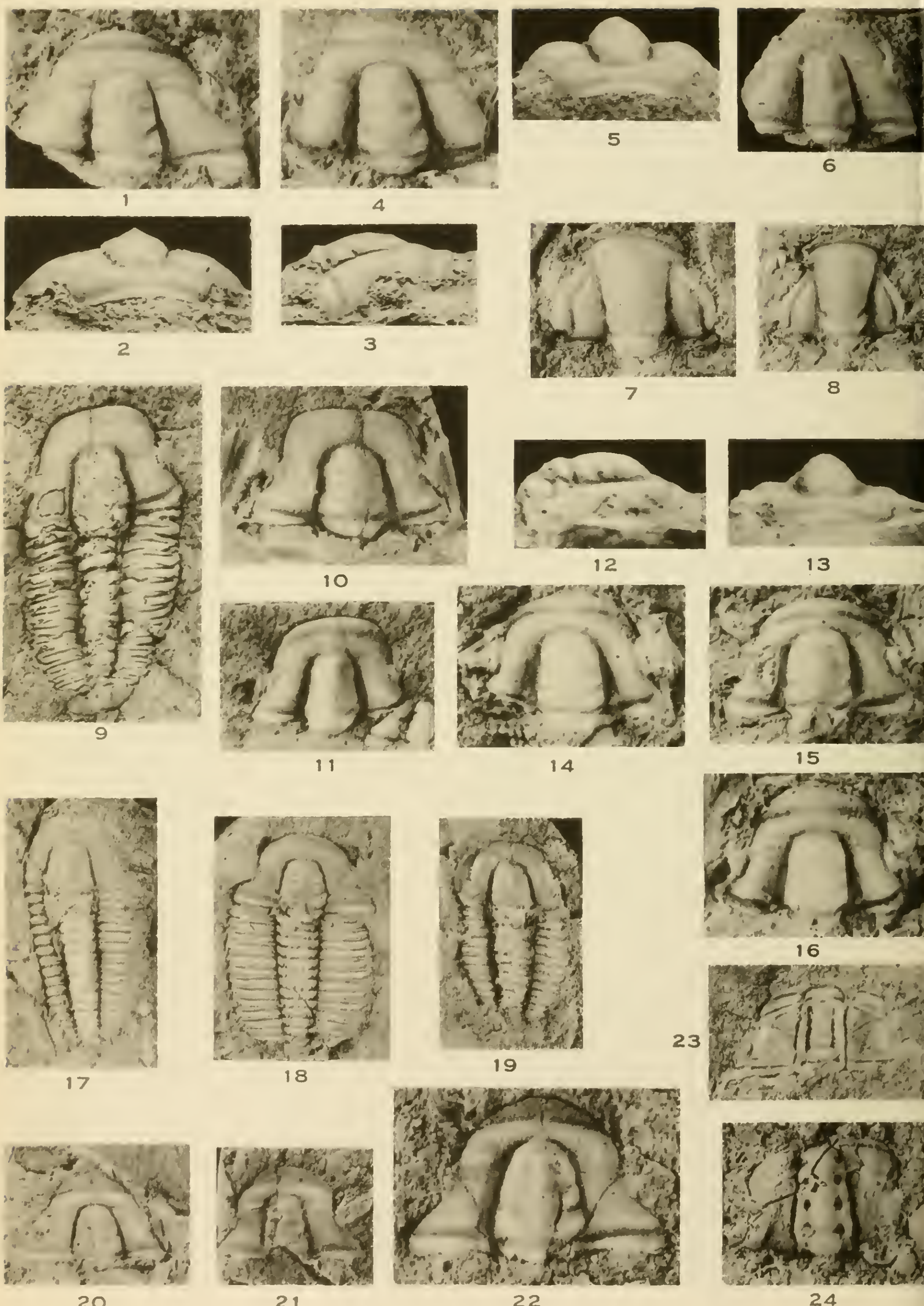


TRILOBITES OF THE BONNIA-OLENELLUS AND WENKCHEMNIA-STEPHENASPIS ZONES

(See explanation of plates at end of text.)



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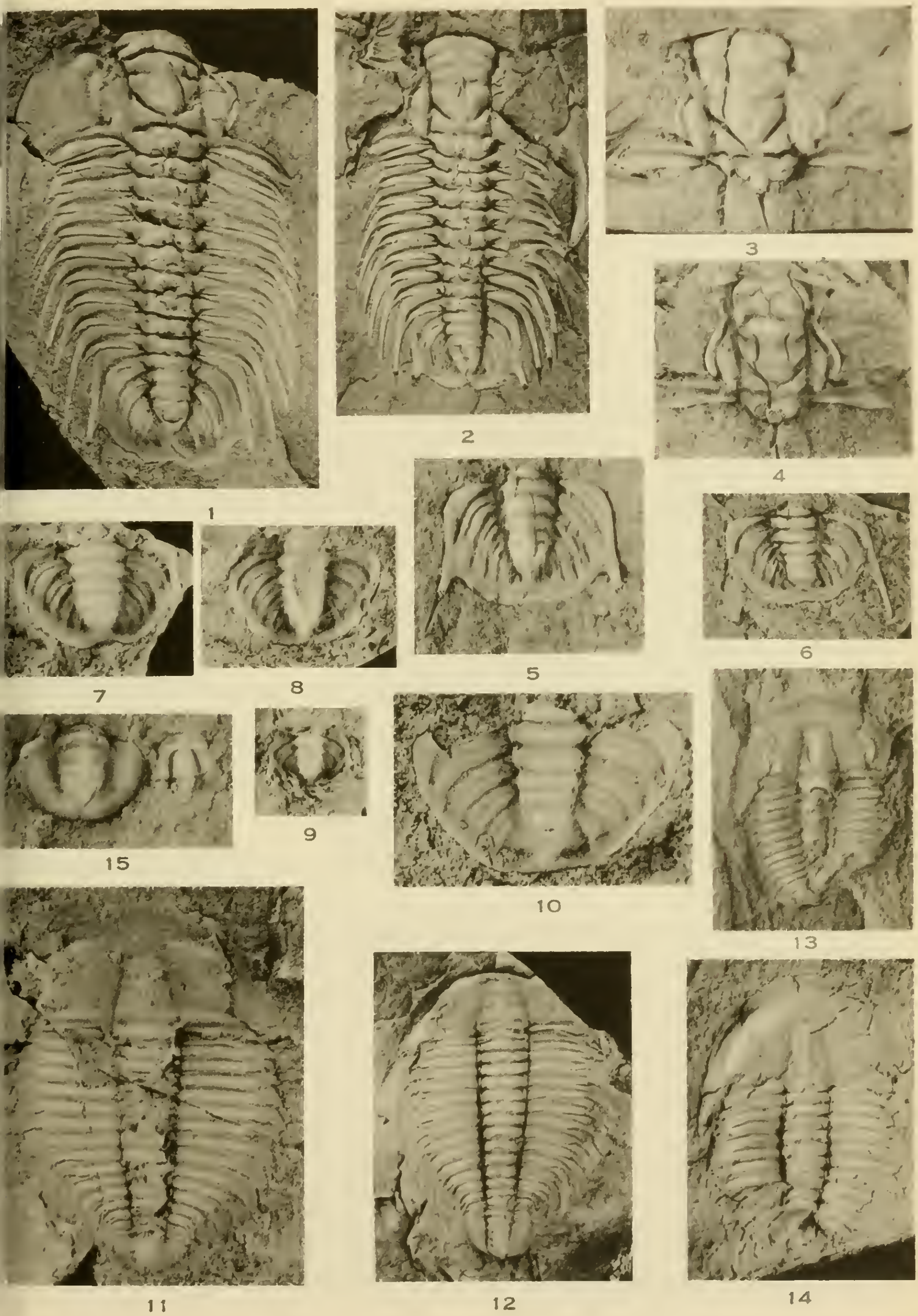
(See explanation of plates at end of text.)



TRILOBITES OF THE WENKCHEMNIA-STEPHENASPIS ZONE

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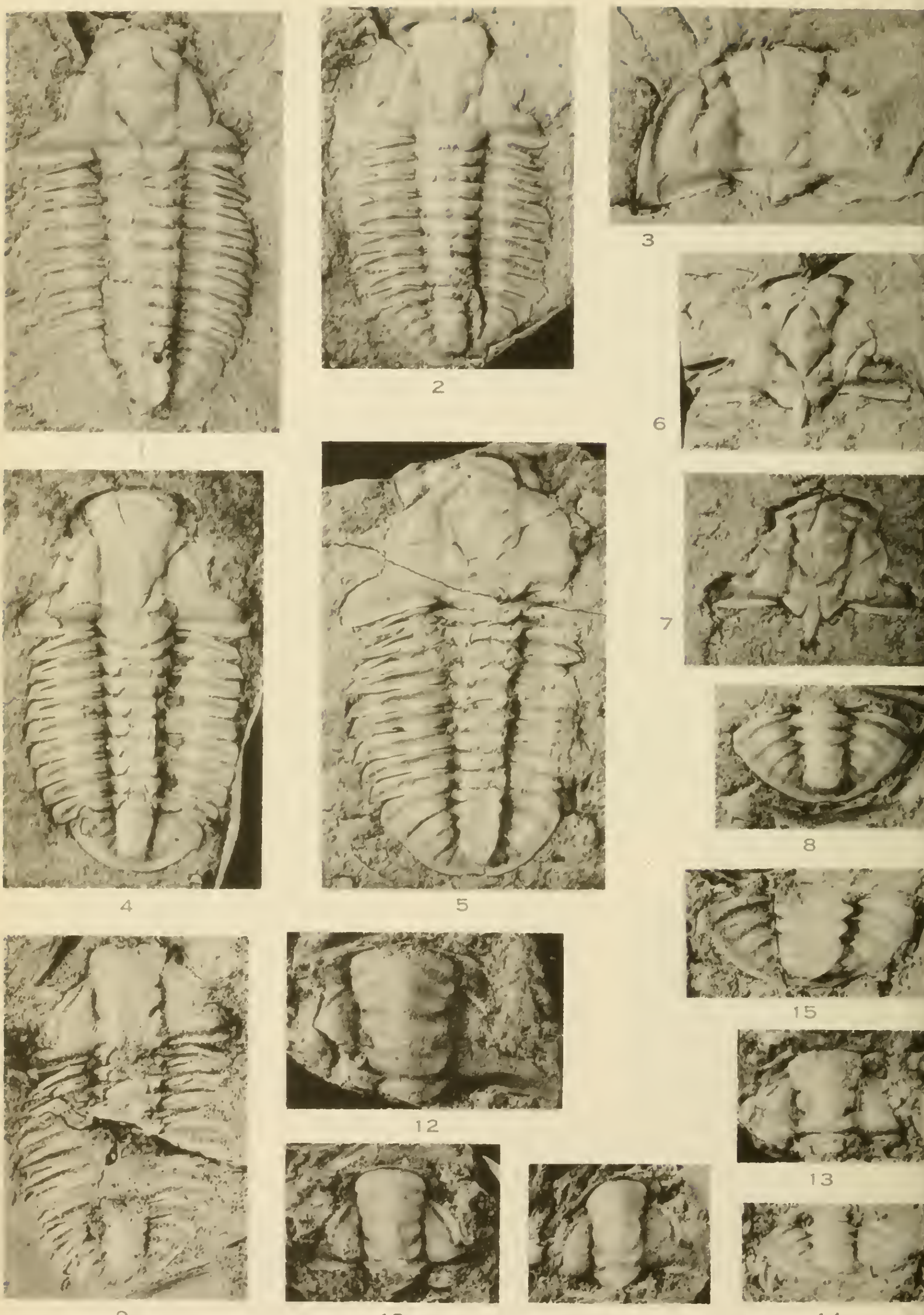

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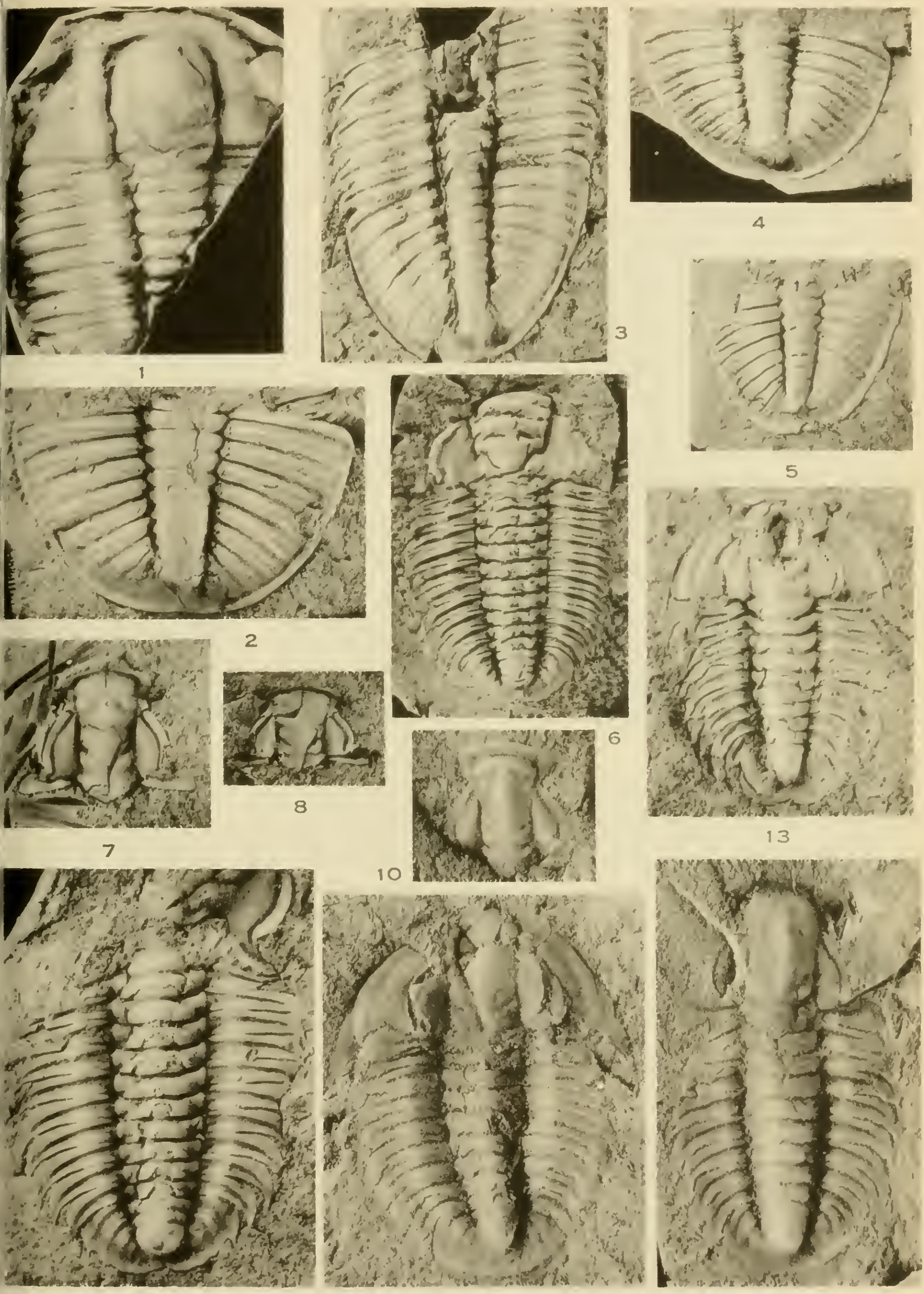

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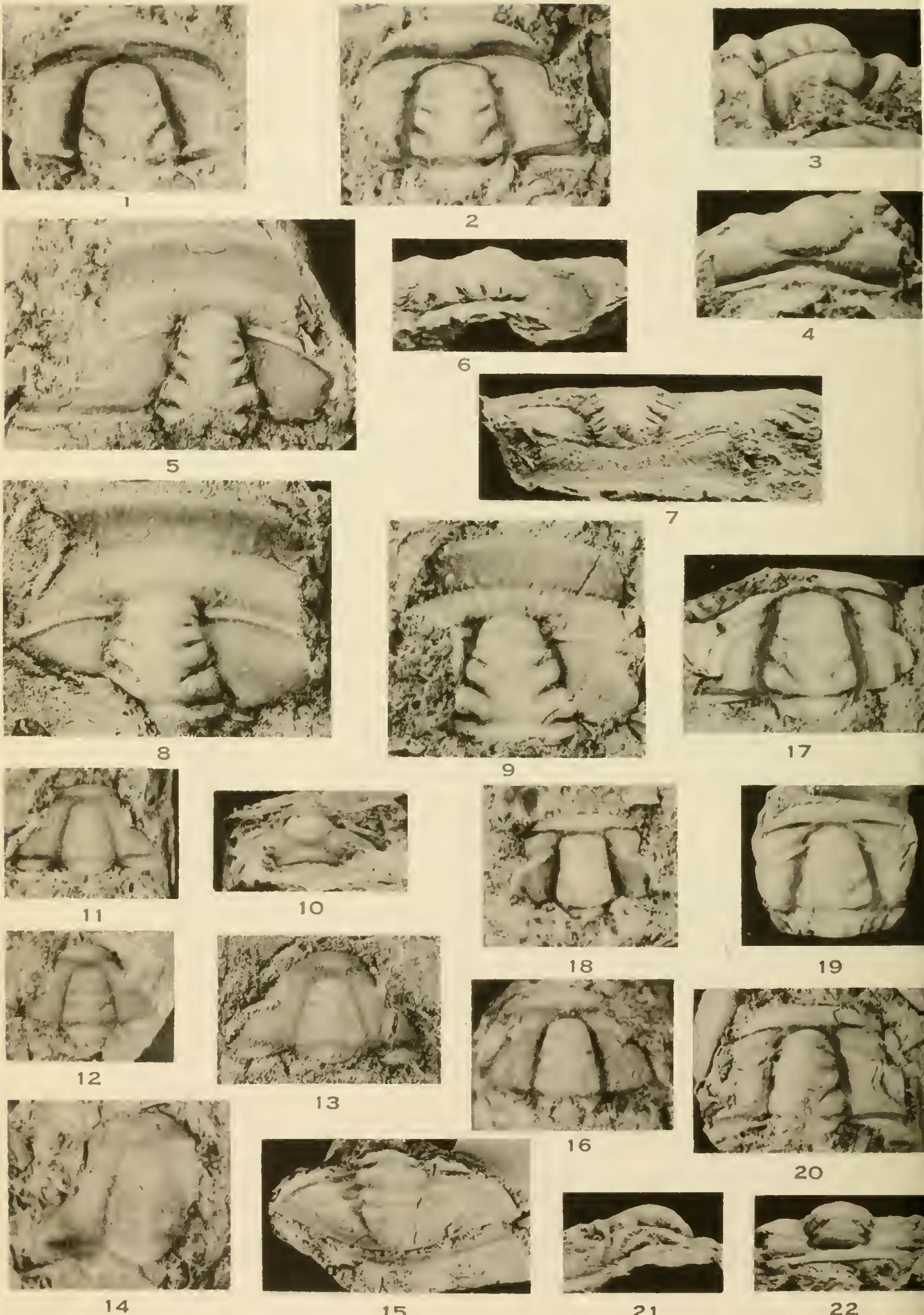

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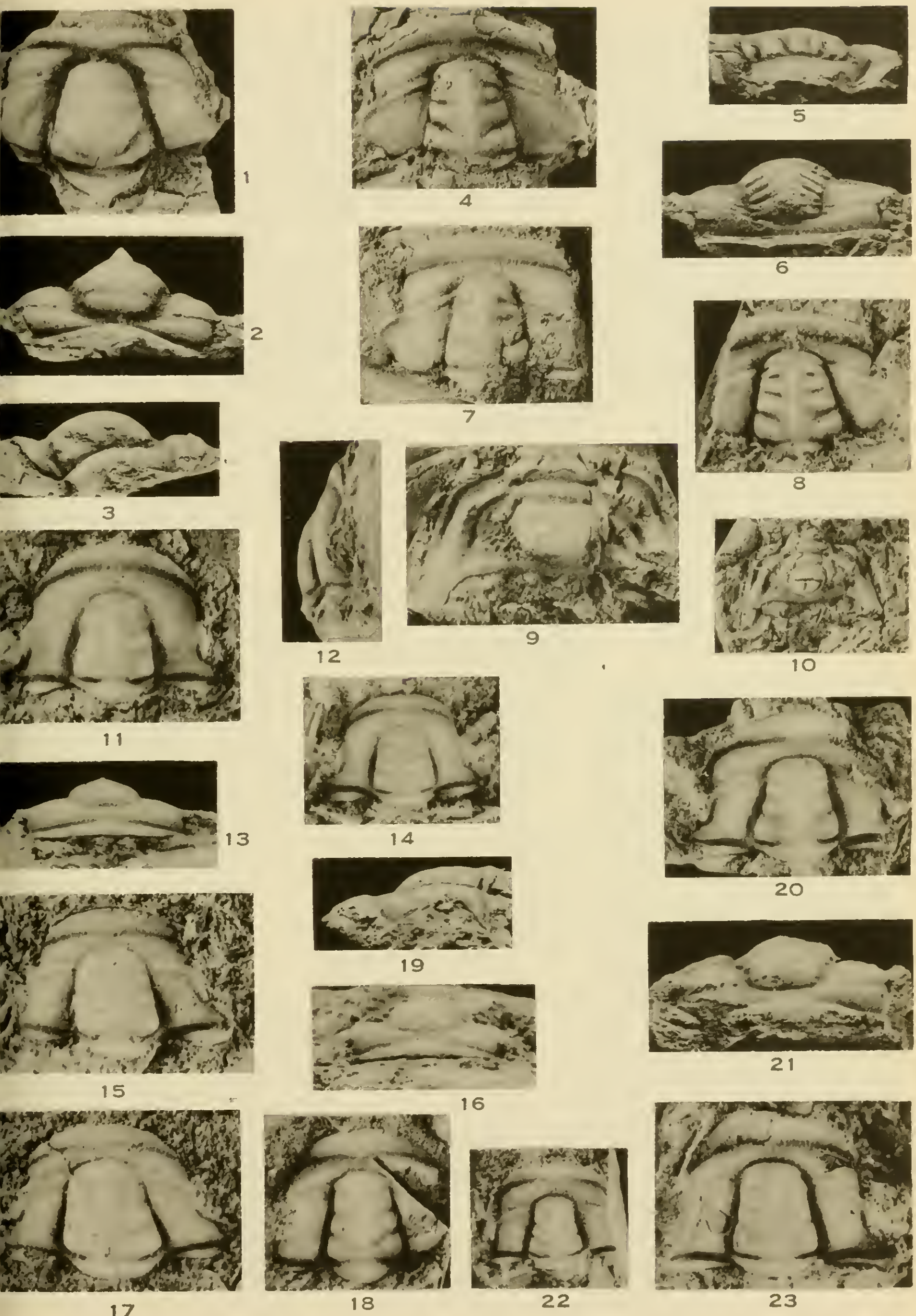

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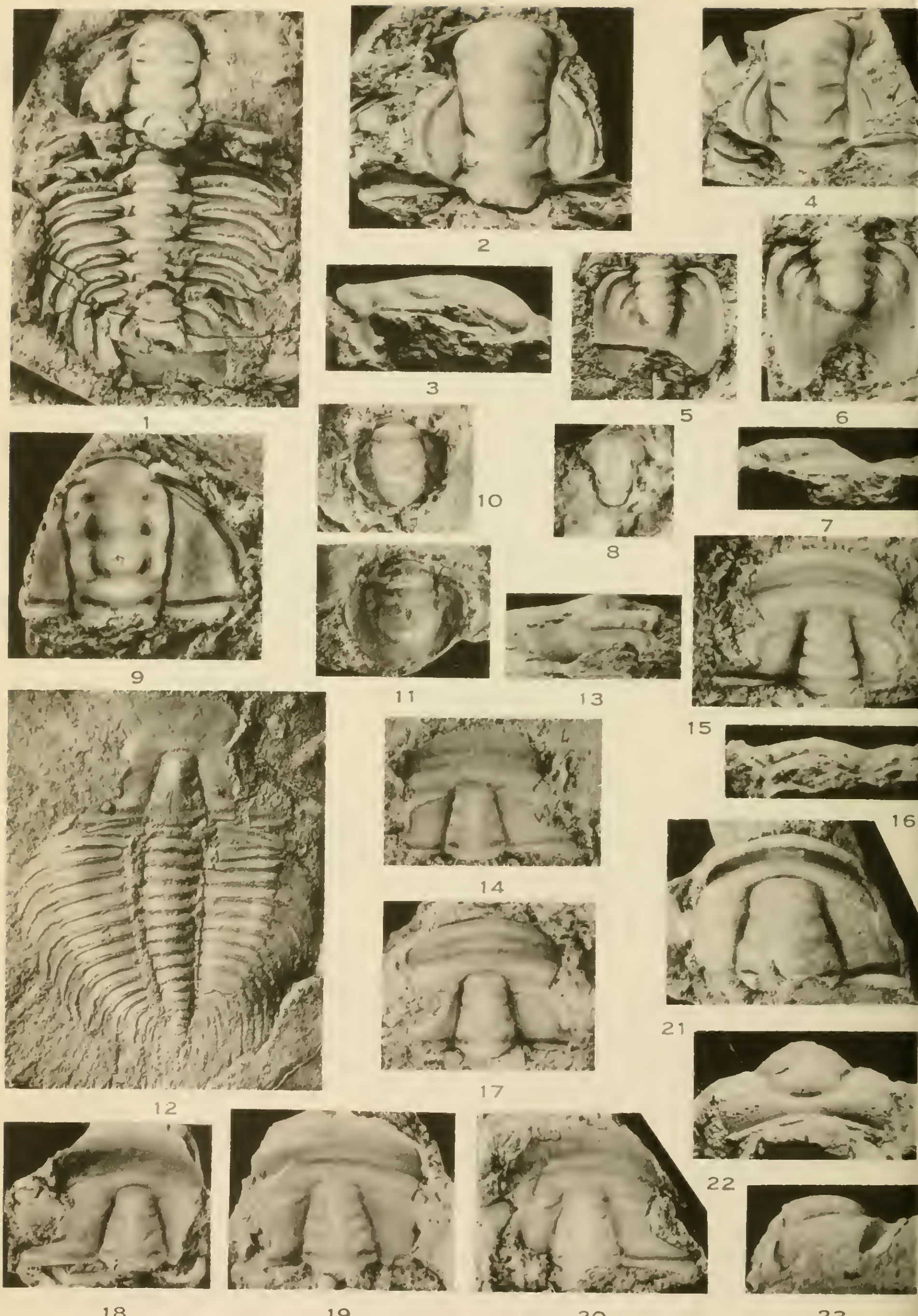

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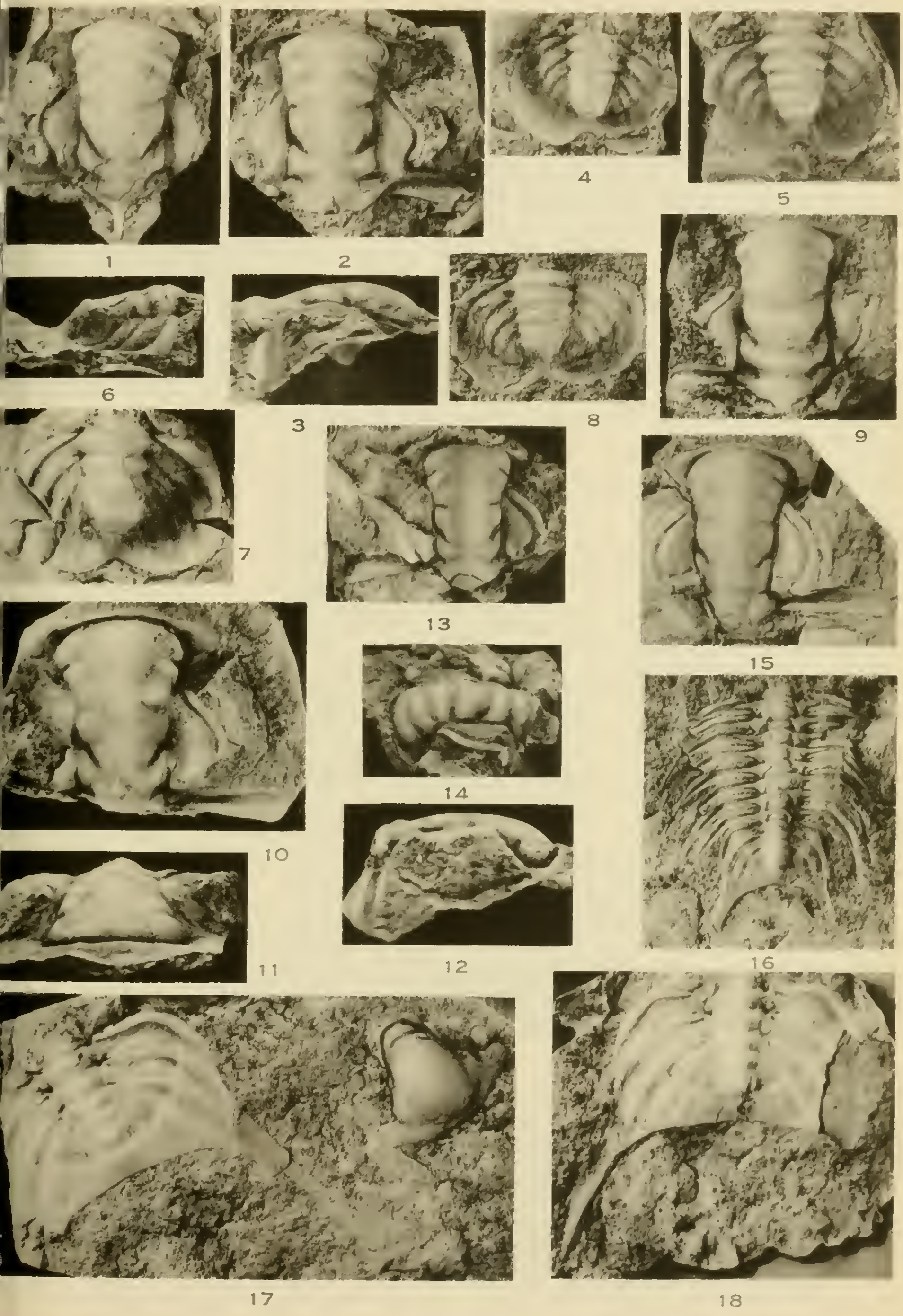

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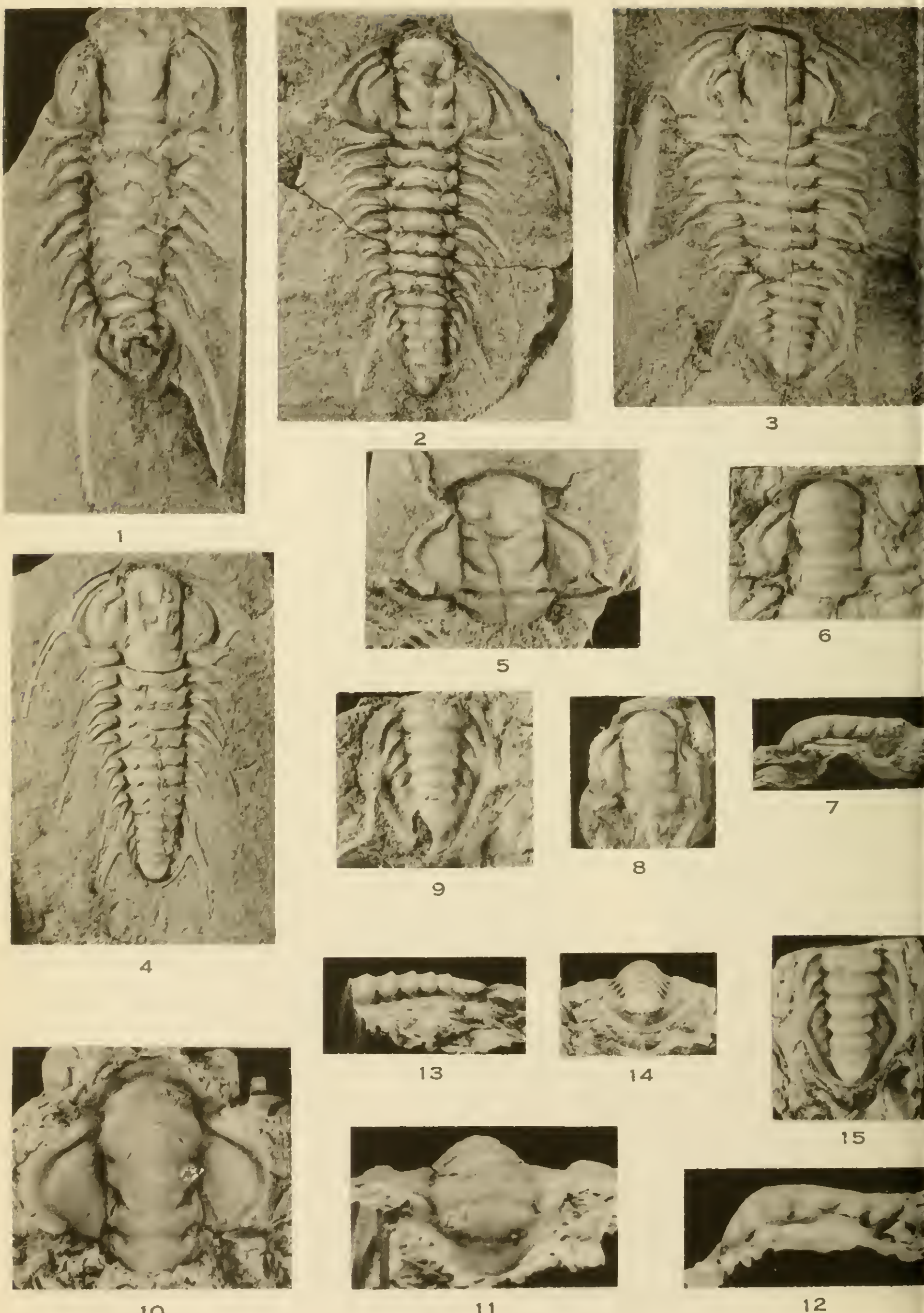

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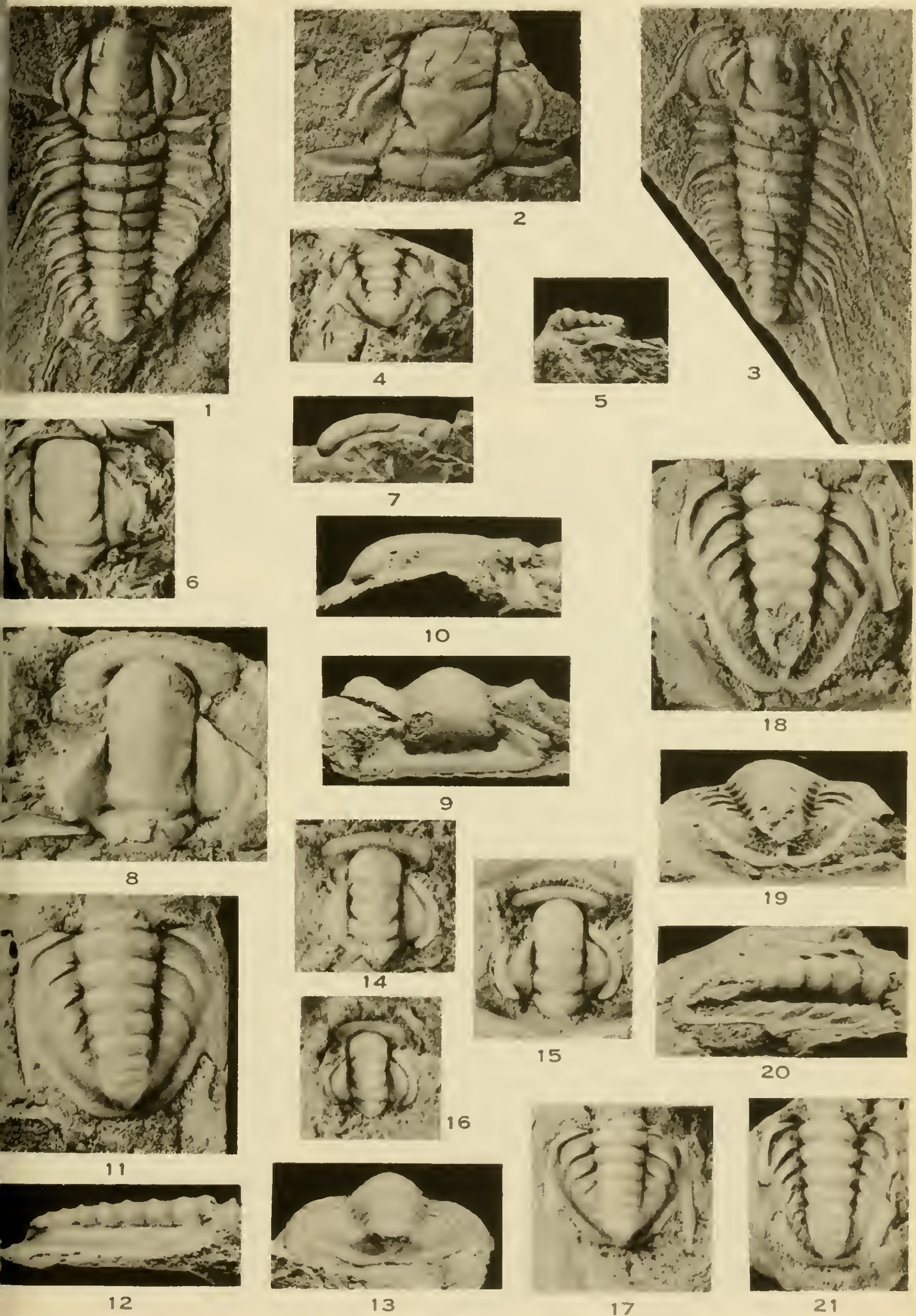
(See explanation of plates at end of text.)



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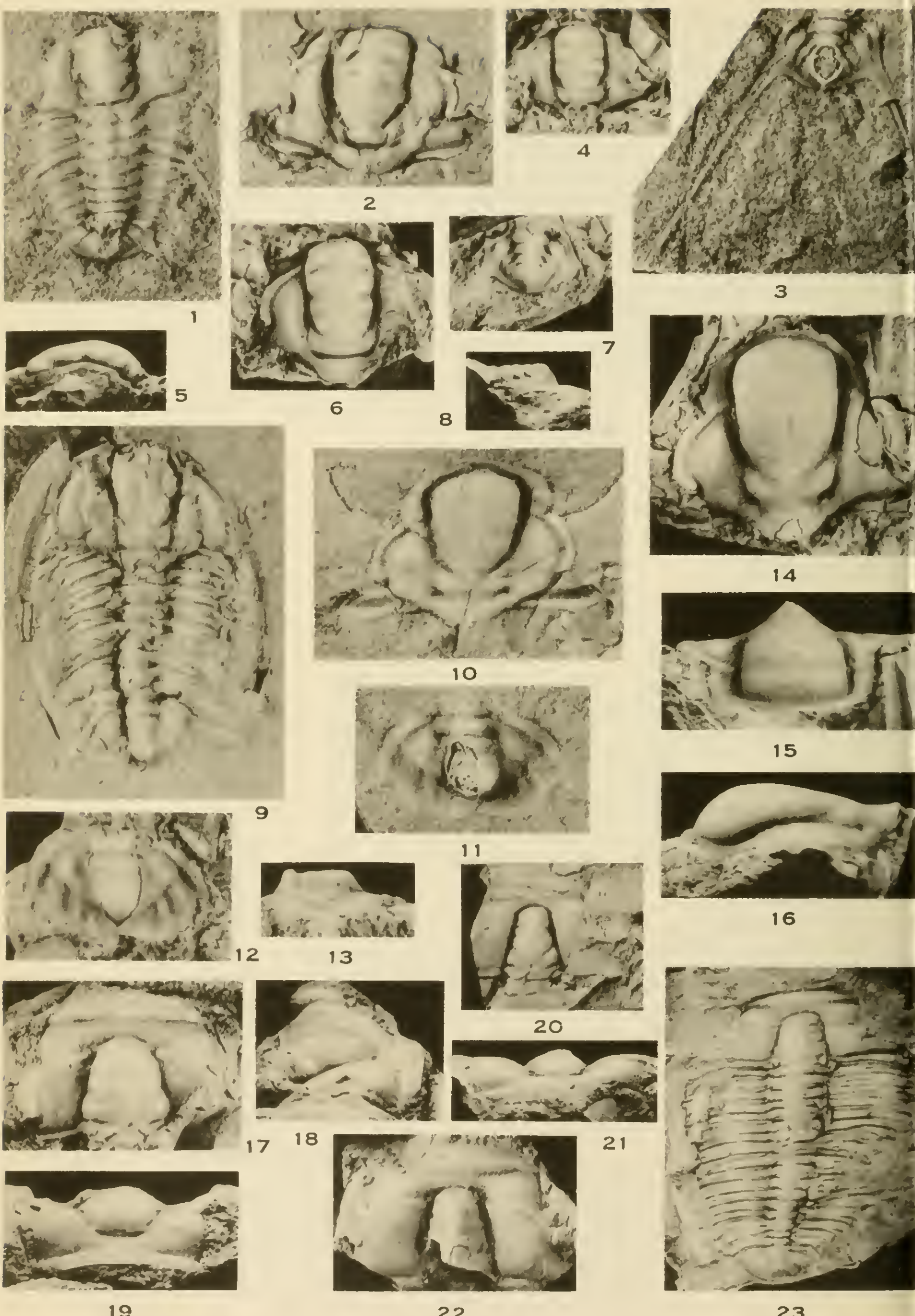

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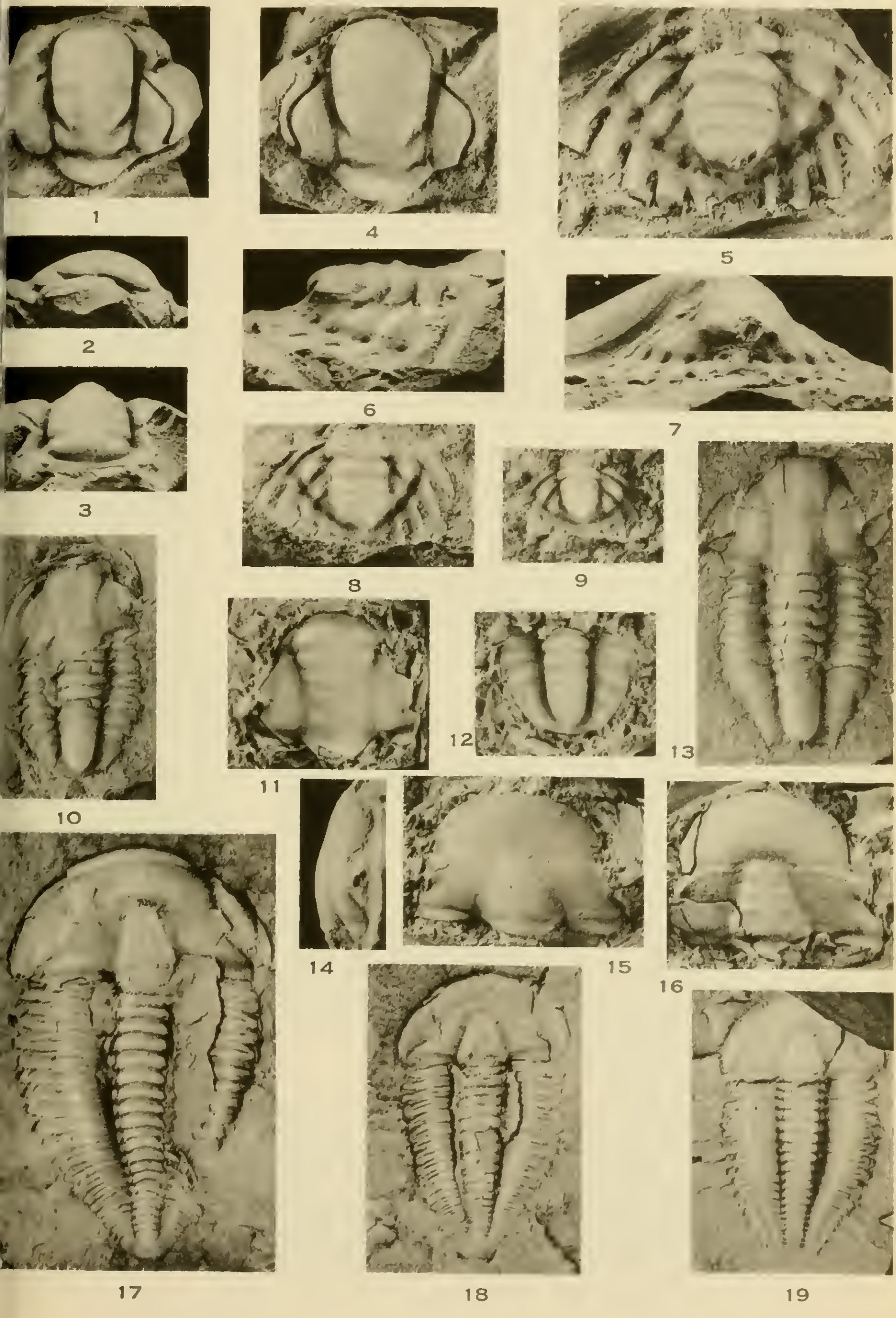

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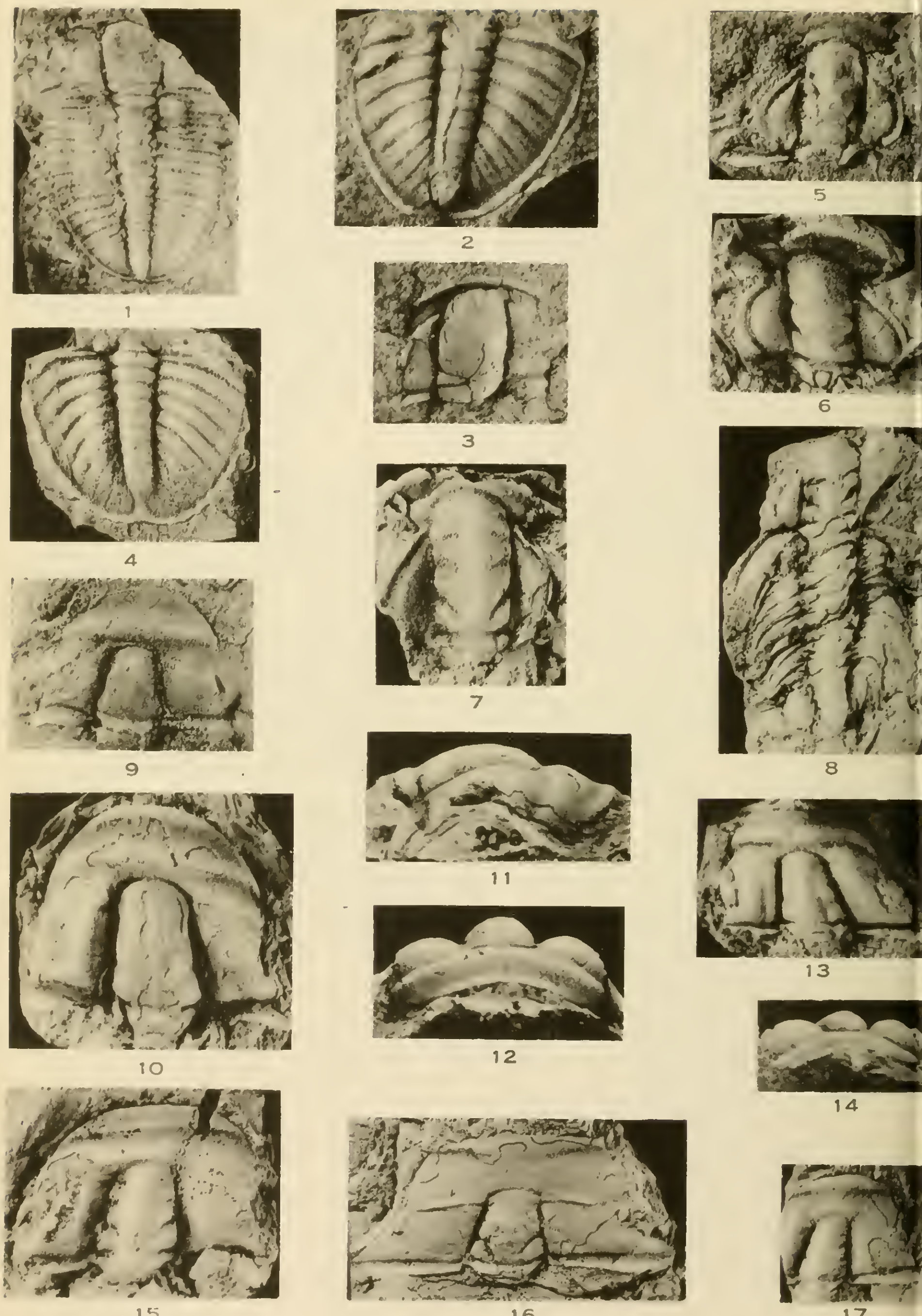

TRILOBITES OF THE ALBERTELLA (?) ZONE

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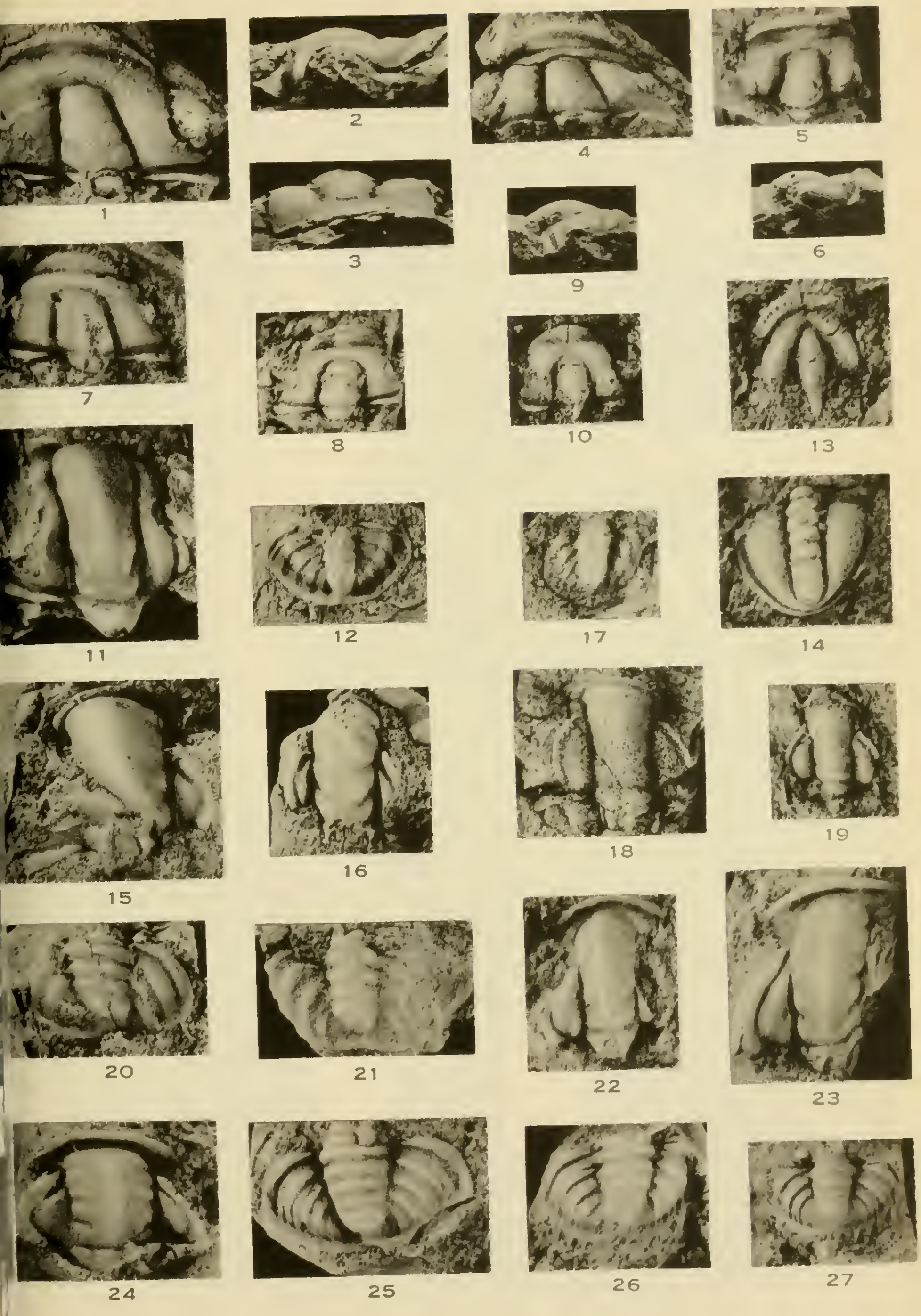

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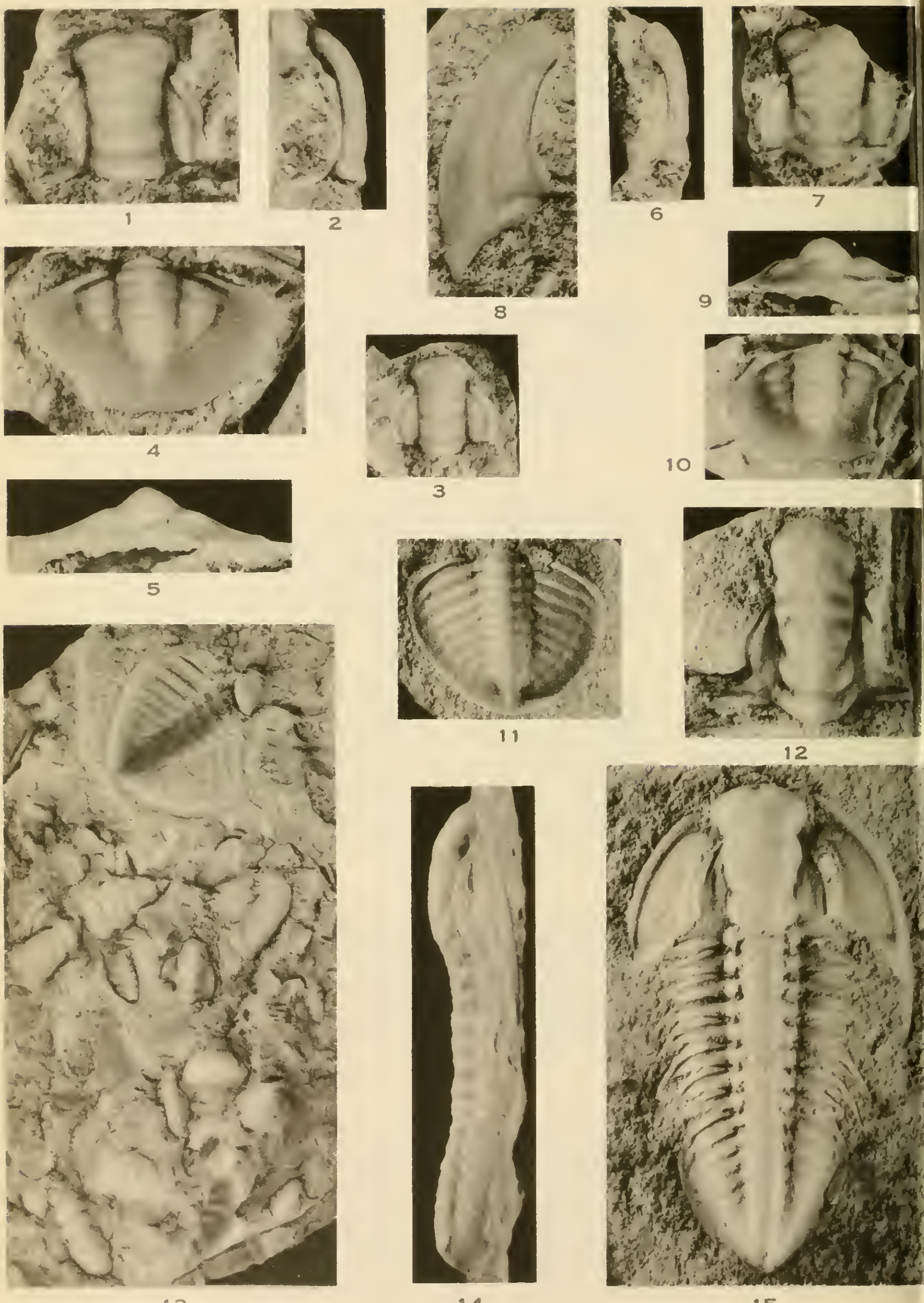

TRILOBITES OF THE GLOSSOPLEURA ZONE

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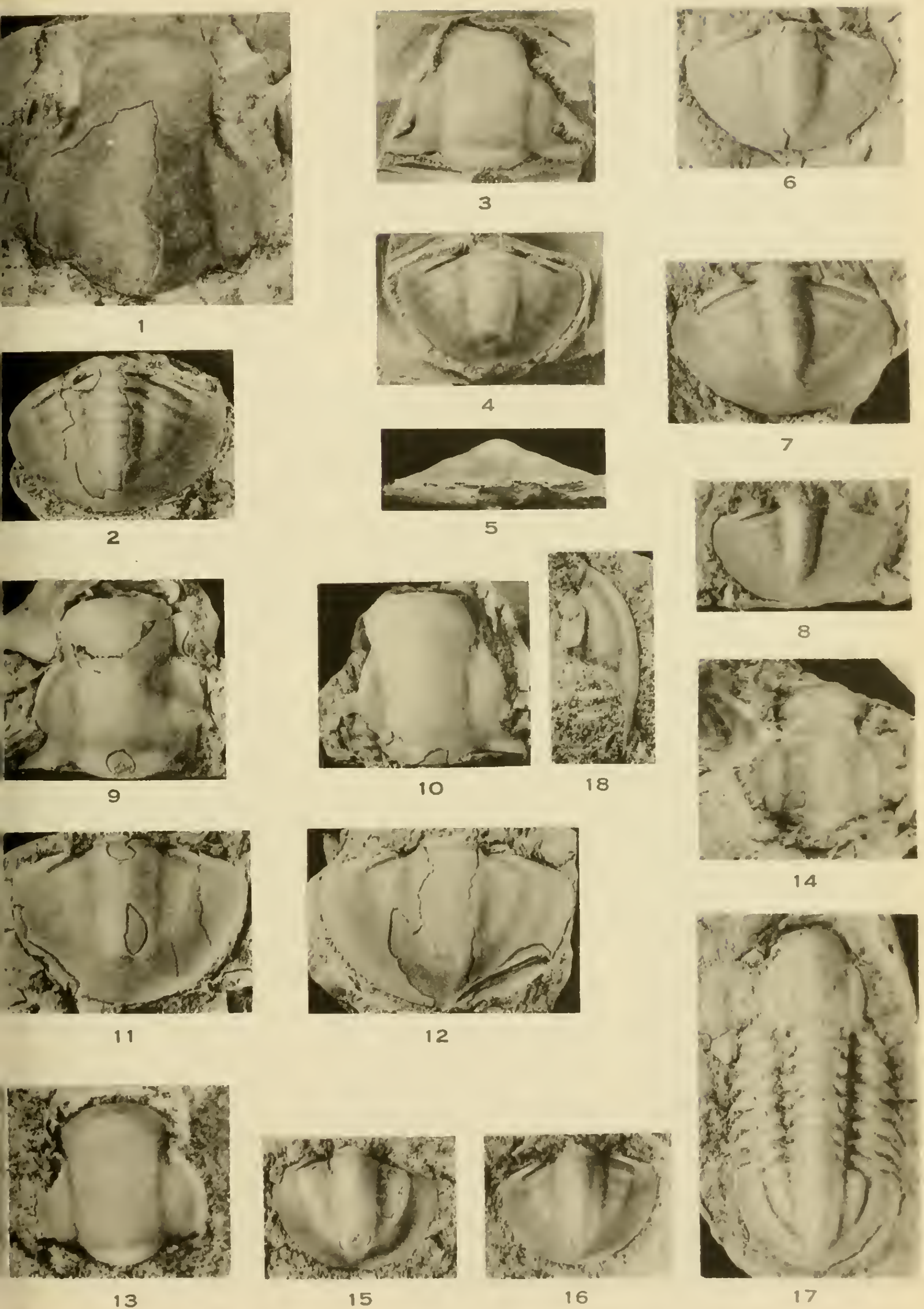

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TRILOBITES OF THE BATHYURISCUS-ELRATHINA ZONE
(BURGESS AND OGYGOPSIS SHALES)

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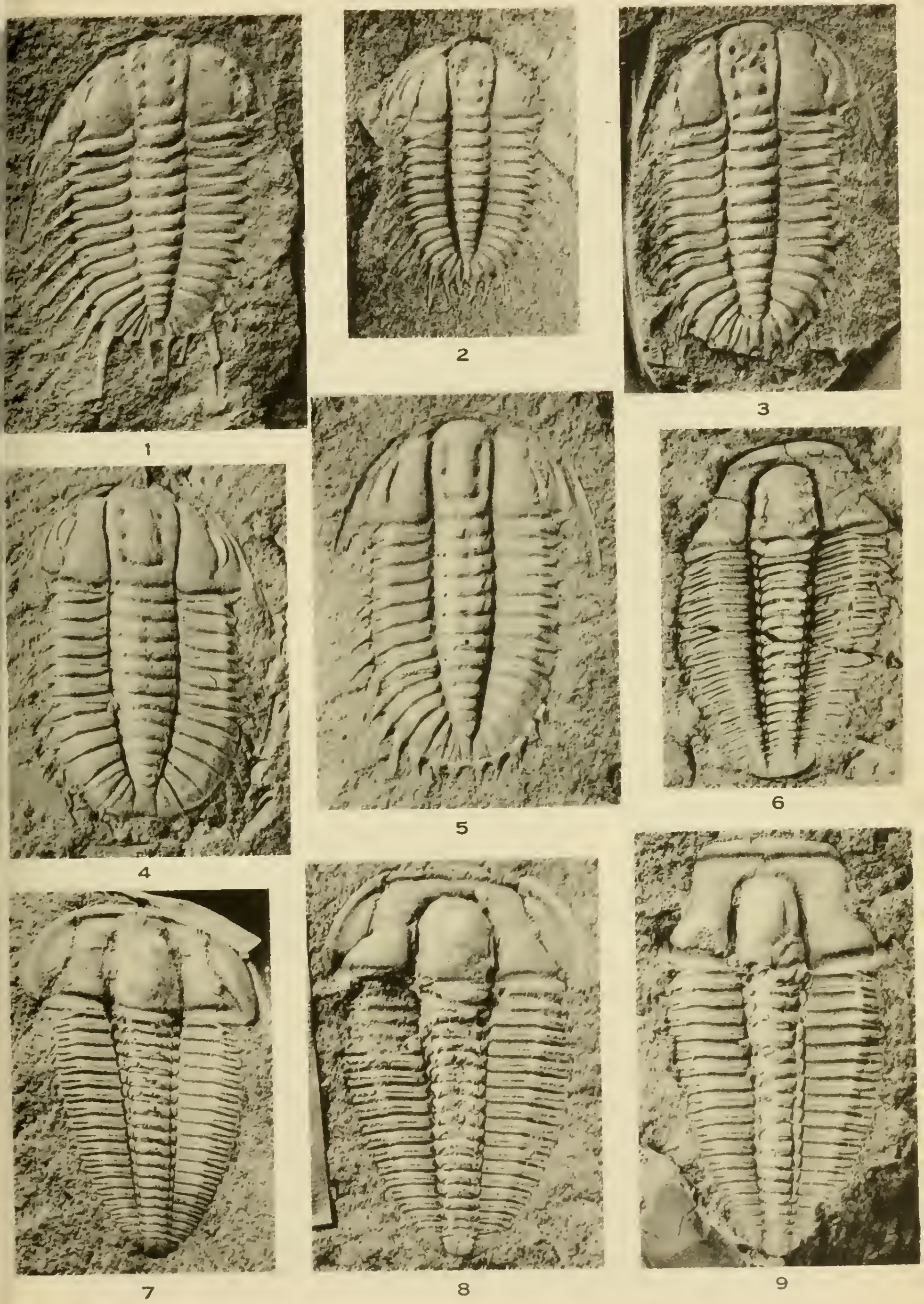

TRILOBITES OF THE BATHYURISCUS-ELRATHINA ZONE
(BURGESS AND OGYGOPSIS SHALES)

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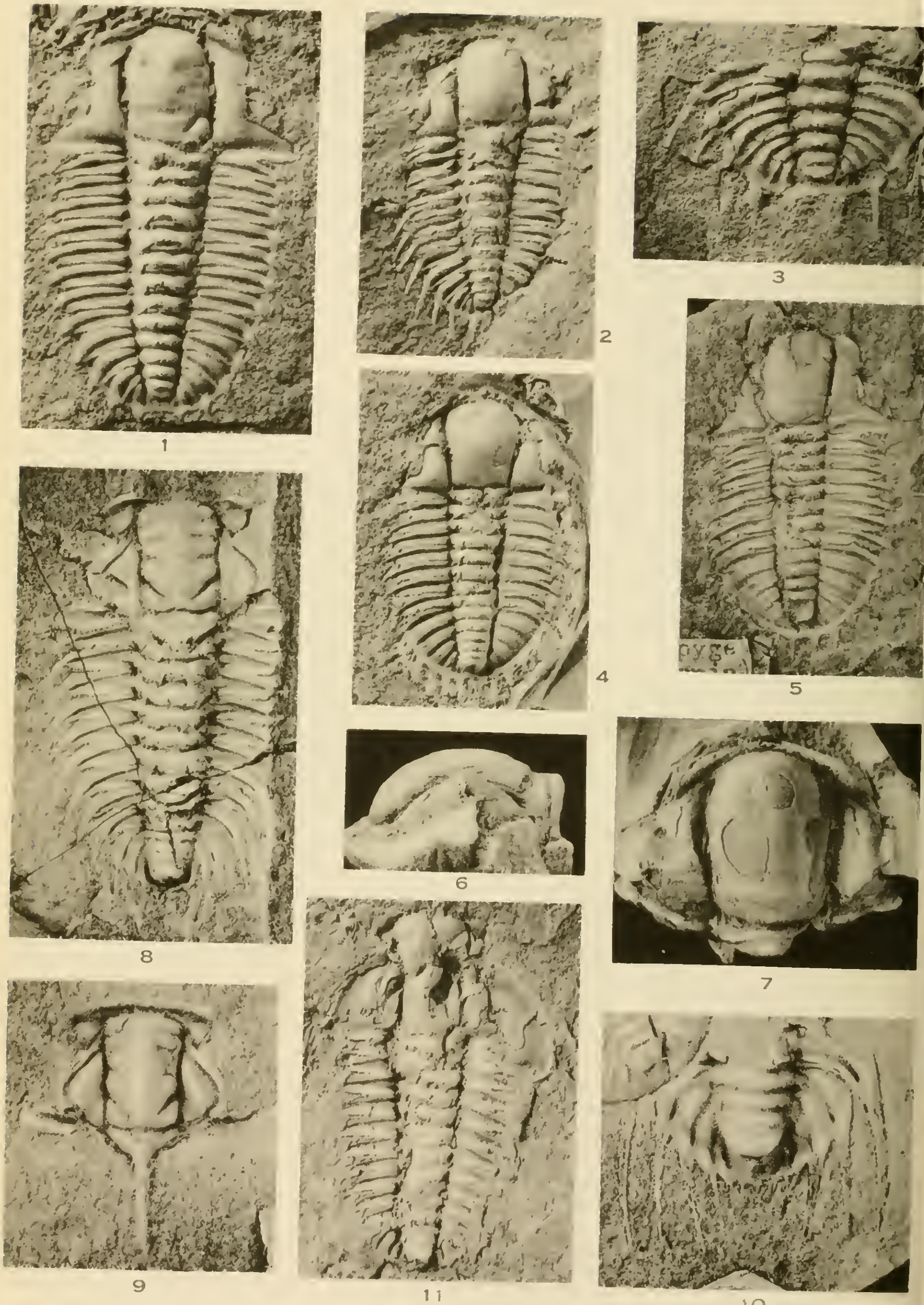
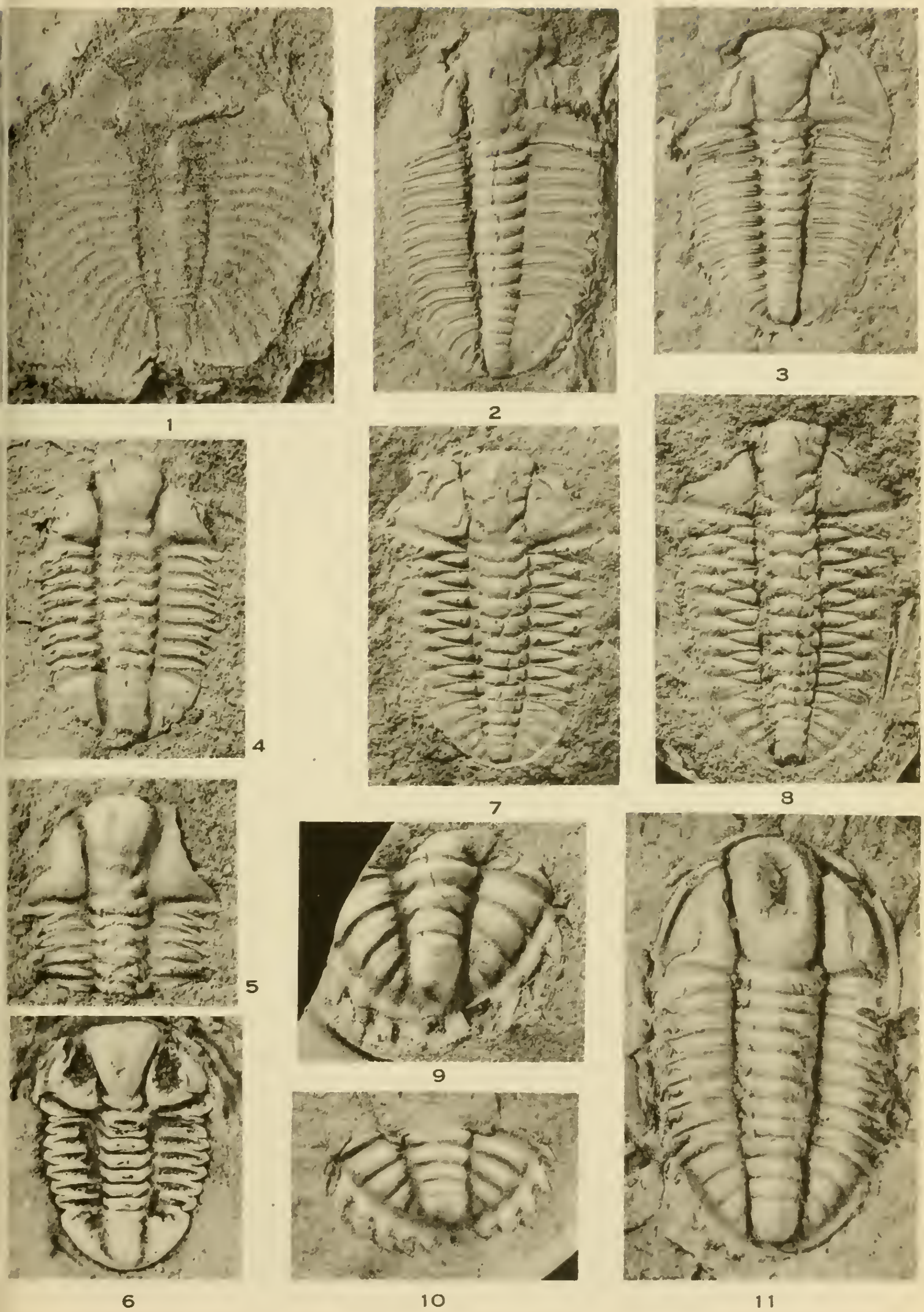


TRILOBITES OF THE BATHYURISCUS-ELRATHINA ZONE
(BURGESS AND OGYGOPSIS SHALES)

(See explanation of plates at end of text.)



TRILOBITES OF THE BATHYURISCUS-ELRATHINA ZONE
(BURGESS AND OGYGOPSIS SHALES)

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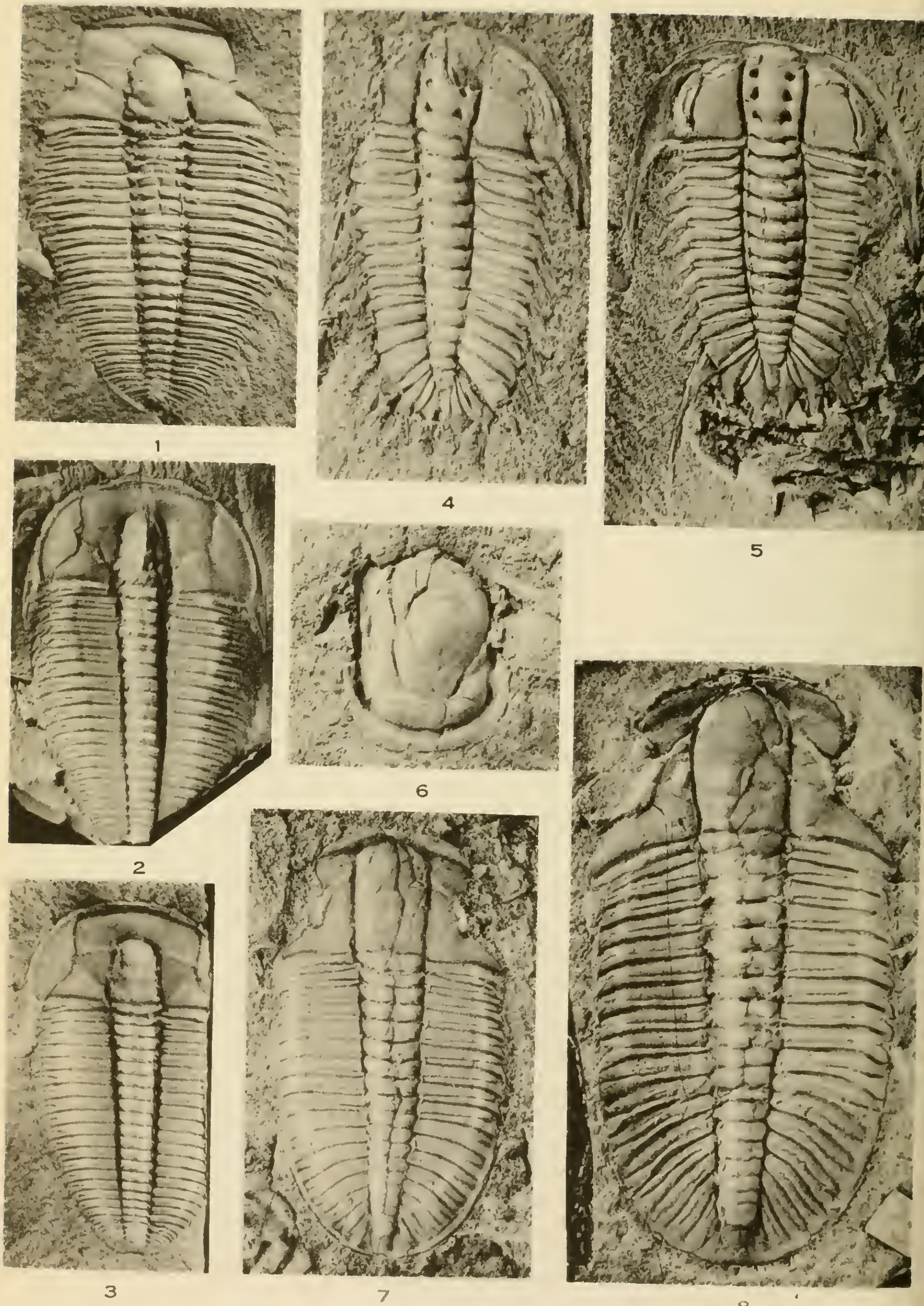

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(BURGESS AND OGYGOPSIS SHALES)

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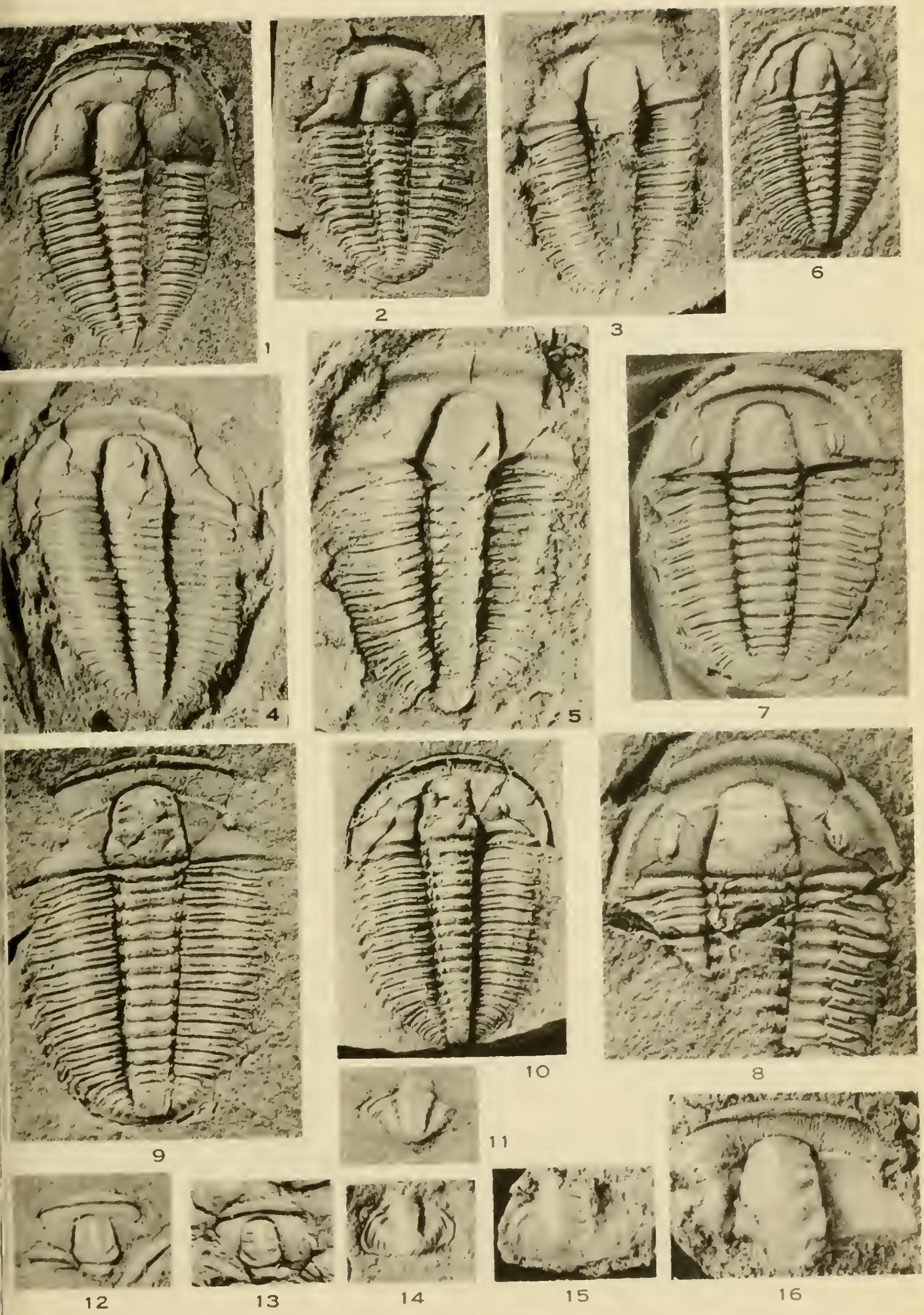

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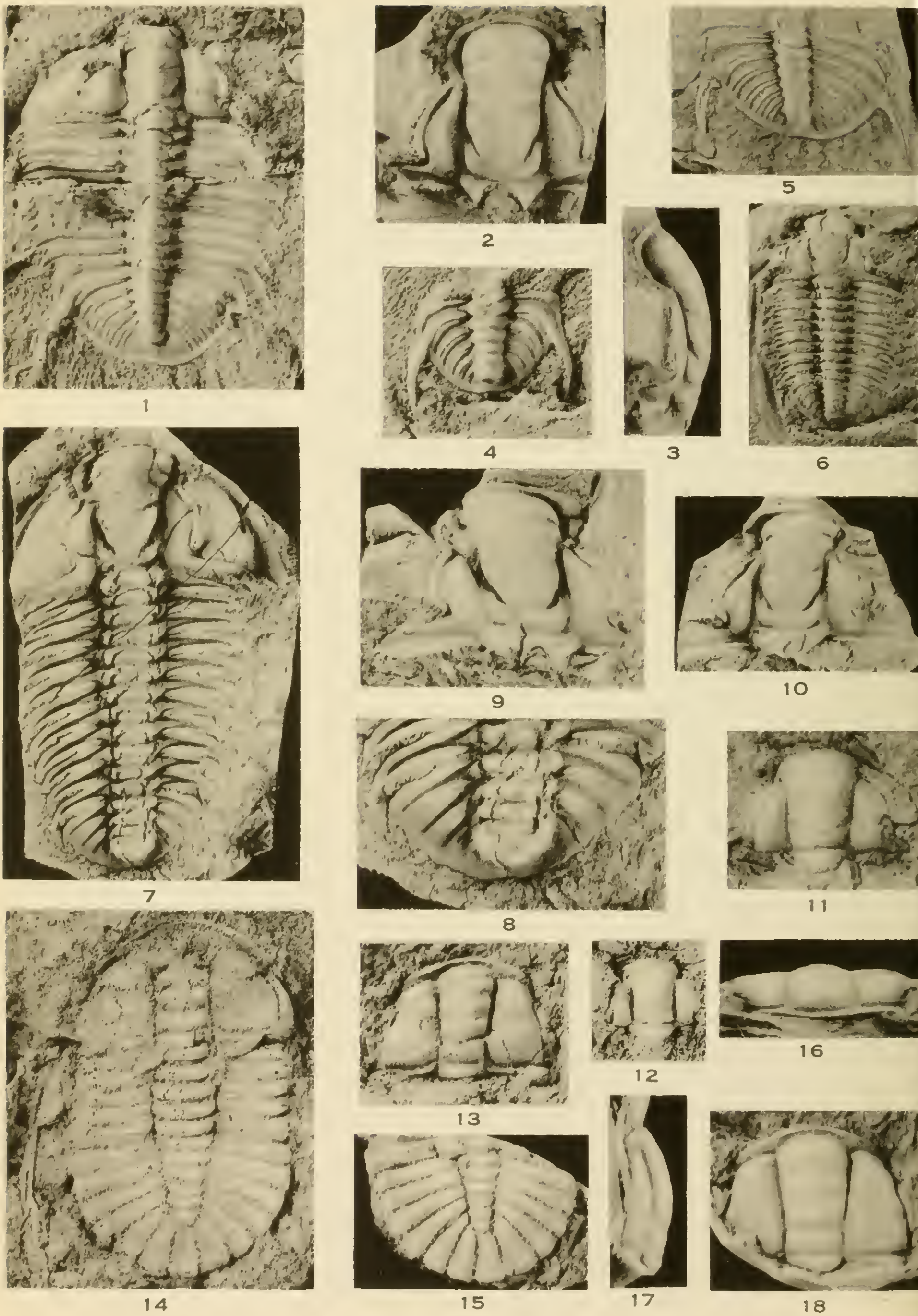

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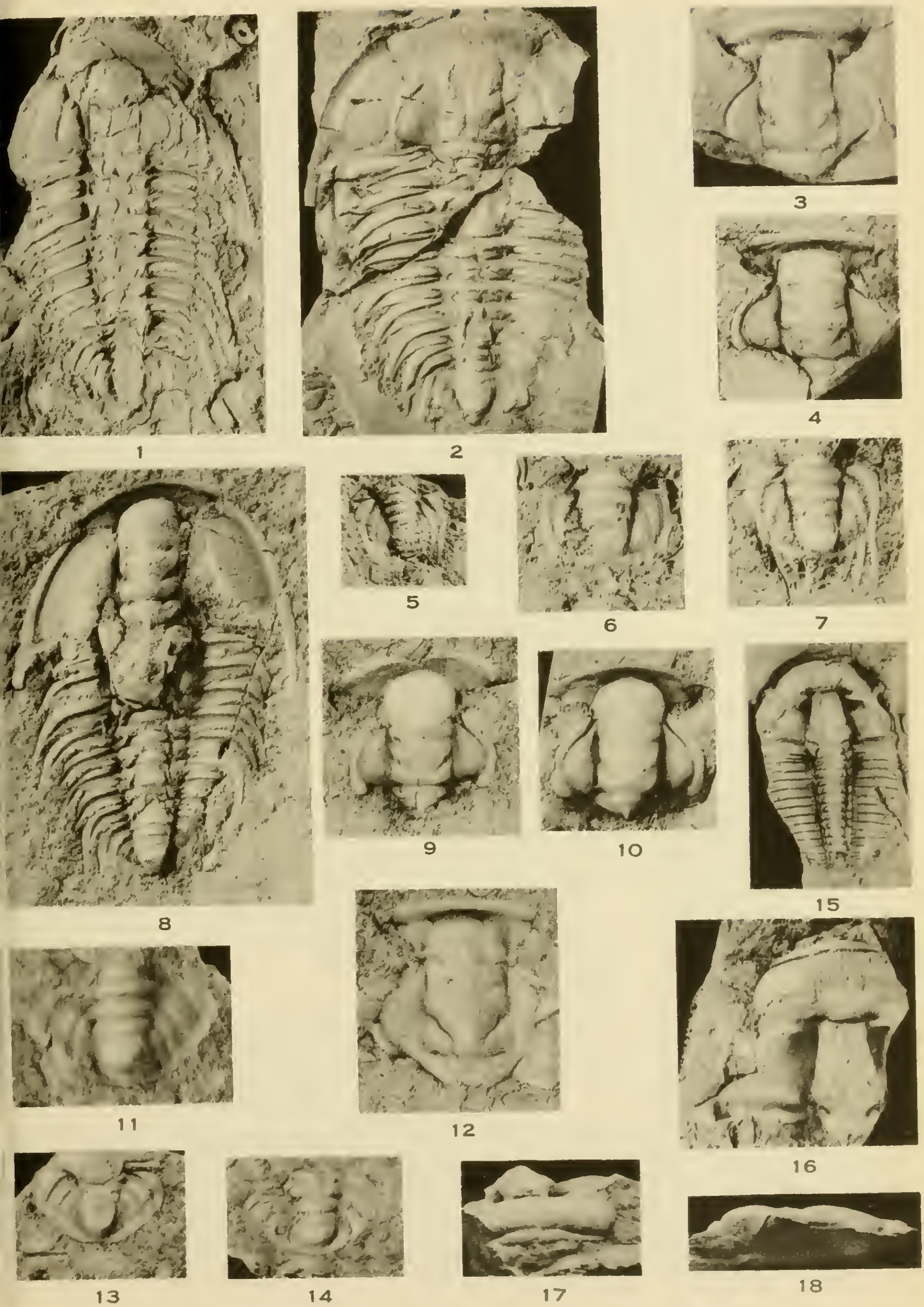

Trilobites of the Bathyuriscus-Elrathina Zone

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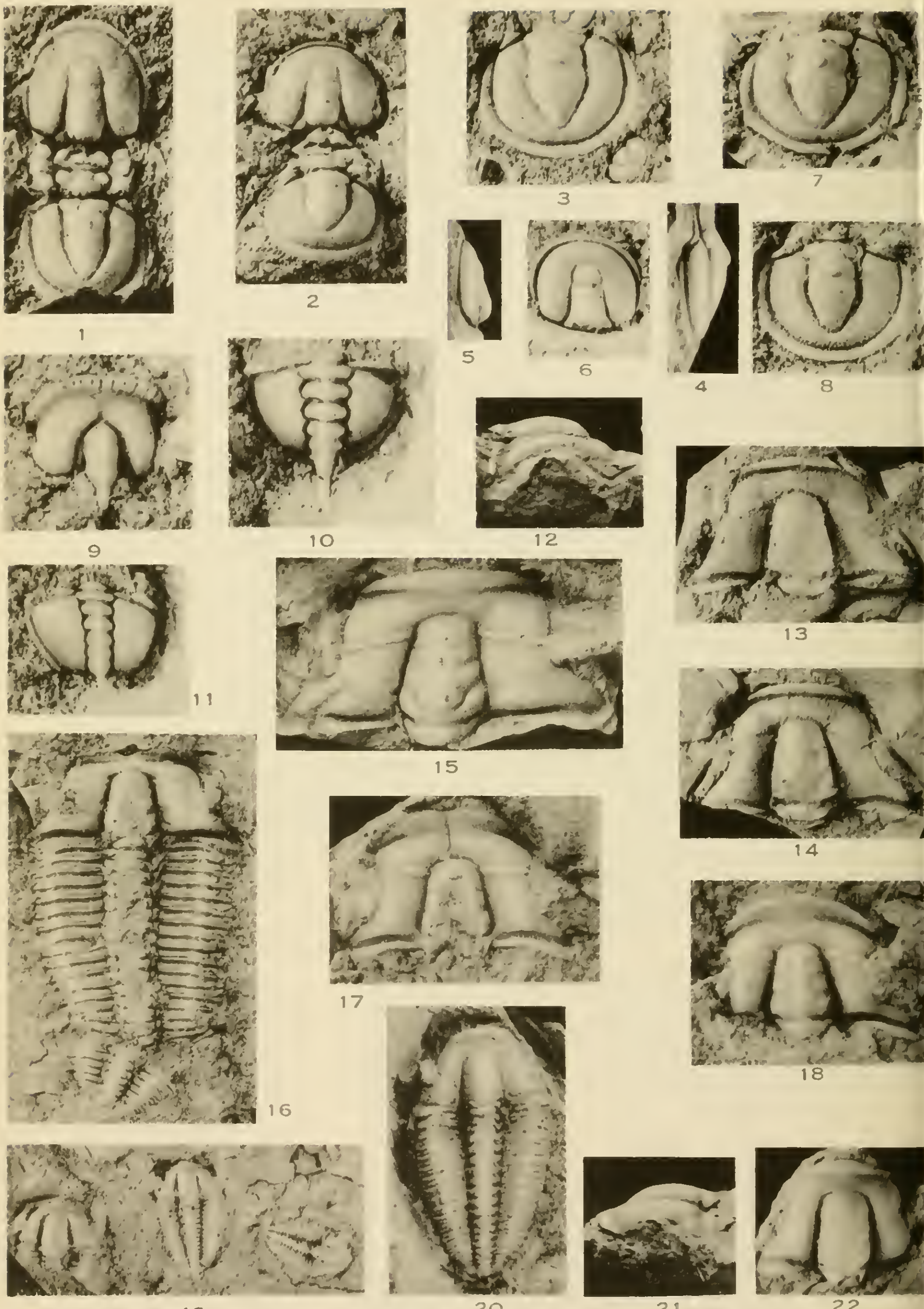

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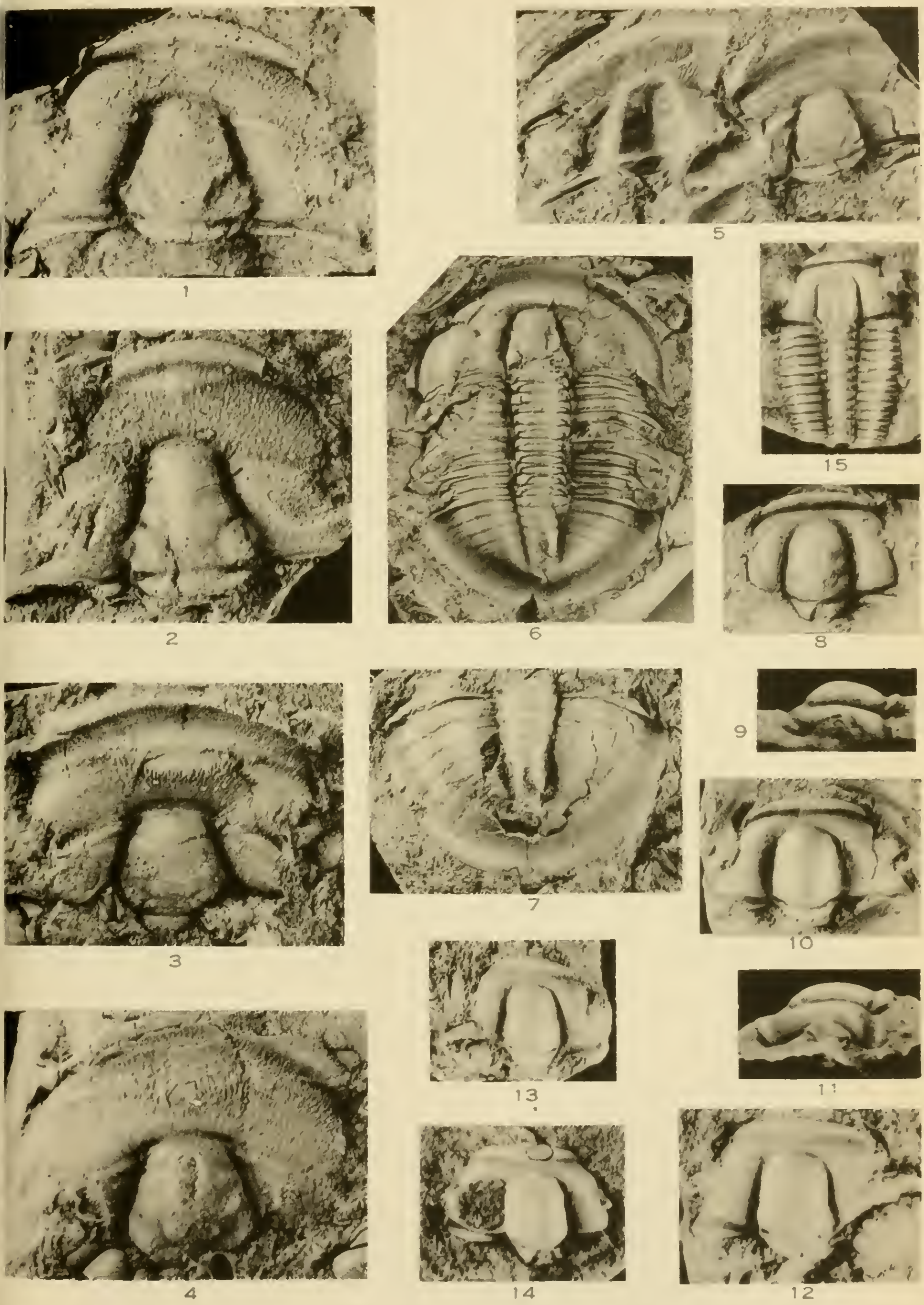

Trilobites of the Bathyuriscus-Elrathina Zone

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