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GEOLOGY AND PALEONTOLOGY

No. 2.—CAMBRIAN TRILOBITES

WITH SIX PLATES

BY

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# CAMBRIAN GEOLOGY AND PALEONTOLOGY

## No. 2.—CAMBRIAN TRILOBITES

By CHARLES D. WALCOTT

(WITH SIX PLATES)

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The monograph on the Cambrian Brachiopoda,<sup>1</sup> upon which I have been working for so long, is about ready for the press, and attention is now being given to the preliminary study of some of the American Cambrian trilobites. If students and collectors in any country know of interesting or new forms of Cambrian or Lower Ordovician trilobites, or of more perfect specimens representing previously described forms, I should very much like to have their coöperation in making this investigation as thorough and complete as possible.

This is the first of a series of brief papers that will be published as new material of interest is worked up. The classification of Dr. Charles E. Beecher<sup>2</sup> will be followed, in the preliminary studies at least, with such modifications as may appear necessary during the course of the investigations.

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<sup>1</sup> To be published as Monograph LI of the U. S. Geological Survey.

<sup>2</sup> American Jour. Sci., 4th ser., vol. III, 1897, pp. 89-106, 181-207.

## Order PROPARIA Beecher

## BURLINGIDÆ, new family

Dorsal shield small, elongate, broad oval in outline. Cephalon about one-fourth the length, transversely semicircular; genal angle acute or spinose; glabella with transverse lobes. Free cheeks small, separate. Facial sutures cut the margin in front of the genal angles, extend in to the posterior portion of the eye lobe and outward from the anterior portion to the antero-lateral margin of the cephalon. Eyes of medium size, clearly defined.

Thorax with fourteen segments in the one species preserving them; pleuræ with flat, straight furrows.

Pygidium large, with strong axis and pleural lobes, or small and with medium axis and pleural lobes.

STRATIGRAPHIC RANGE.—Central portion of the Middle Cambrian to the *Agnostus pisiformis* zone of the Swedish Upper Cambrian.

OBSERVATIONS.—This family includes the genera *Burlingia* and *Schmalenscicia*.<sup>1</sup> The first is represented by entire specimens and the latter by the cephalon, fragments of the thorax, and entire pygidia. The facial sutures and free cheeks relate *Burlingia* to some forms of the Cheiruridæ, while the pygidium of *Burlingia* recalls the simple pygidium of *Paradoxides*, and the pygidium of *Schmalenscicia* recalls that of *Amphion*. The flat, straight furrowed pleuræ of the thorax of *Burlingia* recall the pleuræ of *Olenoides*. The assemblage of characters in *Burlingia* and *Schmalenscicia* clearly indicate a distinct family of the Proparia, more primitive than any other forms of that order.

## BURLINGIA, new genus

Dorsal shield small, elongate, broadly oval. Cephalon semicircular; one-fourth the length of the entire shield; genal angles with spines; cranium<sup>2</sup> with anterior and posterior limbs that extend outward from the glabella to the outer margin; glabella slightly convex, with indications of lobes. Free cheeks subquadrangular, small. Facial sutures extend from in front of the genal angles inward to the eyes and then obliquely outward and forward, cutting the antero-lateral margin. Eyes of medium size.

Thorax with fourteen segments; pleuræ with a flat, direct furrow; pleuræ extended into backward-curving, falcate extremities.

<sup>1</sup> Moberg, 1903, Meddelande från Lunds Geol. Mineral. Inst. No. 5 (Geol. Fören. i Stockholm Förhandlingar, Bd. xxv. Häft 2, 1903, No. 219), p. 96.

<sup>2</sup> The cranium includes all portions of the cephalon except the free cheeks and eye lobes.

Pygidium small, elongate, without defined segments.

GENOTYPE.—*Burlingia hectori*, new species.

OBSERVATIONS.—This genus is represented by a single species from the central portion of the Middle Cambrian fauna. The only form with which it can be directly compared is *Schmalensecia* Moberg,<sup>1</sup> which is represented by specimens of the cranidium, pygidium, and fragments of the thoracic segments belonging to a single species. The cranidium of *Schmalensecia* differs in having a convex glabella divided into four lobes by four transverse furrows, and in the presence of a defined occipital segment. The fragments of the thorax illustrated by Dr. Moberg (1903, pl. IV) and his description of them indicate that the pleuræ were flattened and marked by shallow, direct furrows similar to those on the pleuræ of *Burlingia*. With the present information, it is in the pygidium that the great difference in the two genera is found. The pygidium of *Schmalensecia* is large and it has a strong axial lobe divided into a number of segments; the pleural lobes are broad and marked by numerous backward-curving, flat furrows much like those of the thoracic segments of *Burlingia*. The pygidium of *Burlingia* is small and apparently without segments or pleural lobes; it is a simple plate as in *Paradoxides*.

Dr. Moberg (1903, p. 100) has noted the resemblance between the direction of the facial sutures of *Schmalensecia* and those of some genera of the Cheiruridæ and Encrinuridæ, while the broad anterior margin of the head suggests some of the Conocoryphidæ; he concludes that these resemblances have little value, as the other parts of the shield differ so largely from the representatives of these genera. In this I agree with him. The two genera are unlike all other trilobites and form a family type by themselves.

The genus is named after Mr. Lancaster D. Burling, of the United States National Museum, who found the only three nearly entire specimens of this interesting trilobite.

#### BURLINGIA HECTORI, new species

##### PLATE I, FIGURE 8

Dorsal shield small; longitudinally broad oval; slightly convex. Cephalon one-fourth the length of the complete dorsal shield, semi-circular in outline, with genal angles prolonged into short slender spines that scarcely extend beyond the extremity of the first or anterior thoracic segment; the posterior margin of the cephalon is nearly

<sup>1</sup> Moberg, 1903, Meddelande från Lunds Geol. Mineral. Inst. No. 5 (Geol. Fören. i Stockholm Förhandlingar, Bd. xxv, Häft 2, 1903, No. 219), pp. 93-102, pl. IV.

transverse except at the axial lobe, where it arches slightly forward; the slope from the central portion of the cephalon to the margin is unbroken by any furrow and there is no clearly defined or raised rim. Cranidium with a broad campanulate frontal limb that extends from the anterior base of the eyes obliquely outward and forward and directly forward from the glabella to the outer margin of the cephalon; the posterior limbs, on their inner side, occupy the space between the posterior base of the eye and the posterior margin of the cephalon and extend outward to the lateral margin with a gradually increasing width; there is no fixed cheek between the palpebral lobe and the glabella; palpebral lobe about one-third the length of the cephalon and situated a little back of the center; it is slightly elevated along the outer margin and slopes toward the dorsal furrow next to the glabella. Glabella about three-fifths the length of the cephalon; it has subparallel sides up to the front of the eyes, where the sides curve inward and unite to form an obtusely rounded outline; in front the glabella merges into the frontal limb, so as to make it difficult to indicate a line of division between them; the glabella is gently convex and more or less clearly marked by a narrow median ridge, and, on each side of the ridge, two pits that indicate transverse furrows, very much as do the pits on the glabella of *Oryctocephalus*<sup>1</sup>; there is no trace of an occipital furrow or segment. Free cheeks subquadrangular in outline; on their inner margin they support the visual surface of the eye and from there slope gently to the outer margin. The facial sutures cut the lateral margin of the cephalon some distance in front of the genal angle and extend with a little backward curvature to the posterior base of the eye; after curving over the eye lobe they extend obliquely forward at an angle of about 50° to the margin.

Thorax with fourteen segments; the first is nearly transverse, but each succeeding pleural lobe bends back a little more than the one preceding it, so that the pleural lobe of the posterior segment is bent back parallel to the side of the pygidium; the central axis of the thorax is gently convex, with a low median ridge that rises into a minute node on the two anterior segments; it gradually widens from the first to the seventh segment, and then narrows a little at each segment back to the pygidium; the pleural lobes are flattened between the axial lobe and the angle where the pleuræ bend more or less backward; each pleura has a broad, shallow, direct furrow that extends from the inner end out to the backward curving portion of the pleuræ; the edge of the furrow and of the segment is marked by

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<sup>1</sup> Walcott, 1886, Bull. U. S. Geol. Survey, No. 30, p. 210.

a narrow thread-like ridge; the pleuræ terminate in falcate extremities, some of which, on the two anterior segments, appear to have a very short, fine spine at the posterior termination of each pleura.

Pygidium a narrow, elongate, moderately convex, central plate without defined segments or pleural lobes; it has a small node at the anterior third of its length. None of the specimens show the posterior margin; it may have been a single, broad spine or it may have terminated with a slightly arched posterior margin.

The outer surface of the dorsal shield appears to have been minutely granular or smooth.

DIMENSIONS.—The most perfect specimen of the dorsal shield has a length of 7 mm.; greatest width, 5 mm. The other dimensions are as follows:

Cephalon:	mm
Length.....	2.25
Width at posterior margin.....	4.74
Thorax:	
Length.....	1.75
Greatest width.....	5.00
Axial lobe, greatest width.....	1.50
Pleural lobe, greatest width.....	1.75
Pygidium:	
Length to line of contour of dorsal shield.....	1.50
Width at anterior end.....	.75

OBSERVATIONS.—This interesting trilobite has a cephalon much like that of *Schmalensecia amphionura* Moberg,<sup>1</sup> but it differs in details, and the pygidium is quite unlike that of Dr. Moberg's species; the furrows and ridges on the pygidium of the latter are very similar to those of the thorax of *Burlingia*.

The stratigraphic horizon of this species is 2,400 feet above the Lower Cambrian or *Olenellus* fauna and 2,600 feet below the Upper Cambrian fauna. It is associated with *Zacanthoides spinosus*, *Ogygopsis klotzi*, *Oryctocephalus reynoldsi*, *Bathyriscus rotundatus*, *Bathyriscus ornatus*, and other species of the *Ogygopsis klotzi* fauna of Mount Stephen.

The specific name is given in recognition of Sir James Hector, the Canadian geologist and explorer who discovered the Hector or Kicking Horse Pass in 1858.

FORMATION AND LOCALITY.—Middle Cambrian: *Ogygopsis* shale of the Stephen formation, 2,400 feet (731.5 m.) above the Lower

<sup>1</sup> Moberg, 1903, Meddelande från Lunds Geol. Mineral. Inst. No. 5 (Geol. Fören. i Stockholm Förhandlingar, Bd. xxv, Häft 2, 1903, No. 219), pl. iv, figs. 1 and 2.



Cambrian and 2,600 feet (792.5 m.) below the Upper Cambrian; northwest slope of Mount Stephen, 3,000 feet (914.4 m.) above the Kicking Horse River, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

Order OPISTHOPARIA Beecher

Family PARADOXIDÆ

**ALBERTELLA, new genus**

Dorsal shield elongate-ovate. Cephalon large, semicircular in outline, about one-fourth the length of the dorsal shield; genal angles extended into spines; cranidium subquadrangular in outline, with long palpebral lobes and narrow fixed cheeks; palpebral lobes elongate, with outer rims continued across the fixed cheeks as narrow ocular ridges; glabella subquadrilateral in outline, with short lateral furrows; strong occipital ring. The facial sutures cut the posterior border within the genal angles and pass inward and slightly forward to the base of the eyes, thence about the palpebral lobe, and forward with slight curvature to the front margin.

Thorax with seven segments; pleuræ terminating in short spines, those of the third or fourth segment in longer spines; pleural furrow with broad inner end largely filled in by an elongated tubercle.

Pygidium large, with central axis divided into several rings, and with the first, or first and second combined, anterior, ankylosed segments extended across the border into a long spine on each side.

GENOTYPE.—*Albertella helena*, new species.

STRATIGRAPHIC RANGE.—Upper beds of Lower Cambrian.

GEOGRAPHIC DISTRIBUTION.—Western Alberta, near the line of the Canadian Pacific Railway, Canada, and northern Montana, in the Lewis and Clark Forest Reserve.

OBSERVATIONS.—*Albertella* is a most interesting type of the order Opisthoparia and family Paradoxidæ. It should first be compared with the genus *Zacanthoides* Walcott,<sup>1</sup> which, in the British Columbia section, is first met with in strata 2,000 feet above the beds in which *Albertella* occurs. The cephalons of the two genera are generically the same. The thoracic segments are of the same type, but the third or fourth segment of the thorax of *Albertella* is extended into long pleural spines, and the thorax has seven instead of nine segments, as in *Zacanthoides*. The pygidium of *Albertella* has a long, strong spine extending from the pleural lobes of the first, or first and second combined, anterior segments, and a smooth border otherwise; the

<sup>1</sup> Walcott, 1888, American Jour. Sci., 3d ser., vol. XXXVI, p. 165.



pygidium of *Zacanthoides* has all the pleural segments extended as spines directly across the border.

The prominent differences between the two genera, then, are the extension in adult individuals of the third or fourth segment of the thorax in *Albertella*, and the presence on the pygidium of one pair of spines instead of many spines, as in *Zacanthoides*.

The extension of the third segment of the thorax occurs in the genera *Olenellus* Hall and *Mesonacis* Walcott,<sup>1</sup> and the spinose extension of the pleural elements of the pygidium occurs in *Parabolina* Salter,<sup>2</sup> *Hysterolenus* Moberg,<sup>3</sup> and other genera, but these other genera differ in so many other characters that it is unnecessary to make comparisons between them and *Albertella*.

### ALBERTELLA HELENA, new species

PLATE 2. FIGURES 1-9

Dorsal shield of medium size; with the exception of spines, longitudinally elongate-ovate; moderately convex. Cephalon semicircular in outline, one-third the length of the dorsal shield; marginal border of medium width, slightly convex, delimited from the cheeks by a sharp, shallow furrow, and continued at the genal angles directly into long, slender spines that extend outward and backward to a line back of the union of the thorax and pygidium; posterior border narrow at the inner end next to the dorsal furrow, a little wider at the facial sutures, and arching a little forward before merging into the outer border at the genal spine; the posterior border is delimited from the cheeks by a narrow, shallow furrow that begins opposite the center of the occipital segment, and, arching forward a very little, passes into the furrow within the outer border. Cranium convex, subquadrangular in outline exclusive of the extension of its postero-lateral limbs; the latter are of medium width, with nearly one-half of their area occupied by the posterior furrow and border. Fixed cheeks at the palpebral lobe one-third the width of the glabella; posteriorly they merge into the postero-lateral limbs; anteriorly they pass directly forward to the interborder furrow; palpebral lobe narrow, elongate, about three-fifths the length of the cephalon,

<sup>1</sup> Walcott, 1891, Tenth Ann. Rept. U. S. Geol. Survey, pls. LXXXII, LXXXIII, LXXXIV, LXXXV, and LXXXVII.

<sup>2</sup> Moberg and Möller, 1898, Meddelande från Lunds Geol. Fältklubb, No. 3 (Geol. Fören. i Stockholm Förhandlingar, Bd. xx, Häft 5, 1898, No. 187), pls. XII and XIII.

<sup>3</sup> Moberg, 1898, Meddelande från Lunds Geol. Fältklubb, No. 5 (Geol. Fören. i Stockholm Förhandlingar, Bd. xx, Häft 6, 1898, No. 188), pl. xvii, figs. 1-9.

bordered by a narrow, rounded rim that is continued obliquely inward and forward, as an ocular ridge, across the fixed cheek to the dorsal furrow opposite the anterior pair of glabellar furrows. Glabella, including occipital ring, subquadrilateral, with sides slightly curved inward and front broadly rounded, moderately convex; the average sized glabella is marked by a pair of short, shallow furrows that extend obliquely inward and backward about one-third the distance across the glabella, and a pair of nearly transverse, short furrows that divide it into a short lobe on each side and a large anterior frontal lobe; the latter has a short, shallow furrow on each side about midway of its length that extends directly inward toward the central third of the width of the glabella; the glabella of a crandidium 23 mm. in length has a pair of deep, oblique, posterior furrows, and, in advance of them, four pairs of faint, short, nearly transverse furrows, the posterior pair of which are between the strong, oblique, posterior furrows and the longitudinal, median third of the glabella; a small dorsal shield with a cephalon 1.3 mm. in length, shows the oblique, posterior glabellar furrow and two pairs of the anterior furrows; occipital furrow strong, sharply defined, and curving forward at its ends; occipital ring strong, rounded, arching slightly backward with its anterolateral angle extending forward. Free cheeks slightly convex, with the body rising from the inter-border furrow to the base of the elongate, low eye lobe. The facial sutures cut the posterior margin within the middle third of the distance from the dorsal furrow to the outer margin; they curve gently outward and then inward across the border, and thence with a slight sigmoid curve to the base of the eye lobe; arching over the latter, they extend forward with a slight outward arching to and across the frontal border, so as to cut the frontal margin within a longitudinal line drawn forward from the outer margin of the palpebral lobe.

Thorax with seven nearly transverse segments; axial lobe convex and arching slightly backward; a small, low node occurs at the center near the posterior margin, and a transverse, rounded, low ridge at each end next to the dorsal furrow; the pleura is nearly straight, somewhat flattened, and terminated by a sharp spine that extends obliquely outward and backward a short distance, except on the third segment, which has a strong spine extending backward nearly to a line opposite the posterior third of the pygidium; pleural furrow broad at the dorsal furrow and narrowing to its end at the base of the terminal spine; a rounded, elongate, subtriangular tubercle occupies its inner half; the anterior border of the pleura next to the dorsal furrow is a narrow, rounded ridge, which

widens gradually and passes directly into the terminal spine; the posterior border is a narrow, rounded ridge that merges into the base of the terminal spine.

Pygidium moderately convex, about one-fourth of the length of the dorsal shield, elongate, semicircular in outline; axial lobe convex, divided by five shallow, narrow, transverse furrows into five rings and a terminal section that is within the border; pleural lobes marked by the pleural furrows of four anchylosed segments that merge into the smooth border; a slender but strong, long spine extends from a strong base on each side of the pygidium; this spine appears to be the extension of the anterior anchylosed segment.

Surface finely granulose, with scattered larger granules on small specimens.

DIMENSIONS.—A dorsal shield 40 mm. in length has the following dimensions:

Cephalon:	mm.
Length .....	13.5
Width at posterior margin.....	31.5
Thorax:	
Length .....	17.0
Width at first segment.....	22.0
Pygidium:	
Length .....	9.5
Width .....	15.0

OBSERVATIONS.—A dorsal shield 2.7 mm. in length, with a cephalon 2.3 mm. long, has a fixed cheek nearly as wide as the glabella, an eye lobe fully one-half the length of the cephalon, and the glabella slightly expanded toward the front. A large cranidium, 23 mm. in length, has a glabella proportionally wider in front, and very strong, posterior, oblique furrows.

This species was first found in 1904, on Gordon Creek, Ovando Quadrangle, Montana, in argillaceous shales, a short distance above the supposed Flathead sandstones, in association with

*Acrothele colleni*, new species.

*Wimanelia simplex*, new genus and new species.

*Olenopsis*,

*Ptychoparia*, and

*Bathyriscus*, sp. a.

The stratigraphic position of this subfauna was not determined in Montana, owing to the break in the continuity of the section on Gordon Mountain.

The specific name is given in recognition of the discovery by Mrs.

Walcott, in 1907, of this species and the accompanying subfauna on Mount Bosworth, in the Canadian Rockies. Its position was determined to be at the summit of the Lower Cambrian portion of the section, 2,450 feet below the *Ogygopsis klotzi* fauna of Mount Stephen.

The subfauna at the Mount Bosworth locality includes

- Micromitra (Iphidella) wahta*, new species,
- Obolus parvus*, new species,
- Acrothcle colleni*, new species,
- Wimanelia simplex*, new genus and new species,
- Albertella bosworthi*, new species,
- Albertella helena*, new species, and
- Bathyriscus*, sp. a.

FORMATION AND LOCALITY.—Lower Cambrian: (1) Drift block of siliceous shale on the south slope of Mount Bosworth, on the "Continental Divide," one mile east of Hector, on the Canadian Pacific Railway, British Columbia, Canada; and (2) Wolsey argillaceous shale, on Gordon Creek, 4 miles (2.5 km.) above its union with Danaher Creek, at the southeast foot of Gordon Mountain, Lewis and Clark Forest Reserve, Montana, U. S. A.

#### ALBERTELLA BOSWORTHI, new species

PLATE I. FIGURES 4-7

This species differs from the associated *Albertella helena* in its cephalon, thorax, and pygidium. In the cephalon the eye and palpebral lobe are more elongate and nearer proportionally to the outer margin. In the thorax the pleuræ of the fourth segment are extended into long spines instead of those of the third, as in *A. helena*; the pleural lobes and the entire thorax are narrower in proportion to the length. In the pygidium there are six rings in the axis instead of three or four, and two anchylosed pleural segments pass into the large lateral spines instead of one. Both species have seven thoracic segments and a finely granulated surface and are associated in the same layers of shale at the Mount Bosworth locality.

FORMATION AND LOCALITY.—Lower Cambrian: Drift block of siliceous shale on south slope of Mount Bosworth, on the "Continental Divide;" one mile east of Hector, on the Canadian Pacific Railway, British Columbia, Canada.

## Family OLENIDÆ Salter

## ORYCTOCARA, new genus

Dorsal shield small, elliptical. Cephalon semicircular in outline, from one-third to one-fourth the length of the dorsal shield; genal angles and free cheeks unknown; cranidium subquadrangular in outline exclusive of the narrow postero-lateral limbs; glabella subquadrangular in outline, with three lobes and an occipital ring; the lobes are separated by very slightly defined, transverse furrows terminating in round pits within the lateral margin of the glabella. The facial sutures cut the posterior margin of the head within the genal angles and pass inward and slightly forward to the base of the eye and thence about the palpebral lobe and forward with a slightly outward curvature to the frontal rim. Fixed cheeks broad. Eyes long, with the margin of the palpebral lobe extending across the fixed cheeks as an ocular ridge.

Thorax with eleven segments; pleuræ with straight furrows and abrupt, truncated ends.

Pygidium large, with central axis divided into several rings by transverse furrows, all of which extend across the pleural lobes to the outer margin.

GENOTYPE.—*Oryctocara geikiei*, new species.

OBSERVATIONS.—The cranidium of the cephalon of this genus is much like that of *Oryctocephalus* Walcott,<sup>1</sup> but the thorax and pygidium are unlike. The pleuræ are of the *Olenus* Salter type in having a straight median furrow, while the pygidium is broad and of the *Bathyriscus*<sup>2</sup> type. (See pl. 1, fig. 2, of this paper.)

The genus is referred to the order Opisthoparia Beecher and to the family Olenidæ Salter.

Only one species from the central portion of the Middle Cambrian is now known.

## ORYCTOCARA GEIKIEI, new species

## PLATE I. FIGURES 9, 10

Dorsal shield small, longitudinally elliptical in outline, moderately convex. Cephalon semicircular in outline, a little less than one-third the length of the dorsal shield; free cheeks and genal angles unknown; a narrow, rounded rim extends across the front of the cranidium and it is probable that it continued along the free cheeks and terminated in a small genal spine. Cranidium subquadrangular

<sup>1</sup> Walcott, 1886, Bull. U. S. Geol. Survey, No. 30, p. 210.

<sup>2</sup> Meek, 1873, Sixth Ann. Rept. U. S. Geol. Survey Territories for 1872, p. 484.



in outline exclusive of the postero-lateral limbs; the latter are elongate, subtriangular in outline, and with a narrow, transverse furrow within a rounded rim of medium width. Fixed cheek about two-thirds the width of the glabella and merging posteriorly into the postero-lateral limb and anteriorly extending to the frontal rim; there is no defined frontal limb, owing to the glabella extending to the furrow within the frontal rim; palpebral lobe narrow, rounded, about one-half the length of the cranidium, and with its outer rim extending across the fixed cheek as a narrow ocular ridge nearly parallel to the frontal rim of the cranidium; the palpebral lobe terminates a short distance back of the frontal margin of the glabella. Glabella subquadrangular; slightly narrower at the broadly rounded front than at the occipital ring, moderately convex; divided by four faint, transverse furrows into three transverse lobes, an anterior, terminal lobe and an occipital ring; the faint, transverse furrows terminate on each side in round pits a short distance from and within the margin; occipital ring narrow and rounded. Free cheeks unknown. The facial sutures cut the posterior margin on each side a short distance from the genal angle and extend inward and slightly forward to the base of the eyes; curving over the eyes they extend forward with a slight outward direction, so as to cut the front margin on a line with the outer edge of the palpebral lobe.

Thorax with eleven nearly transverse segments; the axial lobe is convex and one-half the width of the pleural lobes; the segments of the axial lobe have a deep transverse furrow with the margins elevated; the doublure on the front margin of each segment curves downward, so as to pass beneath the downward slope of the posterior half of the next segment in advance of it; the extremity of each segment curves slightly forward, so that the furrow passes out upon the pleura a little in advance of its position at the center of the axial lobe and in front of the pleural furrow; the pleura is straight, nearly flat, and terminating in a blunt, straight margin without spine or backward curvature; the most careful examination fails to reveal spine or falcate extremity; the entire side of the thorax appears as though a sharp knife had cut off the ends of all the pleura from the cephalon to the pygidium; the pleural furrows of each segment originate on a low swelling between the axial and pleural lobes of each segment and extend directly outward to nearly the end of the segment, where they fade away, so as to leave the end of the segment flat; the pleural furrows are about one-third of the width of the segment and arch forward a very little between its two extremities.



Pygidium large, moderately convex; anterior margin slightly arched, so as to join with the posterior segment of the thorax; posterior outline semicircular; axial lobe convex and about two-thirds the length of the pygidium; it is divided into seven transverse rings and a terminal section by transverse furrows; the pleural lobes slope gently from the axial lobe to the lateral and posterior margins; their entire surface is marked by the anchylosed segments, which are similar in appearance to the thoracic segments, except that their backward curvature increases until the pleurae of the posterior segments are nearly parallel to the axis of the pygidium; the furrows and narrow ridges from the terminal segment of the axis extend backward with a slight inward curvature; all furrows and ridges terminate just within the outer margin in the same manner as those of the thoracic pleura.

Surface with relatively large granules on all parts of the dorsal shield.

DIMENSIONS.—A dorsal shield 7.25 mm. in length has the following dimensions:

Cephalon:	mm.
Length .....	1.75
Length of glabella.....	1.50
Width .....	2.50
Width of glabella.....	1.00
Thorax:	
Length .....	3.75
Width .....	4.00
Width of axial lobe at sixth segment.....	8.00
Width of pleural lobe.....	1.60
Pygidium:	
Length .....	1.75
Width at anterior margin.....	3.50

OBSERVATIONS.—This is a very rare species, as only one nearly entire specimen is known; this has the pygidium displaced and the free cheeks are missing. The combination of characters found in several genera is shown (*a*) in the cranidium, in which the glabella is like that of *Oryctocephalus* Walcott; (*b*) in the thorax, which is not unlike that of *Olenus* Salter; and (*c*) in the pygidium, which suggests in relative size and form the pygidium of *Bathyriscus howelli* Walcott.<sup>1</sup> Among the associated fossils are *Micromitra* (*Iphidella*) *pannula* (White), *Ptychoparia piochensis* Walcott, *Ptychoparia cordillera* (Rominger), *Oryctocephalus reynoldsi* Reed, *Zacanthoides idahoensis*, new species, and *Bathyriscus howelli* Walcott.

<sup>1</sup> Walcott, 1886, Bull. U. S. Geol. Survey, No. 30, p. 216.

FORMATION AND LOCALITY.—Middle Cambrian: Spence shale of the Ute formation, 2,755 feet (839.7 m.) below the Upper Cambrian in the Liberty Canyon section; Spence Gulch, a ravine running up into Danish Flat from Mill Canyon, about 15 miles (9.37 km.) west of Montpelier and 5 miles (3.12 km.) west-southwest of Liberty, Bear Lake County, Idaho, U. S. A.

Genus *ZACANTHOIDES* Walcott

*ZACANTHOIDES IDAHOENSIS*, new species

PLATE 3, FIGURES 1-11

Dorsal shield large for a species of this genus, moderately convex, longitudinally elliptical in outline. Cephalon semicircular in outline, one-third the length of the adult dorsal shield; bordered by a rounded rim of medium width that is continued into strong, sharp genal spines that extend backward about one-half the length of the thorax; the posterior border is narrow next to the glabella, from where it widens out to the intergenal spine within the line of the facial suture; beyond the facial suture it curves forward and merges into the lateral border at the base of the genal spine; the posterior intermarginal furrow is sharply defined, and occupies most of the space between the border and the facial suture; on the sides and front of the cephalon the intermarginal furrow is narrow and distinct. Cranidium with a large glabella, short, small antero-lateral limbs, and elongate, slender postero-lateral limbs that have a short, sharp, slender, intergenal spine extending outward and backward from the outer posterior margin; fixed cheeks scarcely more than the inner sides of the large palpebral lobes and a small, subtriangular area in front of the latter; postero-lateral limbs formed of the marginal border and strong, intermarginal furrows; a narrow frontal limb extends across between the glabella and the interborder furrow; palpebral lobe about three-fifths the length of the cranidium and bordered by a narrow, rounded rim that begins, posteriorly, near the median axis opposite the occipital ring, and, curving outward, forward, and then inward, terminates at the dorsal furrow beside the glabella; it is separated from the body of the lobe by a rounded, shallow furrow. Glabella elongate, subquadrilateral in outline, moderately convex in front, sides nearly straight, broadly rounded, and separated from the fixed cheeks and palpebral lobes by a narrow, distinct furrow; surface marked by a pair of posterior furrows that extend obliquely inward, so as to outline two small subtriangular lobes, and two pairs of short, more transverse furrows; the anterior pair is nearly opposite the anterior end of the

palpebral lobe, and the second pair about half way between them and the outer ends of the posterior pair; on some specimens a fourth pair is faintly defined on the large anterior lobe close to the dorsal furrow opposite the rounded angle formed by the sides and rounded front of the glabella. Occipital ring strong, rounded, broadest at the center, and narrowing gradually toward the ends; marked by a small central node near the posterior margin and a rounded, small, depressed tubercle at about one-half the distance between the central node and the dorsal furrow; occipital furrow distinct, narrow, and nearly transverse. Free cheeks large, body gently convex, and rising from the interborder furrow to the base of the elongate, low eye lobe. The facial sutures cut the posterior margin just outside of the intergenal spine and, curving abruptly inward, extend to the posterior base of the eye lobe; arching over the latter, they extend forward and slightly outward with a gentle sigmoid curve, so as to cut the outer margin at a distance from the median line of the cranidium equal to the width of the glabella.

Thorax with nine segments; axial lobe convex, a little wider than the pleural lobes exclusive of the spinose terminations of the pleuræ; a small elongate node occurs at the center on the posterior half of each segment, except on the fifth, which has a long, slender, backward-extending spine; on each side, about half way between the center and the dorsal furrow and nearest the anterior margin, there is a rounded, low tubercle, and on the more perfectly preserved specimens a low, rounded, transverse ridge on each side next to the dorsal furrow; pleural lobes slightly convex; each pleura has a strong furrow that is broad at the inner end next to the dorsal furrow, from whence it narrows gradually to its sharp extremity near the posterior outer end of the pleura just within the base of the terminal spine; a rounded, elongate, subtriangular tubercle occupies much of the broad inner end of the furrow; the front border of each pleura is narrow next to the dorsal furrow; it gradually widens toward the outer end and terminates in a strong, long, backward-extending spine; the narrow posterior border merges into the base of the terminal spine; in most specimens the backward curvature of the anterior margin of the pleura is so abrupt that an obtuse angle is formed, while in some the margin curves gradually into the terminal spine.

Pygidium of medium size; axial lobe convex, narrow, broader than the pleural lobes, divided by narrow, transverse furrows into four rings and a terminal section that, in large specimens, has a slight, transverse furrow that delimits a fifth narrow ring; on the

pleural lobes four anchylosed segments are outlined by narrow, deep furrows; only the two anterior preserve any trace of the pleural furrow, and these are very short and obscure; the pleural segments are mainly made up of the thickened, broad, anterior border and the strong, backward-extending, rounded spines; the outer border is usually obscured until after the fourth spine is passed, and even then in some specimens the short fifth and sixth pairs of spines obscure it; on other specimens the posterior spines are so slightly developed that the outline of the border is preserved.

Surface finely granular.

DIMENSIONS.—A dorsal shield 38 mm. in length has the following dimensions:

Cephalon:	mm.
Length .....	13.0
Width at base.....	30.0
Length of eye lobe.....	7.0
Length of glabella.....	10.0
Width of glabella, base.....	6.0
Width of glabella, front.....	6.5
Thorax:	
Length .....	17.5
Width .....	21.0
Axial lobe, anterior segment.....	8.0
Axial lobe, posterior segment.....	4.5
Pleural lobe, anterior segment.....	6.5
Pleural lobe, posterior segment.....	3.0
Pygidium:	
Length .....	7.5
Width .....	10.0
Axial lobe, anterior segment.....	4.5
Axial lobe, posterior segment.....	2.5

The preceding description is based on adult specimens averaging 38 to 45 mm. in length. A large number of young and small specimens were found in association with the larger adults, some of which exhibit stages of growth. A specimen 1.9 mm. in length (fig. 5) preserves the cranidium and five segments of the thorax. The glabella widens out toward the front, and the occipital furrow is very faint; the base of the palpebral lobe is farther out on the posterior margin than in the adult, and its anterior end is at the dorsal furrow and nearer the antero-lateral, rounded angle of the glabella. The pleural lobe has somewhat broader, more direct furrows on the pleura, and the spine of the fifth segment is very large; another important character is the greater extension of the terminal spines of the third thoracic segment—a character unknown in the

later stages of growth of this species and a character persistent in *Albertella helena*, which occurs over 2,000 feet (609.6 m.) lower than the horizon of *Zacanthoides spinosus* (Rominger) in the Cambrian section of the Canadian Rocky Mountains. It also occurs in the adult forms of *Mesonacis vermontana*<sup>1</sup> and other trilobites of the *Olenellus* fauna. A specimen of the entire dorsal shield 3.2 mm. in length has the same widening of the glabella toward the front as the smaller specimen, but the base of the palpebral lobes have drawn in toward the glabella, and the glabella has extended forward beyond the anterior extremities of the palpebral lobes; the thorax has only adult characters, except that the third segment appears to have on one side a stronger terminal spine, and there are but seven segments; the spines on the border of the pygidium are short, and but four can be seen on each side. Specimens 8 mm. in length have all adult characters in the cephalon and thorax, with the exception of the terminal spines of the pygidium, which are shorter and less clearly defined at the crossing of the border.

OBSERVATIONS.—This species occurs abundantly in Idaho. When collecting it I thought it to be *Zacanthoides typicalis*,<sup>2</sup> but on direct comparison with that species it was found to differ in having the posterior end of the palpebral lobe nearer the glabella; the glabella proportionally narrower in front, and larger antero-lateral parts of the fixed cheek; a broader thoracic axis in proportion to the pleural lobes; a long median spine on the fifth instead of seventh segment; a larger pygidium, with broader pleural lobes, more rings on the axis, and more terminal spines on the pygidium. It is found to differ from *Zacanthoides spinosus* (Walcott)<sup>3</sup> in having the glabella less expanded toward the front; palpebral lobes nearer the glabella at their posterior end; smaller antero-lateral parts of the fixed cheek; absence of a strong occipital spine; in the thorax it differs in having a long median spine on the central axis at the fifth segment instead of the seventh, and the axial lobe is proportionally wider; the pygidium differs in having four rings on the axis instead of three; the axial lobe is proportionally longer, and the spines on the pygidium differ in details of shape and number. The three species occur at the same relative geological horizon, but are widely separated. *Z. typicalis* occurs at Pioche, Nevada, 350 miles south-southwest of the locality of *Z. idahoensis* at Spence Gulch, 15 miles

<sup>1</sup> Walcott, 1891, Tenth Ann. Rept. U. S. Geol. Survey, pl. LXXXVII, fig. 1a; see also pls. LXXXIV and LXXXV.

<sup>2</sup> Walcott, 1886, Bull. U. S. Geol. Survey, No. 30, p. 183.

<sup>3</sup> Walcott, Mon. U. S. Geol. Survey, vol. VIII, 1884, p. 63; and Bull. U. S. Geol. Survey, No. 30, 1886, p. 184.



west of Montpelier, Idaho; *Z. spinosus* is from Mount Stephen, in British Columbia, 685 miles north-northwest of Spence Gulch. Among the associated fossils are *Bathyriscus horwelli* Walcott, *Oryctoccephalus reynoldsi* Reed, *Oryctocara geikiei* Walcott, *Micromitra (Iphidella) pannula* (White).

FORMATION AND LOCALITY.—Middle Cambrian: Spence shale of the Ute formation, 2,755 feet (839.7 m.) below the Upper Cambrian in the Liberty Canyon section; Spence Gulch, a ravine running up into Danish Flat from Mill Canyon, about 15 miles (9.37 km.) west of Montpelier, and 5 miles (3.12 km.) west-southwest of Liberty, Bear Lake County, Idaho, U. S. A.

### Genus **NEOLENUS** Matthew

#### **NEOLENUS INFLATUS**, new species

##### PLATE 5, FIGURES 1-5

Dorsal shield large, elongate-elliptical in outline; axial lobe strongly convex. Cephalon semicircular in outline, with the genal angles produced into sharp spines about one-half the length of the cephalon; a narrow, rounded rim extends across the front of the cranidium, and, widening a little, runs along the outer margins of the free cheeks to the genal angles. The facial sutures cut the posterior margin well within the genal angles with an outward direction to the posterior furrow, where they curve inward and forward to the base of the eye lobe; arching over the eye lobes they curve outward to about the line of the outer rim of the palpebral lobe, forward to the frontal rim, and then obliquely inward across the rim to the front margin. Cranidium with a prominent, tumid glabella, narrow fixed cheeks, small antero-lateral limbs, and strong postero-lateral limbs. Glabella large, convex; the frontal lobe is inflated and, in all but young, small specimens, overhangs the frontal rim; the sides gradually expand from the occipital ring to the broadly rounded front, which extends forward to, and lies parallel with, the furrow within the rounded frontal rim; the anterior half of the glabella is taken up by the expanded, anterior lobe and the posterior half is divided into four narrow lobes by shallow furrows that extend obliquely inward and slightly backward nearly to the median line; in some specimens, especially the young, the furrows are very faintly defined; occipital ring separated from the glabella by a narrow, shallow furrow; it is broad, moderately convex, and with a strong, long, sharp, arching spine that extends back over the thorax nearly to the pygidium; the base of the spine occupies nearly the entire width of the occipital ring at its center. Fixed cheeks



about one-fourth the width of the glabella, gently convex and merging into the anterior and posterior limbs; the posterior limb is about twice as long as deep below the eye lobe and marked by a strong furrow within the broad, slightly convex posterior border; palpebral lobe small, 7 mm. long in a cephalon having a length of 35 mm. at the eye lobes; it is bordered by a rounded rim that continues obliquely forward across the fixed cheek and merges into the side of the glabella. Free cheeks large, gently convex; bordered by a rounded rim that is continued posteriorly into a spine; posterior margin rather broad and about one-third the length of the margin between the genal angles and the occipital ring; eye lobe small and not high. The genal spine is situated some distance out from the central axis, so that it clears the terminal spines of the thoracic pleuræ.

Thorax with seven nearly transverse segments; axial lobe convex, with the segments slightly rounded and a small node at the center of each; a low, narrow, transverse ridge occurs on each side near the union of the axial and pleural lobes; pleural lobes a little wider than the axial lobe and slightly convex; the pleura is straight, out to the backward curving, terminal spine; the narrow pleural furrow originates at the inner end next to the axis and passes obliquely outward, terminating just back of the center of the pleura at the base of the terminal spine; the latter has a strong base and narrows rapidly to a sharp point as it extends outward and backward a short distance.

Pygidium large, moderately convex; anterior margin nearly transverse, posterior outline broadly semi-elliptical; axial lobe convex and narrowing gradually from the anterior margin to the terminal ring at the narrow posterior border; it is divided into ten strong, rounded, transverse rings and a terminal section by ten narrow furrows; the terminal section in large specimens has a transverse pit on each side of its center that indicates an eleventh ring; a low node is indicated at the center of each ring, and a low, narrow, transverse swelling occurs near the dorsal furrow on each side; in a pygidium 8 mm. in length there are nine clearly defined, axial rings, a faint, tenth ring, and an elongate, rounded, terminal section; pleural lobes slightly convex out to the spinose border, which is flattened between the termination of the pleural grooves and its outer edge; the eight marginal spines on each side are similar to those of the pleural lobes of the thorax with the exception of the posterior ones, which extend directly backward; the space between the axial lobe and the margin is marked by the pleural furrows and the narrow

furrows indicating seven anchylosed segments; the posterior furrows are nearly parallel to the sides of the axial lobe; the furrows all terminate on the inner portion of the outer border, the pleural furrows with a slight, elongate pit just within the border.

Surface with variously arranged, irregular, raised lines or narrow, sharp ridges; on the glabella they are very slender and arranged in a somewhat concentric manner, although they are broken and irregular; on the fixed and free cheeks the raised lines are much stronger, irregular, and more or less anastomosing; on the thoracic segments the short, irregular raised lines cross the segments of the axis on each side between the central node and the dorsal furrow, and on the pleuræ they extend obliquely across the raised spaces between the furrows; the pygidium has about the same markings at the thorax except on the flattened border, where the short, elevated, irregular lines extend across the border.

DIMENSIONS.—There are two small, nearly entire dorsal shields. One, having a length of 24 mm. exclusive of the posterior spines of the pygidium, has the following dimensions:

Cephalon:	mm.
Length .....	9.5
Width at posterior margin.....	11.5
Thorax:	
Length .....	8.0
Width at first segment.....	14.0
Pygidium:	
Length .....	7.5
Width at anterior margin.....	10.0

A large cranium, 52 mm. in length, has the following dimensions:

Glabella:	mm.
Length .....	42.0
Width at posterior margin.....	88.0
Width at occipital furrow.....	26.0
Width just in front of ocular ridge.....	34.0
Palpebral rim, length.....	7.0

A large pygidium, 58 mm. in length, has the following dimensions:

	mm.
Width at anterior margin.....	76.0
Axial lobe, length.....	52.0
Axial lobe, width at anterior margin.....	19.0
Axial lobe, width at anterior segment.....	19.0
Axial lobe, width at posterior section.....	10.0
Pleural lobe, width at anterior margin.....	28.5

Hypostoma strongly convex, elongate, strongly rounded at the base, narrowing toward the broadly rounded posterior margin; border slightly flattened, with a rounded edge; this edge is arched slightly upward on the sides at about the posterior third of the length of the hypostoma; a shallow furrow crosses the posterior end of the convex body a short distance in front of the posterior margin and subparallel to it; the alate lateral limbs are subtriangular in outline and slightly convex. The surface is marked by fine, irregular, elevated lines that are subparallel to the rim on the margin and roughly concentric on the body. An hypostoma 26 mm. in length has a width of 28 mm. at its base, 15 mm. at the arches in the margin or at the posterior third; convexity at center, 5 mm.

The above-described hypostoma is associated with this species, *Neolenus superbus*, and a less convex hypostoma which is referred to the latter species.

OBSERVATIONS.—This large species and the associated *Neolenus superbus* appear to mark the extreme development in size of species of *Neolenus* and its latest occurrence in Cambrian time. Fragments of both species are abundant at one locality, and a few entire specimens have been found. It is the largest of the Cordilleran Cambrian trilobites, some of the partially entire specimens indicating a length of 160 mm., width 83 mm.

The most nearly related species is *Neolenus superbus*, from which *Neolenus inflatus* differs in having an inflated glabella, a longer pygidium, and in minor details of the pleuræ of the thoracic segments, pygidium, and cephalon. The inflated glabella, long pygidium with ten rings and spinose terminations of the thoracic pleuræ, separate it from *Neolenus serratus* (Rominger),<sup>1</sup> the type of the genus. The latter also has a granular surface and falcate terminations to the pleuræ of the thoracic segments, and the faunal horizon of *N. serratus* is 1,900 to 2,125 feet below that of *N. inflatus*.

FORMATION AND LOCALITY.—Middle Cambrian: 1,895–2,140 feet (605–653.8 m.) below the Upper Cambrian and about 2,000 feet (609.6 m.) above the beds containing *Zacanthoides typicalis* Walcott and *Bathyriscus howelli* Walcott, the horizon which is correlated with the horizon carrying *Neolenus serratus* (Rominger) in British Columbia,<sup>2</sup> in thin-bedded limestones of the Marjum formation, in ridge on east side of Wheeler Amphitheater, east of Antelope Springs, House Range, Millard County, Utah, U. S. A.

<sup>1</sup> *Ogygia serrata* Rominger, 1887, Proc. Acad. Nat. Sci. Philadelphia, p. 13.

<sup>2</sup> This British Columbia horizon is given in detail in the Formation and locality of *Burlingia hectori*.

## NEOLENUS INTERMEDIUS, new species

## PLATE 6, FIGURES 1-7

This species, as its name implies, is an intermediate form between *N. superbus* and *N. inflatus*. It differs from both of those species in the absence of an occipital spine; and in having the sides of the glabella more nearly parallel and with the glabella less expanded in front, and somewhat more pointed or less abruptly rounded. The pleural lobes of the thorax have a terminal spine on the pleuræ extending backward somewhat more abruptly than in either of the other species.

The pygidium has five or six rings in the axial lobe and a terminal segment. *N. inflatus* has ten or eleven rings in the axial lobe and *N. superbus* has eight rings; *N. intermedius* has the same number of terminal spines as *N. superbus*, but the spines are curved backward much more than in the latter species.

As far as known, this species does not attain the size of either *N. superbus* or *N. inflatus*. The largest cephalon in the collection has a length of 35 mm. The proportions of the head and pygidium are about the same as *N. superbus*. The hypostoma referred to this species is proportionally broader and with a larger body proportionally than that of *N. inflatus* or *N. superbus*. In other respects it is very much like the hypostoma of *N. superbus*.

DIMENSIONS.—A dorsal shield 74 mm. in length has the following dimensions:

Cephalon:	mm.
Length .....	26.5
Length of glabella.....	21.0
Length of eye lobe.....	4.4
Width at posterior margin.....	44.0
Width of glabella at posterior margin.....	13.5
Width of glabella at anterior end.....	15.0
Thorax:	
Length .....	27.0
Width .....	41.0
Width of axial lobe at first segment.....	13.0
Width of pleural lobe at first segment.....	13.5
Pygidium:	
Length .....	20.5
Width .....	35.0
Width of axial lobe at anterior ring.....	10.0
Width of axial lobe at posterior ring.....	7.5

The surface markings of this species are much like those of *N. superbus* and *N. inflatus*, but very much finer. On a cranidium 11 mm. in length the surface appears smooth, except under a strong lens.

FORMATION AND LOCALITY.—Middle Cambrian: 1,895–2,140 feet (605–653.8 m.) below the Upper Cambrian and about 2,000 feet (609.6 m.) above the beds containing *Zacanthoides typicalis* Walcott and *Bathyuriscus howelli* Walcott, the horizon which is correlated with the horizon carrying *Neolenus serratus* (Rominger) in British Columbia,<sup>1</sup> in thin-bedded limestones of the Marjum formation, in ridge on east side of Wheeler Amphitheater, east of Antelope Springs, House Range, Millard County, Utah, U. S. A.

#### NEOLENUS INTERMEDIUS PUGIO, new variety

PLATE 6, FIGURES 8, 9

This variety is founded on four specimens of a pygidium that has four rings and a terminal segment in the axial lobe, four marginal spines on each side and three clearly defined anchylosed pleural segments marked by oblique pleural furrows. A specimen 11 mm. in length has a width at the front of 36 mm. The axial lobe has a width of 5 mm. at the first segment and 3 mm. at the terminal segment.

This variety differs from *N. intermedius* in having four instead of five marginal spines on each side of the pygidium, four axial rings instead of five and a shorter terminal section to the axial lobe. A fragment of the outer surface shows it to have been of the same type as that of *N. superbus*.

FORMATION AND LOCALITY.—Middle Cambrian: 1,895–2,140 feet (605–653.8 m.) below the Upper Cambrian and about 2,000 feet (609.6 m.) above the beds containing *Zacanthoides typicalis* Walcott and *Bathyuriscus howelli* Walcott, the horizon which is correlated with the horizon carrying *Neolenus serratus* (Rominger) in British Columbia,<sup>1</sup> in thin-bedded limestones of the Marjum formation, in ridge on east side of Wheeler Amphitheater, east of Antelope Springs, House Range, Millard County, Utah, U. S. A.

<sup>1</sup> This British Columbia horizon is given in detail in the Formation and locality of *Burlingia hectori*.



**NEOLENUS SUPERBUS, new species**

PLATE 4, FIGURES 1-5

Dorsal shield large, longitudinally elliptical in outline, moderately convex. Cephalon subsemicircular in outline, one-third of the length of the dorsal shield; bordered by a strong, slightly convex outer margin that is continued at the genal angles into strong, sharp spines that extend backward and slightly outward to about opposite the fourth thoracic segment; the posterior marginal border is narrow next to the glabella, from where it gradually broadens to the base of the genal spine; between the facial suture and the genal spine the margin arches abruptly forward, so as to throw the base of the genal spine in front of the line of the posterior margin; a well defined but narrow furrow separates it from the fixed cheek. Cranidium with a large glabella, narrow antero-lateral limbs, and large postero-lateral limbs; fixed cheeks narrow opposite the palpebral lobes; anteriorly they extend as a narrow, short section to the front border, and posteriorly merge into the postero-lateral limb, which is nearly as deep from the eye lobe to the posterior margin as from the glabella to its postero-lateral angle; palpebral lobe narrow, short, and with its outer rim extended diagonally from and across the fixed cheek to the dorsal furrow, next to the glabella.

Glabella elongate, moderately convex; sides nearly straight, and separated from the fixed cheeks by a narrow, strong furrow, slightly wider where the sides touch the frontal border than at the occipital furrow; front broadly rounded and subparallel to the anterior margin of the cranidium; surface marked by three pairs of short, oblique furrows that extend inward and slightly backward about one-third the distance across the glabella; a small pit occurs in the dorsal furrow at the antero-lateral angles, and from it a short, obscure furrow extends directly inward for a short distance; the glabellar furrows are not at all prominent. Occipital ring narrow at the ends, gradually becoming stronger and more convex toward the center, where a strong, backward arching spine has its base; occipital furrow nearly transverse, shallow, and terminating in advance of the furrows of the fixed cheeks. Free cheeks relatively small; the body rises with very little convexity from within the strong outer border to the base of the short, low eye lobe. The facial sutures cut the posterior margin a short distance within the genal spine, curve slightly outward across the border, and then inward with a gentle sigmoid curve to the base of the eye lobe; arching over the latter, they extend forward with a slight outward arching across the border, so as to cut the front margin on a line with the center of the eye lobe.



Thorax with seven segments; axial lobe convex, and as wide as the pleural lobes exclusive of the terminal spines; a strong, short, sharp spine occurs at the center of each segment, and a narrow, transverse, low, rounded ridge on each side next to the dorsal furrow; the pleural lobes are slightly convex; each pleura has a strong, diagonal furrow that originates near the front margin next to the dorsal furrow and gradually widens toward the outer end, where it terminates nearly at the center of the pleura and within the base of the sharp, terminal spine; a narrow, rounded ridge occurs on each side of the pleural furrow that forms the margins of the pleuræ; the terminal spines have a broad base and extend obliquely outward and slightly backward a short distance.

Pygidium large, moderately convex; anterior margin nearly transverse and posterior outline semicircular; axial lobe convex, a little shorter than the entire length; it is divided into seven rings and a terminal section by seven nearly transverse, narrow furrows; a low, narrow median ridge is indicated by the termination of the deeper portion of each transverse furrow just outside of the median line; five anchylosed pleural segments are outlined on the pleural lobes on each side of the axial lobe; the furrows all terminate within the slightly flattened, rounded border, which has five straight, narrow spines extending out from it on each side; the anterior segment of the pygidium is so much like the segments of the thorax that it is difficult to distinguish it from the thorax.

Hypostoma similar to that of *Neolenus inflatus*, except that its body is less convex, and small specimens show an elongate tubercle on each side just back of the line separating the convex body from its posterior, less convex, and narrower portion.

Surface with variously arranged, irregular, short, very fine, raised lines or minute ridges; on the glabella they are arranged in a concentric manner, although very irregular and interrupted by numerous breaks in continuity and strength; on the cheeks the lines are somewhat coarser; on the thorax and pygidium the lines are exceedingly fine and inconspicuous; where seen they have about the same arrangement as those of the surface of *Neolenus inflatus*.

DIMENSIONS.—A dorsal shield 65 mm. in length has the following dimensions:

Cephalon:	mm.
Length .....	23.00
Length of glabella.....	17.00
Length of eye lobe.....	2.75
Width at base.....	38.00
Width of glabella at posterior margin.....	12.00
Width of glabella at anterior end.....	13.50

Thorax :	mm.
Length .....	24.00
Width .....	30.00
Width of axial lobe at first segment.....	10.00
Width of pleural lobe at first segment.....	10.00
Pygidium :	
Length .....	18.00
Width .....	26.00
Width of axial lobe at anterior ring.....	9.00
Width of axial lobe at posterior ring.....	6.50
Hypostoma :	
Length .....	29.00
Length of body.....	26.00
Width .....	18.00
Width at base.....	23.00
Width at junction with head.....	33.00
Greatest width of body.....	19.00

OBSERVATIONS.—This species attains a large size. A cephalon and six thoracic segments has a length of 73 mm., a width of thorax of 70 mm.; with the seventh segment and the pygidium, exclusive of spines, the entire shield would have had a length of 107 mm. Fragments occur that indicate even a larger size.

*Neolenus superbus* and the associated *Neolenus inflatus* have many characters common to each; both attain a large size, both have small eyes, subquadrilateral glabellas, spinose genal angles, seven thoracic segments, spinose terminations to pleural segments and border of pygidium, occipital and thoracic median spines, lined surfaces, and resemble each other in minor details. The two species differ in the glabella of *N. superbus* being slightly convex with nearly parallel sides, instead of being inflated and expanded toward the front. The pygidium of *N. superbus* has seven axial rings and five spines on the border; that of *N. inflatus* has nine rings and eight spines. *Neolenus serratus* (Rominger)<sup>1</sup> has a broader dorsal shield, falcate terminations to the pleural segments, four rings on the axis of the pygidium, a subquadrangular glabella and genal spines that are formed by the union of the outer border and posterior border, instead of being a continuation of the outer border, as in *N. superbus* and *N. inflatus*. The surface of *N. serratus* is granular and not raised lines, as in *N. superbus*.

FORMATION AND LOCALITY.—Middle Cambrian: 1,895–2,140 feet (605–653.8 m.) below the Upper Cambrian and about 2,000 feet (609.6 m.) above the beds containing *Zacanthoides typicalis* Walcott and *Bathyriscus howelli* Walcott, the horizon which is correlated

<sup>1</sup> *Ogygia serrata* Rominger, 1887, Proc. Acad. Nat. Sci. Philadelphia, p. 13.

with the horizon carrying *Neolenus serratus* (Rominger) in British Columbia,<sup>1</sup> in thin-bedded limestones of the Marjum formation, in ridge on east side of Wheeler Amphitheater, east of Antelope Springs, House Range, Millard County, Utah, U. S. A.

Genus **BATHYURISCUS**. Meek

**BATHYURISCUS ORNATUS**, new species

PLATE I, FIGURES 1-3

Dorsal shield small for the genus, longitudinally oval in outline, moderately convex. Cephalon semicircular in outline; a little less than one-third the length of the dorsal shield; bordered by a narrow, rounded margin that passes, at the rounded genal angle, into the very narrow posterior border; the interborder furrow is sharply defined all about the outer border, and within the posterior border it is a straight, rather broad, shallow furrow. Cranidium large, with very small antero-lateral and large postero-lateral limbs; the former are nearly as long as broad and separated from the fixed cheeks by the strong ocular ridges; the postero-lateral limbs and fixed cheeks merge into each other so as to form subtriangular areas, with the narrow palpebral lobes on their front outer margins for about one-third of their length; the palpebral lobes are small, about one-fourth to one-fifth the length of the cranidium and bordered by a strong, narrow, rounded rim that extends across the fixed cheeks to the dorsal furrow, beside the glabella.

Glabella large, a little wider in front than at the occipital furrow and with slightly diverging sides; front broadly rounded; surface marked by four pairs of furrows, the posterior of which extends obliquely inward across the posterior portion nearly to the center, so as to separate a small subtriangular lobe on each side; the three anterior pairs of furrows are short, close to the dorsal furrow, and about equal distances from each other. Occipital ring very narrow at its ends, from where it broadens rapidly to its full width; a short, oblique furrow occurs on each side that is subparallel to the posterior pair of glabellar furrows, that serve to separate the central portion of the occipital ring from its end sections; occipital furrow narrow, distinct, transverse, and terminating in advance of the posterior intermarginal furrows of the fixed cheeks. Free cheeks small, elongate, and with rounded posterior angles; eye lobes small. The facial sutures cut the posterior margin just within the genal angle and extend obliquely forward and inward with a slight sigmoid

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<sup>1</sup>This British Columbia horizon is given in detail in the Formation and locality of *Burlingia heceteri*.

curvature to the base of the eye lobes; curving over and around the eye lobes, they pass forward and a little outward to the front margin; the distance between the eye lobes and margin is about the length of the eye lobe.

Thorax with eight segments; axial lobe moderately convex, about as wide as the pleural lobes in partially compressed specimens; on the outer side of each segment a rounded, transverse node or ridge is separated from the main body of the segment by a slightly oblique furrow transverse to the segment; the furrows are similar to those crossing the occipital ring; pleural lobes slightly convex and with the extremities of the pleuræ bending slightly downward; each pleura has very narrow, raised margins next to the axial lobe that gradually broaden and slope inward out to the slight geniculation, where they form an elongated node with straight outer edge, which, touching against the nodes upon the adjoining pleura, forms an elongated, rounded node transversely divided by the line separating the pleuræ; an elongated, tapering, rounded node, with its base at the dorsal furrow, occupies the inner half of the pleura; a narrow groove on each side of the node united to form a shallow pleural furrow that terminates within the somewhat abruptly pointed outer extremity of each pleura.

Pygidium of medium size, about one-fourth the length of the dorsal shield; anterior margin nearly transverse, except where it bends backward near the outer ends; posterior outline semicircular; axial lobe moderately convex and tapering gradually toward the posterior section; it is divided by four transverse furrows into four rings and a terminal segment; four anchylosed pleural segments are outlined on the pleural lobes on each side of the axial lobe by furrows that progressively curve backward from the first to the posterior adjoining the terminal segment; the furrows all terminate within the narrow, slightly flattened border.

Surface finely granulose.

DIMENSIONS.—A dorsal shield 13.5 mm. in length has the following dimensions:

Cephalon:	mm.
Length .....	5.0
Length of eye lobe.....	0.9
Width at posterior margin.....	9.0
Width of glabella at posterior margin.....	2.4
Thorax:	
Length .....	5.5
Width .....	8.5
Width of axial lobe at first segment.....	2.3
Width of axial lobe at eighth segment.....	1.9

Pygidium :	mm.
Length .....	2.9
Width at union with thorax.....	6.0

OBSERVATIONS.—This species is rather rare at Mount Stephen, although 18 specimens were found in the collections of 1907. The largest specimen of the dorsal shield has a length of 18 mm. The strong triangular nodes on the pleural portion of the segments next to the axial lobe and the nodes at the geniculation, combined with the clearly defined furrows about them, give the thorax a very striking ornamental effect that leads to giving the specific name *ornatus*. This type of thoracic segment serves to distinguish the species from all other species of the genus *Bathyuriscus*. The associated *B. rotundatus* (Rominger)<sup>1</sup> has quite a different pleural segment, larger pygidium in proportion to the length of the dorsal shield, and nine thoracic segments instead of the eight, as in *B. ornatus*.

Another associated species, *Bathyuriscus occidentalis* (Matthew),<sup>2</sup> has nine segments with an open pleural furrow, relatively smaller pygidium, and larger free check.

FORMATION AND LOCALITY.—Middle Cambrian: Ogygopsis shale of the Stephen formation, 2,400 feet (731.5 m.) above the Lower Cambrian and 2,600 feet (792.5 m.) below the Upper Cambrian; northwest slope of Mount Stephen, 3,000 feet (914.4 m.) above the Kicking Horse River, above Field, on the Canadian Pacific Railway, British Columbia, Canada.

<sup>1</sup> *Embolinus rotundatus* Rominger, 1887, Proc. Acad. Nat. Sci. Philadelphia, p. 16.

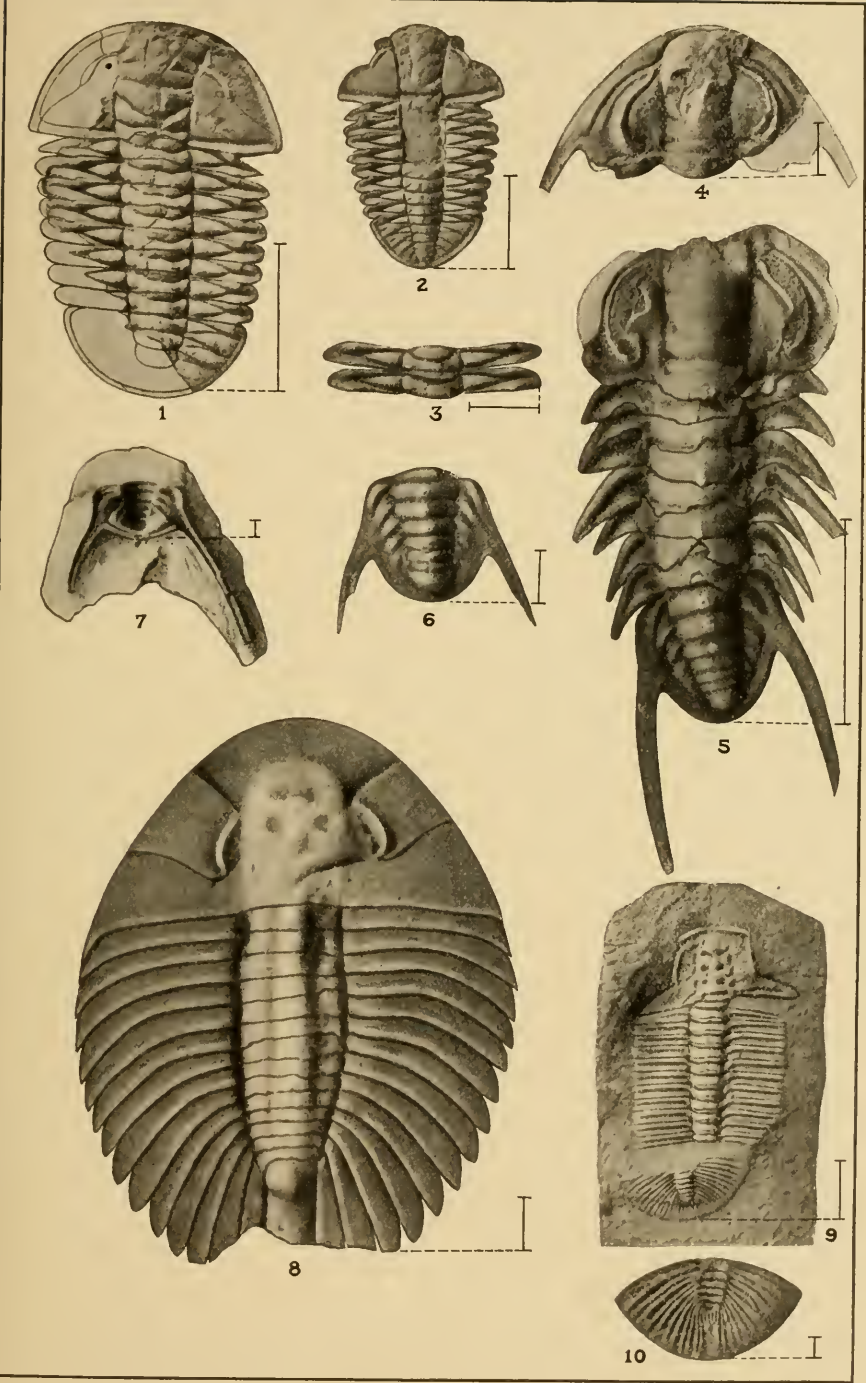
<sup>2</sup> *Dolichometopus occidentalis* Matthew, 1899, Trans. Roy. Soc. Canada for 1899, 2d ser., vol. v, sec. 4, No. 2, p. 49.



## DESCRIPTION OF PLATE I

- |  | Page |
|--|------|
| <i>Bathyuriscus ornatus</i> , new species.....   | 39   |
| FIG. 1. A broken specimen, showing character of cephalon and thorax. U. S. National Museum, Catalogue No. 53420.   |      |
| 2. A small nearly entire dorsal shield, with the exception of the free cheeks. U. S. National Museum, Catalogue No. 53421.   |      |
| 3. Two segments of the thorax enlarged to show the details of the axial and pleural lobes. U. S. National Museum, Catalogue No. 53423.   |      |
| The specimens represented by figures 1-3 are from the Middle Cambrian Ogygopsis shale of the Stephen formation, 2,400 feet (731.5 m.) above the Lower Cambrian, on the northwest slope of Mt. Stephen, near Field, British Columbia.   |      |
| <i>Albertella bosworthi</i> , new genus and new species.....   | 22   |
| FIG. 4. Cephalon, showing character of the palpebral lobes. Compare this with the cephalon of <i>Albertella helena</i> on pl. 2, figs. 1, 4, and 5. U. S. National Museum, Catalogue No. 53413.  |      |
| 5. A specimen showing the character of the thorax and pygidium. U. S. National Museum, Catalogue No. 53416.  |      |
| 6. Pygidium, which compare with pygidium of <i>A. helena</i> pl. 2, fig. 2. U. S. National Museum, Catalogue No. 53415.  |      |
| 7. Inner side of a very small pygidium. U. S. National Museum, Catalogue No. 53406.  |      |
| The specimens represented by figures 4-7 are from a drift block of Lower Cambrian shales found on the slopes of Mt. Bosworth, just north of the Canadian Pacific Railway, one mile (0.62 km.) east of Hector, British Columbia.  |      |
| <i>Burlingia hectori</i> , new genus and new species.....  | 15   |
| FIG. 8. A nearly entire specimen greatly enlarged. U. S. National Museum, Catalogue No. 53418.   |      |
| The specimen represented by figure 8 is from the Middle Cambrian Ogygopsis shale of the Stephen formation, 2,400 feet (731.5 m.) above the Lower Cambrian, on the northwest slope of Mt. Stephen, near Field, British Columbia.  |      |
| <i>Oryctocara geikici</i> , new genus and new species.....   | 23   |
| FIG. 9. A nearly entire dorsal shield with the exception of the free cheeks. U. S. National Museum, Catalogue No. 53426.   |      |
| 10. Greatly enlarged matrix of a small pygidium. U. S. National Museum, Catalogue No. 53427.   |      |
| The specimens represented by figures 9-10 are from the Spence shale of the Ute formation, near the base of the Middle Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 15 miles (9.37 km.) west of Montpelier, and 5 miles (3.12 km.) west-southwest of Liberty, Bear Lake County, Idaho. |      |





CAMBRIAN TRILOBITES

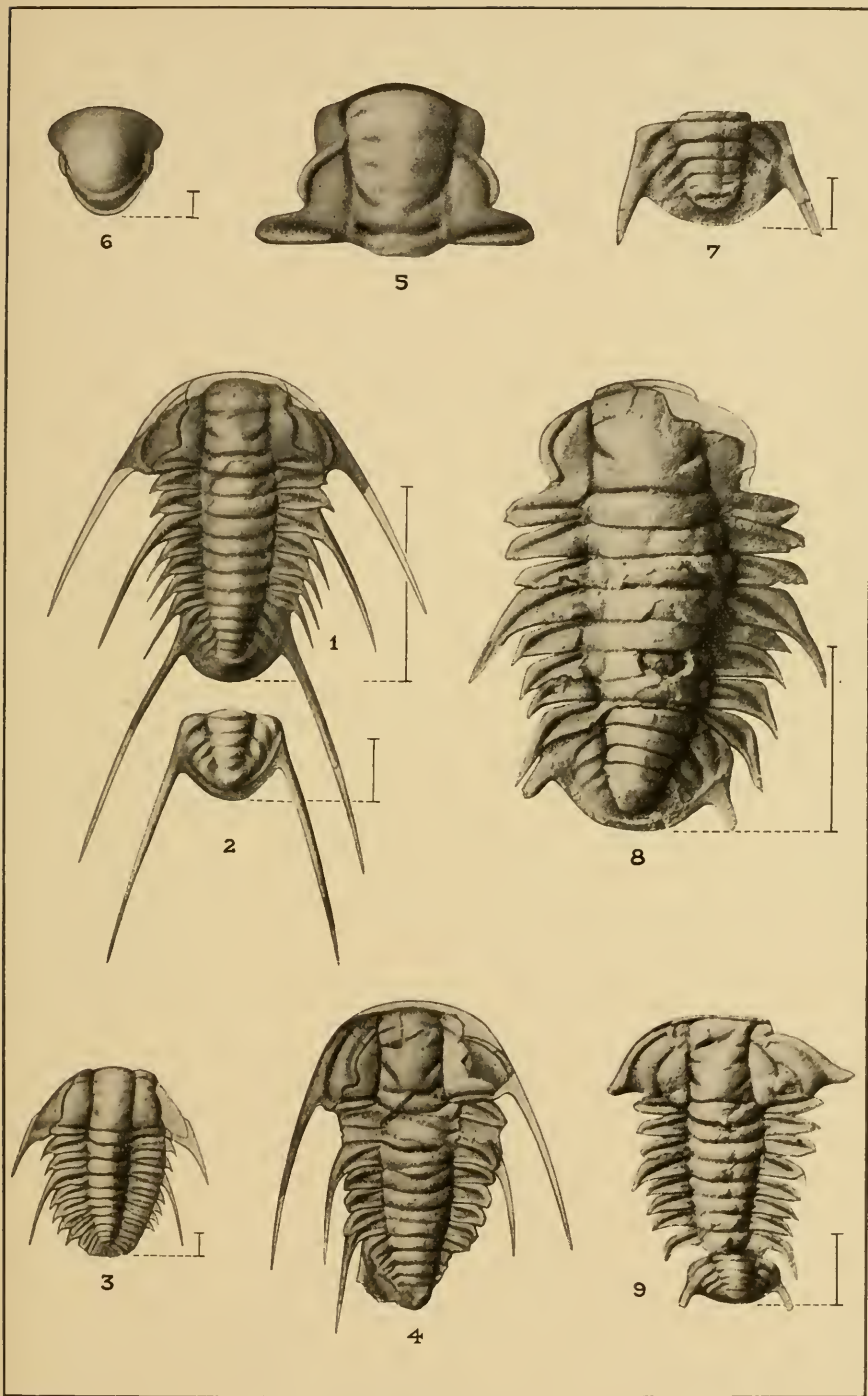




## DESCRIPTION OF PLATE 2

	Page
<i>Albertella helena</i> , new genus and new species.....	19
FIG. 1. A nearly entire dorsal shield. U. S. National Museum, Catalogue No. 53410.	
2. A pygidium retaining much of its natural form. The outer test is exfoliated about the margins. U. S. National Museum, Catalogue No. 53411.	
3. A very small dorsal shield. U. S. National Museum, Catalogue No. 53409.	
4. A large, broken dorsal shield. U. S. National Museum, Catalogue No. 53407.	
5. A large cranium. U. S. National Museum, Catalogue No. 53408.	
6. Hypostoma associated with this species. U. S. National Museum, Catalogue No. 53414.	
7. A pygidium which compare with the pygidium of <i>A. bosworthi</i> on pl. 1, fig. 6. U. S. National Museum, Catalogue No. 53403.	
8. A broken dorsal shield, broadened by compression. U. S. National Museum, Catalogue No. 53402.	
9. A small dorsal shield. U. S. National Museum, Catalogue No. 53404.	

The specimens represented by figures 1-5 are from Lower Cambrian shales on Gordon Creek, Ovando Quadrangle, Powell County, Montana, and those represented by figures 6-9 are from a drift block of Lower Cambrian shales found on the slopes of Mt. Bosworth, just north of the Canadian Pacific Railway, one mile (0.62 km.) east of Hector, British Columbia.



CAMBRIAN TRILOBITES





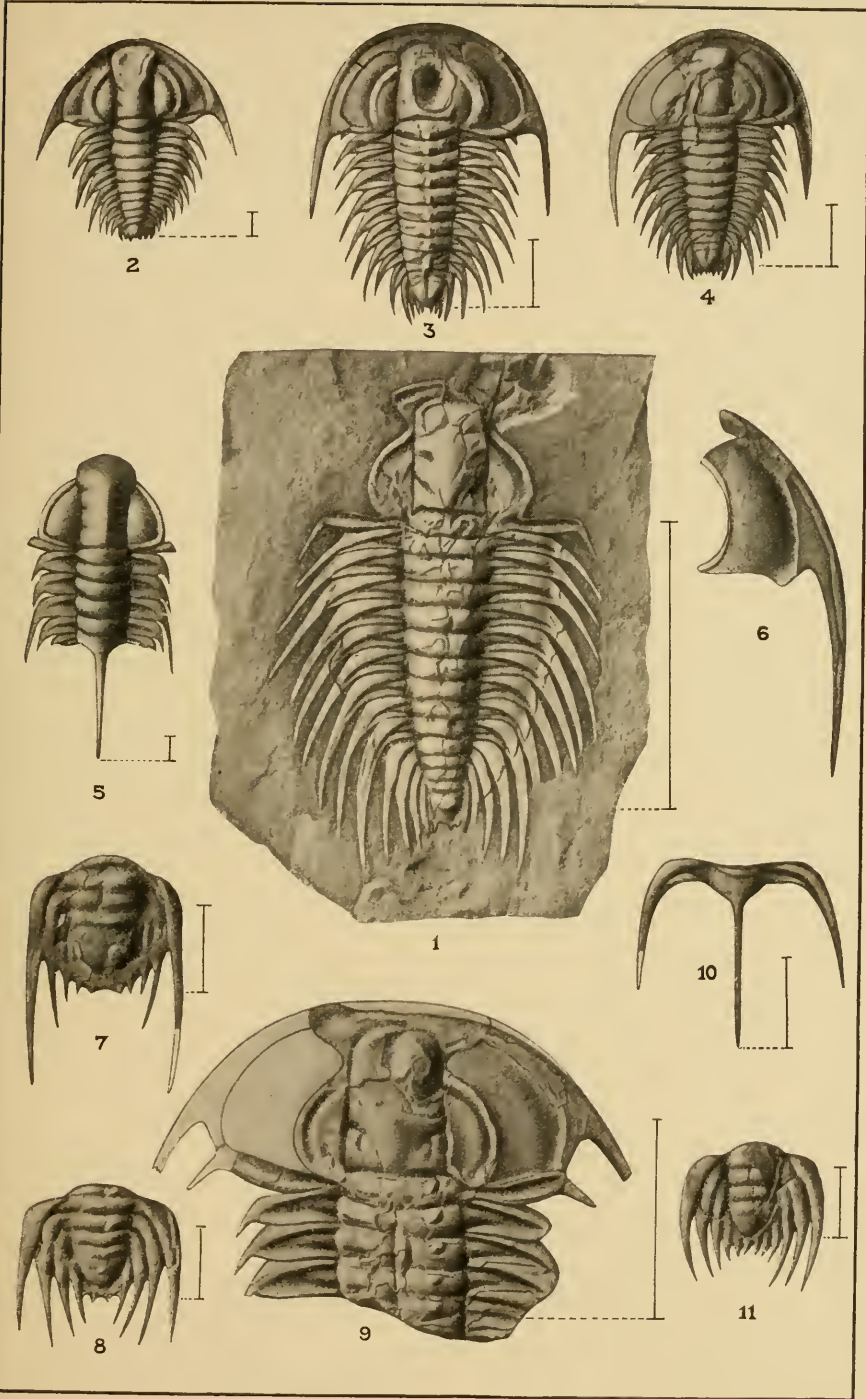


## DESCRIPTION OF PLATE 3

	Page
<i>Zacanthoides idahoensis</i> .....	26

- FIG. 1. A large dorsal shield compressed in the shale. U. S. National Museum, Catalogue No. 53434.
2. A small dorsal shield with seven thoracic segments and three spines on each side of pygidium. U. S. National Museum, Catalogue No. 53437.
3. Small dorsal shield with adult characters. U. S. National Museum, Catalogue No. 53435.
4. Small dorsal shield with adult characters. U. S. National Museum, Catalogue No. 53436.
5. Dorsal shield of a very young individual with a strong spine on the axial lobe of the fifth segment. U. S. National Museum, Catalogue No. 53440.
6. Large free cheek. U. S. National Museum, Catalogue No. 53432.
- FIGS. 7, 8, and 11. Pygidia illustrating variations in spinose border. U. S. National Museum, Catalogue Nos. 53429, 53430, and 53431.
- FIG. 9. Fragment of a large adult dorsal shield showing interocular spine, free cheek in position, and the lateral position of the genal spine on the free cheek. U. S. National Museum, Catalogue No. 53433.
10. Fifth thoracic segment with median spine. U. S. National Museum, Catalogue No. 53438.

The specimens represented by figures 1-10 are from the Spence shale of the Ute formation, near the base of the Middle Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 15 miles (9.37 km.) west of Montpelier, and 5 miles (3.12 km.) west-southwest of Liberty, Bear Lake County, Idaho.



CAMBRIAN TRILOBITES



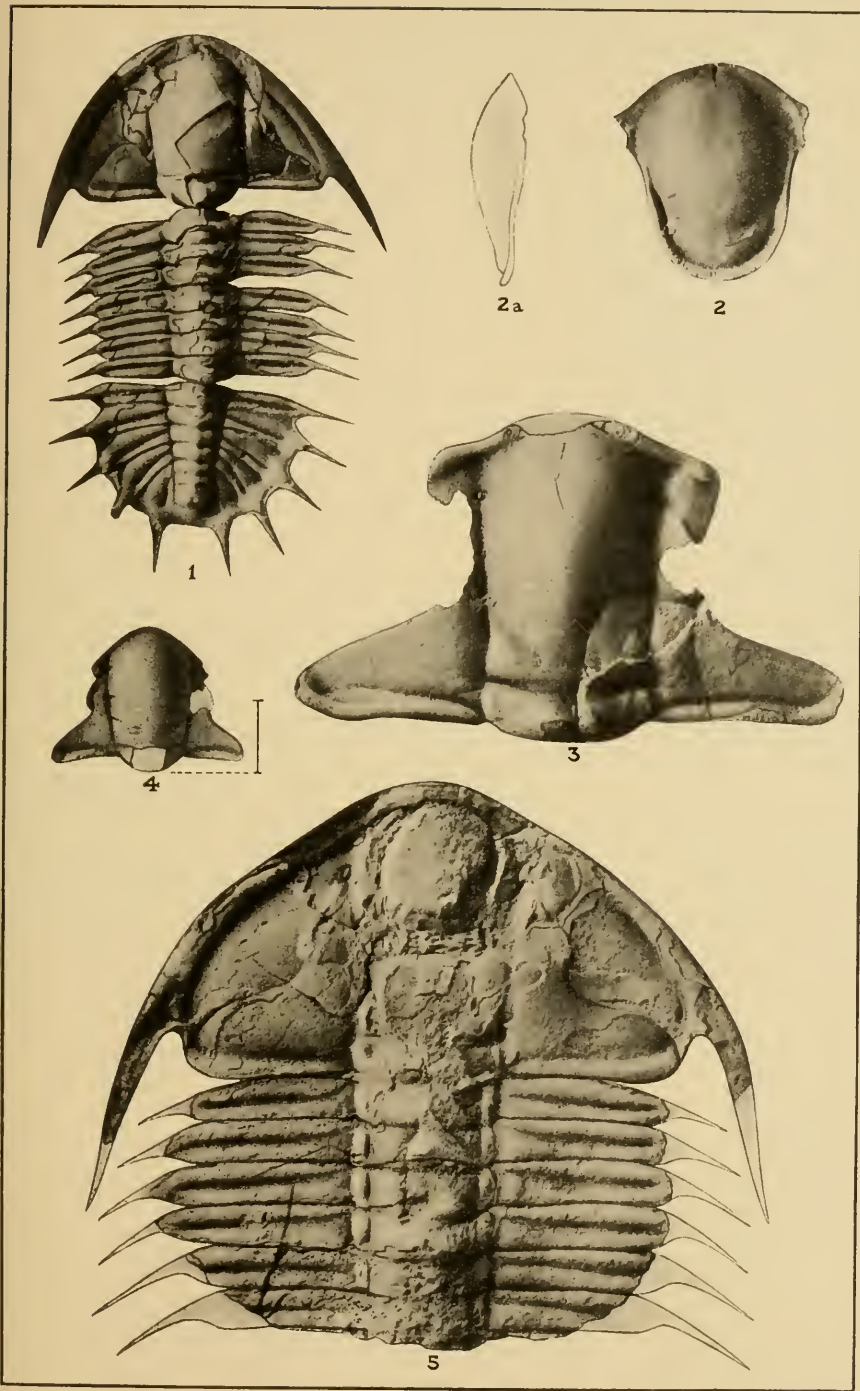




## DESCRIPTION OF PLATE 4

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<i>Neolennus superbus</i> , new species.....	36
FIG. 1. A nearly entire dorsal shield with the occipital spine broken off. U. S. National Museum, Catalogue No. 53383.	
FIGS. 2 and 2a. Hypostoma associated with this species. U. S. National Museum, Catalogue No. 53381.	
FIG. 3. Large compressed cranidium. U. S. National Museum, Cata- logue No. 53384.	
4. Small convex cranidium. U. S. National Museum, Catalogue No. 53382.	
5. Portion of a large dorsal shield with well preserved outline of the cephalon. U. S. National Museum, Catalogue No. 53380.	

The specimens represented by figures 1-5 are all from thin-bedded Middle Cambrian limestones of the Marjum formation, 2,140 feet (652.3 m.) above the top of the Lower Cambrian, in ridge on east side of Wheeler Amphitheater, east of Antelope Springs, House Range, Millard County, Utah.



CAMBRIAN TRILOBITES



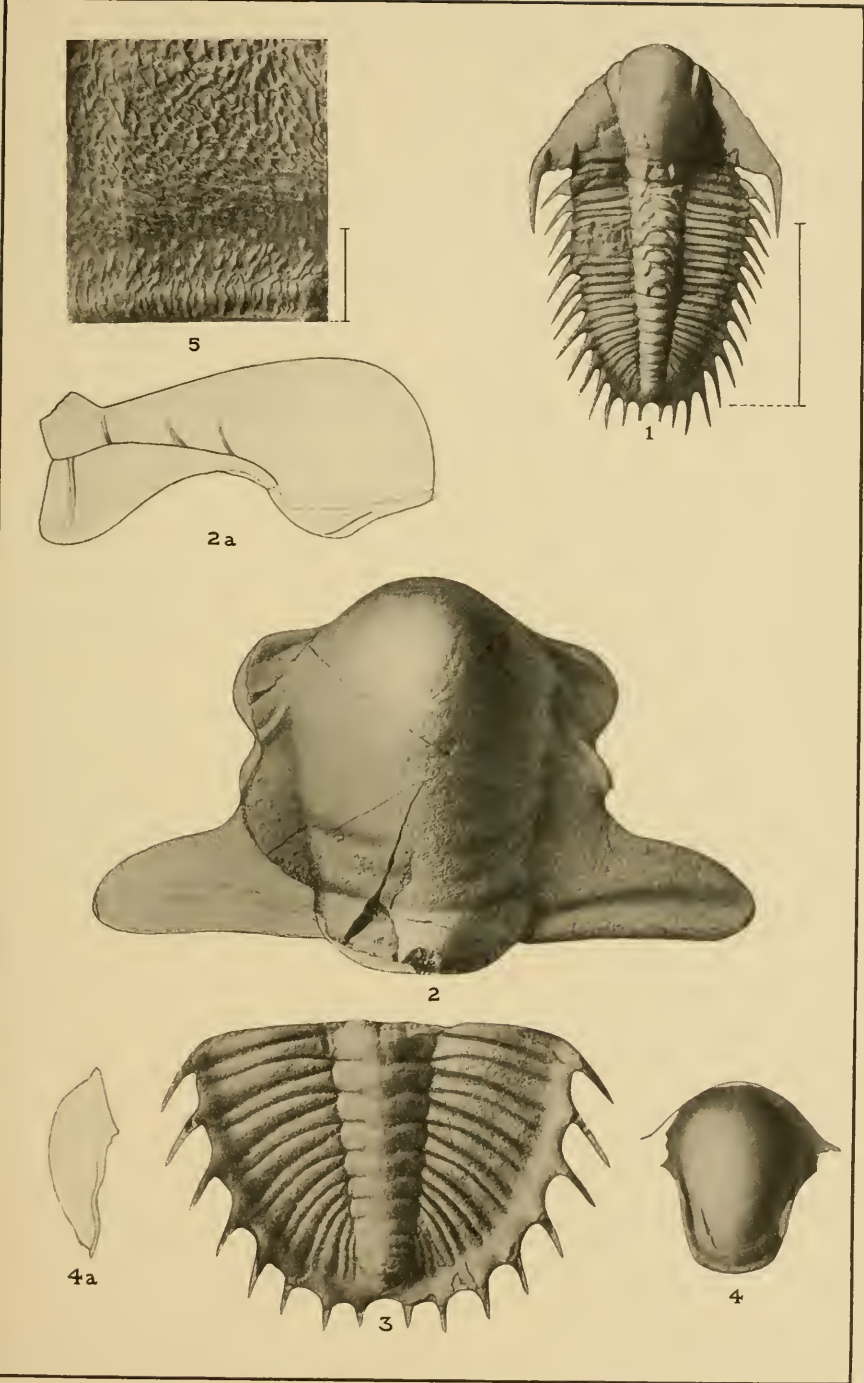




## DESCRIPTION OF PLATE 5

	Page
<i>Neolenus inflatus</i> , new species. ....	30
FIG. 1. A small nearly entire dorsal shield with the exception of the free cheeks. U. S. National Museum, Catalogue No. 53390.	
FIGS. 2 and 2a. A large cranidium. U. S. National Museum, Catalogue No. 53389.	
FIG. 3. A characteristic pygidium. U. S. National Museum, Catalogue No. 53388.	
FIGS. 4 and 4a. Associated hypostoma. U. S. National Museum, Catalogue No. 53386.	
5. Enlargement of the exterior ornamentation of the surface of the fixed cheek back of the palpebral lobe. U. S. National Museum, Catalogue No. 53387.	

The specimen represented by figure 1 is from thin-bedded Middle Cambrian limestones 2,300 feet (701 m.) above the Lower Cambrian; and the specimens represented by figures 2-5 are from thin-bedded Middle Cambrian limestones 2,140 feet (652.3 m.) above the top of the Lower Cambrian, both in the Marjum formation, in the ridge on east side of Wheeler Amphitheater, east of Antelope Springs, Millard County, Utah.



CAMBRIAN TRILOBITES





## DESCRIPTION OF PLATE 6

- |   | Page |
|---|------|
| <i>Neolenus intermedius</i> , new species.....  | 34   |
| FIG. 1. Cranidium and thorax; natural size. U. S. National Museum, Catalogue No. 53397.   |      |
| 2. Cranidium; natural size. U. S. National Museum, Catalogue No. 53394.   |      |
| 3. A pygidium with five marginal spines. Compare this pygidium with that of <i>Neolenus superbus</i> on pl. 4, fig. 1. U. S. National Museum, Catalogue No. 53398.  |      |
| 4. A pygidium with six marginal spines that is doubtfully referred to this species. U. S. National Museum, Catalogue No. 53392.   |      |
| 5. A small convex cranidium doubtfully referred to this species. U. S. National Museum, Catalogue No. 53395.  |      |
| 6. A small cranidium with a strong occipital node. U. S. National Museum, Catalogue No. 53396.  |      |
| 7. Hypostoma associated with this species. U. S. National Museum, Catalogue No. 53393.  |      |
| <p>The specimen represented by figure 6 is from thin-bedded Middle Cambrian limestones 2,075 feet (632.5 m.) above the Lower Cambrian; that represented by figure 5 is from thin-bedded Middle Cambrian limestones 2,140 feet (652.3 m.) above the Lower Cambrian; and those represented by figures 1-4, and 7 are from thin-bedded Middle Cambrian limestones 2,300 feet (701 m.) above the Lower Cambrian; all in the Marjum formation, in ridge on east side of Wheeler Amphitheater, east of Antelope Springs, House Range, Millard County, Utah.</p> |      |
| <i>Neolenus intermedius pugio</i> , new variety.....  | 35   |
| FIG. 8. Fragment of a large dorsal shield with missing parts restored in outline. U. S. National Museum, Catalogue No. 53400.   |      |
| 9. A broken pygidium. U. S. National Museum, Catalogue No. 53401.   |      |
| <p>The specimens represented by figures 8 and 9 are from thin-bedded Middle Cambrian limestones of the Marjum formation, 2,300 feet (701 m.) above the Lower Cambrian, in ridge on east side of Wheeler Amphitheater, east of Antelope Springs, House Range, Millard County, Utah.</p>  |      |











CORRECTIONS TO BE INSERTED IN SMITHSONIAN MISCELLANEOUS COLLECTIONS, VOLUME LIII.

NOTE.—This slip is so arranged that it may be torn apart and pasted in papers Nos. 1, 2, and 3.

CAMBRIAN GEOLOGY AND PALEONTOLOGY. WALCOTT.

NO. 1.—NOMENCLATURE OF SOME CAMBRIAN CORDILLERAN FORMATIONS.

Page 2. The Mount Whyte formation which is placed in the Middle Cambrian on page 2 should be in the Lower Cambrian as indicated on page 4.

CAMBRIAN GEOLOGY AND PALEONTOLOGY. WALCOTT.

NO. 2.—CAMBRIAN TRILOBITES.

Page 22. 17th line, strike out "Wolsey."

" 22. 18th line, (2.5 km.) should read (6.41 km.)

" 26. 4th and 5th lines,

" 30. 9th and 10th lines, } (9.37 km.) and (3.12 km.) should read (24.14

" 42. 43d and 44th lines, } km.) and (8.05 km.), respectively.

" 46. 29th and 30th lines, }

" 33. 33d line, }

" 35. 6th line, } (605-653.8 m.) should read (577.6-652.3 m.)

" 35. 28th line, }

" 38. 41st line, }

" 42. 27th line, } (0.62 km.) should read (1.61 km.)

" 44. 27th line, }

CAMBRIAN GEOLOGY AND PALEONTOLOGY. WALCOTT.

NO. 3.—CAMBRIAN BRACHIOPODA: DESCRIPTIONS OF NEW GENERA AND SPECIES.

Page 57. 32d line, "base of the Wolsey shale" should read "top of the quartzitic sandstones."

" 101. 18th line, strike out "Wolsey." The shale mentioned on these pages is not the equivalent of the Wolsey shale.