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IV

No. 2.—THE ALBERTELLA FAUNA IN BRITISH
COLUMBIA AND MONTANA

(WITH PLATES 1 TO 7)

BY

CHARLES D. WALCOTT



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INTRODUCTION

When discussing the Dearborn River section in 1908¹ I stated: that the *Albertella* fauna of the Montana sections was placed in the Lower Cambrian as the fauna was strikingly similar to that occurring in the drift blocks which were believed to have come from the lower portion of the Mount Whyte formation of the Mount Bosworth section of British Columbia; that the Mount Whyte formation was

¹ Smithsonian Misc. Coll., Vol. 53, 1908, pp. 202, 203.

placed in the Lower Cambrian owing to the presence of trilobites of the genus *Olenellus*; that the presence of *Albertella* in the Mount Whyte formation was based on the occurrence of numerous trilobitic cranidia that appeared to be generically identical with the cranidia of *Albertella*.

The genus *Albertella* was subsequently identified in the Robson Peak District in a drift block supposed to have been derived from the *Middle Cambrian* Chetang formation limestone about 350 feet above the Hota formation which was referred to the Lower Cambrian.¹

In 1914 Mr. L. D. Burling concluded after a thorough and admirable study that on paleontological evidence the *Albertella* fauna was of Middle Cambrian age and that the specimens of *Olenellus* found in the Mount Whyte formation were examples of recurrence.² On the basis of this conclusion Burling placed the Mount Whyte formation in the Middle Cambrian.

A notice of the discovery of the genus *Albertella* near the line of the North Kootenay Pass by Dr. Frank D. Adams and Mr. W. J. Dick,³ when looking for deposits of phosphate of lime, escaped my attention until Dr. Adams mentioned it to me. There is nothing in the section, however, to indicate the stratigraphic position of the fossils in relation to a known Lower Cambrian fauna.

Recently (January, 1917) through the courtesy of Dr. Adams I have had the opportunity of looking over the fossils. They are not well preserved on the surface of the shaly limestone, but it is possible to tentatively determine the following genera and species:

Agraulos stator Walcott
Vanuxemella nortia Walcott
Albertella bosworthi Walcott
Asaphiscus rossensis Walcott

In 1916 Burling described a locality of the *Albertella* fauna *in situ* on Mount Bosworth and stated that the fauna was of Middle Cambrian age.⁴

IDENTIFICATION OF THE GENUS ALBERTELLA

At the time of the preliminary identifications of the faunas, in connection with the publication of "Cambrian Sections of the Cordil-

¹ Smithsonian Misc. Coll., Vol. 57, 1913, p. 338.

² Canadian Geol. Surv., Museum Bull., No. 2, Geol. Ser., No. 17, 1914, p. 36.

³ Commission of Conservation, Canada, Discovery of Phosphate of Lime in the Rocky Mountains. 8vo pamphlet. Ottawa, 1915, p. 13.

⁴ Summed up in article in American Journal Science, Dec., 1916, 4th Ser., Vol. 42, pp. 469-472.

leran Area," in 1908,¹ I did not fully appreciate that trilobites with almost identical cranidia might have a dissimilar thorax and pygidium and belong to quite distinct genera. This conclusion came later, when studying groups of Cambrian trilobites retaining their entire dorsal shield so that the cephalon, thorax, and pygidium of many genera might be compared.²

During the winter of 1915-16 I studied all the material available of the genus *Bathyriscus*, and found that my previous conception of that genus was inaccurate,³ and that species from the Mount Whyte formation I had referred to a new genus, *Bornemannia*,⁴ were to be included under a subgenus of *Bathyriscus*.⁵ Another result was to question the identification and presence of the genus *Albertella* in the Mount Whyte formation as it was based only on specimens of the cranidium. This was not carried further before I left for the field in June, 1916, but was taken up on my return in October. This review has now led to the elimination of the genus *Albertella* from the lists of the fauna of the Mount Whyte formation and this includes the lists from localities 35e and 57e as published in the description of *Bathyriscus (Poliella) primus*.⁵

The available field notes and fossils of the Mount Whyte formation are now being studied, but it may be necessary for me to visit some of the typical localities before expressing an opinion as to the desirability of including a portion of the Mount Whyte formation in the Middle Cambrian as so strongly urged by Burling.⁶

STRATIGRAPHIC POSITION

The exact stratigraphic position of the typical *Albertella* fauna was unknown to me when I went to the field in June, 1916, although Burling had stated in a general way that he had found it on Mount Bosworth in the Cathedral formation and I had a specimen from the Cathedral limestone of Castle Mountain. The fauna was originally referred to the Lower Cambrian,⁷ but neither in British Columbia nor Montana was there at that time a known occurrence of the fauna

¹ Smithsonian Misc. Coll., Vol. 53, 1908, pp. 167-220.

² See *Asaphiscus*. Smithsonian Misc. Coll., Vol. 64, 1916, pp. 382, 383.

³ Smithsonian Misc. Coll., Vol. 64, 1916, p. 332.

⁴ Idem, p. 352.

⁵ Idem, p. 353.

⁶ Geol. Surv. Canada, Museum Bull. No. 2, Geol. Ser., No. 17, 1914, pp. 112-115.

⁷ Smithsonian Misc. Coll., Vol. 53, 1908, p. 202.

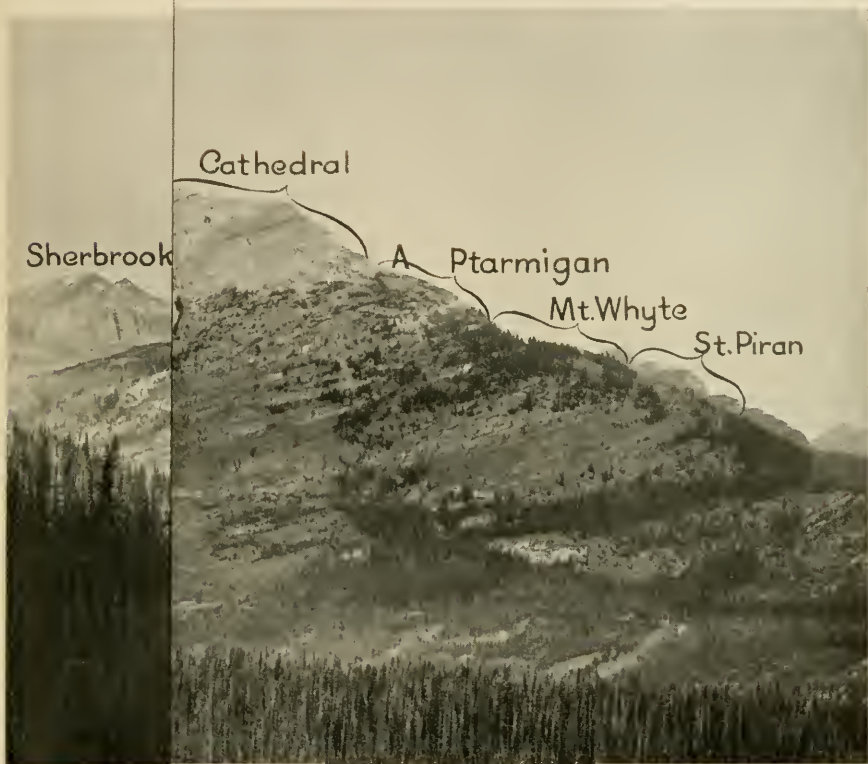
as a whole *in situ* in a section that proved to me beyond question its stratigraphic relation.

The position of the fauna found in drift blocks in British Columbia was assumed from the identification of cranidia in the Mount Whyte formation, and this was also extended to a similar fauna found in broken and isolated sections in Montana. During several field seasons in Alberta and British Columbia a general outlook was kept for traces of the *Albertella* fauna, but at no time was it convenient for me to go back to Mount Bosworth to systematically search for it, but in July, 1916, I began a search for the fauna in the Mount Whyte formation and the superjacent Cathedral limestones. The latter were included as in 1907 the cranidium and pygidium of a species of *Albertella* were found in the limestones of the Cathedral formation 275 feet (84.6 m.) above the top of the Lower Cambrian on the east shoulder of Castle Mountain, Alberta, which is 19.5 miles (31.2 km.) east-southeast of the Ross Lake section of 1915 and I had also noted the presence of the cranidium and pygidium of *Albertella bosworthi* in debris of the Chetang formation which was referred to the Middle Cambrian.¹

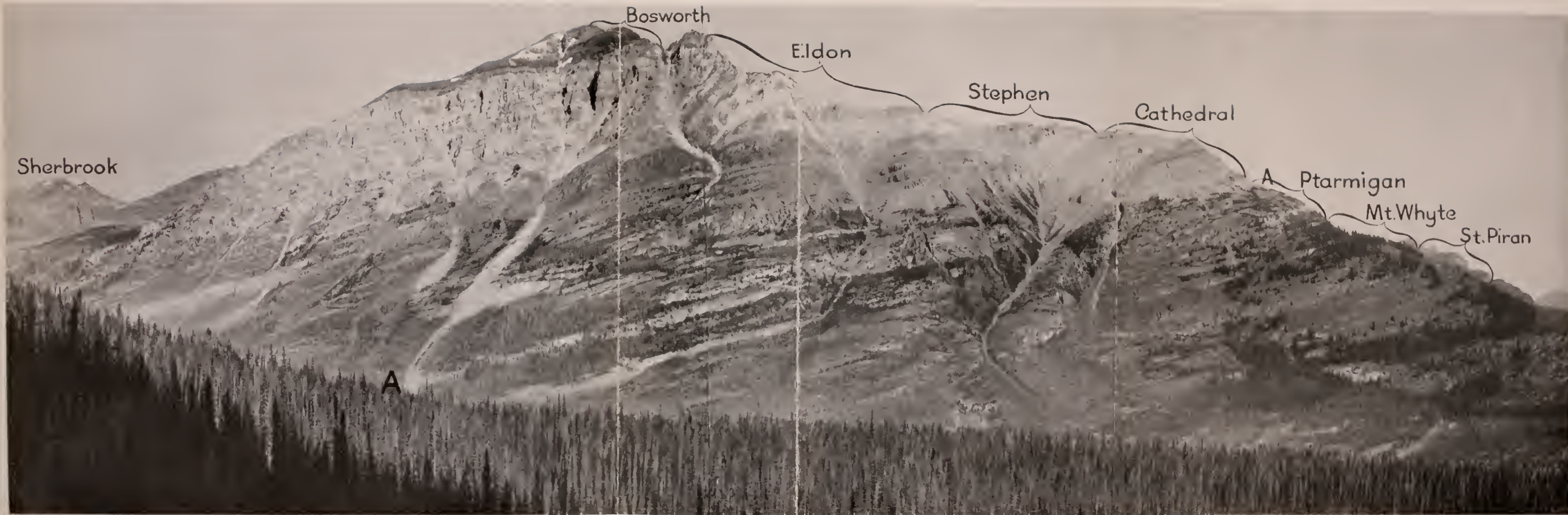
We knew from the collection of 1907 at Castle Mountain and from Burling's find on Mount Bosworth that the genus was present in the Middle Cambrian Cathedral limestone, but I did not know that the genus *Albertella* was not present in the Mount Whyte formation. I have not discussed the finds in the Middle Cambrian heretofore as I was waiting for the time when the *Albertella* fauna of Mount Bosworth should be accurately located in the section.

The first section examined was that of the eastern ridge of Mount Assiniboine 18 miles (28.8 km.) southwest of Banff, Alberta, but without finding any trace of the fauna. Section after section was then studied on the main range to the north and northwest, but it was not until August 24 that the *Albertella* fauna was located *in situ* in a hanging glacier cirque above Ross Lake and 1 mile (1.6 km.) south-southwest of Stephen on the Canadian Pacific Railway. After locating the stratigraphic horizon of the siliceous shale and included *Albertella* fauna I crossed to the north side of the broad Kicking Horse Pass and found it after a day's search *in situ* on the southern slope of Mount Bosworth west of Burling's locality. The band of shale is from 7 to 11 feet (2 to 3.3 m.) in thickness, and the little terrace formed by it is almost always covered by dirt, broken rock,

¹ Smithsonian Misc. Coll., Vol. 57, 1913, p. 338.



Panoramic view of the best exposed Cambrian sections in the Rocky Mountains.¹
 Including 4 m.) in thickness of strata are exposed. The approximate position of the foot of Burling is on the right toward or near A. (Photograph by Walcott, 1916.)



Panoramic view of Mount Bosworth, on the Continental Divide, from Ross Lake cirque, looking north across the Kicking Horse Pass. This is one of the best exposed Cambrian sections in the Rocky Mountains.¹

Including the Lower Cambrian sandstones on the right (east) and the Upper Cambrian Sherbrook limestones on the left (west) over 12,000 feet (3,657.4 m.) in thickness of strata are exposed. The approximate position of the formation is indicated and the *Albertella* zone by *A. A.* We found the latter fauna *in situ* on the left at *A*, and I suppose that the locality of Burling is on the right toward or near *A*. (Photograph by Walcott, 1916.)

¹ Smithsonian Misc. Coll., Vol. 53, 1908, pp. 204-217.

trees, and brush. This so effectually conceals the band of shale that unless one knows just where to look there is little chance of finding it except in some such favorable locality as that above Ross Lake or the two known places on Mount Bosworth. The *Albertella* fauna is probably present all the way from Mount Assiniboine to Ross Lake, but conditions were not favorable for its discovery either in shale or limestone.

Stratigraphically the fauna as now known has a limited vertical range and a rather wide geographic distribution. The Ross Lake shale has a thickness of 7 feet (2 m.) in the Ross Lake section and about 10 feet (3 m.) on Mount Bosworth. *Albertella* also occurs in the adjoining limestone, but its vertical range there is unknown.

The genus is known from the Robson Peak District about 200 miles (320 km.) north-northwest of Mount Bosworth, also about 285 miles (456 km.) to the south in the vicinity of Gordon Mountain in the state of Montana.¹

Albertella helena occurs in Montana and at Mount Bosworth, and *Albertella bosworthi* in the Robson Peak District.

ROSS LAKE SECTION

Ross Lake is situated on the south side of the Canadian Pacific Railway 1 mile (1.6 km.) south-southwest of Stephen Station on the Continental Divide. The section was measured on the northeast and northwest sides of the amphitheater above Ross Lake on the north end of the northern spurs of Popes Peak. The base of the Mount Whyte formation rests on the purplish-colored massive quartzites of the St. Piran formation on the west slope of the east spur and about 500 feet (152 m.) above Ross Lake; the summit of the section as given here is on the east face of the west spur.

MIDDLE CAMBRIAN

CATHEDRAL FORMATION

Cliffs of massive-bedded rough arenaceous limestone rise one above the other to the summit of the ridge. At Mount Bosworth on the north side of the Kicking Horse Pass the Cathedral limestones have a thickness of 1,086 feet (334 m.) exclusive of a lower division of 509 feet² (156.6 m.), which I have now included in a recently recognized formation named Ptarmigan from its typical section on Ptarmigan Mountain above Ptarmigan Pass, 8 miles (12.8 km.) east-northeast of Ross Lake.

¹ Smithsonian Misc. Coll., Vol. 53, 1908, pp. 18-22.

² This is 1c-f of the Cathedral formation section of 1908 (Smithsonian Misc. Coll., Vol. 53, 1908, p. 212).

PTARMIGAN FORMATION

Feet

1. Thin-bedded, more or less arenaceous and mottled limestone... 155
 1a. Bluish-gray limestone in thin irregular layers interbedded in a greenish siliceous shale..... 3
 2. Greenish and dark gray, compact siliceous shale weathering to a light gray color when long exposed. The shale forms compact, solid, hard layers from 2 to 3 feet (0.6 to 0.9 m.) thick that break first into blocks on joint planes and then split up into shale on long exposure to frost and water..... 7

This is the Ross Lake shale member of the Ptarmigan formation which is characterized by the *Albertella* fauna which is most abundant in many places in it. At the Ross Lake section the fauna includes (Loc. 63j) :

Siliceous sponge spicules
Eocystites ? sp. ?
Micromitra (*Paterina*) *wapta* Walcott
Obolus parvus Walcott
Acrothele colleni Walcott
Wimanella simplex Walcott
Hyolithellus flagellum (Matthew)
Hyolithes cecrops Walcott
Agraulos stator Walcott
Olenopsis cf. *americanus* Walcott
Vanuxemella nortia Walcott
Albertella bosworthi Walcott
Albertella helena Walcott
Bathyriscus rossensis Walcott

On the slope of Mount Bosworth the shale is a little thicker and we collected from it *in situ* (Loc. 63m.) :

Acrothele colleni Walcott
Wimanella simplex Walcott
Hyolithes cecrops Walcott
Agraulos stator Walcott
Vanuxemella nortia Walcott
Ptychoparia sp. undt.
Olenopsis cf. *americanus* Walcott
Albertella bosworthi Walcott
Albertella helena Walcott
Bathyriscus rossensis Walcott

From the boulders (Loc. 35c) found below the outcrop on the south slope of Mount Bosworth in earlier years there have been collected :

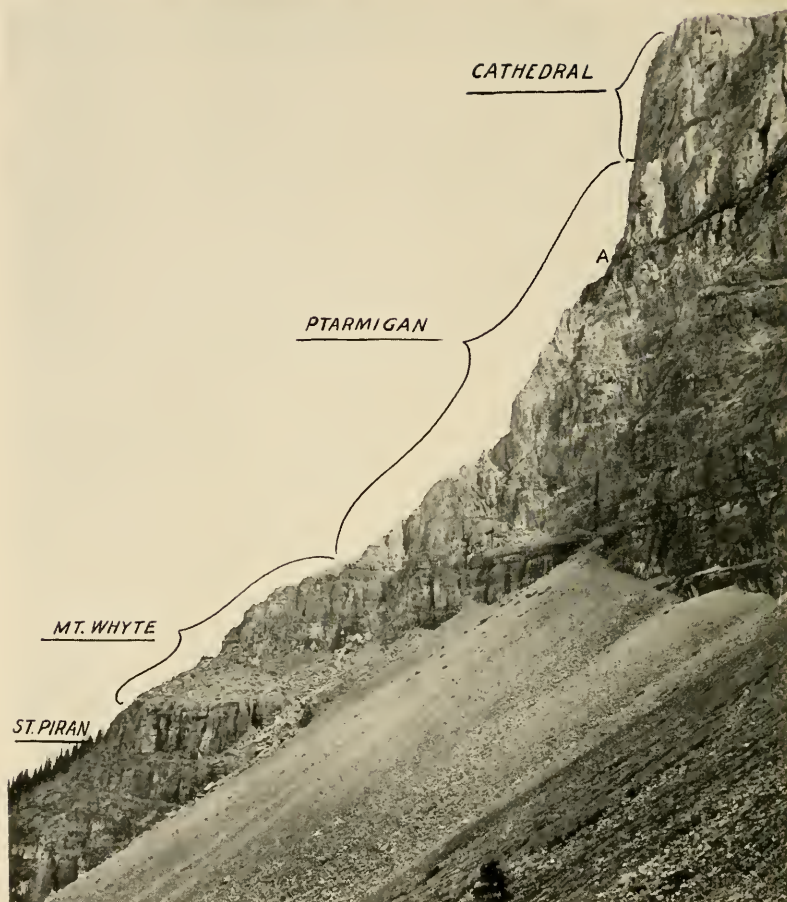
Micromitra (*Paterina*) *wapta* Walcott
Obolus parvus Walcott
Acrothele colleni Walcott
Wimanella simplex Walcott
Hyolithellus flagellum (Matthew)
Hyolithellus hectori Walcott



View of Ross Lake cirque on the south side of Kicking Horse Pass and south of Stephen, Continental Divide, on the Canadian Pacific Railway, British Columbia, Canada.

Popes Peak in center, Narao Peak at right, and Ross Lake Ridge on the left. At A on the left the dark, narrow *Albertella* zone is clearly shown and also on the right where a narrow ledge is formed. Just above where the stream pours over the cliff the dark shales of the *Albertella* zone occur in huge blocks in the stream bed.

This view should be studied in connection with plate 3. (Photograph by George Vaux, Jr., 1901.)



North profile of ridge above and southeast of Ross Lake, 1 mile (1.6 km.) south of Stephen Station on the Canadian Pacific Railway.

The position of the Albertella zone is shown at *A* where the thin band of shale forms a dark, narrow band that may be seen from the Kicking Horse Pass.

The relative positions of the Cathedral, Ptarmigan, Mount Whyte, and St. Piran formations are indicated on the plate.

This view should be studied in connection with plate 2. (Photograph by Walcott, 1916.)

Hyolithes cecrops Walcott
Agraulos stator Walcott
Ptychoparia sp. undt.
Olenopsis cf. *americanus* Walcott
Vanuxemella nortia Walcott
Albertella bosworthi Walcott
Albertella helena Walcott
Bathyriscus rossensis Walcott

Feet

3. Massive-bedded, gray and mottled, rough weathering arenaceous limestone	160
4. Compact, dove-gray colored limestone in thin layers.....	12
5. Massive-bedded, dirty gray colored, rough weathering calcareous sandstone	275
6. Alternating layers of bluish-black and steel-gray hard limestone	52

Total referred to Ptarmigan formation..... 664

LOWER CAMERIAN

MOUNT WHYTE FORMATION

1. Gray to grayish-black thin-bedded oolitic limestone..... 43

Fossils: Many small fragments of trilobites.

At this horizon 5.5 miles (8.8 km.) to the south at the west foot of Mount Shaffer, British Columbia (Loc. 61d), the following fauna has been collected:

Acrotreta sagittalis taconica Walcott
Nisusia (Jamesella) lowi Walcott
Scenella varians Walcott
Pelagiella sp. undt.
Micromitra (Paterina) labradorica (Billings)
Micromitra (Iphidella) pannula (White)
Corynexochus senectus (Billings)
Agraulos unca Walcott
Zacanthoides
Ptychoparia (Emmrichella) lux Walcott
Ptychoparia sp.
Mesonacis gilberti (Meek)

2. Finely banded gray sandstone and hard arenaceous limestone. . 5
 3. Gray, finely oolitic limestone in thick beds that break down into thin irregular layers..... 18

Fauna: At 15 feet from summit (Loc. 63k):

Nisusia (Jamesella) lowi Walcott
Pelagiella sp. undt.
Helcionella elongata (Walcott)
Scenella varians Walcott
Hyolithes billingsi Walcott
Ptychoparia cercops Walcott
Ptychoparia pia Walcott
Olenopsis agnesensis Walcott

	Feet
4. Banded sandstone and finely arenaceous shale in massive beds that break down on weathering into shaly arenaceous layers usually covered more or less thickly with annelid trails and more rarely tracks of trilobites	70
5. Greenish, drab and buff-colored very fine siliceous shale with partings of thin layers of compact sandstone.....	85
Fossils: Noted a valve of <i>Micromitra</i> and cranidium of <i>Ptychoparia</i> .	
6. Calcareous sandstone with dirty brown and rusty layers and shaly sandstone partings.....	27
Fossils:	
<i>Corynexochus fieldensis</i> Walcott	
<i>Olenellus</i> (many fragments)	—
Total thickness of Mount Whyte formation.....	248

ST. PIRAN FORMATION

Massive-bedded purplish quartzitic sandstones that form cliffs above Ross Lake.

The above sections of the Mount Whyte and Ptarmigan formations show that the *Albertella* fauna is located in the Ross Lake section some 500 feet (153.8 m.) above the top of the Mount Whyte formation and the *Olenellus* fauna. In the section of Castle Mountain 15 miles (24 km.) southeast of Ross Lake a specimen of the pygidium of *Albertella bosworthi* was found in 1907 260 feet (79.2 km.) above the Mount Whyte formation in a thin-bedded limestone that was then referred to the Cathedral formation, but which is now included in the Ptarmigan formation.

MONTANA AREA

In Montana the *Albertella* zone is well developed in Powell County at localities about 285 miles (456 km.) south of Kicking Horse Pass, British Columbia, and 135 miles (216 km.) south of Dr. Frank D. Adams' locality near North Kootenay Pass. The Cambrian section in this area, as I measured it in 1905, resembles that of Dearborn River and that of the Little Belt Mountains, but as the known fauna is different in the lower shale containing *Albertella*, I have named that shale the Gordon shale.

GORDON MOUNTAIN SECTION

The section is exposed along the ridge between Youngs Creek and Gordon Creek. The base of the section begins on the saddle beneath the limestone cliff half-way between Gordon Mountain summit and Cardinal Peak, and extends east-northeast along the ridge above-mentioned. Beginning with the top of the section we have the following succession. The section above 1a of the Yogo limestone is cut off by a twist and a fault in the beds.

YOGO LIMESTONE	Feet
1a. Light gray limestone in layers 3 to 8 inches thick. It is oolitic in some layers and has many annelid borings and trails.....	430
1b. Dark gray limestone similar to 1a.....	190
Strike E. and W., dip 45° N. (Mag.).	
1c. Thin-bedded, bluish-gray limestone with many annelid borings and trails	215
Total of Yogo limestone.....	835
DRY CREEK SHALE	
2. Green, argillaceous shale with a few thin layers of limestone interbedded. The thickest of these is a band 3 feet thick 20 feet from the top	64
Fauna:	
<i>Micromitra</i>	
<i>Hyolithes</i>	
<i>Asaphiscus</i> (like <i>whecleri</i>)	
<i>Ptychoparia</i>	
PILGRIM LIMESTONE	
3. Thin, irregular layers of bluish-gray limestone that form massive layers when not broken down by weathering.....	545
Traces of fossils	
Dip reaches 80° near the top.	
PARK SHALE	
4. Green and gray argillaceous and arenaceous shale.....	47
Fauna, locality 8j:	
<i>Micromitra</i> (<i>Paterina</i>) <i>superba</i> Walcott	
<i>Bathyriscus</i> sp. undt.	
<i>Ptychoparia</i> sp.	
<i>Zacanthoides</i> sp.	
MEAGHER LIMESTONE	
5. Thin-bedded, gray, arenaceous limestone becoming purer a little above the base.....	145
At 45 feet above the base the beds become more massive but break down into thin layers on weathering.	
Fragments of fossils occur.	
GORDON FORMATION	
6a. Chocolate or purple argillaceous and sandy shales.....	64
Fauna: Fragments of a fauna appear here which is well developed in 6b.	
6b. Dark greenish argillaceous shales, weathering a lighter green...	35
Fauna, locality 4q:	
<i>Micromitra</i> (<i>Iphidella</i>) <i>nyssa</i> Walcott	
<i>Micromitra</i> (<i>Iphidella</i>) <i>pannula</i> (White)	
<i>Acrothelae colleni</i> Walcott	
<i>Wimanella simplex</i> Walcott	
<i>Ptychoparia candace</i> Walcott	
<i>Ptychoparia charax</i> Walcott	
<i>Ptychoparia pylas</i> Walcott	
<i>Bathyriscus belesis</i> ? Walcott (Pygidia)	
<i>Zacanthoides cnopus</i> Walcott	

	Feet
6c. Layers of impure, gray weathering, buff-colored limestone with bands of dark greenish shale between them.....	21
6d. Greenish and bluish-gray argillaceous shales with irregularly interbedded sandy shales and thin layers of compact gray sandstone...	164

At 82 feet (25 m.) from the base a thin layer of sandstone contains fragments of *Albertella* and the shales above carry quite a fauna.

Locality 4v at the foot of the ridge on Gordon Creek is considered to come in at about this horizon. It is 75 feet (22.9 m.) to 90 feet (26.8 m.) above the sandstone of 7a. It includes—

Algæ

Hyolithes cf. *cecrops* Walcott

Micromitra (*Iphidella*) *pannula* (White)

Obolus (*Westonia*) *ella* (Hall and Whitfield)

Lingulella sp. undt.

Acrothele colleni Walcott

Acrothele panderi Walcott

Wimanella simplex Walcott

Ptychoparia candace Walcott

Ptychoparia charax Walcott

Olenopsis americanus Walcott

Albertella helena Walcott

Bathyriscus belesis Walcott

Vanuxemella contracta Walcott

Zacanthoides cnopus Walcott

Hyolithes and *Ptychoparia* occur below in several bands of greenish argillaceous shale between more sandy layers. —

Total of Gordon formation..... 284

FLATHEAD ? SANDSTONE

7a. Thin-bedded greenish and brown sandstone with shaly sandstone partings. Annelid borings and trails, mud cracks and ripple marks occur 43

Strike E. and W. (magnetic), dip 48° N.

Fauna: See footnote.¹

7b. Gray sandstone in thick beds, some of which are a fine quartz conglomerate with pebbles up to one-fourth of an inch in diameter.... 82

In a thin arenaceous layer 20 feet (6 m.) above the contact with the Algonkian strata numerous fragments of a species of *Albertella* were found. —

Total of Flathead ? sandstone..... 125

¹ At locality 150d, on the Continental Divide, about 24 miles (38.6 km.) northwest of Scapegoat Mountain and 12 miles (19.2 km.) northeast of Gordon Mountain, the *Albertella* fauna occurs in a thin-bedded shaly, brownish sandstone. The following species were found:

Cruziana sp. undt.

Agraulos cf. *stator* Walcott

Albertella cf. *helena* Walcott

Vanuxemella contracta Walcott

This locality is of importance as it extends the stratigraphic range of the fauna to the sandstones beneath the horizon of the Gordon shale.

RÉSUMÉ

	Feet
1. Yogo limestone	835
2. Dry Creek shale.....	64
3. Pilgrim limestone	545
4. Park shale	47
5. Meagher limestone	145
6. Gordon shale	284
7. Flathead ? sandstone.....	125
<hr/>	
Total	2,045

The Cambrian section rests on gray and red shales and hard sandstones of the Camp Creek series (Walcott, 1906¹) of the Algonkian. This section is, as far as known, on the western limit of the Cambrian strata in Montana. To the north the same series extends north up the valley of the South Fork of Flathead River.

FAUNAL CHARACTERISTICS

The fauna of the Ross Lake shale or *Albertella* zone is of interest both from its biological and stratigraphic aspects. Biologically, it represents a small subfauna of the Middle Cambrian that is rich in brachiopods and trilobites. The shale in which it occurs indicates very favorable conditions for the presence of a much more varied invertebrate life but as yet the fauna is limited to 14 known genera and 16 known species.

RELATIONS TO SUBJACENT FAUNA

The fauna of the subjacent Mount Whyte formation has been misunderstood very largely through tentatively including in it the *Albertella* fauna of the superjacent Ptarmigan formation. With this eliminated we find the fauna at the base of the Mount Whyte formation of a Lower Cambrian facies, and near the summit the Lower Cambrian fauna still predominating but with some genera that are much more developed in the Middle Cambrian fauna above, notably *Crepicephalus*, which is represented in the upper beds of the Mount Whyte formation.

I have already mentioned the difficulty met with in identifying the genus *Albertella* from fragments of the cephalon. The cranidium of *Albertella* is similar in form to some species of *Bathyriscus*, notably that of *B. (P.) primus*, which occurs in the Mount Whyte formation. This is best seen by comparing the cranidia of the two genera as

¹ Bull. Geol. Soc. America, Vol. 17, 1906, p. 3.

illustrated for *Albertella* on plates 1 and 2, Vol. 53, Smithsonian Miscellaneous Collections, 1908, and for *Bathyriscus primus* on plate 46, Idem, Vol. 64, 1916. Thinking that probably the specimens of *Albertella helena* and *A. bosworthi* found in loose blocks came from a siliceous shale of the Mount Whyte formation, I identified separate cranidia from that shale as *Albertella*, but now that I know that *Albertella helena* and *A. bosworthi* in the Canadian Rockies section occur in a siliceous shale 500 feet (152.4 m.) or more above the Mount Whyte formation and that no typical form of the *pygidium* or *thorax* of *Albertella* is known to have been found in the siliceous shales or limestones of the Mount Whyte formation I do not hesitate to refer the cranidia from the Mount Whyte formation to *Bathyriscus* (*P.*) *primus*. This removes *Albertella* from the Mount Whyte formation and restricts it to the Ross Lake shale and the *Albertella* zone, and the limestones of the Ptarmigan formation in which the Ross Lake shale occurs.

The remaining species of the *Albertella* shale fauna that were identified as occurring in the Mount Whyte formation are:

Micromitra (*Paterina*) *wapta* Walcott

Obolus parvus Walcott

Acrothele colleni Walcott

Another species that occurs higher up in the Middle Cambrian section, but not in the *Albertella* zone, is *Micromitra* (*Iphidella*) *pannula* (White).

A careful study of the specimens that were hastily identified when writing out the geologic sections in 1908¹ results as follows in relation to the species assumed to be identical from the *Albertella* zone and the Lake Agnes shales of the Mount Whyte formation.

Micromitra (*Paterina*) *wapta* Walcott.—Fragments of larger specimens of *Micromitra* (*P.*) *pannula* White were identified as *Micromitra* (*Paterina*) *wapta* by me in 1908 and credited to (locality 35e) the Mount Whyte formation,² where they occur with *Acrothele* n. sp. In the form of fragments and with the outer surface injured or exfoliated it is exceedingly difficult to recognize characters that with better material indicate specific differences.

Obolus parvus Walcott from (locality 35c) the *Albertella* zone is a small species nearly circular in outline. The species identified with it from (locality 58t) the Mount Whyte formation is represented by the interior of a ventral valve that is distinctly elongate and with

¹ Smithsonian Misc. Coll., Vol. 53, 1908, pp. 204-217.

² Idem, p. 214, 3 of section.

a very definite and nearly straight 'cardinal' slope from the beak outward to the lateral margins of the valve, and it is not *Obolus parvus*. The specimens identified as *Obolus parvus* from (locality 35e) the Mount Whyte formation¹ were probably dorsal valves of young shells of *Acrothele* n. sp., which is abundant but usually poorly preserved.

Acrothele colleni was identified from Mount Stephen in 1c of section.² The specimens differ from the types of *A. colleni* from the *Albertella* zone in uniformly smaller size and the presence in the dorsal valve of a very long and strong median ridge, in this respect resembling *Acrothele bellula* of the Middle Cambrian of Alabama.³

By oversight *Mesonacis gilberti* is given as occurring in the fauna of the Lake Agnes locality (35e).⁴ It occurs in the same stratigraphic section but at a lower horizon. On the opposite side of the Victoria Range at Mount Shaffer *M. gilberti* occurs above the horizon of the Lake Agnes shale fauna (35e) at locality 61d associated with a typical Lower Cambrian fauna (List, p. 15).

RELATION TO SUPERJACENT FAUNA

The *Albertella* fauna is a small subfauna that includes primitive forms usually found in the Lower Cambrian fauna, such as *Micromitra* (*Paterina*) *wapta*, *Agraulos stator*, along with typical Middle Cambrian forms. The next well-known superjacent fauna is the so-called *Ogygopsis* fauna of the Stephen formation and just above this the Burgess shale fauna, both of which are well-known Middle Cambrian subfaunas. Between the *Albertella* zone and the base of the Stephen formation there is a series of almost unfossiliferous limestones forming the upper 165 feet (50.3 m.) of the Ptarmigan formation and also the entire Cathedral formation of about 1,000 feet (304.8 m.) in thickness. That the period between the *Albertella* zone and the *Ogygopsis* zone was of considerable length is evidenced by the change in the faunas and by the appearance of a greater diversity of forms in the *Ogygopsis* zone. This latter statement is qualified by the possibility of the *Ogygopsis* fauna being an immigrant fauna from outside of the area where it is now found.

One of the problems now is to find the subfauna or faunas that existed in early and late Ptarmigan time and throughout the period

¹ Smithsonian Misc. Coll., Vol. 53, 1908, p. 214, 3 of section.

² Idem, listed on p. 213.

³ U. S. Geol. Surv. Monogr., No. 51, 1912, pl. 58, figs. 5f, 5h.

⁴ Idem, p. 130.

of deposition of the Cathedral formation. That this can be successfully accomplished by a systematic search in the Robson Peak District and to the north of it is quite possible as there are a number of interbedded bands of thin-bedded limestones in the Chetang formation and bands of shale in the Hitka formation which appears to be below the horizon of the *Ogygopsis* shale zone of the Stephen formation.

NOTES ON THE FAUNA

In order that the geologist and paleontologist may have before them what is known of the Ross Lake shale fauna as a whole, also the *Albertella* fauna of the Gordon shale and the limestone of the Ptarmigan formation and the Chetang formation, I have brought together on plates 4-7 illustrations of the species known to me as they have been found in the vicinity of Kicking Horse Pass, British Columbia; in Montana, and the Robson Peak District, Alberta. The following references are simply for the purpose of indicating where the old species are described, also the plates on which illustrations may be found in this paper.

The species from the Gordon shale have (Gordon) after the specific name; those from the Chetang limestone (Chetang); those from the Ptarmigan limestone (Ptarmigan), and those from the Ross Lake shale are without a designation.

Tholiasterella ? *hindei* n. sp., pl. 4, figs. 1, 1a

Eocystites ? sp. undt., pl. 4, fig. 2.

Micromitra (*Paterina*) *wapta* Walcott (Monogr. 51, U. S. Geol. Surv., 1912, p. 357), pl. 4, fig. 3

Micromitra (*Iphidella*) *nyssa* Walcott (Gordon) (Idem, p. 360, pl. 3, fig. 9)

Micromitra (*Iphidella*) *pannula* (White) (Gordon) (Idem, p. 361, pl. 4, fig. 1g)

Obolus parvus Walcott (Idem, p. 408), pl. 4, figs. 4, 4a

Obolus (*Westonia*) *ella* (Hall and Whitfield) (Gordon) (Idem, p. 455, pl. 47, fig. 1b)

Lingulella sp. undt. (Gordon)

Acrothele collemi Walcott (Idem, p. 640), pl. 4, figs. 5, 5a-f

Acrothele panderi Walcott (Gordon) (Idem, p. 651, pl. 59, fig. 5)

Wimanelia simplex Walcott (Idem, p. 748), pl. 4, figs. 6, 6a-c, 7, 7a-c, 8, 8a-c

Nisusia cf. *alberta* Walcott (Chetang), pl. 4, fig. 9

Hyolithellus flagellum (Matthew) (Canadian Alpine Journ., Vol. 1, 1908, pl. 1, figs. 8, 8a), pl. 5, figs. 2, 2a

Hyolithellus hectori n. sp., pl. 5, fig. 1

Hyolithes cecrops n. sp., pl. 5, figs. 3, 3a-c

Agraulos stator Walcott (Smithsonian Misc. Coll., Vol. 64, 1916, p. 173), pl. 6, fig. 6

Agraulos sp. undt. (fragment of a cranidium)

- Ptychoparia candace* n. sp. (Gordon), pl. 6, figs. 3, 3a
Ptychoparia charax n. sp. (Gordon), pl. 6, fig. 1
Ptychoparia ? cilles n. sp. (Ptarmigan), pl. 6, fig. 2
Ptychoparia pylas n. sp. (Gordon), pl. 6, figs. 4, 4a-c
Ptychoparia sp. undt.
Crepicephalus chares n. sp. (Ptarmigan), pl. 6, figs. 5, 5a-c
Vanuxemella contracta Walcott (Gordon) (Smithsonian Misc. Coll., Vol. 64, 1916, p. 221, pl. 36, figs. 4, 4a)
Vanuxemella nortia Walcott (Idem, p. 222), pl. 7, fig. 7
Olenopsis americanus Walcott (Gordon) (Idem, Vol. 57, p. 243, pl. 36, figs. 8-11)
Olenopsis cf. americanus Walcott (Idem), pl. 6, figs. 8, 8a-b
Albertella bosworthi Walcott (Idem, Vol. 53, 1908, p. 22), pl. 7, figs. 2, 2a-b, 3, 3a-d
Albertella helena Walcott (Idem, p. 19), pl. 7, figs. 4, 5, 5a
Albertella levis n. sp. (Chetang), pl. 7, figs. 1, 1a
Zacanthoides charilla n. sp. (Chetang), pl. 6, figs. 9, 9a
Zacanthoides ? cimon n. sp. (Ptarmigan), pl. 7, figs. 6, 6a
Zacanthoides cnopus n. sp. (Gordon), pl. 6, figs. 10, 10a
Neolemus constans n. sp. (Ptarmigan), pl. 6, figs. 7, 7a
Bathyriscus belesis Walcott (Gordon) (Smithsonian Misc. Coll., Vol. 64, 1916, p. 338, pl. 50, figs. 1, 1a-i)
Bathyriscus belus Walcott (Gordon) (Idem, p. 339, pl. 50, figs. 2, 2a-d)
Bathyriscus rossensis n. sp., pl. 5, figs. 5, 5a-d
Bathyriscus cf. rossensis n. sp., pl. 5, figs. 6, 6a
Bathyriscus (Poliella) chilo n. sp. (Ptarmigan), pl. 5, fig. 4
Bathyriscus (Poliella) sylla Walcott (Chetang) (Smithsonian Misc. Coll., Vol. 64, 1916, p. 354, pl. 48, figs. 3, 3a-f)

The fauna of the Gordon shale in Montana includes (4q, 4v) :

Algæ

- **Hyolithes cf. cecrops* Walcott
Micromitra (Iphidella) nyssa Walcott
Micromitra (Iphidella) pannula (White)
Obolus (Westonia) ella (Hall and Whitfield)
Lingulella sp. undt.
 **Acrothele colleni* Walcott
Acrothele panderi Walcott
 **Wimanella simplex* Walcott
Ptychoparia candace Walcott
Ptychoparia charax Walcott
Ptychoparia pylas Walcott
 **Olenopsis americanus* Walcott
 **Albertella helena* Walcott
Bathyriscus belesis Walcott
 **Vanuxemella contracta* Walcott
Zacanthoides cnopus Walcott

* The species common to the Gordon shale and the Ross Lake shale are marked by an asterisk.

From the Chetang formation only six species were collected:

Nisusia cf. *alberta* Walcott
Albertella bosworthi Walcott
Albertella levis Walcott
Agraulos cf. *stator* Walcott
Zacanthoides charilla Walcott
Bathyriscus (Poliella) syla Walcott

The Ptarmigan formation limestones have yielded but six species:

Ptychoparia cilles Walcott
Crepicephalus chares Walcott
Albertella bosworthi Walcott
Zacanthoides ? cimon Walcott
Neolenus constans Walcott
Bathyriscus (Poliella) chilo Walcott

DESCRIPTION OF GENERA AND SPECIES

THOLIASTERELLA Hinde

Tholiasterella HINDE, 1888, Monogr. British Fossil Sponges, Pal. Soc., London, Pt. II, p. 168. (Described and discussed.)

Dr. Hinde describes the sponge spicules referred to this genus as follows:

Form of Sponge unknown; the skeleton consists of spicules, which . . . bear a general resemblance to the handle and ribs of an umbrella. The handle or vertical ray of the spicule supports on its summit a variable number of rays which radiate from it in a generally horizontal direction. A central disc of variable proportions is formed by the union of the bases of the horizontal rays and the upper surface of this, and of the rays, may be either smooth or covered with tubercles or blunted vertical spines.

Dr. Zittel, in speaking of the genus, says: "As a rule, two of the rays lying in the same plane divide dichotomously from the nodes outward, so as to produce a six-armed instead of a four-armed cross."¹

Stratigraphic range.—Carboniferous.

It is not probable that the Middle Cambrian species now described belongs in this genus, but with only the spicules flattened in the shale for comparison it does not seem best to found a new genus for them. The six-rayed spicule with a central nodule suggests some forms of the spicules referred to *Tholiasterella*. They appear to be more nearly related to the latter than to the spicules of *Astræospongia* Roemer from the Silurian.²

¹ Text-book Pal., edited by Eastman, Vol. 1, 1913, p. 62.

² As defined by Hinde. Fossil Sponges, pp. 133-134, pl. 1, figs. 7, 7a-d.

THOLIASTERELLA ? HINDEI, new species

Plate 4, figs. 1, 1a

Six-rayed spicules with a central canal in the rays, a tubercle where the ray merges into the central disc of the spicule, also a central tubercle which suggests that it may have been the base of a central ray or shaft.

There is a trace of longitudinal, raised lines on one of the arms. The type spicule measures 16 mm. from tip to tip of opposite rays.

The original substance of the spicule has been replaced by the dark siliceous sediment forming the shale.

The doubtful character of the generic reference is mentioned in the note on the genus.

Formation and locality.—Middle Cambrian: (63j) Ross Lake shale member of the Ptarmigan formation; cliffs above Ross Lake 1.5 miles (2.4 km.) south-southwest of Stephen on the Canadian Pacific Railway, British Columbia, Canada.

EOCYSTITES ? species undetermined

Plate 4, fig. 2

A single crushed specimen of the calyx and arms of this species is all that is known of it. There is not sufficient evidence on which to base an accurate generic and much less a specific determination.

Formation and locality.—Middle Cambrian: (63j) Ptarmigan formation, Ross Lake shale; outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway, British Columbia, Canada.

BRACHIOPODA

MICROMITRA (PATERINA) WAPTA Walcott

Plate 4, fig. 3

Micromitra (Paterina) wapta WALCOTT, 1912. (See Monogr. 51, U. S. Geol. Surv., 1912, p. 357, text figs. 29, A, B.)

OBOLUS PARVUS Walcott

Plate 4, figs. 4, 4a

Obolus parvus WALCOTT, 1912. (See Monogr. 51, U. S. Geol. Surv., 1912, p. 408, text figs. 37, A, B.)

ACROTHELE COLLENI Walcott

Plate 4, figs. 5, 5a-f

Acrothele colleni WALCOTT, 1912. (See Monogr. 51, U. S. Geol. Surv., 1912, p. 640, text figs. 55, A-E; pl. 63, figs. 6, 6a-b.)

WIMANELLA SIMPLEX Walcott

Plate 4, figs. 6, 6a-c, 7, 7a-c, 8, 8a-c

Wimanella simplex WALCOTT, 1912. (See Monogr. 51, U. S. Geol. Surv., 1912, p. 748, text fig. 64; pl. 89, figs. 2, 2a-c.)

NISUSIA cf. **ALBERTA** Walcott

Plate 4, fig. 9

Nisusia alberta WALCOTT, 1889. (See Monogr. 51, U. S. Geol. Surv., 1912, p. 726, pl. 100, figs. 3, 3a-d.)

Only one small ventral valve of this type has been found in the Chetang limestone. It is strikingly similar to the small shells referred to *Nisusia alberta* as found in the shales and limestones of the central and lower portions of the Stephen formation at Mount Stephen, British Columbia.

The narrow, rather strong radiating ribs with nodes on them indicating spines and minute pores penetrating some of the layers of the shell indicate the genus *Nisusia*.

Formation and locality.—Middle Cambrian: (61 o) Chetang formation; gray shaly limestone in massive beds; on northeast slope of Chetang Cliffs above Coleman Glacier Creek, 7 miles (11.2 km.) north-northeast in direct line from summit of Robson Peak, northwest of Yellowhead Pass, western Alberta, Canada.

HYOLITHELLUS FLAGELLUM (Matthew)

Plate 5, figs. 2, 2a

Urotheca flagellum MATTHEW, 1899, Trans. Roy. Soc. Can., 2d ser., Vol. 5, Sec. 4, p. 40, pl. 1, fig. 1. (Species described and figured.)

Hyolithellus flagellum WALCOTT, 1908, Canadian Alpine Journ., Vol. 1, No. 2, p. 14, pl. 1, figs. 8, 8a. (Changes generic reference and illustrates species.)

This species is represented in the collection by four small tubes that appear to have been attached to the dorsal valve of *Wimanella simplex*. The specimens are not very well preserved and it may be that they are the young or small tubes of *H. annulatus* (Matthew).

Formation and locality.—Middle Cambrian: (63j) Ptarmigan formation; Ross Lake shale; outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway, British Columbia, Canada.

HYOLITHELLUS HECTORI, new species

Plate 5, fig. 1

This species is represented by a single specimen of a slender, rather thick tube, about 1 mm. in diameter, of which a portion 21 mm. in length is preserved. The tube has the form of the tube of *Hyolithellus flagellum* (pl. 5, fig. 4), but it is thicker and its surface is longitudinally ribbed by 24 or more narrow, sharp elevated lines or ribs; exceedingly fine transverse striæ of growth also occur between the crests of the ribs. A somewhat similar surface occurs on *Hyolithes* (*Orthotheca*) *rosmarus* Holm¹ and on *Hyolithes cymbium* Holm.²

Formation and locality.—Middle Cambrian: (35c) Ptarmigan formation; Ross Lake shale, *Albertella* zone; drift blocks of siliceous shale from the Ptarmigan formation, found on the south slope of Mount Bosworth, about 500 feet (152 m.) northwest of the Canadian Pacific Railway track between Stephen and Hector, eastern British Columbia, Canada.

HYOLITHES CECROPS, new species

Plate 5, figs. 3, 3a-c

Shell nearly if not quite straight; the angle of divergence of the lateral borders from the median line is from 12 to 14 degrees. The dorsal side gently arched or nearly flat. Ventral side rising from the lateral borders to a rounded angle at the median line. The transverse section forms a triangle, with the base two or three times as great as the height. Surface of shell with very fine transverse striæ and rather distinct lines of growth.

Dimensions.—A large shell has a length of 40 mm. with a breadth of the mouth of 16 mm. Another has a length of 42 mm.; breadth at the mouth, 13 mm. A small shell, 15 mm. in length, has a breadth at the mouth of 8 mm., but it has been shortened and widened by distortion in the shale. The specimen 42 mm. long and 13 mm. wide at the mouth is probably the nearest to the original size of the shell.

Operculum.—The associated operculum is illustrated by figure 3c. Although the shells are abundant, only three specimens of the operculum have been found.

Observations.—This species is uniformly larger than *Hyolithes billingsi* of the Mount Whyte formation, and has a more triangular

¹ Sveriges Geol. Undersökning, Ser. C, No. 112, 1893, Sv.-Kambrisk-Siluriska Hyolithidæ och Conularidæ, pl. 1, figs. 45, 46.

² Idem, pl. 3, fig. 7.

section. It differs from *Hyolithes carinatus* Matthew of the Stephen formation in absence of longitudinal ridges on the ventral side and also in its more triangular section.

Formation and locality.—Middle Cambrian: Ross Lake shale member of Ptarmigan formation; (63j) outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway; (63m) south slope of Mount Bosworth, about 500 feet (152.4 m.) above the Canadian Pacific Railway track, 1 mile (1.6 km.) east of Hector, 1.25 miles (2 km.) west of Stephen on the Continental Divide; (35c) drift boulder below locality 63m, all in British Columbia, Canada.

AGRAULOS STATOR Walcott

Plate 6, fig. 6

Agraulos stator WALCOTT, 1916, Smithsonian Misc. Coll., Vol. 64, p. 173, pl. 36, fig. 6. (Described and illustrated.)

This very neat and fine species is quite abundant in some localities of the Ross Lake shale.

Formation and locality.—Middle Cambrian: (63j) Ptarmigan formation; Ross Lake shale; outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway; also (35c) drift blocks of siliceous shale from the Ptarmigan formation, found on the south slope of Mount Bosworth, about 500 feet (152 m.) northwest of the Canadian Pacific Railway track between Stephen and Hector, eastern British Columbia, Canada.

An apparently similar species as far as can be determined from the cranium occurs in the limestone of the Chetang formation: (61w) gray, thin-bedded limestone; float rock in Terrace Creek, the head of which comes from Terrace Glacier, which joins Coleman Glacier on the divide east of Chetang Cliffs. Terrace Creek enters Moose River about 6 miles (9.6 km.) below Moose Pass and 10 miles (16.1 km.) east-northeast of Robson Peak, northwest of Yellowhead Pass, eastern British Columbia, Canada.

PTYCHOPARIA CANDACE, new species

Plate 6, figs. 3, 3a

Dorsal shield.—Dorsal shield rather small but strong. Axial lobe relatively broad, and doubtless strongly arched before compression;

greatest width probably falling a little in front of the thorax and equal to a little less than two-thirds of the length.

Cephalon.—Cranidium only preserved. Glabella moderately large relatively, elongate trapezoidal; dorsal furrows moderately impressed, converging so rapidly that the width in front is but little more than half of that of the base; anterior extremity of the glabella broadly rounded or obscurely truncate; glabellar furrows broadened or deepened by compression in the somewhat flattened cranidium figured; posterior furrows oblique, posteriorly directed, medial pair somewhat cuneate, the anterior margin of the furrow at right angles to the axis of the shield, the posterior margin oblique; anterior pair of furrows also cuneate but anteriorly directed, the lobe between the anterior and medial furrows with parallel sides at right angles to the axis; occipital furrow quite deeply impressed distally but almost obsolete upon the crest of the glabella; occipital ring expanded medially and bearing a rather large median node. Fixed cheeks low and quite broad, the distance from the palpebral lobe to the dorsal furrow more than half the width of the medial portion of the glabella; postero-lateral lobe very broad, trigonal in outline, the distal extremity tapering to an angle of about 45° ; posterior groove broad but not very deep. Palpebral lobe very short, not very prominent, placed far forward opposite the anterior glabellar furrows. Palpebral ridge cordate, moderately elevated, cutting across the fixed cheeks almost at right angles to the shield, and intercepting the dorsal furrows about half-way between the anterior glabellar furrows and the anterior extremity. Frontal limb rather wide, probably evenly sloping before compression. Frontal border almost as wide medially as the medial portion of the limb and cut off from it by a shallow groove. Facial sutures angular, the posterior arm oblique, the anterior arm feebly convex; arc included between the facial sutures almost double the width of the base of the glabella. Free cheeks not preserved.

Thorax.—Thorax rather slender, tapering posteriorly. Thoracic segments 16 in number. Axial lobe flattened in the shale and relatively very broad, as a rule, decidedly more than half as wide as either of the pleural lobes; axial annulations conspicuously coarse. Pleural segments rather narrow, compactly arranged, obtusely angulated at the geniculation which falls about two-thirds of the distance from the axial furrow to the outer extremity; pleural furrows broad and rather shallow for the most part, narrower and much deeper

toward the distal extremity; ends of segments feebly inclined posteriorly and acutely falcate.

Pygidium.—Pygidium very short, only about one-eighth the length of the entire shield, rudely lenticular in outline. Axial lobe coarse, wider than either of the pleural segments, becoming increasingly lower posteriorly but persisting almost to the extremity; axial annulations very obscure anteriorly, obsolete medially and posteriorly; component segments probably 4 or 5 in number. Pleural lobes trigonal, bearing traces anteriorly of an obscure grooving. Peripheral rim not defined. Peripheral margin an arc of a little less than 180° .

Surface.—Surface ornamentation lost or undeveloped.

Dimensions.—Length of shield, $12.5 \pm$ mm.; greatest width of shield, $8.0 \pm$ mm.

Type locality.—(4v) Gordon Creek, Powell County, Montana.

Observations.—The elongate body, small pygidium and small palpebral lobe all suggest *Agraulos stator* Walcott,¹ but the cranidium is that of *Ptychoparia* and there are 16 thoracic segments, while *A. stator* has 22. *P. candace* appears to be a form that unites strong characters both of *Agraulos* and *Ptychoparia*.

It differs from *Ptychoparia perola* of the subjacent Mount Whyte formation of British Columbia in details of the cranidium and in its broader thoracic lobes; its glabella is more elongate, frontal limb deeper, palpebral lobe larger. The largest dorsal shield has a length of 20 mm. A small dorsal shield 2.25 mm. in length has 10 thoracic segments and the cranidium indicates a narrowing of the glabellar lobe and widening of the fixed cheeks back of the palpebral lobes. The specimens occur in an argillaceous shale and do not retain the original surface characters. *Ptychoparia candace* is found in the *Albertella* fauna of Montana but not in that fauna in British Columbia. The genus is represented in the latter area by *Ptychoparia ? cilles*, which is quite distinct.

Formation and locality.—Middle Cambrian: (4v) Gordon shale; about 200 feet (61 m.) above the unconformable base of the Cambrian and 75 feet (22.9 m.) above the top of the quartzitic sandstones, Gordon Creek, 6 miles (9.6 km.) from South Fork of Flathead River, Ovando quadrangle (U. S. G. S.), Powell County, Montana.

¹ Smithsonian Misc. Coll., Vol. 64, p. 173, pl. 36, fig. 6. See p. 28, and pl. 6, fig. 6, this paper.

PTYCHOPARIA ? CHARAX, new species

Plate 6, fig. 1

Species known only from two cranidia.

Cephalon.—Glabella rather small relatively, not much more than half as long as the cranidium, low, elongate, trapezoidal in outline, the front between one-half and two-thirds as wide as the base; dorsal furrows moderately impressed, evenly converging toward the broadly rounded anterior extremity; glabellar furrows rather broad and obscure, obsolete medially; posterior pair somewhat oblique; medial pair approximately horizontal; anterior pair indicated merely by very feeble depressions a little behind the anterior extremity; occipital furrow rather broad but not very deep, approximately uniform in depth between the dorsal furrows; occipital ring not very wide, expanding medially, possibly bearing a small medial node. Fixed cheeks rather low, broad, the distance from the palpebral lobe to the dorsal furrow a little more than half as wide as the medial portion of the glabella; postero-lateral lobe narrow, not very long, cuneate, acutely rounded at the distal extremity; posterior groove broad and sharply defined excepting near the dorsal furrow, widest a little less than half-way from the inner to the outer extremity; posterior margin of the lobe narrow, elevated, uniform in width; anterior margin of the groove acute, excepting along the inner third of its extent, rudely bisecting the outer cuneate portion of the lobe. Frontal limb and border not sharply differentiated from one another, upturned and slightly thickened along the outer rim; width of limb and border in front of the glabella about three-fifths the length of the glabella; profile gently concave medially, convexo-concave in front of the palpebral ridge. Palpebral lobe approximately one-half as long as the glabella, obliquely arcuate, quite prominently elevated, placed quite far back, so that the medial portion of the lobe is opposite the posterior glabellar furrows. Palpebral ridge not sharply differentiated from the lobe, cutting obliquely across the fixed cheeks from the anterior extremity of the lobe, and intercepting the dorsal furrows a little behind the anterior extremity of the glabella. Facial sutures irregular in outline, the posterior section oblique, the outer margin of the palpebral lobe asymmetrically arcuate and the anterior section conspicuously broad and evenly convex. Other characters not preserved.

Surface.—External surface shagreened with an exceedingly fine punctation.

Dimensions.—Length of cranium, 9.6 mm. Length of glabella, 6.0 mm. Width of anterior extremity of the glabella, 3.0 mm. Width of base of the glabella, 5.0 mm.

Type locality.—(4v) Gordon Creek, Montana.

Observations.—This is one of the *Ptychoparia*-like cranidia with a broad concave frontal border and rim that will undoubtedly be placed in a subgenus of *Ptychoparia* when the American species of the latter genus are clearly studied. The genus *Agraulos* is suggested, but that is forcing a form in that genus that apparently belongs elsewhere.

Formation and locality.—Middle Cambrian: (4v) Gordon shale; about 200 feet (61 m.) above the unconformable base of the Cambrian and 75 feet (22.9 m.) above the top of the quartzitic sandstones, Gordon Creek, 6 miles (9.6 km.) from South Fork of Flathead River; and (4q) about 315 feet (96 m.) above the unconformable base of the Cambrian and 190 feet (57.9 m.) above the top of the quartzitic sandstones in a shale on the ridge between Gordon and Youngs Creeks, about half-way between Gordon Mountain and Cardinal Peak, both in Ovando quadrangle (U. S. G. S.), Powell County, Montana.

PTYCHOPARIA ? CILLES, new species

Plate 6, fig. 2

Species known only from imperfect cranidia.

Cephalon.—Cranidium very strongly contoured. Glabella conspicuously elevated, approximately two-thirds the length of the cranium and as broad at the base as it is long; medial section broad and obtuse, very gradually disappearing toward the anterior extremity; dorsal furrows very obscurely defined, converging so rapidly that the broadly rounded anterior extremity is only half as wide as the base; glabellar furrows sharply impressed upon the sides of the glabella but obsolete upon the crest; posterior pair cuneate, widening toward the crest, obliquely directed; medial pair not quite so broad nor so oblique; anterior pair linear but deeply incised at right angles to the axis of the shield; occipital furrow rather broad, extending across the crest of the glabella but deepening toward the dorsal furrows; occipital ring imperfectly preserved, expanded medially, and probably of moderate width. Fixed cheeks rising abruptly to almost the level of the summit of the glabella, the slope from the dorsal furrow to the crest of the glabella very similar to the slope from the dorsal furrow to the palpebral lobe; postero-lateral

lobe almost if not quite as broad as it is long, obtuse at the outer extremity; postero-lateral groove narrow toward the axis and in line with the occipital groove, broadening and deepening away from the axis. Palpebral lobe small but conspicuously high, arcuate, placed far forward opposite the lobe between the medial and anterior glabellar furrows. Palpebral ridge very narrow and rather obscure, forming an acute angle with the anterior extremity of the palpebral lobe, and slightly inclined posteriorly in crossing the fixed cheek so that it intercepts the dorsal furrows near the origin of the anterior glabellar furrows. Frontal limb narrow, feebly convex in front of the glabella and merging into the frontal border which is as wide or wider than the limb, and very strongly upturned so that the outline of the anterior portion of the cranidium is decidedly concave. Facial sutures following a sine curve from the genal angle along the anterior margin of the postero-lateral lobe to the eye lobe; anterior section of the suture more strongly convex than the posterior. A single imperfectly preserved free cheek, terminating in a rather short but acutely tapering spine, is associated with the cranidia.

Surface.—External surface microscopically shagreened.

Dimensions.—Length of cephalon, 3.0 mm. Length of glabella, 2.0 mm.

Type locality.—(63d) Ptarmigan formation; Ptarmigan Peak.

Observations.—This small species is quite distinct from any other known to me. Its high eyes, concave frontal border and convex, strongly marked glabella distinguish it and also indicate a distinct subgenus or genus.

Formation and locality.—Middle Cambrian: (63d) Ptarmigan formation; dark, thin-bedded finely arenaceous limestone, east base of Ptarmigan Peak, 5.5 miles (8.8 km.) in an air line northeast of Lake Louise Station on the Canadian Pacific Railway, Alberta, Canada.

PTYCHOPARIA PYLAS, new species

Plate 6, figs. 4, 4a-c

Dorsal shield.—Dorsal shield rather small, elongate oval or cuneate in outline, doubtless quite strongly contoured before being compressed in the shale.

Cephalon.—Head shield exclusive of the genal spines approximately one-third of the length of the dorsal shield, and a little less than twice as broad as it is long. Glabella angular, elongate-trapezoidal in outline; only about half as wide at the anterior ex-

tremity as it is at the base; dorsal furrows deeply impressed, intercepting the frontal furrow at an acute angle; glabellar furrows very obscure but persistent, in some individuals, across the crest of the glabella; posterior and medial pairs oblique and approximately parallel to one another, the anterior pair shorter, transverse to the axis, and in some individuals apparently undeveloped; occipital furrow broad and conspicuously deep, in most individuals, completely isolating the occipital ring; occipital ring similar in character to the anterior segments of the thorax, probably not spinose medially.

Fixed cheeks quite wide and rather plump; postero-lateral lobe narrow, moderately produced, angulated at the outer extremity; posterior groove narrow, deeply impressed, in line with the occipital furrow; posterior margin sharply elevated. Palpebral lobe large, conspicuously elevated, quite strongly crescentic. Palpebral ridge not sharply differentiated from the lobe as a rule, cutting across the fixed cheek almost at right angles to the axis and almost in line with the anterior furrow, and forming with the palpebral lobes and the anterior furrow of the glabella a rudely elliptical area. Frontal limb quite wide, evenly declining, or more frequently somewhat convex especially towards the sides. Frontal border moderately wide, not thickened, upturned, cut off from the limb by a shallow, ill-defined groove. Facial sutures roughly a spreading W with a broad arcuate base, a rather long, oblique, posterior limb and a rather short, convex, anterior limb. Free cheeks quite wide and smoothly inflated, the outer margin flattened and produced posteriorly into acutely tapering genal spines which terminate opposite the third thoracic segment.

Thorax.—Thoracic segments probably 14 in number. Axial lobe quite prominent, moderately broad, cut off from the pleura by deep furrows. Pleural segments flexuous, even in the shale, obtusely angulated at the geniculation which falls, in the majority of individuals, a little less than half-way from the proximal to the distal extremity; pleural furrows very narrow and deeply incised, sub-medial in position. Ends of segments cut away along the posterior margin, slightly inclined posteriorly, and acutely falcate.

Pygidium.—Pygidium very small and very imperfectly known.

Surface.—Character of external surface not preserved.

Dimensions.—Length of dorsal shield, 4.7 mm. Greatest width of dorsal shield, 3.2 mm. Length of the cranium of another individual, 6.5 mm. Length of glabella, 4.0 mm.

Type locality.—(49) Gordon Creek, Montana.

Observations.—This species is strongly characterized by its small pygidium, straight, deep pleural grooves on the thoracic segments, and broad frontal limb of the cranidium.

Formation of locality.—Middle Cambrian: (4q) Gordon shale; about 315 feet (96 m.) above the unconformable base of the Cambrian and 190 feet (57.9 m.) above the top of the quartzitic sandstones in a shale on the ridge between Gordon and Youngs Creeks, about half-way between Gordon Mountain and Cardinal Peak, both in Ovando quadrangle (U. S. G. S.), Powell County, Montana.

CREPICEPHALUS CHARES, new species

Plate 6, figs. 5, 5a-c

Species known only from a few imperfect cranidia and associated pygidia.

Cephalon.—Cephalon as restored from cranidium and free cheeks rather short and broad. Glabella a little less than two-thirds the length of the cranidium, low and moderately broad, rudely trapezoidal in outline, elevated along an obscure medial ridge which gradually disappears toward the front; dorsal furrows not sharply defined, converging toward the squarely truncate anterior extremity with such rapidity that the front of the glabella is only half as wide as the base; glabellar furrows also rather obscure and, upon the crest of the glabella, entirely obsolete; posterior pair rather broad, obliquely directed; medial and anterior pairs also rather broad and almost at right angles to the axis; occipital furrow of the same general character as the glabellar furrows, not very deep but uniformly impressed throughout its extent; occipital ring of only moderate width, expanded medially and possibly obtusely angulated along the posterior margin. Fixed cheeks very low and broad, the distance from the palpebral lobe to the dorsal furrows more than half the width of the medial portion of the glabella; more strongly convex along the axis of the shield than at right angles to it; postero-lateral lobe not preserved but necessarily narrow; groove in front of the posterior margin shallow toward the axis and in line with the occipital ring. Palpebral lobe imperfectly preserved, apparently short, crescentic, rather low and placed far back opposite the posterior lobe and furrow. Palpebral ridge cordate, moderately elevated, curving across the fixed cheek from the anterior extremity of the eye lobe and intercepting the dorsal furrows a little behind the anterior extremity of the glabella; palpebral ridges and lobes forming roughly a semi-ellipse interrupted by the glabella. Frontal limb

moderately wide, gently convex. Frontal border almost as wide as the limb, gently concave. Facial sutures very imperfectly preserved. Associated free cheek rather narrow, smoothly convex; peripheral border very wide and flattened, terminating posteriorly in a rather short but acute spine.

Pygidium.—Associated pygidium rudely cordate in outline, exclusive of the posterior constriction, the length and breadth approximately equal. Axial lobe not quite half as long as the caudal shield including the spines, but approximately two-thirds the length measured along the axis; limiting furrows not impressed, the lobe differentiated only by its low convexity and the rather obscure annulation; component segments apparently five in number including the terminal section. Pleural lobes somewhat flexuous, broadest a little in front of the median line, produced posteriorly into a pair of acute subspinose processes; margin between these tapering extremities sharply constricted. Pleural furrows ill defined; three or four shallow grooves usually developed parallel to the outer margin, least obscure anteriorly but on the posterior portion of the shield entirely obsolete. Peripheral margin very slightly raised anteriorly, not differentiated from the rest of the shield posteriorly.

Surface.—Entire external surface crowded with a fine granulation; very sparse macroscopic granulation also developed on the cephalon and less so on the pygidium; granules most numerous and most regularly arranged upon the frontal border.

Dimensions.—Length of cephalon, 8.5 mm. Length of glabella, 5.0 mm. Width of glabella at base, 4.6 mm. Length of pygidium, including spines, $5.6 \pm$ mm. Length of pygidium, excluding spines, 3.7 mm. Breadth of pygidium, 5.6 mm.

Type locality.—(63d) Ptarmigan formation; Ptarmigan Peak.

Observations.—The most nearly related species appears to be *Crepicephalus camiro* Walcott.¹ It differs from the latter in the details of form of the various parts of the cranium and associated pygidium and in its granulated surface. *C. camiro* is from the Upper Cambrian of the southern Appalachian area and *C. chares* is from the Middle Cambrian of the Canadian Rocky Mountains.

The cranium of *C. clora*, a new species from the Mount Whyte formation, is much like that of *C. camiro* but differs in its wider frontal border and other details of the cranium.

Formation and locality.—Middle Cambrian: (63d) Ptarmigan formation; dark, thin-bedded finely arenaceous limestone, east base

¹ Smithsonian Misc. Coll., Vol. 64, 1916, p. 205, pl. 32, figs. 2, 2a.

of Ptarmigan Peak, 5.5 miles (8.8 km.) in an air line northeast of Lake Louise Station on the Canadian Pacific Railway, Alberta, Canada.

VANUXEMELLA NORTIA Walcott

Plate 7, fig. 7

Vanuxemella nortia WALCOTT, 1916, Smithsonian Misc. Coll., Vol. 64, p. 222, pl. 36, fig. 5. (Described and illustrated.)

Nothing has been added to our information of this species by recent collections.

Formation and locality.—Middle Cambrian: (63j) Ptarmigan formation; Ross Lake shale; outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway, British Columbia; and (35c) drift blocks of siliceous shale from the Ptarmigan formation, found on the south slope of Mount Bosworth, about 500 feet (152 m.) northwest of the Canadian Pacific Railway track between Stephen and Hector, eastern British Columbia, both in Canada.

OLENOPSIS cf. AMERICANUS Walcott

Plate 6, figs. 8, 8a-b

Olenopsis americanus WALCOTT, 1912, Smithsonian Misc. Coll., Vol. 57, p. 243, pl. 36, figs. 8-11. (Description and illustration of species.)

Cranidia that appear to be identical with the cranidium of this species occur in association with *Albertella helena* in British Columbia, and the latter species is also associated with the type specimen of *Olenopsis americanus* in the Gordon shale of Montana.

Formation and locality.—Middle Cambrian: (63j) Ptarmigan formation; Ross Lake shale; outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway; also (35c) *Albertella* shale; drift blocks of siliceous shale from the Ptarmigan formation, found on the south slope of Mount Bosworth about 500 feet (152 m.) northwest of the Canadian Pacific Railway track between Stephen and Hector, eastern British Columbia, Canada.

The Montana locality of the type specimens of the species is (4v) Middle Cambrian; Gordon shale; about 200 feet (61 m.) above the unconformable base of the Cambrian and 75 feet (22.9 m.) above the top of the quartzitic sandstones, in a shale which corresponds in stratigraphic position to shale No. 6 of the Dearborn River section,¹

¹ Smithsonian Misc. Coll., Vol. 53, 1908, p. 202.

Gordon Creek, 6 miles (9.6 km.) from South Fork of Flathead River, Ovando quadrangle (U. S. G. S.), Powell County, Montana.

ALBERTELLA BOSWORTHII Walcott

Plate 7, figs. 2, 2a-b, 3, 3a-d

Albertella bosworthi WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, p. 22, pl. 1, figs. 4-7. (Description and illustration of the species.)

Albertella bosworthi WALCOTT, 1913, The Cambrian Faunas of China, Pub. No. 54, Carnegie Inst. of Washington, p. 105, pl. 12, fig. 2. (Figured on same plate with *A. pacifica* for purpose of comparison.)

The type specimen of this species was found in a drift boulder on the slopes of Mount Bosworth. Since 1908 entire specimens of the species have been found *in situ* on Mount Bosworth, also above Ross Lake south of Mount Bosworth and represented by fragments in the limestones of Castle Mountain, British Columbia, and in the Robson District of Alberta and British Columbia.

The specimens of the cranidium and pygidium from the limestones (figs. 3, 3b) are more convex and narrower than those from the shale in the Mount Bosworth area, owing to their not having been widened and distorted by compression as are the shale specimens.

Formation and locality.—Middle Cambrian: Ptarmigan formation; Ross Lake shale; (63j) outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway; (35c) drift blocks of siliceous shale from the Ptarmigan formation, found on the south slope of Mount Bosworth, about 500 feet (152 m.) north-west of the Canadian Pacific Railway track between Stephen and Hector; also (63m) Ross Lake shale; south slope of Mount Bosworth, about 500 feet (152 m.) above the Canadian Pacific Railway track, 1 mile (1.6 km.) east of Hector and 1.25 miles (2 km.) west of Stephen on Continental Divide, all in British Columbia, Canada.

At the locality 63m the species was found in thin layers of limestone interbedded in the shale: (58h) about 275 feet (85 m.) above the top of the Lower Cambrian in thin-bedded bluish-black limestone (272 feet=84 m.) forming 13 in Ptarmigan formation, Castle Mountain section; just below the big cliff on the east shoulder of Castle Mountain, north of Canadian Pacific Railway, Alberta, Canada.

Also from (61p) Chetang formation; gray shaly limestone in massive beds; on northeast slope of Chetang Cliffs above Coleman Glacier Creek, 7 miles (11.2 km.) north-northeast in direct line from

summit of Robson Peak, northwest of Yellowhead Pass, western Alberta, Canada.

ALBERTELLA HELENA Walcott

Plate 7, figs. 4, 5, 5a

Albertella helena WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, p. 19, pl. 2, figs. 1-9. (Description and illustration of species.)

Albertella helena GRABAU and SHIMER, 1910, North American Index Fos., Vol. 2, p. 274, fig. 1572c. (Characterized and figured.)

Albertella helena WALCOTT, 1913, The Cambrian Faunas of China, Pub. No. 54, Carnegie Inst. of Washington, p. 106, pl. 12, fig. 1. (Figured on same plate with *A. pacifica* for purpose of comparison.)

This species was described at length in 1908. Recent collections have added very little to the information about it.

Formation and locality.—Middle Cambrian: (63j) Ptarmigan formation; Ross Lake shale; outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway; (35c) Drift blocks of siliceous shale from the Ptarmigan formation, found on the south slope of Mount Bosworth, about 500 feet (152 m.) north-west of the Canadian Pacific Railway track between Stephen and Hector; and (63m) Ross Lake shale; south slope of Mount Bosworth, about 500 feet (152 m.) above the Canadian Pacific Railway track, 1 mile (1.6 km.) east of Hector and 1.25 miles (2 km.) west of Stephen on Continental Divide, all in British Columbia, Canada.

ALBERTELLA LEVIS, new species

Plate 7, figs. 1, 1a

This species is represented by the cranidium and associated pygidium. The cranidium differs from that of *A. bosworthi* by its glabella being more expanded towards the front, much fainter glabellar furrows, relatively shorter palpebral lobes and almost smooth instead of finely granulated outer surface of the test. A minute median node occurs near the posterior margin of the occipital ring in both *A. levis* and *A. bosworthi*.

The pygidium associated with the cranidia, also the cranidium and pygidium of *A. bosworthi*, in two blocks of limestone, are quite unlike the pygidia of typical *Albertella*, as the two spines emerge from the border at the postero-lateral margins and the pygidium is wider posteriorly and shorter. The axial lobe is narrow, strongly convex and with five segments and a terminal section; pleural lobes marked by three slightly impressed narrow furrows.

Surface of cranidium and pygidium smooth except when a strong lens is used to bring out a very fine irregular, closely inosculating series of ridges.

The largest cranidium has a length of 7.5 mm.

Formation and locality.—Middle Cambrian: (61p) Chetang formation; gray shaly limestone in massive beds, on northeast slope of Chetang Cliffs above Coleman Glacier Creek, 7 miles (11.2 km.) north-northeast in direct line from summit of Robson Peak, northwest of Yellowhead Pass, western Alberta, Canada.

ZACANTHOIDES CHARILLA, new species

Plate 6, figs. 9, 9a

Species known only from an imperfect cranidium and from two pygidia.

Cephalon.—Glabella large relative to the size of the cranidium, broadest anteriorly, gradually contracting toward the rather slender base, slightly expanding at the occipital ring, broadly and feebly arched, the curvature greatest a little in front of the median line; dorsal furrows quite deeply impressed, slightly concave, most strongly constricted opposite the posterior lobe; anterior extremity broadly arcuate; posterior glabellar furrows linear, converging toward the occipital groove, obsolete upon the summit of the glabella; medial glabellar furrows suggested by a very shallow and obscure depression extending across the glabella at right angles to the axis, about half way between the anterior extremity and the occipital ring; anterior glabellar furrows even more obscure than the medial, directed forward, but entirely obsolete upon the summit of the glabella; occipital groove moderately wide, uniform in depth between the dorsal furrows; occipital ring quite wide and flattened. Fixed cheeks very much reduced; the area between the eye lobe and the dorsal furrow not much greater than the lobe; postero-lateral lobe very narrow, deeply furrowed in front of the posterior margin; outer extremity of lobe not preserved. Anterior limb very narrow and merging into the antero-lateral margin of the glabella; frontal limb obsolete, frontal border a narrow wire-like rim. Palpebral lobe very large, approximately half as long as the glabella, feebly arcuate, quite prominently elevated, cut off from the fixed cheek by a shallow groove; posterior extremity of the eye lobe opposite the posterior lobe of the glabella, the anterior extremity of the eye lobe intercept-

ing the dorsal furrows at the origin of the anterior glabellar furrows. Other characters of the cephalon not preserved.

Pygidium.—Associated pygidium rather large for the cephalon, trigonal in outline, exclusive of the peripheral fringe of spines. Axial lobe decidedly wider than the pleural exclusive of their spinose annulations rather coarse, obscure only near the posterior extremity, indicating three component segments and a large terminal section. Pleural lobes very narrow, only the two anterior retaining any semblance to anchylosed segments of the thorax; extremities of extremities, prominently elevated, acutely tapering posteriorly; segments attenuated and spinose, the spines drooping posteriorly and approximately parallel; second spine from the thorax the longest of all, the third nearly in line with it; four shorter subequal spines included between these two pairs.

Surface.—External surface smooth under low magnification but minutely roughened by very fine, irregular anastomosing ridges when examined with a strong lens.

Dimensions.—Length of glabella, 3.5 mm. Breadth of glabella in front, 2.7 mm. Breadth of glabella at base, 1.5 mm.

Type locality.—(610) Middle Cambrian: Chetang formation; Chetang Cliffs, 7 miles (11.2 km.) north-northeast of Robson Peak.

Observations.—This species recalls at once *Zacanthoides idahoensis*. It is closely allied to it but differs in its narrower antero-lateral limb of the fixed cheek, shorter palpebral lobe, and apparent absence of the frontal limb. The associated pygidium differs in the size and arrangement of the spines of the flattened border.

Formation and locality.—Middle Cambrian: (610) Chetang formation; gray shaly limestones in massive beds; on northeast slope of Chetang Cliffs above Coleman Glacier Creek, 7 miles (11.2 km.) north-northeast in direct line from summit of Robson Peak, northwest of Yellowhead Pass, western Alberta, Canada.

ZACANTHOIDES ? CIMON, new species

Plate 7, figs. 6, 6a

Species known only from imperfect cranidia and fragments of a pygidium.

Cephalon.—Cranidium rather small. Glabella very long relatively, more than nine-tenths the length of the cranidium, but not quite twice as broad as its length, broadly and quite prominently elevated medially, very feebly constricted laterally but expanding anteriorly, both in

the direction of the axis and at right angles to it; glabellar furrows rather broad and shallow, cutting up the glabella into obscure annulations which are perceptible even upon the crest of the glabella; occipital furrow moderately broad, uniform in depth between the dorsal furrow; occipital ring rather low, broad, expanded medially and possibly nodose. Fixed cheeks exclusive of the postero-lateral lobe appearing as semielliptical extensions on either side of the medial posterior portion of the glabella; greatest width of the fixed cheek, exclusive of the postero-lateral lobe which has not been preserved, rarely more than half the width of the medial portion of the glabella. Palpebral lobe and ridge not differentiated, the two together forming a cordate, strongly arcuate ridge with one extremity near the occipital ring, the other directly in front of the anterior glabellar furrows, the ridge cut off from the fixed cheek by a clearly defined groove; medial portion of the palpebral arc nearly in line with the posterior glabellar furrows. Frontal limb obliterated medially. Frontal border very narrow, upturned, probably somewhat thickened. Facial sutures imperfectly preserved, the anterior section apparently diverging rapidly from the anterior extremity of the palpebral arc. Free cheeks not preserved.

Pygidium.—Pygidium known only from a couple of proximate, parallel, caudal spines attached to the peripheral rim and connected with a fragment of the axial lobe.

Surface.—External surface microscopically shagreened.

Dimensions.—Length of cranium, 6.2 mm. Length of glabella, 5.7 mm. Width of medial portion of glabella, 3.2 mm.

Type locality.—(63b) Ptarmigan Peak, Alberta, Canada.

Observations.—The two caudal spines which have been preserved were probably about 10 mm. long before the loss of their tips. They are exactly parallel to one another and separated by a space no greater than the width of one of the slender spines.

The cranium and the fragment of the associated pygidium both suggest *Zacanthoides*, but as the cranium might possibly belong to a species of *Albertella* the generic reference is tentative. I do not know of a similar described form of cranium or pygidium.

Formation and locality.—Middle Cambrian: (63b) Ptarmigan formation; bluish-black, more or less finely arenaceous limestone in layers 0.5 to 8 inches thick that form massive layers 450 feet (138 m.) thick beneath the great Cathedral limestone; east base of Ptarmigan Peak, 5.5 miles (8.8 km.) in an air line northeast of Lake Louise station on the Canadian Pacific Railway, Alberta, Canada.

ZACANTHOIDES CNOPUS, new species

Plate 6, figs. 10, 10a

Species known only from an imperfect cephalon and a portion of the thorax.

Dorsal shield.—Dorsal shield rather small for the group, elongate-oval in outline. Axial lobe convex, strong, as wide as the pleura exclusive of the spinose extremities and elevated high above them even in the shale.

Cephalon.—Cephalon apparently a little less than one-third of the length of the dorsal shield, and about twice as broad as it is long. Cranium exclusive of the postero-lateral lobes somewhat pitcher-shaped, broadly convex medially and posteriorly, flaring anteriorly. Glabella rather low but relatively long, expanding slightly anteriorly both with the axis and at right angles to it, broadly and very feebly constricted medially; dorsal furrows not very deeply impressed and, between the posterior glabellar furrows and the occipital ring, almost obsolete; anterior furrow also shallow, broadly arcuate; glabellar furrows quite pronounced; posterior pair oblique, quite deeply gouged toward the dorsal furrows but obsolete upon the subangular crest of the glabella; medial pair similar in general character to the posterior but shorter and less oblique; anterior pair reduced to very obscure, lateral depressions at some little distance behind the anterior extremity; occipital furrow deeply incised distally but broad and shallow upon the summit of the glabella; occipital ring low and broad, expanded medially and bearing near the posterior margin traces of an occipital node. Fixed cheeks narrow, the distance from the palpebral lobe to the dorsal furrow less than half the width of the glabella, auriculate in outline, exclusive of the postero-lateral lobe; postero-lateral lobe not preserved but doubtless very slender, and probably petaloid. Palpebral lobe and palpebral ridge not differentiated, the two together forming a cordate, sickle-shaped ridge with one extremity near the occipital ring, the other directly in front of the anterior glabellar furrows but at some little distance behind the anterior extremity of the glabella; palpebral lobe and ridge cut off from the cheek by a narrow deeply incised groove. Frontal limb narrow, flattened, but little wider than the cordate frontal border. Free cheeks wide and probably rather low, peripheral border abruptly constricted and produced posteriorly into very slender, acutely tapering spines which apparently terminate opposite the fourth thoracic segment.

Thorax.—Thoracic segments eight or nine in number, probably nine. Axial lobe very coarse, wider than the pleural lobes and strongly convex; annulations sharply defined and bearing a medial node, probably indicating the former presence of a medial spine; the slender spine upon the seventh thoracic segment still preserved, probably about 10 mm. long, or more than half the length of the dorsal shield. Pleural segments, exclusive of the attenuated spinose extremities, very short; pleural furrows broad, almost as wide as the including segment and moderately deep; extremity of first thoracic segment apparently not spinose; extremity of second thoracic segment attenuated, posteriorly inclined and produced into a slender spine a little longer than the unflexed portion of the segments; extremities of the medial and posterior thoracic segments between two and three times the length of the rest of the segment, strongly inclined posteriorly.

Pygidium.—Pygidium not very well preserved, short. Axial lobe relatively large and strong, obtusely truncate posteriorly; caudal annulations almost as prominent as those of the thorax, four in number with a terminal section. Pleural lobes of the pygidium not preserved except the spinose extensions of the pleura which extend backward approximately parallel to the axis of the shield, and almost twice the length of the axial lobe.

Surface.—Character of external surface not preserved; surface of spines covered with a microscopically fine lacy venation.

Dimensions.—Length of dorsal shield, $13.5 \pm$ mm. Length of cephalon, $4.0 \pm$ mm. Greatest width of thorax, including the spinose extremities, $11.0 \pm$ mm. Greatest width of thorax, excluding the spinose extremities, $6.0 \pm$ mm.

Type locality.—(4v) Gordon Creek, Montana.

Observations.—The cranium of this species is much like that of *Z. idahoensis*,¹ but the thorax has the great median spine on the eighth segment instead of the fifth and the spinose extensions of this pleura are relatively longer. The imperfection of the specimens prevents closer comparison. *Zacanthoides cnopus* differs from *Z. typicalis* and *Z. spinosus* very much as *Z. idahoensis* differs from them.²

Formation and locality.—Middle Cambrian: Gordon shale; (4v) about 200 feet (61 m.) above the unconformable base of the Cambrian and 75 feet (22.9 m.) above the top of the quartzitic sandstones,

¹ Smithsonian Misc. Coll., Vol. 53, 1908, pl. 3, figs. 1-11.

² Idem, p. 29.

Gordon Creek, 6 miles (9.6 km.) from South Fork of Flathead River, Ovando quadrangle (U. S. G. S.), Powell County Montana.

NEOLENUS CONSTANS, new species

Plate 6, figs. 7, 7a

Species known only from a single caudal shield.

Pygidium.—Pygidium large and coarse, roughly semielliptical in outline, about four-fifths as long as it is broad; component segments five in number including the terminal section. Axial lobe elongate-conic in outline, almost as broad anteriorly as one of the pleural lobes, evenly tapering toward the sharply rounded posterior extremity of the lobe; annulations distinct, becoming less prominent and more closely spaced posteriorly. Lateral lobes strongly convex; segments feebly anchylosed especially toward the thorax; pleural furrows broad and, toward the posterior extremity, obscure, arcuate anteriorly, approximating more and more closely to the axis of the shield posteriorly; outer extremities of segments discrete and falcate or even semispinose. Peripheral rim not very sharply defined, outlined by the flattening of the shield and by a series of shallow pits which mark the terminations of the pleural furrows; outer margin serrated by four broad-based, rather short spines quite sharply concave opposite the extremity of the axial lobe.

Surface.—External surface finely punctate, having the appearance under high magnification of having been very finely etched with acid.

Dimensions.—Length of caudal shield, $20 \pm$ mm. Greatest breadth of caudal shield, $25.0 \pm$ mm.

Type locality.—(63b) Ptarmigan Peak, Alberta, Canada.

Observations.—Although the extremity of the axial lobe is sharply defined, there is a very obscurely elevated cuneate area extending backward from the extremity and wedging out at the margin.

I do not usually like to found a species on a pygidium, but this form is so distinct and strong that it seems worthy of such recognition. It differs from the pygidium of *Neolenus serratus* in having one less pair of border spines, one less pleural segment indicated on the pleural lobes, and a relatively shorter, broader axial lobe.

Formation and locality.—Middle Cambrian: (63b) Ptarmigan formation; bluish-black, more or less finely arenaceous limestone in layers 0.5 to 8 inches thick that form massive layers 450 feet (138 m.) thick beneath the great Cathedral limestone; east base of Ptarmigan Peak 5.5 miles (8.8 km.) in an air line northeast of Lake Louise Station on the Canadian Pacific Railway, Alberta, Canada.

BATHYURISCUS ROSSENSIS, new species

Plate 5, figs. 5, 5a-d

Bathyriscus (Poliella) sp. undt. WALCOTT, 1916, Smithsonian Misc. Coll., Vol. 64, No. 5, p. 355, pl. 46, fig. 7. (Described and illustrated.)

Dorsal shield.—Dorsal shield a very smooth elongated oval, the greatest breadth in the type less than two-thirds of the length. Axial lobe well differentiated, moderately convex; pleura flattened in the shale but retaining traces of rather a strong downward flexure at the genal angle.

Cephalon.—Cephalon, exclusive of the genal spines, about two-fifths as long as the entire dorsal shield, strongly contoured even in the shale. Glabella quite low, almost as long as the cephalon, strictly clavate in outline; dorsal furrows distinct, deepening anteriorly; anterior extremity expanded and broadly arcuate; posterior lateral furrows rather broad and deeply intrenched, directed backward at an angle of approximately 45° but evanescent abruptly before reaching the medial line; other lateral furrows obsolete; occipital ring distinct, trigonal; occipital furrow deeply gouged toward the distal extremities but shallow and rather ill defined upon the crest of the glabella; occipital ring posteriorly produced and sharply angulated, and bearing a short acute spine at the apex of the angle. Fixed cheeks lower than the glabella, rather wide relatively, the distance from the palpebral lobe across to the dorsal furrow a little more than half the width of the medial portion of the glabella; postero-lateral lobes very narrow and petaloid; groove behind the posterior margin very broad, especially toward the outer extremity. Palpebral lobe narrow, strongly crescentic, about one-third as long as the glabella, set so far back that the posterior extremity of the lobe is almost in line with the occipital furrow. Palpebral ridge often rather obscure, arching obliquely across from the anterior extremity of the palpebral lobe and intercepting the dorsal furrow about half-way between the outer extremity of the posterior lateral furrow and the anterior extremity of the glabella. Facial sutures conspicuously sinuous, following along the low arch of the postero-lateral lobes of the fixed cheeks, around the strongly convex palpebral lobe and the shorter but almost equally convex anterior lobe; arc included between the extremities of the facial sutures approximately one-third the periphery of the cephalon exclusive of the genal spines.

Free cheeks of about the same width as the fixed cheeks, but more plump, bearing short and rather broad infragenal spines and very long, slender acute, scimiter-like genal spines which lie close to the

outer extremities of the thoracic segments and are produced backward at least as far as the pygidium. Frontal border very narrow anteriorly, widening slightly laterally.

Thorax.—Thoracic segments moderately wide, eight in number. Axial lobe not quite so wide as the pleura and arched well above them; distal extremities of the axial segments produced into falcate extremities about one-third as long as the pleural segments which they overlie; medial portion of the axial segment probably elevated into an obtuse node. Pleural segments doubtless rather strongly flexed at their falcate outer extremities; pleural furrows broad and quite deep, much more steeply channeled along the anterior margin than along the posterior, gradually disappearing distally; outer extremities of the pleura acute and posteriorly directed, rounded away along the underlapping anterior margin.

Pygidium.—Pygidium quite large, contained between three and four times in the length of the shield, sharply differentiated from the thorax; axial lobe of the pygidium subcylindrical, relatively slender, abruptly evanescent at some little distance in front of the posterior extremities; included segments probably five in number, annulations obsolete posteriorly but strongly defined anteriorly, that in front and often the next behind it bearing an acute spine. Lateral furrows broad and rather ill defined, approximately parallel, and inclined at an angle of about 45° to the axis of the shield. Anterior segment of the fused portion of the pygidium produced into a rather short, posteriorly directed spine. Periphery of pygidium indented at the caudal spine, squarely truncate or broadly constricted posteriorly.

Surface.—There is very little trace of an external sculpture excepting upon the genal spines which are longitudinally striated with very fine anastomosing groovings. One cranium, however, is shagreened with rather a coarse granulation and on this same individual there are traces of three pairs of short, horizontal glabellar furrows in front of the oblique posterior pair.

Dimensions.—Length, 49.5 mm. Maximum width, 35.0 mm. Length of cranium, 21.0 mm. Length of pygidium, 13.0 mm.

Type locality.—(63j) Ptarmigan formation, *Albertella* shale zone; above Ross Lake, British Columbia, Canada.

Observations.—*B. rossensis* Walcott is, perhaps, best characterized by the very much produced genal spines. They certainly extend as far back as the pygidium and their attenuated extremities may persist even to the posterior margin of the shield. There is a strong tendency in this species toward the development of spines and nodes.

There are infragenal as well as genal spines developed, and the occipital ring and the axial ring both of the thorax and the pygidium are nodulated. The triangular axial extensions in the pleural grooves so characteristic of the genus are unusually well developed in this species. The glabella is broad relatively, and only the posterior lateral furrows are perceptible on the majority of the individuals. The caudal shield is moderately large but less strongly annulated and furrowed than in the majority of *Bathyriscus*. The number of thoracic segments is the same in the half-dozen individuals in which the complete shields have been preserved.

The pygidium of *B. adamsi*¹ has a somewhat similar marginal spine on each side, but otherwise the pygidia differ in many details. The cranidium of *B. belesis*² is very similar but the associated pygidia are quite dissimilar.

The pygidium described and illustrated as *Bathyriscus (Poliella)* sp. undt. 1³ is now referred to this species. The two specimens then known of were broken along the outer border and did not show the spine on each side. By error the locality of the specimens was given as 35e. They came from 35c as defined below.

In the collection made by Dr. Frank D. Adams and Mr. W. J. Dick, 4 miles (6.4 km.) north of North Kootenay Pass, Alberta, there are specimens of large species of *Bathyriscus* that are apparently identical with *B. rossensis*. They occur on the surface of very thin layers of bluish-gray limestone in association with a typical *Albertella* fauna as follows:

Agraulos stator Walcott
Vanuxemella nortia Walcott
Albertella bosworthi Walcott
Asaphiscus rossensis Walcott

Formation and locality.—Middle Cambrian: (63j) Ross Lake shale member of the Ptarmigan formation; outlet of cirque above and south of Ross Lake on north slope of Popes Peak, 1.5 miles (2.4 km.) south-southwest of Stephen on Canadian Pacific Railway; (63m) *Albertella* zone; south slope of Mount Bosworth, about 500 feet (152.4 m.) above the Canadian Pacific Railway track, 1 mile (1.6 km.) east of Hector and 1.25 miles (2 km.) west of Stephen on Continental Divide; and (35c) also *Albertella* zone; drift blocks of silice-

¹ Smithsonian Misc. Coll., Vol. 64, 1916, pl. 47, figs. 3, 3b.

² Idem, p. 338, pl. 50, figs. 1, 1b.

³ Idem, p. 355, pl. 46, fig. 7.

ous shale from the Ptarmigan formation,¹ found on the south slope of Mount Bosworth about 500 feet (152.4 m.) northwest of the Canadian Pacific Railway track between Stephen and Hector, all in British Columbia, Canada.

Also 4 miles (6.4 km.) north of North Kootenay Pass, Alberta, Canada. Specimens in Museum of McGill University, Montreal.

BATHYURISCUS cf. ROSSENSIS, new species

Plate 5, figs. 6, 6a

Cephalon.—Cranidium large and strongly contoured. Glabella long and relatively narrow, somewhat clavate in outline, slightly expanded anteriorly both along the transverse and the longitudinal axis, the maximum elevation falling in front of the transverse median line; glabellar furrows obscure in the majority of individuals, the posterior pair rather broad and very strongly oblique, the pair in front of them approximately horizontal or feebly inclined posteriorly, the two anterior pairs very slightly inclined anteriorly; occipital furrow broad but not very deep, persisting across the crest of the glabella; occipital ring rather wide, cuneate, the posterior margin produced, acutely ridged and angulated and bearing an obtuse spine at the apex of the angle; dorsal furrows moderately impressed, broad and feebly constricted medially, in the majority of individuals more strongly divergent anteriorly than posteriorly; anterior extremity of the glabella broadly arched. Fixed cheeks low, rather broad relatively, the distance from the palpebral lobe across to the dorsal margin approximately half the width of the medial portion of the glabella; postero-lateral lobe narrow but produced laterally; posterior furrow broad, oblique, its anterior margin in line with the oblique posterior margin of the occipital ring; palpebral lobe moderately wide, reniform, about three times the length of the glabella, the median transverse line of the lobe falling a little behind the median transverse line of the glabella; palpebral ridge obscure in the majority of individuals, arching across from the palpebral lobe and intercepting the dorsal furrows at or a little in front of the next to the anterior pair of lateral furrows. Facial sutures outlined as in figure, the anterior limb broadly arched. Character of free cheeks not known.

Surface.—Smooth or slightly roughened by obscure granulation.

Dimensions.—Length of cranidium, 30.0 mm. Length of glabella, 28.5 mm.

¹ Smithsonian Misc. Coll., Vol. 53, No. 5, 1908, p. 214.

Type locality.—(63m') Mount Bosworth, British Columbia, Canada.

Observations.—This form is known only from cranidia and pygidia occurring in thin limestone lentiles in the shale with *B. rossensis*. The glabella is longer and more slender proportionally than that of *rossensis*. These differences are apparently too great to be due to individual variation, or to compression and distortion. The glabellæ of *Bathyriscus* sp. are strongly convex and on some specimens the median ridge is strongly defined, especially toward the anterior portion.

The associated pygidia are closely related if not identical with those of *B. rossensis* except that the limestone form is narrower and more elongate proportionally.

Formation and locality.—Middle Cambrian: (63m') Ptarmigan formation (Ross Lake shale); thin lentiles of limestone included in the shale; south slope of Mount Bosworth, about 500 feet (152.4 m.) above the Canadian Pacific Railway track, 1 mile (1.6 km.) east of Hector and 1.25 miles (2 km.) west of Stephen on Continental Divide, British Columbia, Canada.

BATHYURISCUS (POLIELLA) CHILO, new species

Plate 5, fig. 4

Dorsal shield.—Dorsal shield rather small, quite slender, elongate-oval in outline, the greatest width, exclusive of the free cheeks which have not been preserved, a little more than half the length. Axial lobe relatively broad in all three divisions of the shield and conspicuously elevated above the flattened pleura.

Cephalon.—Cephalon more than one-third the length of the dorsal shield. Glabella large relatively, rather tumid, subrectangular in outline, expanding very slightly near the front; dorsal furrows feebly impressed, rudely parallel excepting near the anterior extremity where they tend to diverge; front of glabella ill defined, very broadly and very feebly arcuate; glabellar furrows obscure, the posterior pair oblique, the medial and anterior pairs more nearly transverse; occipital furrow shallow; occipital ring imperfectly preserved, apparently rather wide and similar in character to the anterior segments of the thorax. Fixed cheeks imperfectly known, apparently rather wide and broadly convex, the distance from the palpebral lobe to the dorsal furrow more than half the width of the medial portion of the glabella; postero-lateral lobe narrow, short, obtusely petaloid at its extremity; posterior groove not very deep, in line with the occipital

ring; margin behind the groove increasingly wide away from the axis. Palpebral lobe conspicuously elevated and not differentiated from the palpebral ridge which cuts obliquely across the fixed cheek and intercepts the dorsal furrows near the origin of the posterior glabellar furrows; raised margin of the lobe probably cut off from the surface of the cheek by a broad and rather deep furrow. Other characters of the cephalon not preserved.

Thorax.—Thoracic segments nine in number. Axial lobe strongly convex, broader than the pleural lobes. Pleura short, the anterior medial segments the most produced; pleural furrows rather shallow, almost as wide as the including segment; extremities of the anterior and medial segments apparently obtuse; last three segments in front of the caudal shield acutely falcate distally.

Pygidium.—Pygidium short, rudely lenticular in outline. Axial lobe, strongly convex, relatively broad, subcylindrical, tapering slightly toward the broadly rounded posterior extremity; annulations distinct but not conspicuous, indicating two component segments and a terminal section. Pleural lobes somewhat flexuous, of approximately the same width as the axial; pleural grooving very obscure, rudely parallel to the anterior margin. Peripheral rim narrow, smooth, flattened, broadly arcuate.

Surface.—External surface microscopically shagreened.

Dimensions.—Length of dorsal shield, $12.5 \pm$ mm. Greatest width of dorsal shield, exclusive of the fixed cheek, $7.0 \pm$ mm.

Type locality.—(63n) Ptarmigan formation; Wonder Pass, west of Gog Lake, British Columbia, Canada.

Observations.—When in the field I referred this species to *B. (P.) sylla*¹ of the Chetang formation, but comparison with the type specimen of the latter showed that they differed in the nearly straight sides of the glabella and narrower and shorter associated pygidium. The most nearly related species appear to be *B. (P.) primus* and *B. (P.) anteros*² from which it differs in many details.

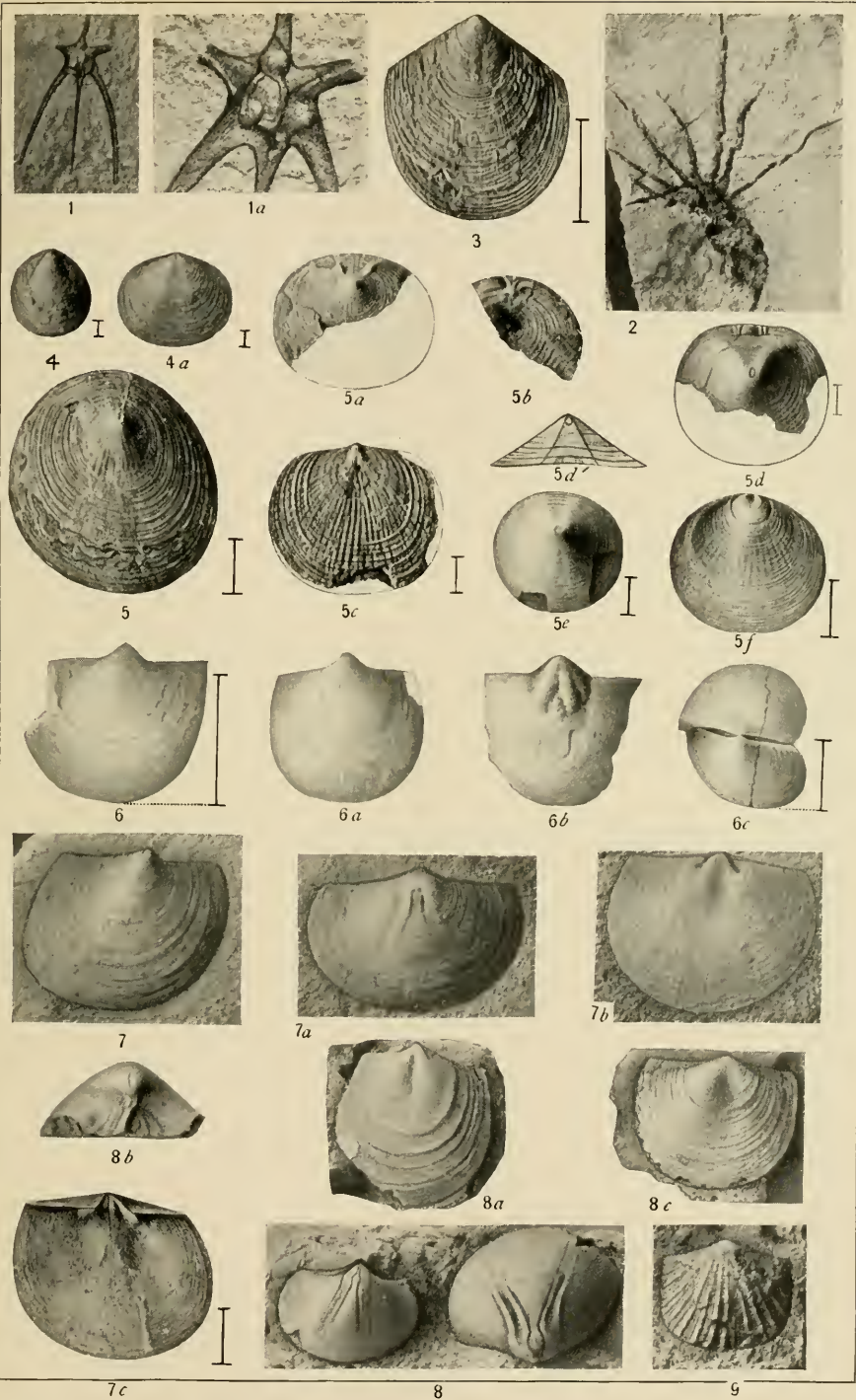
Formation and locality.—Middle Cambrian: (63n) Ptarmigan ? formation; bluish thin-bedded limestone northwest side of Wonder Pass at east base of ridge west of Gog Lake, on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Canada.

¹ Smithsonian Misc. Coll., Vol. 64, 1916, p. 354, pl. 48, figs. 3, 3a-e.

² Idem, pl. 46, figs. 5, 6, 6a-c.

DESCRIPTION OF PLATE 4

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| <i>Tholiasterella ? hindei</i> Walcott..... | 25 |
| FIG. 1. (× 2.) A six-rayed spicule showing a central nodule. U. S. National Museum, Catalogue No. 63711. (63j.) | |
| 1a. (× 6.) Central portion of the disk of fig. 1 enlarged to show structure. | |
| <i>Eocystites ?</i> sp. undt. | 25 |
| FIG. 2. (Natural size.) The only specimen known to me of this form. U. S. National Museum, Catalogue No. 63712. | |
| The specimens represented by figs. 1, 1a, and 2 are from (Locality 63j) Middle Cambrian: Ptarmigan formation (Ross Lake shale); above Ross Lake, British Columbia. | |
| <i>Micromitra (Paterina) wapta</i> Walcott..... | 25 |
| FIG. 3. (× 2.) Exterior of ventral valve. The type specimen (U. S. National Museum, Catalogue No. 51402a). The figure 3 is copied from Walcott, Smithsonian Misc. Coll., Vol. 53, 1908, pl. 7, fig. 6. Also Monogr. 51, U. S. Geol. Surv., 1912, text fig. No. 29A, p. 357. | |
| The specimen represented is from (Locality 35c) Middle Cambrian: Ptarmigan formation (Ross Lake shale); Mount Bosworth, British Columbia. | |
| <i>Obolus parvus</i> Walcott | 25 |
| FIG. 4. (× 4.) Exterior of a ventral valve, the type specimen (U. S. National Museum, Catalogue No. 51400a). | |
| 4a. (× 4.) Exterior of a dorsal valve. U. S. National Museum, Catalogue No. 51400b. | |
| The specimens represented by figs. 4 and 4a are copied from Walcott, Smithsonian Misc. Coll., Vol. 53, 1908, pl. 7, figs. 10, 10a. Also Monogr. 51, U. S. Geol. Surv., 1912, text figs. 37A and 37B, p. 408. | |
| The specimens represented are from (Locality 35c) Middle Cambrian: Ptarmigan formation (Ross Lake shale); Mount Bosworth, British Columbia. | |
| <i>Acrothele colleni</i> Walcott | 25 |
| FIG. 5. (× 4.) A large ventral valve. U. S. National Museum, Catalogue No. 51410c. | |
| 5a. (× 4.) Broken ventral valve showing false area. U. S. National Museum, Catalogue No. 51410b. | |
| 5b. (× 4.) Cast of a ventral valve showing the incurving of the growth lines across the false area. U. S. National Museum, Catalogue No. 51410d. | |
| 5c. (× 4.) Exterior of a dorsal valve. U. S. National Museum, Catalogue No. 51410e. | |
| The figures 5, 5a-c are copied from Walcott, Monogr. 51, U. S. Geol. Surv., 1912, text figs. 55, B, C, D, and E, p. 641. | |
| The specimens represented are from (Locality 35c) Middle Cambrian: Ptarmigan formation (Ross Lake shale); Mount Bosworth, British Columbia. | |
| 5d, 5d'. (× 4.) Top and back views of the posterior portion of a ventral valve. U. S. National Museum, Catalogue No. 51973b. | |
| 5e. (× 4.) Side view of the type specimen, a ventral valve. U. S. National Museum, Catalogue No. 51973a. | |



SPONGE, CYSTID, AND BRACHIOPODS

Acrothele colleni Walcott—Continued.

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- 5f. ($\times 2.5$.) Exterior of a dorsal valve with the cardinal slopes rounded in by pressure. An imperfect valve beside it has the outline of figure 5c. U. S. National Museum, Catalogue No. 51973c.

The figures 5d, 5e, and 5f are copied from Walcott, Monogr. 51, U. S. Geol. Surv., 1912, pl. 63, figs. 6, 6a, 6b.

The specimens represented are from (Locality 4q) Middle Cambrian: Gordon shale near Gordon Mountain, Ovando quadrangle (U. S. G. S.), Montana.

Wimanella simplex Walcott 26

- Figs. 6, 6a. (Natural size.) Ventral valves of varying outline owing to distortion in the shale. U. S. National Museum, Catalogue Nos. 52277a and 52277b.

- 6b. (Natural size.) Cast of interior of a ventral valve. U. S. National Museum, Catalogue No. 52277d.

- 6c. ($\times 2$.) Ventral and dorsal valves compressed and resting against each other at the posterior margins. U. S. National Museum, Catalogue No. 52278b.

The figures 6, 6a-c are from Walcott, Monogr. 51, U. S. Geol. Surv., 1912, pl. 89, figs. 2a, 2b, 2c, 2c.

The specimens represented are from (Locality 4w) Middle Cambrian: Gordon shale on Youngs Creek, Ovando quadrangle (U. S. G. S.), Montana.

- 7, 7a. ($\times 2$.) Ventral valves of varying outline owing to distortion in the shale. U. S. National Museum, Catalogue Nos. 63713 and 63714. (63j.)

- 7b. ($\times 2$.) Cast of interior of a dorsal valve. U. S. National Museum, Catalogue No. 63715. (63j.)

- 7c. ($\times 3$.) Interior of a compressed dorsal valve. U. S. National Museum, Catalogue No. 51407. This figure is from Walcott, Monogr. 51, U. S. Geol. Surv., 1912, text fig. No. 64, p. 748.

The specimen represented by 7c is from (Locality 35c) Middle Cambrian: Ptarmigan formation (Ross Lake shale): Mount Bosworth, British Columbia.

8. ($\times 2$.) Cast of two ventral valves in limestone. U. S. National Museum, Catalogue No. 63716. (63m.)

- 8a. ($\times 3$.) Exterior of a ventral valve. U. S. National Museum, Catalogue No. 63717. (63m.)

- 8b. ($\times 3$.) Area of a ventral valve. U. S. National Museum, Catalogue No. 63718. (63m.)

- 8c. ($\times 2$.) Exterior of a dorsal valve. U. S. National Museum, Catalogue No. 63719. (63m.)

The specimens represented by figs. 7, 7a-b are from siliceous shale (Locality 63j), Middle Cambrian: Ptarmigan formation (Ross Lake shale); above Ross Lake; and figs. 8, 8a-c from limestone interbedded in the shale of locality 63m, Middle Cambrian: Ptarmigan formation; Mount Bosworth, both in British Columbia.

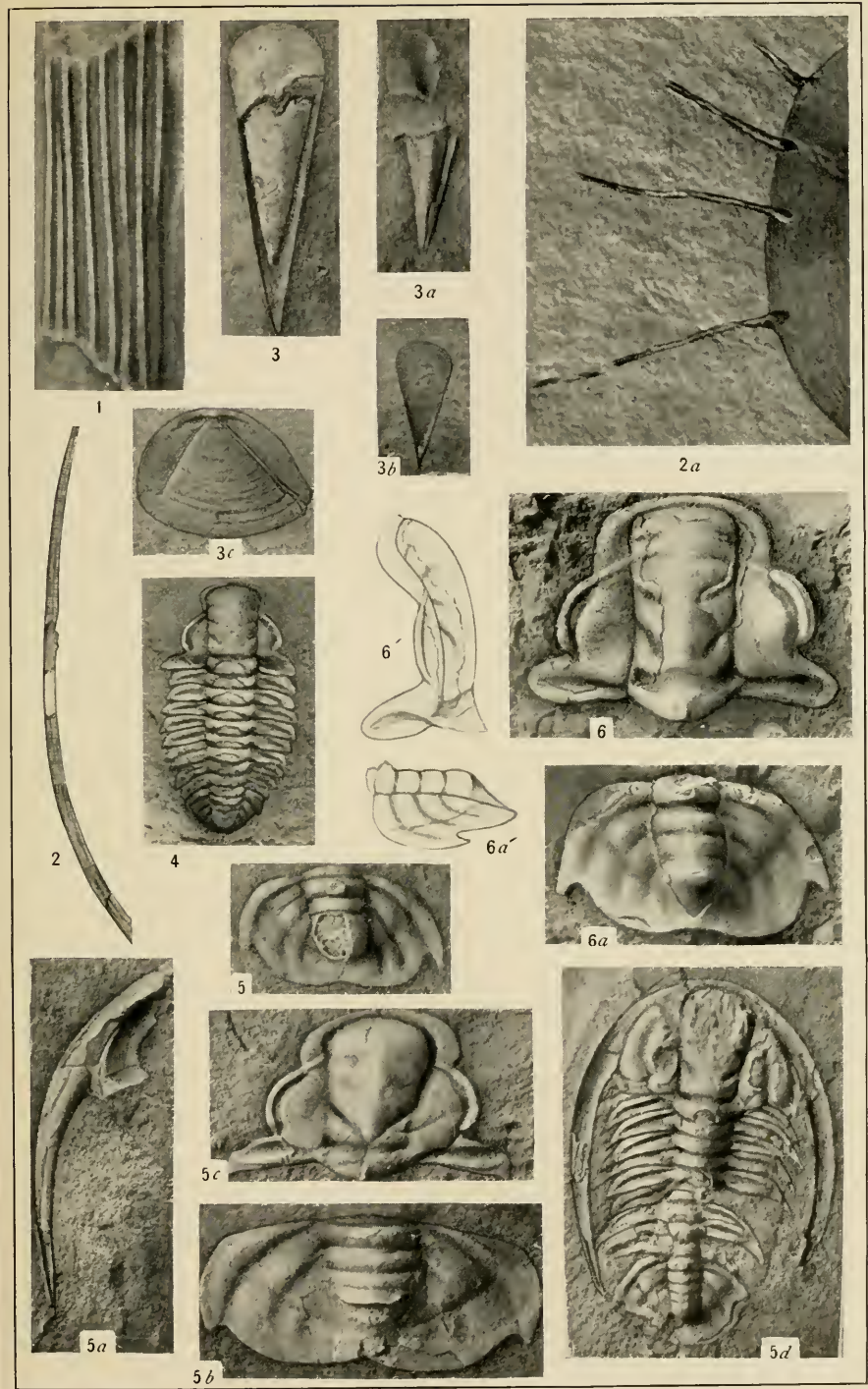
Nisusia cf. alberta Walcott 26

- Fig. 9. ($\times 3$.) Imperfect exterior of a small ventral valve. U. S. National Museum, Catalogue No. 63720.

The specimen represented by fig. 9 is from limestone (Locality 61 o), Middle Cambrian: Chetang formation; Robson District, Alberta.

DESCRIPTION OF PLATE 5

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| <i>Hyolithellus hectori</i> Walcott..... | 27 |
| FIG. 1. (× 8.) Section of a tube enlarged to show surface characters.
U. S. National Museum, Catalogue No. 63721. | |
| The specimen represented is from (Locality 35c) Middle Cambrian: Ptarmigan formation (Ross Lake shale); Mount Bosworth, British Columbia. | |
| <i>Hyolithellus flagellum</i> (Matthew)..... | 26 |
| FIG. 2. (× 3.) A long curved tube. U. S. National Museum, Catalogue No. 63722. The figure 2 is the same as fig. 8, pl. 1, Walcott, Canadian Alpine Journ., Vol. 1, 1908. | |
| From (Locality 14s) Middle Cambrian: Stephen formation; Mount Stephen, British Columbia. | |
| 2a. (× 4.) A group of four small tubes attached to a valve of <i>Wimanella simplex</i> . U. S. National Museum, Catalogue No. 63723. | |
| From (Locality 63j) Middle Cambrian: Ptarmigan formation (Ross Lake shale); above Ross Lake, British Columbia. | |
| <i>Hyolithes cecrops</i> Walcott..... | 27 |
| FIG. 3. (Natural size.) Dorsal view with shell broken away. The type specimen. U. S. National Museum, Catalogue No. 63724. | |
| 3a. (× 4.) Ventral view of a small specimen that is only slightly compressed. U. S. National Museum, Catalogue No. 63725. | |
| 3b. (Natural size.) Dorsal view of a small wide specimen flattened in the shale. U. S. National Museum, Catalogue No. 63726. | |
| 3c. (× 2.) Inner side of an operculum associated with the specimen illustrated by figs. 3, 3a-b. U. S. National Museum, Catalogue No. 63727. | |
| The specimens represented by figs. 3, 3a-c are from (Locality 63j) Middle Cambrian: Ptarmigan formation (Ross Lake shale); above Ross Lake, British Columbia. | |
| <i>Bathyriscus (Poliella) chilo</i> Walcott..... | 50 |
| FIG. 4. (× 3.) Small dorsal shield a little injured by weathering. U. S. National Museum, Catalogue No. 63728. | |
| From limestone (Locality 63n), Middle Cambrian: Ptarmigan formation: Wonder Pass, British Columbia. | |
| <i>Bathyriscus rossensis</i> Walcott..... | 46 |
| FIG. 5. (× 1.5.) A nearly perfect cranium. U. S. National Museum, Catalogue No. 63729. | |
| 5a. (Natural size.) Interior of a large free cheek. U. S. National Museum, Catalogue No. 63730. | |
| 5b. (× 2.) A pygidium somewhat crushed in the shale. U. S. National Museum, Catalogue No. 63731. | |



PTEROPODS, ANNELIDS, AND TRILOBITES

Bathyriscus rossensis Walcott—Continued.

PAGE

5c. ($\times 2$.) A small, fairly well-preserved pygidium. U. S. National Museum, Catalogue No. 63732.

5d. (Natural size.) A crushed dorsal shield, illustrating the general characters of the species. U. S. National Museum, Catalogue No. 63733.

The specimens represented by figs. 5, 5a-d are from (Locality **63j**) Middle Cambrian: Ptarmigan formation (Ross Lake shale); above Ross Lake, British Columbia.

Bathyriscus cf. *rossensis* Walcott..... 49

.Fig. 6. (Natural size.) A large, partially exfoliated cranidium. U. S. National Museum, Catalogue No. 63734.

6'. Side outline of fig. 6.

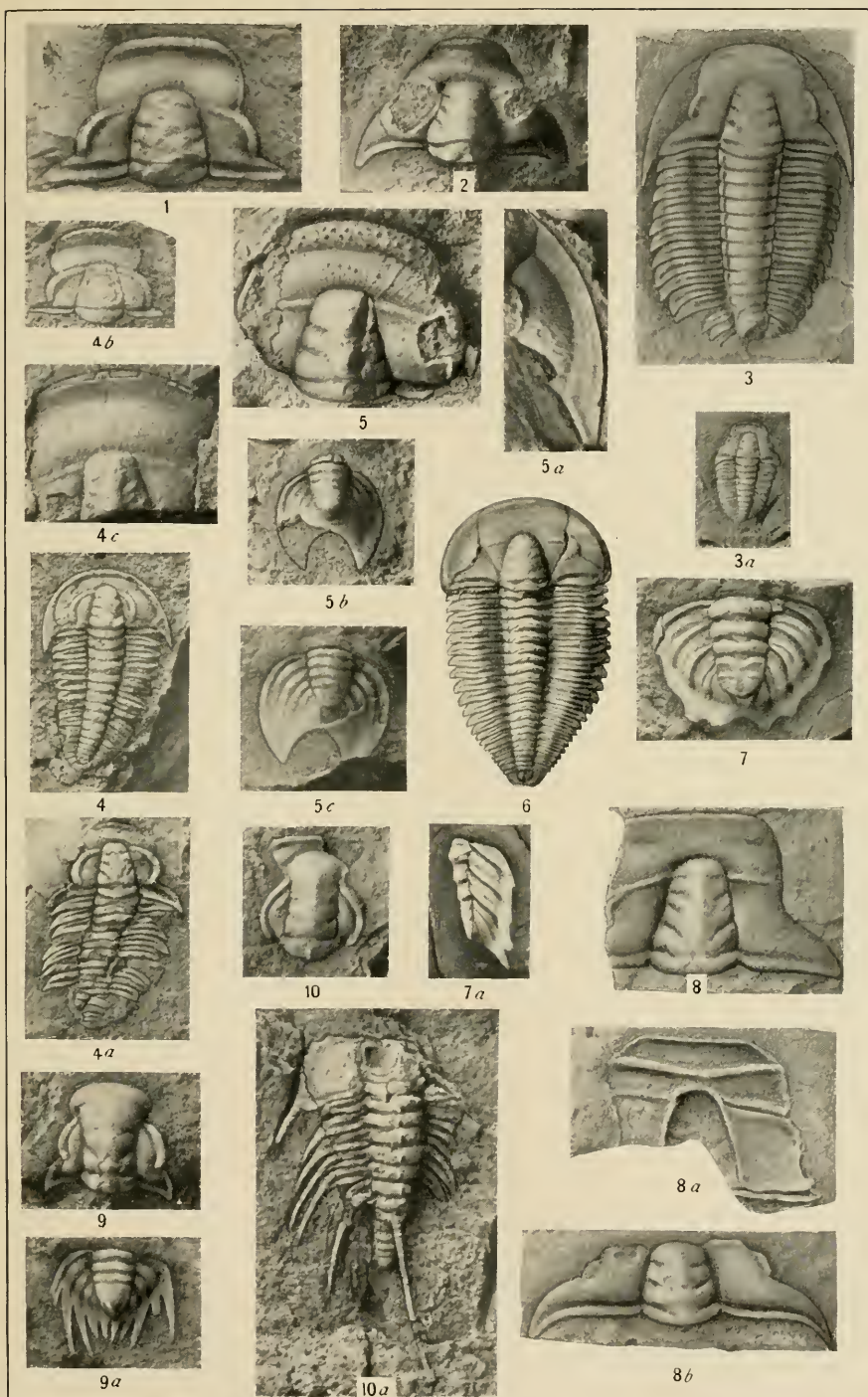
6a. ($\times 3$.) Pygidium associated with the cranidium represented by fig. 6. U. S. National Museum, Catalogue No. 63735.

6a'. Side outline of fig. 6a.

The specimens represented by figs. 6, 6a are from thin limestone layers interbedded in the Ross Lake shale (Locality **63m'**), Middle Cambrian: Ptarmigan formation; Mount Bosworth, British Columbia.

DESCRIPTION OF PLATE 6

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| <i>Ptychoparia charax</i> Walcott..... | 31 |
| FIG. 1. (× 2.) A cranium, and the type specimen of the species. | |
| U. S. National Museum, Catalogue No. 63736. | |
| From locality 4v, Middle Cambrian: Gordon shale; Gordon Creek, Montana. | |
| <i>Ptychoparia ? cilles</i> Walcott..... | 32 |
| FIG. 2. (× 5.) A small cranium and the type specimen of the species. | |
| U. S. National Museum, Catalogue No. 63737. | |
| From limestone of locality 63d, Middle Cambrian: Ptarmigan formation; Ptarmigan Mountain, Alberta. | |
| <i>Ptychoparia candace</i> Walcott..... | 28 |
| FIG. 3. (× 2.) A flattened dorsal shield with its pygidium broken and pressed down and free cheeks detached. They are outlined from another cephalon which has one free cheek on which there appears to be the base of a postero-lateral spine. U. S. National Museum, Catalogue No. 63738. | |
| 3a. (× 6.) Specimen of a dorsal shield with ten thoracic segments. U. S. National Museum, Catalogue No. 63739. | |
| From locality 4v, Middle Cambrian: Gordon shale; Gordon Creek, Powell County, Montana. | |
| <i>Ptychoparia pylas</i> Walcott..... | 33 |
| FIG. 4. (× 6.) A small dorsal shield. The palpebral lobes and some details restored from other specimens. U. S. National Museum, Catalogue No. 63740. | |
| 4a. (× 4.) A badly crushed dorsal shield well illustrating thoracic segments and parts of cranium. U. S. National Museum, Catalogue No. 63741. | |
| 4b. (× 2.) A small cranium flattened in the shale. U. S. National Museum, Catalogue No. 63742. | |
| 4c. (× 2.) The largest cranium observed, illustrating the rapid increase in size of the frontal limb with increase in size of cranium. U. S. National Museum, Catalogue No. 63743. | |
| From locality 4q, Middle Cambrian: Gordon shale; on ridge between Gordon and Youngs Creeks, Powell County, Montana. | |
| <i>Crepicephalus chares</i> Walcott..... | 35 |
| FIG. 5. (× 3.) Broken cranium showing surface characters. U. S. National Museum, Catalogue No. 63744. | |
| 5a. (× 3.) Free cheek associated with fig. 5. U. S. National Museum, Catalogue No. 63745. | |
| 5b, 5c. (× 3.) Pygidia associated with specimen represented by fig. 5. U. S. National Museum, Catalogue Nos. 63746 and 63747. | |
| From locality 63d, Middle Cambrian: Limestone of Ptarmigan formation; Ptarmigan Peak, Alberta. | |

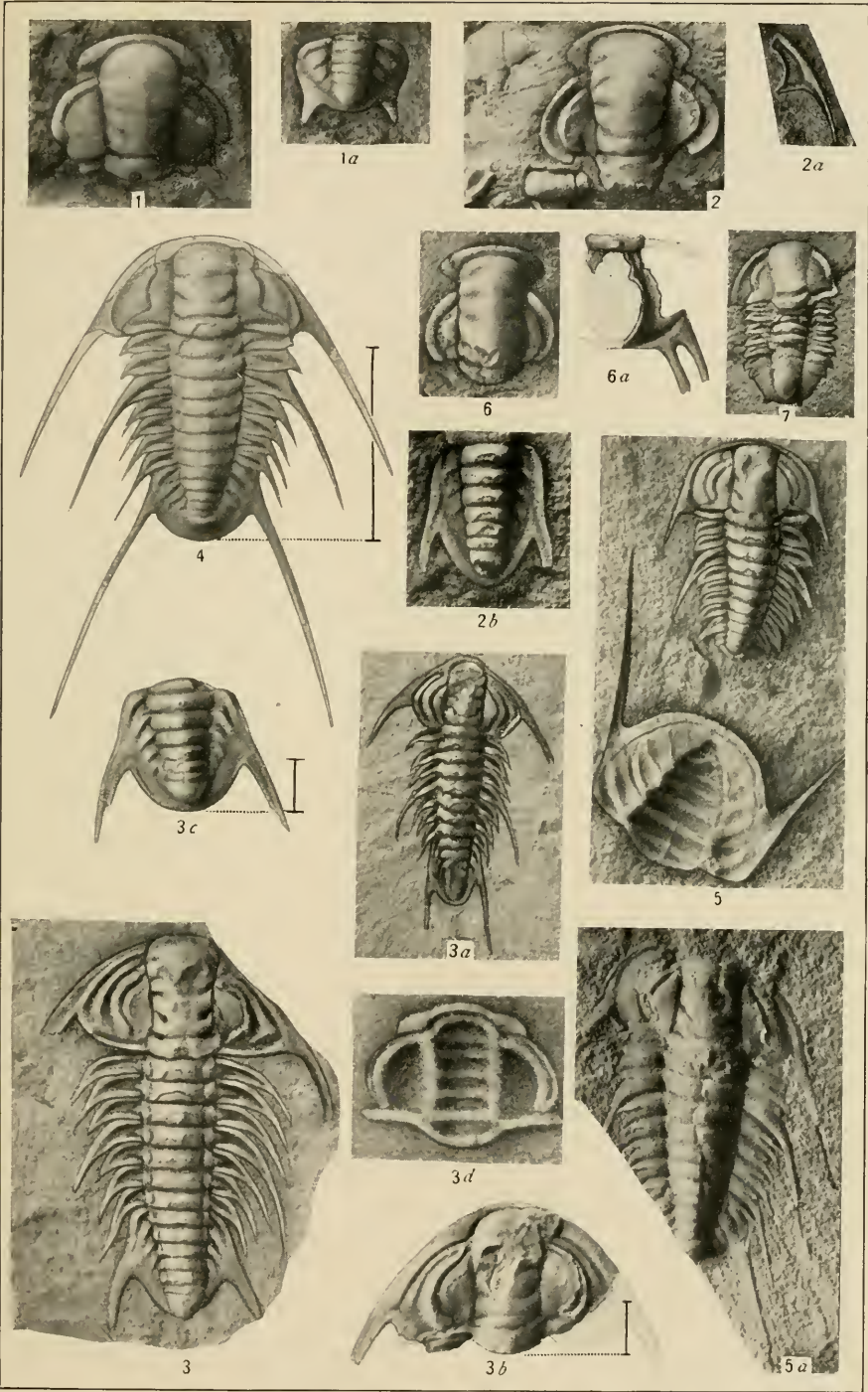


CAMBRIAN TRILOBITES

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- Agraulos stator* Walcott..... 28
- FIG. 6. (Natural size.) A nearly perfect dorsal shield, the type specimen. U. S. National Museum, Catalogue No. 61729. After Walcott, Smithsonian Misc. Coll., Vol. 64, pl. 36, fig. 6.
- From locality **35c**, Middle Cambrian: Ptarmigan formation (Ross Lake shale); Mount Bosworth, British Columbia.
- Neolenus constans* Walcott..... 45
- FIGS. 7, 7a. (Natural size.) Top and side views of the type specimen of pygidium. U. S. National Museum, Catalogue No. 63748.
- From locality **63b**, Middle Cambrian: Limestone of Ptarmigan formation; Ptarmigan Peak.
- Olenopsis* cf. *americanus* Walcott..... 37
- FIGS. 8, 8a, 8b. ($\times 1.5$.) Broken cranidia that illustrate the form and details of the cranidium. U. S. National Museum, Catalogue Nos. 63749, 63750, 63751.
- From locality **63j**, Middle Cambrian: Ptarmigan formation (Ross Lake shale); above Ross Lake.
- Zacanthoides charilla* Walcott..... 40
- FIG. 9. ($\times 4$.) The type specimen of the cranidium, which is preserved in limestone and retains its original convexity. U. S. National Museum, Catalogue No. 63752.
- 9a. ($\times 4$.) Pygidium associated with fig. 9. U. S. National Museum, Catalogue No. 63753.
- From locality **61 o**, Middle Cambrian: Limestone of Chetang formation; Robson Peak district, Alberta.
- Zacanthoides cnopus* Walcott..... 43
- FIG. 10. ($\times 3$.) A broken dorsal shield illustrating thorax. U. S. National Museum, Catalogue No. 63754.
- 10a. ($\times 2$.) A cranidium associated with fig. 10. U. S. National Museum, Catalogue No. 63755.
- From locality **4v**, Middle Cambrian: Gordon shale; Gordon Creek, Montana.

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| <i>Albertella levis</i> Walcott..... | 39 |
| FIG. 1. (× 3.) The type specimen of cranium. U. S. National Museum, Catalogue No. 63757. | |
| 1a. (× 4.) Pygidium associated with fig. 1. U. S. National Museum, Catalogue No. 63758. | |
| From locality 61w , Middle Cambrian: Chetang formation limestone; Terrace Creek, Robson district, Alberta. | |
| <i>Albertella bosworthi</i> Walcott..... | 38 |
| FIG. 2. (× 4.) A cranium preserving its natural convexity. U. S. National Museum, Catalogue No. 63759. | |
| 2a. (× 3.) A small associated free cheek. U. S. National Museum, Catalogue No. 63760. | |
| 2b. (× 4.) An associated pygidium preserving its convexity and narrow form. U. S. National Museum, Catalogue No. 63761. | |
| From locality 61p , Middle Cambrian: Chetang formation limestone; Coleman Creek, Robson district, Alberta. | |
| 3, 3a. (× 1.5.) Almost entire dorsal shields somewhat flattened in the shale. U. S. National Museum, Catalogue Nos. 63762 and 63763. | |
| The specimens represented are from (Locality 63j) Middle Cambrian: Ptarmigan formation (Ross Lake shale); above Ross Lake, British Columbia. | |
| 3b, 3c. (× 2.) Cranium and pygidium for comparison with those of <i>Albertella helena</i> . U. S. National Museum, Catalogue Nos. 53413 and 53415. The figs. 3b, 3c are after Walcott, Smithsonian Misc. Coll., Vol. 53, 1908, pl. 1, figs. 4 and 6. | |
| The specimens represented by figs. 3b and 3c are from (Locality 35c) Middle Cambrian: Ptarmigan formation (Ross Lake shale); Mount Bosworth, British Columbia. | |
| 3d. (× 12.) Matrix of a minute cranium impressed on the surface of a valve of <i>Wimanella simplex</i> . U. S. National Museum, Catalogue No. 63764. | |
| From locality 63j , associated with figs. 3, 3a. | |
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| FIG. 4. (Natural size.) A nearly entire dorsal shield, the type specimen. U. S. National Museum, Catalogue No. 53410. The fig. 4 is after Walcott, Smithsonian Misc. Coll., Vol. 53, 1908, pl. 2, fig. 1. | |
| The specimen represented by fig. 4 is from (Locality 5j) Middle Cambrian: Gordon shale; Scapegoat Mountain, Powell County, Montana. | |



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5. (× 2.) A dorsal shield with a more perfect cephalon than that on fig. 5a. A matrix of a fine pygidium occurs just below on the same fragment of rock. U. S. National Museum, Catalogue No. 63765.
- 5a. (× 3.) A nearly entire dorsal shield. U. S. National Museum, Catalogue No. 63766.

The specimens represented by figs. 5, 5a are from the siliceous shales of (Locality 63j) Middle Cambrian: Ptarmigan formation (Ross Lake shale) ; above Ross Lake, British Columbia.

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FIG. 6. (× 3.) Cranidium preserved in limestone. U. S. National Museum, Catalogue No. 63767.

- 6a. (× 3.) Fragment of an associated pygidium. U. S. National Museum, Catalogue No. 63768.

From locality 63b, Middle Cambrian: Ptarmigan formation; Ptarmigan Peak, Alberta.

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FIG. 7. (× 2.) A nearly entire dorsal shield somewhat crushed in the shale. The type specimen. U. S. National Museum, Catalogue No. 61728. After Walcott, Smithsonian Misc. Coll., Vol. 64, pl. 36, fig. 5.

The specimen represented is from locality 35c, Middle Cambrian: Ptarmigan formation (Ross Lake shale) ; Mount Bosworth, British Columbia.